Sustaining Water Population and the Future of Renewable Water Supplies

Population Action International

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This is the first of a series of reports by Population Action International on the impact of population size, growth, distribution and consumption patterns on natural resources critical to human well-being. Upcoming reports will examine emissions of greenhouse gases and the availability of arable land.

The Population and Environment Program, which is producing the series, was established to make scientific findings and policy debates in this emerging field more accessible to the public and to policymakers. The program works to encourage environment, women's rights and development groups to address population issues; to ensure that reproductive health and family planning services become part of efforts to conserve natural resources and improve the quality of human life; and to help establish conditions that will enable population growth rates to decline, with full respect for individual reproductive rights.

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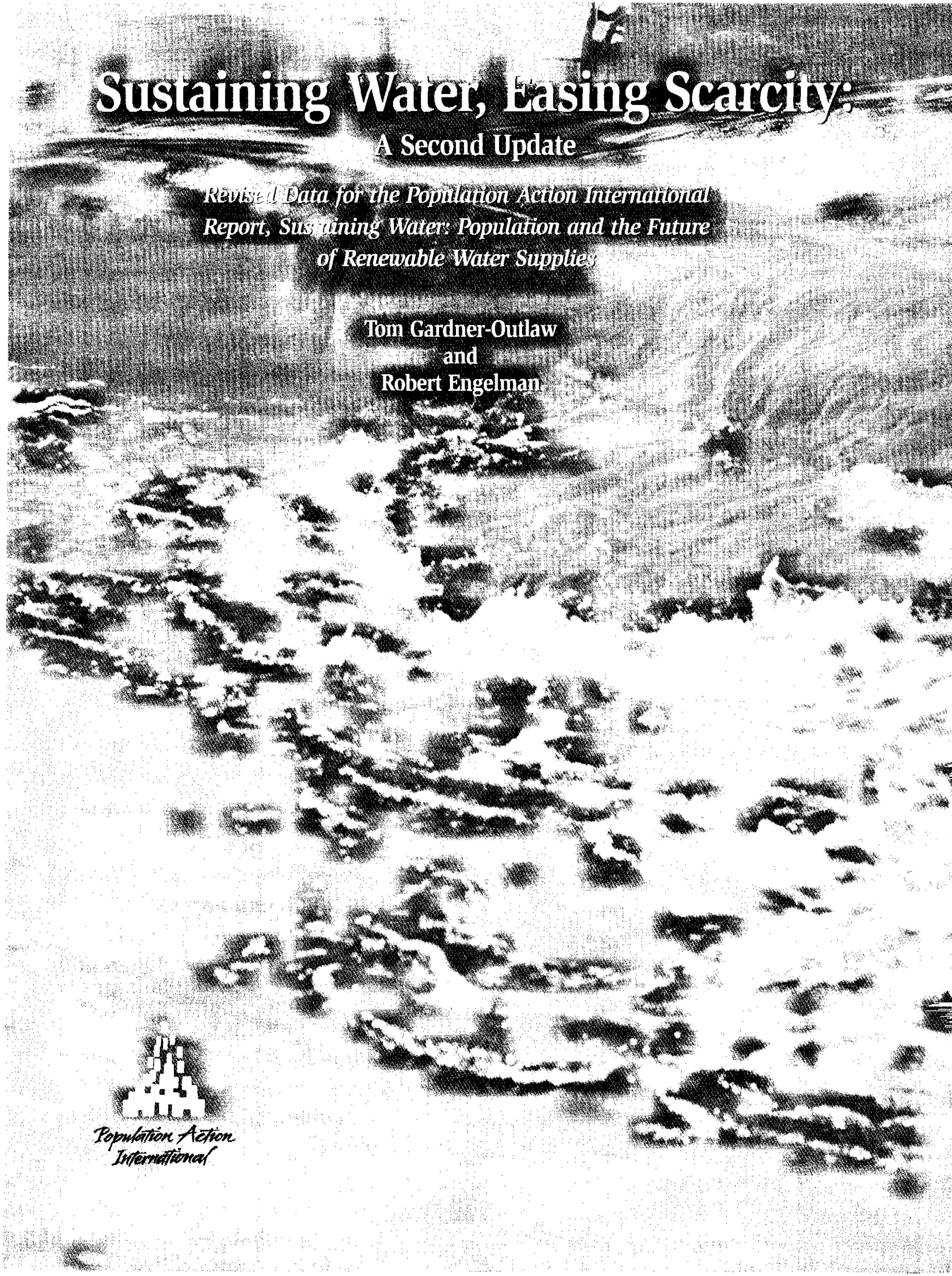


Sustaining Water, Easing Scarcity:

A Second Update

Revised Data for the Population Action International Report, Sustaining Water: Population and the Future of Renewable Water Supplies

Tom Gardner-Outlaw
and
Robert Engelman

Population Action International

Population Action International (PAI) is dedicated to advancing policies and programs that slow population growth in order to enhance the quality of life for all people.

PAI advocates the expansion of voluntary family planning, other reproductive health services, and educational and economic opportunities for girls and women. These strategies promise to improve the lives of individual women and their families while slowing the world's population growth.

To these ends, PAI seeks to increase global political and financial support for effective population policies and programs grounded in individual rights.

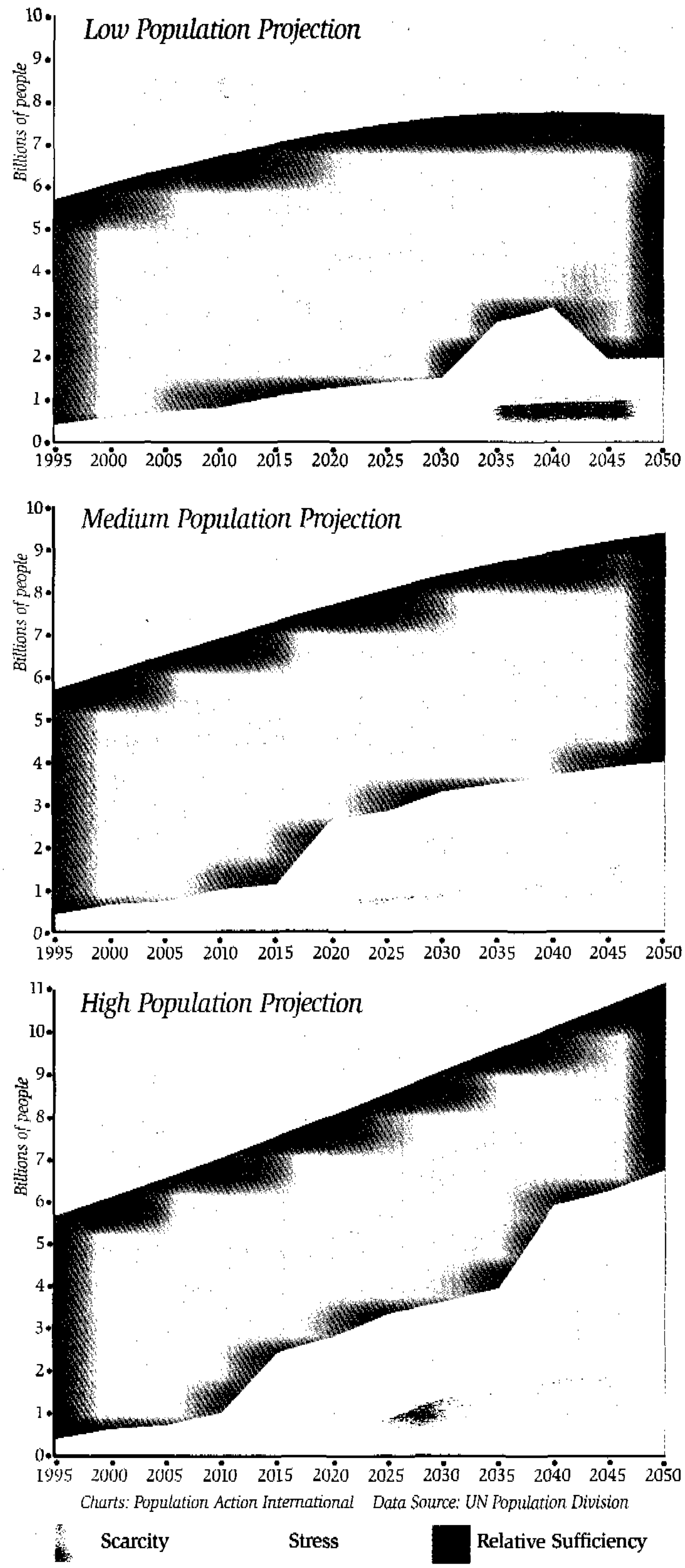
PAI fosters the development of U.S. and international policy on urgent population issues through an integrated program of policy research, public education and political advocacy. PAI reaches out to government leaders and opinion makers through the dissemination of strategic, action-oriented publications, broader efforts to inform public opinion, and coalitions with other development, reproductive health and environmental organizations.

Board of Directors

Printed on recycled paper with organic ink.

Figure 1

World Population Experiencing Freshwater Scarcity, Stress and Relative Sufficiency 1995–2050



Charts: Population Action International Data Source: UN Population Division

These figures show the number of people living in countries experiencing water stress, scarcity or relative sufficiency at five-year increments under the UN low, medium and high population growth projections. As the population growth rate increases, so does the proportion of people living in countries experiencing water stress and scarcity.

Summary

As a result of an unexpected recent slowing of population growth, the United Nations projects that world population will be smaller by 450 million people in the year 2050 than it projected just three years ago. This reduction is primarily the result of significant declines in birthrates throughout the world. While this is good news by itself, reductions in population growth also have beneficial effects on the amount of renewable natural resources such as water, air and forests that are available to each of us. Using the United Nations 1996 population projections, Population Action International (PAI) has revised previous estimates and projections of the amount of fresh water available to each person in most of the world's countries from today to the middle of the coming century. Based on this new range of population figures, PAI calculates that depending on how rapidly population grows, there will be between 400 million and 1.5 billion fewer people living in water short countries in the year 2050 than previously projected.

This improvement in the assessment of the future availability of renewable fresh water has a wide range of potential benefits, from less pressure on freshwater ecosystems and underground aquifers to less tension between nations competing for shared water resources. However, even under this improved scenario, renewable freshwater scarcity will continue to remain a problem for millions of people around the world. There are currently more than 430 million people living in countries considered water stressed. Moreover, PAI projects that by 2050, the percentage of the world's population living in water stressed countries will increase by anywhere from three to fivefold.

This update outlines the causes and consequences of water scarcity and explains the importance of slower population growth—and eventual population stability—in helping to achieve a sustainable pattern of global water use.

Introduction

The database on pages 14 to 19 contains revised estimates for annual per capita availability of renewable fresh water for 161 countries through the year 2050. Population Action International originally presented water resource data of this type in its 1993 report, *Sustaining Water: Population and the Future of Renewable Water Supplies.*[1] In 1995, PAI updated these figures in *Sustaining Water: An Update,*[2] based on new population projections but not on new estimates of water availability.

This current data update is based on new population estimates and projections made by the United Nations in *World Population Prospects: The 1996 Revision,*[3] and also includes more recent data for renewable water by nation from *World Resources 1996-1997: A Guide to the Global Environment.*[4] These water data reflect political changes such as the creation of Eritrea as a nation and the breakup of the former Soviet Union into the Russian Federation and the adjoining republics.

Why a second update? Beyond simply presenting more recent data, this update provides additional evidence of the influence of demographic change on the availability of critical natural resources such as fresh water. And, perhaps most importantly, the update illustrates the significant impact that sound population policies can have on the long-term sustainability of these resources. Through comparisons of current and previous projections, it becomes evident that even small changes in the rate of population growth can have enormous implications for future generations. While many countries will continue to face problems of freshwater availability in the future, the good news reflected in these data is that policies that slow population growth can reduce the severity and duration of such natural resource scarcities.

What Do the Population Data Reveal?

The 1996 United Nations population projections show that world population growth is slowing more dramatically than previously thought (Figure 2). This comes as a pleasant contrast to the increasingly pessimistic predictions about the fate of the global environment. According to the UN *medium variant* projection, the world will have 450 million *fewer* people by the year 2050 than had been projected in 1994. Although increasing mortality rates are important in some regions, the dominant factor in the slowdown of population growth is a decline in fertility, the average number of live births to each woman, that has exceeded earlier expectations.[5]

What does this mean for renewable freshwater resources? As more people share the same amounts of fresh water, there is less available to each person. China and Canada, for example, have roughly the same amount of renewable fresh water and the same land area. However, China's population is more than 40 times larger than Canada's. This means that each person in China has less than three percent of the fresh water available to each Canadian. Although higher living standards can effect the *demand* for fresh water through increases in a nation's rate of water consumption, higher population size is perhaps the most significant human influence on the *availability* of fresh water. Thus, although populations are still growing—and will for some time to come—slower growth means less future water scarcity, as defined here, than previously anticipated. This means countries will have more fresh water for good health, for irrigating food crops and for economic development. Finally, fewer people almost certainly means less pressure on the health of freshwater ecosystems from land

Figure 2

DOWNWARD REVISIONS OF WORLD POPULATION PROJECTIONS FROM 1994 TO 1996

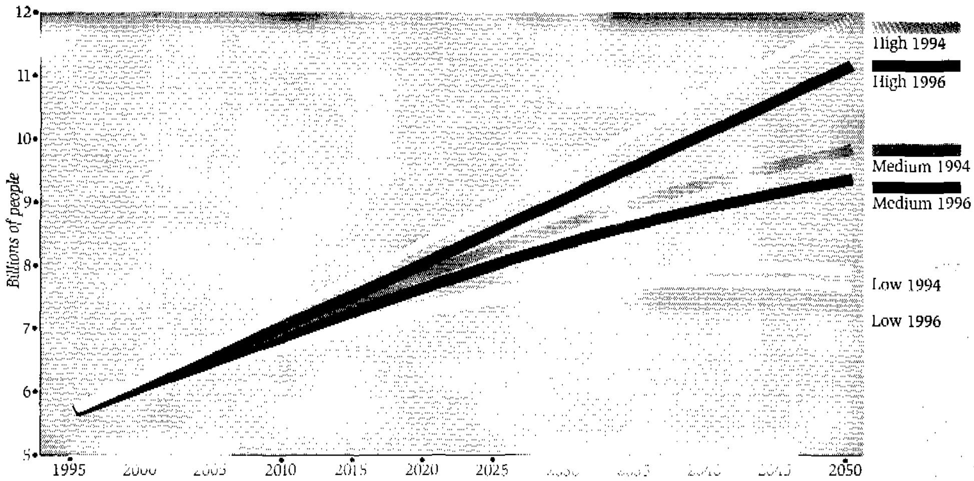


Chart: Population Action International Data Source: UN Population Division

The 1996 line in each projection reflects recent downward revisions in population growth.

use changes, deforestation, pesticide applications and waste disposal.

How Are Water Stress and Scarcity Measured?

Before examining in detail the revised data on per capita water availability, it is useful to review the criteria for quantifying the relationship between population growth and water availability. Swedish hydrologist Malin Falkenmark originated the idea of a *water stress index* based on an approximate minimum level of water needed per capita to maintain an adequate quality of life in a moderately developed country. Working with existing hydrological principles and benchmarks, Falkenmark estimated that 100 liters per person per day is the rough minimum required for basic household needs such as drinking, bathing and cooking. She further determined that 5 to 20 times this amount is needed to meet the demands of the agricultural, industrial and energy production sectors.[6]

Based on these calculations, Falkenmark derived benchmarks indicating the onset of water stress and water scarcity. A country with more than approximately 1,700 cubic meters of renewable fresh water per person per year will generally experience only intermittent or localized water shortages. As the amount of available fresh water sinks below this level, countries begin to experience *water stress*—that is, water supply problems tend to become chronic and widespread. Having a stress indicator serves as a kind of caution light to countries falling below this benchmark, signifying that population growth is reducing the amount of available water per person to troublesome levels. As the renewable water supply falls below 1,000 cubic meters per person, *water scarcity* begins to occur. For most countries in this category, chronic water shortages can hamper economic development and cause serious environmental degradation.[7]

What Do the Data Reveal about Water and Population?

By using the same measures of scarcity in this update as in PAI's two previous water studies, comparisons are possible that highlight the influence of changing population growth rates on renewable water supplies. In 1995, Population Action International projected that by the middle of the 21st century, the number of people living in countries experiencing either water stress or scarcity could grow to at least 3.5 billion, more than tenfold the number in 1990. Moreover, this estimate was made using the most optimistic of the UN population projections, the low variant. Under the high variant, PAI projected the number of people living in water stress or scarcity by 2050 to be 7 billion, nearly two thirds of the planet's total projected population of 11.2 billion.[8]

The new figures presented here by PAI represent the most recent estimates of water stress and scarcity for 161 countries. The new projections show that today the future of water availability

Figure 3

NUMBER OF PEOPLE LIVING IN COUNTRIES IN WATER STRESS AND WATER SCARCITY IN 2050

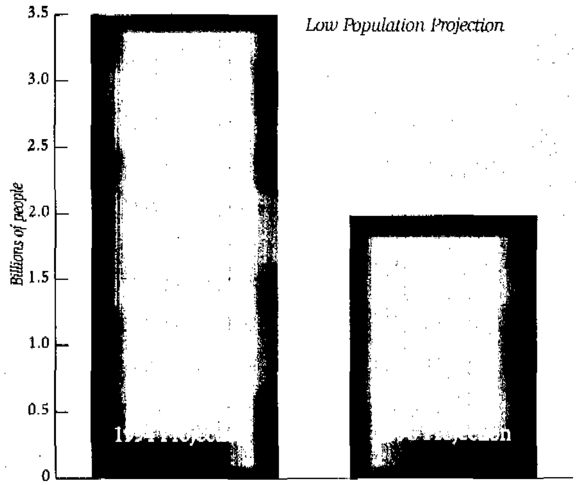


Chart: Population Action International   Data Source: UN Population Division

looks brighter, largely as a result of lower rates of population growth in many countries around the world. As shown in Figure 3, the number of people living in countries that are water stressed or water scarce could actually be less than 2 billion in 2050, 1.5 billion fewer than PAI projected in 1995, based on the UN low projection. Even under the medium variant, PAI's new projection shows almost 400 million fewer people living in water stressed or scarce countries in 2050 than was predicted in 1994.

The impact of population growth on water resources becomes even more apparent at the country level. For example, PAI previously calculated that Sri Lanka, an island nation located off the southeastern tip of India, and El Salvador, in Central America, would fall below the water stress benchmark by the years 2030 and 2040, respectively. As Figures 4 and 5 show, PAI now estimates that these countries' transition into a condition of water stress will be delayed by at least 10 years as a result of the slower population growth rates reflected in the newest UN projections. Postponing such transitions can provide much needed breathing room during which countries facing water shortages can develop their existing water resources, improve the efficiency of water usage patterns and implement water conservation programs. Using the high projection, other countries that avoid crossing the stress benchmark through at least the year 2050 as a result of the new projections include Thailand, Iraq and North Korea, whose total combined population could number almost 200 million by that time.

In countries with already sizable populations,

Figure 4

COMPARISON OF SRI LANKA'S ANNUAL PER CAPITA RENEWABLE FRESHWATER AVAILABILITY 1995-2050

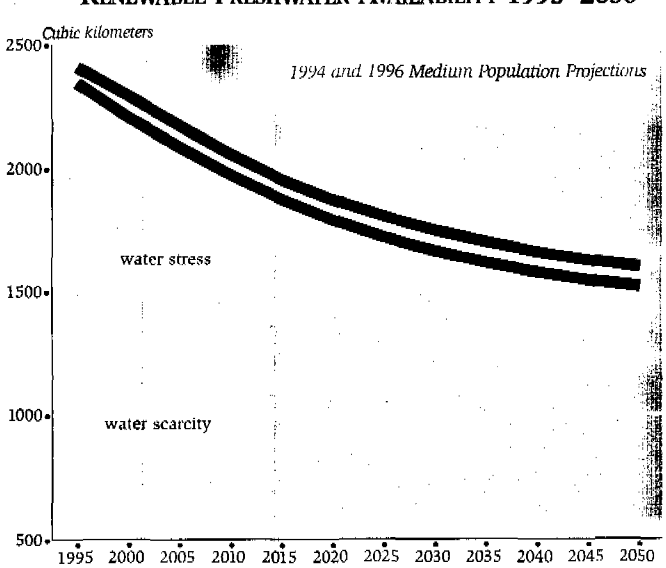


Chart: Population Action International   Data Source: UN Population Division

Figure 5

COMPARISON OF EL SALVADOR'S ANNUAL PER CAPITA RENEWABLE FRESHWATER AVAILABILITY 1995-2050

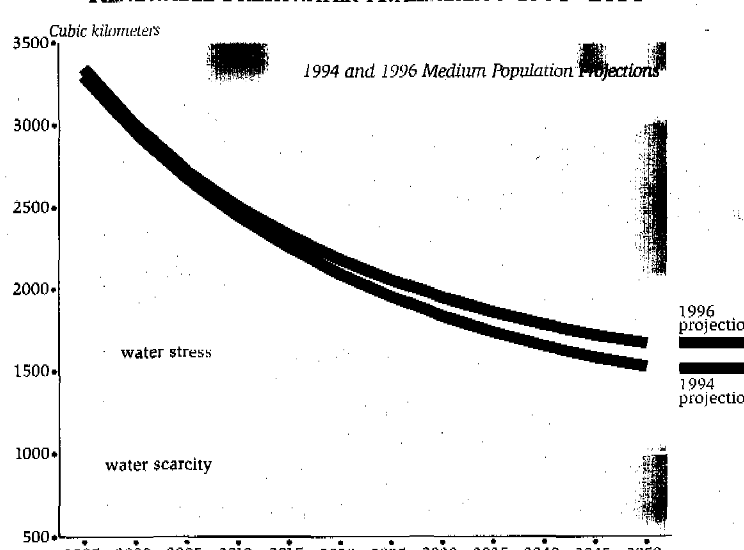


Chart: Population Action International   Data Source: UN Population Division

As a result of the slower population growth rates reflected in the newest UN projections, Sri Lanka and El Salvador are now projected to cross the water stress benchmark a full decade later than the earlier 1994 projection had indicated.

Figure 6

World Population Experiencing Freshwater Scarcity, Stress and Relative Sufficiency 2020-2050

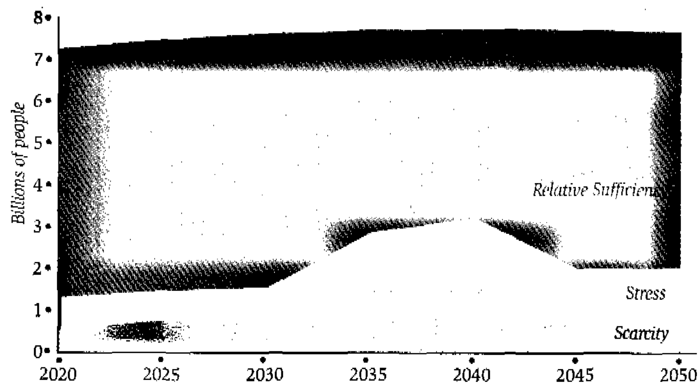


Chart: Population Action International   Data Source: UN Population Division

The sharp rise in the number of people experiencing water stress between 2030 and 2035 is caused by India crossing the water stress benchmark due to its growing population. The sharp decline in the population experiencing water stress between 2040 and 2045 is a result of India's escaping water stress by slowing its population growth.

the effects of slower population growth on water resources can be even more dramatic. India, for example, whose current population approaches one billion, was projected in 1994 to begin experiencing water stress as early as 2015 and to remain water stressed through at least the year 2050. Under the new UN projections, however, it is conceivable that India will not cross the water stress benchmark until 2035, a full decade later than the most optimistic projection made in 1994. More important, if its total fertility rate were to fall in accordance with the low projection, India's population could actually begin to decline towards the middle of the next century, bringing the country back out of water stress within a decade. Figure 6, which uses the UN 1996 low projection, shows India crossing the water stress benchmark by 2035—*then returning to a state of relative water sufficiency* by 2045 as a result of declining population growth.

The example of India helps illustrate the enormous potential for conflict, or alternatively, the opportunity for cooperation, inherent in the relationship between population growth and renewable fresh water. For years India and Bangladesh have bitterly disputed the rights to water from the Ganges River, which flows through Nepal and India before reaching Bangladesh. The river system is estimated to affect the lives of more than 500 million Indians, who depend on its flows for everything from irrigation, fishing and navigation to washing, drinking and worship.[9] The river is also essential for the more than 40 million Bangladeshis whose wheat and rice crops it waters during the spring planting season.[10]

After almost 50 years of asserting it had the right to take as much water from the river as it needed in order to cope with the demands of its rapidly expanding population, the Indian government in December 1996 signed a 30-year treaty with Bangladesh that will provide both countries with a guaranteed flow of water from the river during the crucial months of March, April and May.[11] The treaty is looked on by many as a promising example that even countries with burgeoning populations can negotiate how to share their limited freshwater supplies. The need for such cooperative efforts will continue to increase in regions such as Africa, the Middle East and parts of Asia, where population growth will continue to put pressure on available freshwater resources well into the 21st century.

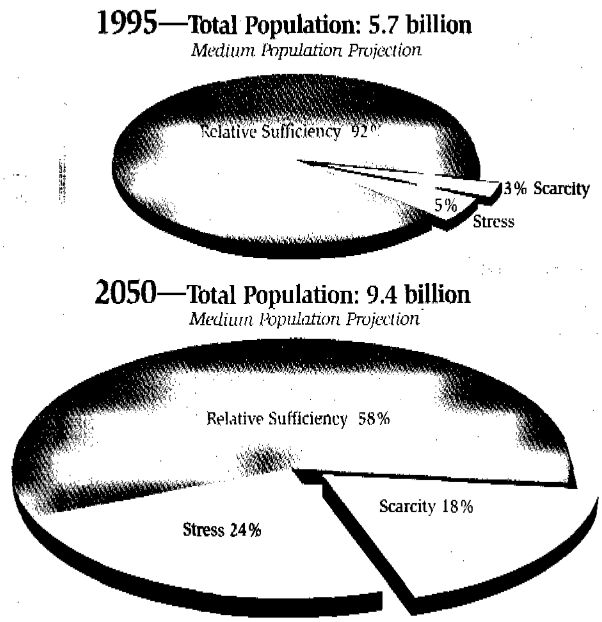
Impacts of Water Scarcity

Do these new data mean water availability is improving? Hardly. Even given the more encouraging population projections from the 1996 UN data, the problem of water scarcity will still get worse before it gets better. Currently, 166 million people in 18 countries are suffering from water scarcity, while almost 270 million more in 11 additional countries are considered water stressed. As Figure 7 indicates, PAI estimates that by the year 2050, according to the UN 1996 medium projection, the percentage of the world's population in countries experiencing water stress and scarcity will increase more than fivefold.

This demographic pressure has led one international water resources expert to predict that for these and many other countries, the lack of adequate supplies of renewable fresh water could soon become *the* main constraint on their economic development.[12] This is already the case in several water scarce countries in northern and southern Africa, where population growth rates remain high, placing increasing pressure on limited water resources to meet the growing demand for food production. In fact, all of the five countries projected to cross the water scarcity benchmark within the next 10 years are in Africa—adding more than 100 million people to those already coping with severe water resource shortages. In these and many other countries, increasing water scarcity will cause the cost of producing and delivering fresh water to grow tremendously just to keep pace with current levels of service. This will drain financial resources that would otherwise be available for investment in the development of other sectors of the economy.[13] With the UN projecting that more than 90 percent of population growth

Figure 7

WORLD POPULATION IN FRESHWATER SCARCITY, STRESS AND RELATIVE SUFFICIENCY IN 1995 AND 2050



Note: The sizes of the pies are proportional to world population in both years.
Chart: Population Action International   Data Source: UN Population Division

between now and 2050 will occur in developing countries,[14] the demand placed on freshwater resources by these countries will make sustainable economic development increasingly difficult. The examples of regional water stress presented here provide some indication of the seriousness and extent of the growing competition between nations for water resources.

The Case of Southern Africa

One place where the pressure for renewable water resources is beginning to mount is in the southern region of Africa, where Namibia and neighboring Botswana are engaged in a dispute over use of the Okavango River. On the basis of the amount available per person, Namibia seems to have a relatively abundant freshwater supply. However, Namibia is the driest country in sub-Saharan Africa—nearly 83 percent of all rain evaporates soon after it falls and only 1 percent of what remains is available to recharge groundwater aquifers. Worse, Namibia has no perennial rivers, only seasonally flowing ones that are reduced to a trickle several months of the year.[15]

Traditionally, this was not a problem in many regions of Namibia, where the mostly rural population would simply move to other sources of water during the dry season. However, rapid population growth and more densely populated human settlements are hampering this migratory lifestyle. To meet the needs of its growing population, Namibia has in recent years been forced to experiment with a variety of water supply options, including desalination and pumping groundwater from its fossil aquifers. The cost of large-scale desalination has thus far proved prohibitive, as Namibia's major population centers are too far inland for water to be pumped economically from the coast. The desalination plants that do operate require enormous amounts of energy, generating levels of pollution that are excessive relative to the volume of fresh water produced. And the overpumping of groundwater has already led to dangerous increases in salinity as well as the rapid depletion of the aquifers themselves.[16]

This has led Namibia to launch a planning process aimed at extending its already massive network of supply pipelines to the Okavango River, which runs throughout the year along its northeastern border with Angola. The plan would divert an estimated 20 million cubic meters of water from the river through the 155-mile pipeline. The problem is that the river flows into Botswana, where it feeds the largest delta—and one of the most delicate ecosystems—in the world. Moreover, at least 100,000 people living along the edges of the Okavango Delta depend on the water for survival.[17]

With its water needs expected to double within the next 20 years,[18] Namibia sees the pipeline as the only feasible solution to keep pace with the water demands of its growing urban centers. Botswana, on the other hand, contends that the diversion could damage the biologically diverse marshlands along the Okavango Delta, which is Botswana's main tourist attraction, and dry up the floodplain along which most of the delta's inhabitants live.[19] Hydrologists now predict that Windhoek, Namibia's capital, could begin to run short of water in 1998.[20] Clearly, the need for both governments to negotiate a long-term solution is urgent.

The Case of the Tigris-Euphrates Basin

A situation with more serious international implications is the growing demand for the waters of the Euphrates River by Turkey, Syria and Iraq. Rising in Turkey and flowing south through Syria and Iraq into the Persian Gulf, the Euphrates is the primary water source for millions of people who depend on it for power generation and irrigation in an extremely arid climate. Although the conflict over water between these countries is decades old, it has intensified in recent years as a result of a massive Turkish dam building program known as the Greater Anatolia Project (GAP). Designed to provide a supply of water and power adequate to fuel the development needs of Turkey's population, which is growing at 1.6 percent annually, GAP is one of the most massive water infrastructure projects in history. When completed, it will provide Turkey with a generating capacity of 7,500 megawatts of electricity—nearly four times the capacity of Hoover Dam—and open at least 1.5 million hectares of land to irrigated cultivation.[21]

Though GAP promises to bring prosperity to the estimated 7 million Turks who live in the region, Syria and Iraq have good reason to worry about the project's impact on their water supplies. Full implementation of the GAP system of dams could result in a 40 percent reduction of the Euphrates' flow into Syria and an 80 percent reduction of flow into Iraq. Such a scenario has the potential to reduce the electrical output of Syria's Tabqa Dam, one of its primary power sources, to 12 percent of capacity, while Iraq could lose irrigation water to one million hectares, or approximately 20 percent of its total arable land. In addition, the reduction of the river's flow and the development in Turkey that will be fueled by the project will increase the level of salinity as well as the amounts of agricultural and industrial pollution in the remaining waters that will be conveyed into Syria and Iraq.[22]

Both Syria and Iraq have already threatened war over their access to the Euphrates, heightening the urgency of a regional water-sharing agreement before the existing water shortages become even more acute.[23] As the populations of these nations continue to expand, driven by fertility rates well above the global average, the competition for fresh water between agriculture and development could engender increased instability in a region that is already dangerously unstable.

The Lessons of Water Scarcity Benchmarks

The benchmarks of water stress and water scarcity used in this report are not intended to describe Malthusian limits to growth or strict natural thresholds governing population-environment interactions with consistent and unalterable effects. Rather, they serve as indicators of the likelihood of adverse consequences related to water shortage. As such, these benchmarks can help predict the future urgency of problems related to freshwater availability. Equally important, they can provide insight into how true natural thresholds related to population-environment interactions might operate. In the real world some countries with less than 1,000 cubic meters of renewable fresh water per person per year manage to develop economically, while many countries with abundant water still experience severe problems in supplying water to farms, factories and homes. Despite these apparent inconsistencies, these benchmarks are recognized and used by many hydrologists and by the World Bank and help illustrate important population-water relationships. To understand different responses to water availability, it is important to explain a few of the principles and limitations of the terms and analyses presented in this report.

First, the figures for per capita water availability presented here refer only to *renewable fresh water*. This is defined as salt free water that is fully replaced in any given year through rain and snow that falls on continents and islands and flows through rivers and streams to the oceans. The figures do not include water that *evaporates* through the heat of the sun or *transpires* through plants to the atmosphere, processes known collectively as *evapotranspiration*. Excluding the amount of water lost to evapotranspiration helps standardize the water availability figures for countries with dry climates and those with wetter climates by counting only that amount of water that is available for human uses—except to the extent that water availability varies by season.

Second, the water availability figures do not include supplies of groundwater that are not replenished by precipitation on human time scales—also called *nonrenewable* or *fossil* water. Many countries supplement their renewable water supplies by drawing down their groundwater aquifers. Relying on nonrenewable supplies of groundwater is one way that countries with less than 1,700 cubic meters of renewable fresh water per person per year can avoid, at least temporarily, feeling the constraints of limited supplies of renewable fresh water. However, for most countries this situation cannot be sustained for long, especially as their populations continue to grow, their pumping costs begin to escalate and their development requires greater quantities of water.

In addition, the water availability figures take no account of the *timing* or *seasonality* of this availability. Fresh water is often more abundant in some seasons than in others. Throughout the tropics, for example, rainy seasons often produce deluges of renewable fresh water that cause damaging floods and can scarcely be captured for later use. Months later the dry season sets in, drying rivers and streams to a trickle and causing severe, though temporary, freshwater shortages. Under these circumstances, a watershed or country that in theory has sufficient water for its inhabitants can face shortages not accounted for by the annual availability of renewable fresh water. Much more data on seasonal inventories of freshwater availability will be needed before the concept of timing can play a significant role in analyses of population and water relationships.

As previously discussed, the ability of individuals and institutions to adapt to different challenges can obviously vary widely among nations. For this reason, some can naturally manage better than others as the per capita availability of renewable fresh water declines. It would be inappropriate, therefore, to propose any precise levels as absolute *thresholds* of water scarcity, or insist that they apply equally to all countries. Instead we use the term *benchmark* to convey that these figures represent approximate levels of freshwater availability—averaged over different climates, soil conditions and economic development levels—below which concern about water shortage tends to rise significantly. By applying these approximate benchmarks, we can establish a framework that helps explain how population dynamics interact with finite resources such as renewable fresh water.

Finally, the benchmarks described here are not meant to imply that countries having more than 1,700 cubic meters of renewable fresh water available to each inhabitant are automatically considered water abundant. This term proved to be misleading when used in *Sustaining Water: Population and the Future of Renewable Water Supplies* because in many countries—from India to Iran to the United States—the per capita water availability is higher than the 1,700 cubic meter stress benchmark, yet the drier regions of these countries experience significant water shortages at times. In addition, although countries may appear to have a plentiful supply of renewable water, not all of these sources can be exploited at an acceptable cost, given their location relative to population centers. Thus the supply of economically available fresh water is often much lower than the estimates provided here. In this update of *Sustaining Water,* the term *relative water sufficiency* conveys the fact that countries with a per capita water availability in excess of the stress and scarcity benchmarks are not guaranteed an abundant freshwater supply in all times and in all places. Even the term "sufficiency" often overstates the reality of freshwater availability in these countries—in the United States the examples of southern California, the Florida Everglades and south Texas come to mind. Nonetheless, it seems the most apt term to describe the condition of renewable water resources in countries with a per capita renewable freshwater supply that exceeds the benchmark levels for water stress or scarcity described in this update.

The Case of the Nile River Basin

Perhaps the most vivid example of the interaction of population growth, water scarcity and international conflict is the vast basin of the Nile River in northeastern Africa. The 10 countries with territory in the Nile basin contain 40 percent of Africa's population (not all actually within the basin) and make up 10 percent of its land mass. More than 85 percent of the Nile's water comes from the Blue Nile, which originates in Ethiopia.[24] However, the vast majority of the river's flow, estimated at about 85 billion cubic meters annually, is used by Egypt, the last nation on the Nile's path to the Mediterranean Sea.[25]

For centuries the cultural symbol of Egypt, the Nile provides almost all the fresh water used by more than 60 million Egyptians living along its banks. When few people lived upstream—and modern economic development was a distant dream for the entire basin—Egypt saw no reason to worry about its dependence on the Nile's waters. Its complacency is now ending, however, as the upstream nations begin to harness the Nile's waters to provide economic prosperity for their growing numbers.

Ethiopia, for example, recently emerged from a long period of civil war and famine into a period of accelerated growth and economic development. The government has overseen the construction of more than 200 small dams that will use nearly 500 million cubic meters of the Nile's flow annually. Additional dams are being planned to increase the country's irrigation and hydropower capacity.[26] Though Ethiopia's current development plans will require only a small portion of the Nile's water, its potential demands could significantly reduce the river's flow into Egypt. Ethiopia has an estimated 3.7 million hectares of land, an area larger than Belgium, that could be irrigated.[27] With a population nearly the size of Egypt's and a faster annual rate of population growth—3.2 percent annually for Ethiopia versus 2 percent for Egypt—Ethiopia will need to develop a large portion of this land for agricultural use.[28] Irrigating only half this land area with water from the Nile could reduce the river's flow to Egypt by 15 percent.[29] Hydrologists doubt the basin produces enough renewable fresh water to satisfy the irrigation plans of both Ethiopia and Egypt.[30]

Egypt itself is raising the stakes with ambitious plans for its New Valley land reclamation project. Pressed by population growth within its own borders, the Egyptian government has begun a massive irrigation project in the country's western desert in an attempt to persuade seven million Egyptians to move there from the crowded Nile Valley. When completed, a pipeline will carry up to five billion cubic meters of Nile water from the Lake Nasser reservoir to the New Valley site to facilitate the construction of new cities and provide irrigation to more than 200,000 hectares of desert, an area more than twice the size of New York City.[31]

Sudan, meanwhile, plans to build its own dam on the Nile north of the capital, Karthoum, where the Blue Nile and the White Nile converge before flowing into Egypt.[32] The remaining Nile basin countries currently use only a small portion of the river's water. However, with their cumulative population now numbering over 140 million and projected to grow to more than 340 million by the year 2025, it is inevitable that these countries will soon begin to lay claim to a larger share of the Nile's flow to meet their growing irrigation and development needs.[33]

The Egyptian government has long recognized upstream development of the Nile's waters as a potential national security threat and has stated its willingness to go to war to preserve its access to fresh water. As the basin's governments come to understand the dynamics of the population-water relationship, however, advance planning and diplomacy may win out over saber rattling and armed conflict. In recent years, representatives of the 10 nations of the Nile watershed have met to review past agreements and consider possible future ones

Comparison of Current and Projected Freshwater Stress and Scarcity

Using 1994 and 1996 UN Population Projections

Current Freshwater Availability

1995	population	# of countries
Scarcity	166 million	18
Stress	270 million	11
Total World Population	5.7 billion	

	1994 UN Projections		1996 UN Projections	
	population	# of countries*	population	# of countries*
2050 (LOW)				
Scarcity	1.1 billion	33	1.0 billion	31
Stress	2.4 billion	18	970 million	17
Total World Population	7.9 billion		7.7 billion	
2050 (MEDIUM)				
Scarcity	1.9 billion	43	1.7 billion	39
Stress	2.5 billion	15	2.3 billion	15
Total World Population	9.8 billion		9.4 billion	
2050 (HIGH)				
Scarcity	2.4 billion	44	2.2 billion	42
Stress	5.3 billion	22	4.6 billion	18
Total World Population	11.9 billion		11.2 billion	

**The table on the left lists the number of people currently living in countries considered water scarce or water stressed. The table above compares estimates of number of people projected to live in water scarce or water stressed countries in 2050 based on low, medium and high 1994 and 1996 UN population projections. Note that the total number of countries and people estimated to experience water stress and scarcity is lower under all three 1996 projections.*

related to their use of this shared natural resource.[34]

The whole world is watching the Nile and similar international watersheds. At a March 1997 forum on international water issues in Marrakech, Morocco, UN Secretary General Kofi Annan stressed that the projected growth of world population over the next 30 years makes developing cooperative international agreements on shared water resources "one of the most urgent issues on the global agenda."[35] And in May, the UN General Assembly approved a convention to establish guidelines for cooperation on sharing the benefits of international watercourses.[36] The U.S. State Department and Environmental Protection Agency have opened field offices called *environmental hubs* to help developing nations negotiate transboundary solutions to regional environmental problems such as freshwater scarcity, deforestation and air pollution, and to raise the profile of environmental issues in global diplomacy. The Eastern Africa hub, which specializes in Nile Basin water resource issues, recently opened in Addis Ababa.[37]

The growing interest in the region's water issues is encouraging, but the challenge of reconciling competing claims on the Nile will continue to be complicated by political and economic concerns. The scope for water conservation and international cooperation is large, but the competition is unlikely to find permanent resolution until the region's population approaches stabilization.

Why Population Matters

As recent changes in projected population growth illustrate, population projections can change for the worse or for the better depending on the factors that influence them. The difference between the 1994 and 1996 UN projections demonstrates the impact that even slight changes in population growth rates can have over time on the amount of renewable fresh water available to each person. Slower population growth rates do not, however, occur on their own. They result from the desires of hundreds of millions of women and men to have fewer children—and the efforts of governments and other institutions to help them achieve these goals throughout their reproductive years. Now more than ever, sound policies that will promote the transition to a stable population size remain critical. Pursued consistently, such efforts can delay the onset of water stress and scarcity in many countries, buying precious time for strategies that can make freshwater resources endure for generations to come.

Population, Annual Renewable Freshwater Availability, 1950, 1995, 2025 and 2050

Population figures are in thousands; per capita water availability figures are in cubic meters.

Country	Total annual renewable fresh water available by country (cubic kilometers)	1950 Population (thousands)	1950 Per capita water availability (cubic meters)	1995 Population (thousands)	1995 Per capita water availability (cubic meters)	2025 Low Projection Population (thousands)	2025 Low Projection Per capita water availability (cubic meters)
Afghanistan	50.00	8,958	5,582	19,661	2,543	41,697	1,199
Albania	21.30	1,230	17,317	3,383	6,296	3,908	5,450
Algeria	14.80	8,753	1,691	28,109	527	43,374	341
Angola	184.00	4,131	44,541	10,816	17,012	24,853	7,404
Argentina	994.00	17,150	57,959	34,768	28,590	43,281	22,966
Armenia	13.30	1,354	9,801	3,632	3,654	3,911	3,393
Australia	343.00	8,219	41,733	17,866	19,198	21,871	15,683
Austria	90.30	6,935	13,021	8,045	11,224	8,051	11,216
Azerbaijan	33.00	2,896	11,388	7,531	4,379	8,769	3,761
Bahrain	0.09	116	776	557	162	795	113
Bangladesh	2,357.00	41,783	56,411	118,229	19,936	166,535	14,153
Barbados	0.05	211	237	261	192	276	181
Belarus	73.80	7,745	9,529	10,352	7,129	9,308	7,929
Belgium	12.50	8,639	1,447	10,127	1,234	9,737	1,284
Belize	16.00	69	231,884	213	75,117	343	46,647
Benin	25.80	2,046	12,610	5,409	4,770	11,862	2,175
Bhutan	95.00	734	129,428	1,770	53,672	3,369	28,198
Bolivia	300.00	2,714	110,538	7,414	40,464	11,930	25,147
Botswana	14.70	389	37,789	1,450	10,138	2,432	6,044
Brazil	6,950.00	53,975	128,763	159,015	43,707	194,616	35,711
Bulgaria	205.00	7,251	28,272	8,509	24,092	7,207	28,445
Burkina Faso	28.00	3,654	7,663	10,479	2,672	22,558	1,241
Burundi	3.60	2,456	1,466	6,064	594	11,986	300
Cambodia	498.10	4,346	114,611	10,024	49,691	16,231	30,688
Cameroon	268.00	4,466	60,009	13,192	20,315	27,631	9,699
Canada	2,901.00	13,737	211,181	29,402	98,667	33,127	87,572
Cape Verde	0.30	146	2,055	386	777	630	476
Central African Rep.	141.00	1,314	107,306	2,929	48,139	5,791	24,348
Chad	43.00	2,658	16,178	6,335	6,788	12,257	3,508
Chile	468.00	6,082	76,948	14,210	32,935	18,025	25,964
China	2,800.00	554,760	5,047	1,220,224	2,295	1,366,883	2,048
Colombia	1,070.00	11,946	89,570	35,814	29,877	49,160	21,766
Comoros	1.02	173	5,896	612	1,667	1,289	791
Congo	832.00	808	1,029,703	2,593	320,864	5,580	149,104
Costa Rica	95.00	862	110,209	3,424	27,745	5,136	18,497
Côte d'Ivoire	77.70	2,776	27,990	13,694	5,674	22,640	3,432
Croatia	61.40	3,850	15,948	4,505	13,629	4,058	15,131
Cuba	34.50	5,850	5,897	10,964	3,147	11,402	3,026
Cyprus	0.90	494	1,822	745	1,208	904	996
Czech Republic	58.20	8,925	6,521	10,263	5,671	9,193	6,331
Denmark	13.00	4,271	3,044	5,223	2,489	4,881	2,663
Djibouti	2.30	62	37,097	601	3,827	1,100	2,091
Dominican Republic	20.00	2,353	8,500	7,823	2,557	10,450	1,914
Ecuador	314.00	3,387	92,707	11,460	27,400	16,570	18,950
Egypt	58.10	21,834	2,661	62,096	936	87,577	663
El Salvador	18.95	1,951	9,713	5,662	3,347	8,636	2,194
Equatorial Guinea	30.00	226	132,743	400	75,000	773	38,810
Eritrea	8.80	1,140	7,719	3,171	2,775	6,244	1,409
Estonia	17.60	1,101	15,985	1,488	11,828	1,198	14,691

2025 Medium Projection		2025 High Projection		2050 Low Projection		2050 [redacted]		2050 High Projection	
Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)
45,262	1,105	48,324	1,035	50,585	988	61,373	815	72,560	689
4,295	4,959	4,649	4,582	3,753	5,675	4,747	4,487	5,821	3,659
47,322	313	50,615	292	47,843	309	58,991	251	70,232	211
25,547	7,202	27,539	6,681	34,690	5,304	38,897	4,730	46,396	3,966
47,160	21,077	51,023	19,481	43,887	22,649	54,522	18,231	66,659	14,912
4,185	3,171	4,411	3,008	3,537	3,752	4,376	3,032	5,105	2,599
23,931	14,333	25,442	13,482	20,012	17,140	25,286	13,565	29,440	11,651
8,305	10,873	8,600	10,500	6,496	13,901	7,430	12,153	8,340	10,827
9,714	3,395	10,744	3,070	8,527	3,868	10,881	3,031	13,769	2,395
863	104	928	97	760	118	940	96	1,138	79
179,980	13,096	193,782	12,163	178,188	13,228	218,188	10,803	264,681	8,905
296	169	311	161	247	202	306	163	353	142
9,641	7,655	10,459	7,056	7,523	9,810	8,726	8,457	10,994	6,713
10,271	1,217	10,619	1,177	8,116	1,540	9,763	1,280	10,932	1,143
375	42,667	406	39,409	389	41,131	480	33,333	584	27,397
12,276	2,102	12,675	2,036	15,853	1,627	18,095	1,426	20,432	1,263
3,646	26,056	3,886	24,447	4,286	22,165	5,184	18,326	6,092	15,594
13,131	22,847	13,927	21,541	13,569	22,109	16,966	17,682	19,955	15,034
2,576	5,707	2,721	5,402	2,807	5,237	3,320	4,428	3,881	3,788
216,596	32,087	241,390	28,792	188,015	36,965	243,259	28,570	312,132	22,266
7,453	27,506	7,806	26,262	5,773	35,510	6,690	30,643	7,788	26,323
23,451	1,194	24,456	1,145	30,867	907	35,419	791	40,500	691
12,341	292	13,209	273	15,028	240	16,937	213	19,978	180
16,990	29,317	17,738	28,081	18,355	27,137	21,394	23,282	24,627	20,226
28,521	9,397	29,544	9,071	36,775	7,288	41,951	6,388	47,831	5,603
36,385	79,731	38,792	74,783	28,885	100,433	36,352	79,803	41,837	69,341
679	442	727	413	711	422	864	347	1,033	290
6,006	23,477	6,208	22,713	7,166	19,676	8,215	17,164	9,295	15,169
12,648	3,400	13,544	3,175	15,955	2,695	18,004	2,388	21,317	2,017
19,548	23,941	20,864	22,431	17,957	26,062	22,215	21,067	26,658	17,556
1,480,430	1,891	1,561,429	1,793	1,198,215	2,337	1,516,664	1,846	1,765,222	1,586
52,668	20,316	57,117	18,733	51,380	20,825	62,284	17,179	76,405	14,004
1,342	760	1,397	730	1,621	629	1,876	544	2,153	474
5,747	144,771	6,143	135,439	7,757	107,258	8,729	95,314	10,286	80,887
5,608	16,940	5,899	16,104	5,547	17,126	6,902	13,764	8,050	11,801
24,397	3,185	26,169	2,969	26,086	2,979	31,706	2,451	37,993	2,045
4,243	14,471	4,404	13,942	3,369	18,225	3,991	15,385	4,532	13,548
11,798	2,924	12,558	2,747	9,806	3,518	11,284	3,057	13,460	2,563
950	947	1,008	893	867	1,038	1,029	875	1,207	746
9,627	6,045	10,133	5,744	7,186	8,099	8,572	6,790	9,807	5,935
5,324	2,442	5,438	2,391	4,084	3,183	5,234	2,484	5,752	2,260
1,134	2,028	1,168	1,969	1,334	1,724	1,506	1,527	1,688	1,363
11,164	1,791	12,191	1,641	10,910	1,833	13,141	1,522	16,287	1,228
17,796	17,644	19,341	16,235	17,561	17,881	21,190	14,818	25,903	12,122
95,766	607	103,979	559	92,596	627	115,480	503	141,702	410
9,221	2,055	10,095	1,877	9,498	1,995	11,364	1,668	14,030	1,351
798	37,594	854	35,129	1,015	29,557	1,144	26,224	1,354	22,157
6,504	1,353	6,765	1,301	7,605	1,157	8,808	999	10,109	871
1,256	14,013	1,338	13,154	908	19,383	1,084	16,236	1,315	13,384

Country	Total annual renewable fresh water available by country (cubic kilometers)	1950 Population (thousands)	1950 Per capita water availability (cubic meters)	1995 Population (thousands)	1995 Per capita water availability (cubic meters)	2025 Low Projection Population (thousands)	2025 Low Projection Per capita water availability (cubic meters)
Ethiopia	110.00	18,434	5,967	56,404	1,950	125,993	873
Fiji	28.55	289	98,789	784	36,416	1,075	26,558
Finland	113.00	4,009	28,187	5,107	22,126	4,928	22,930
France	198.00	41,829	4,734	58,104	3,408	57,825	3,424
Gabon	164.00	469	349,680	1,076	152,416	1,991	82,371
Gambia	8.00	294	27,211	1,111	7,201	1,884	4,246
Germany	171.00	68,376	2,501	81,594	2,096	77,628	2,203
Ghana	53.20	4,900	10,857	17,338	3,068	35,045	1,518
Greece	58.65	7,566	7,752	10,454	5,610	9,657	6,073
Guatemala	116.00	2,969	39,070	10,621	10,922	19,632	5,909
Guinea	226.00	2,550	88,627	7,349	30,752	14,545	15,538
Guinea-Bissau	27.00	505	53,465	1,069	25,257	1,825	14,795
Guyana	241.00	423	569,740	830	290,361	997	241,725
Haiti	11.00	3,261	3,373	7,124	1,544	11,103	991
Honduras	63.40	1,380	45,942	5,654	11,213	9,984	6,350
Hungary	120.00	9,338	12,851	10,106	11,874	8,268	14,514
Iceland	168.00	143	1,174,825	269	624,535	317	529,968
India	2,085.00	357,561	5,831	929,005	2,244	1,222,833	1,705
Indonesia	2,530.00	79,538	31,809	197,460	12,813	249,836	10,127
Iran	117.50	16,913	6,947	68,365	1,719	120,647	974
Iraq	109.20	5,158	21,171	20,095	5,434	39,251	2,782
Ireland	50.00	2,969	16,841	3,546	14,100	3,434	14,560
Israel	2.15	1,258	1,709	5,525	389	7,183	299
Italy	167.00	47,104	3,545	57,204	2,919	50,213	3,326
Jamaica	8.30	1,403	5,916	2,468	3,363	3,063	2,710
Japan	547.00	83,625	6,541	125,068	4,374	117,738	4,646
Jordan	1.71	1,237	1,382	5,373	318	11,375	150
Kazakhstan	169.40	6,703	25,272	16,817	10,073	18,007	9,407
Kenya	30.20	6,265	4,820	27,150	1,112	47,245	639
Kuwait	0.16	152	1,053	1,691	95	2,647	60
Kyrgyzstan	61.70	1,740	35,460	4,460	13,834	5,450	11,321
Laos	270.00	1,755	153,846	4,882	55,305	9,271	29,123
Latvia	34.00	1,949	17,445	2,536	13,407	2,008	16,932
Lebanon	5.58	1,443	3,867	3,009	1,854	4,030	1,385
Lesotho	5.20	734	7,084	2,027	2,565	3,861	1,347
Liberia	232.00	824	281,553	2,123	109,279	6,117	37,927
Libya	0.60	1,029	583	5,407	111	12,422	48
Lithuania	24.20	2,567	9,427	3,736	6,478	3,359	7,205
Luxembourg	5.00	296	16,892	407	12,285	429	11,655
Madagascar	337.00	4,229	79,688	14,874	22,657	33,308	10,118
Malawi	18.70	2,881	6,491	9,673	1,933	19,855	942
Malaysia	456.00	6,110	74,632	20,140	22,642	29,053	15,695
Mali	67.00	3,520	19,034	10,795	6,207	22,794	2,939
Malta	0.03	312	96	367	82	395	76
Mauritania	11.40	825	13,818	2,274	5,013	4,252	2,681
Mauritius	2.20	493	4,462	1,117	1,970	1,418	1,551
Mexico	357.40	27,737	12,885	91,145	3,921	121,079	2,952
Moldova	13.70	2,341	5,852	4,437	3,088	4,481	3,057
Mongolia	24.60	761	32,326	2,463	9,988	3,763	6,537
Morocco	30.00	8,953	3,351	26,524	1,131	36,286	827
Mozambique	208.00	6,198	33,559	17,260	12,051	34,477	6,033
Myanmar	1,082.00	17,832	60,677	45,106	23,988	62,948	17,189
Namibia	45.50	511	89,041	1,536	29,622	2,881	15,793
Nepal	170.00	7,862	21,623	21,456	7,923	38,660	4,397
Netherlands	90.00	10,114	8,899	15,482	5,813	15,633	5,757
New Zealand	327.00	1,908	171,384	3,561	91,828	4,510	72,506

2025		2025		2050		2050		2050	
[redacted]		High Projection		Low Projection		[redacted]		High Projection	
Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)
136,288	807	145,072	758	176,495	623	212,732	517	250,018	440
1,170	24,402	1,265	22,569	1,124	25,400	1,393	20,495	1,698	16,814
5,294	21,345	5,529	20,438	4,156	27,190	5,172	21,848	5,926	19,069
60,393	3,279	62,768	3,154	49,832	3,973	58,370	3,392	65,922	3,004
2,118	77,432	2,247	72,986	2,488	65,916	2,952	55,556	3,464	47,344
1,984	4,032	2,086	3,835	2,226	3,594	2,604	3,072	3,020	2,649
80,877	2,114	84,513	2,023	59,406	2,878	69,542	2,459	80,094	2,135
36,341	1,464	37,632	1,414	44,669	1,191	51,205	1,039	58,151	915
10,074	5,822	10,317	5,685	7,657	7,660	9,013	6,507	9,816	5,975
21,668	5,354	21,892	5,299	23,385	4,960	29,353	3,952	32,125	3,611
15,286	14,785	16,365	13,810	19,353	11,678	22,914	9,863	27,174	8,317
1,921	14,055	2,047	13,190	2,258	11,957	2,674	10,097	3,156	8,555
1,114	216,338	1,240	194,355	953	252,886	1,239	194,512	1,588	151,763
12,513	879	12,807	859	13,201	833	17,524	628	18,945	581
10,656	5,950	11,809	5,369	11,668	5,434	13,920	4,555	17,425	3,638
8,667	13,846	9,128	13,146	6,442	18,628	7,715	15,554	8,828	13,593
336	500,000	357	470,588	301	558,140	363	462,810	425	395,294
1,330,201	1,567	1,438,866	1,449	1,230,522	1,694	1,532,674	1,360	1,885,390	1,106
275,245	9,192	300,582	8,417	250,780	10,089	318,264	7,949	395,238	6,401
128,251	916	135,921	864	143,810	817	170,269	690	199,617	589
41,600	2,625	44,082	2,477	47,922	2,279	56,129	1,946	65,393	1,670
3,723	13,430	3,904	12,807	3,040	16,447	3,809	13,127	4,373	11,434
7,977	270	8,744	246	7,271	296	9,144	235	11,213	192
51,744	3,227	53,545	3,119	37,109	4,500	42,092	3,967	47,196	3,538
3,370	2,463	3,721	2,231	3,086	2,690	3,886	2,136	4,899	1,694
121,348	4,508	125,389	4,362	96,263	5,682	109,546	4,993	122,352	4,471
11,894	144	12,414	138	14,412	119	16,671	103	19,106	90
20,047	8,450	22,176	7,639	17,211	9,843	22,260	7,610	28,332	5,979
50,202	602	53,129	568	55,473	544	66,054	457	77,648	389
2,904	55	3,160	51	2,727	59	3,406	47	4,187	38
5,950	10,370	6,461	9,550	5,785	10,666	7,182	8,591	8,810	7,003
10,202	26,465	11,030	24,479	11,179	24,152	13,889	19,440	16,740	16,129
2,108	16,129	2,300	14,783	1,574	21,601	1,891	17,980	2,417	14,067
4,424	1,261	4,828	1,156	4,143	1,347	5,189	1,075	6,400	872
4,031	1,290	4,201	1,238	4,888	1,064	5,643	921	6,453	806
6,573	35,296	7,057	32,875	8,189	28,331	9,955	23,305	11,798	19,664
12,885	47	13,359	45	16,748	36	19,109	31	21,635	28
3,521	6,873	3,771	6,417	2,764	8,755	3,297	7,340	4,006	6,041
466	10,730	480	10,417	364	13,736	461	10,846	516	9,690
34,476	9,775	35,658	9,451	44,513	7,571	50,807	6,633	57,561	5,855
20,391	917	20,926	894	26,714	700	29,825	627	33,087	565
31,577	14,441	34,088	13,377	31,026	14,697	38,089	11,972	46,063	9,899
24,575	2,726	26,378	2,540	30,688	2,183	36,817	1,820	43,603	1,537
424	71	448	67	358	84	442	68	514	58
4,443	2,566	4,652	2,451	5,264	2,166	6,077	1,876	7,013	1,626
1,481	1,485	1,581	1,392	1,402	1,569	1,654	1,330	1,963	1,121
130,196	2,745	143,353	2,493	127,135	2,811	154,120	2,319	192,658	1,855
4,869	2,814	5,400	2,537	4,032	3,398	5,138	2,666	6,518	2,102
4,052	6,071	4,334	5,676	4,103	5,996	4,986	4,934	5,962	4,126
39,925	751	43,774	685	37,737	795	47,276	635	58,538	512
35,444	5,868	37,814	5,501	46,186	4,504	51,774	4,017	60,814	3,420
67,643	15,996	72,301	14,965	66,755	16,209	80,896	13,375	96,598	11,201
2,999	15,172	3,116	14,602	3,624	12,555	4,167	10,919	4,746	9,587
40,554	4,192	42,443	4,005	45,737	3,717	53,621	3,170	62,192	2,733
16,141	5,576	16,644	5,407	13,112	6,864	14,956	6,018	16,598	5,422
4,878	67,036	5,119	63,880	4,222	77,451	5,271	62,038	6,055	54,005

Country	Total annual renewable fresh water available by country (cubic kilometers)	1950 Population (thousands)	1950 Per capita water availability (cubic meters)	1995 Population (thousands)	1995 Per capita water availability (cubic meters)	2025 Low Projection Population (thousands)	2025 Low Projection Per capita water availability (cubic meters)
Nicaragua	175.00	1,098	159,381	4,123	42,445	7,144	24,496
Niger	32.50	2,400	13,542	9,151	3,552	21,441	1,516
Nigeria	280.00	32,935	8,502	111,721	2,506	222,409	1,259
North Korea	67.00	9,488	7,062	22,097	3,032	27,902	2,401
Norway	392.00	3,265	120,061	4,332	90,489	4,291	91,354
Oman	1.93	456	4,232	2,207	874	6,044	319
Pakistan	468.00	39,513	11,844	136,257	3,435	256,701	1,823
Panama	144.00	860	167,442	2,631	54,732	3,483	41,344
Papua New Guinea	801.00	1,613	496,590	4,301	186,236	7,196	111,312
Paraguay	314.00	1,488	211,022	4,828	65,037	8,350	37,605
Peru	40.00	7,632	5,241	23,532	1,700	32,505	1,231
Philippines	323.00	20,988	15,390	67,839	4,761	97,708	3,306
Poland	56.20	24,824	2,264	38,557	1,458	37,800	1,487
Portugal	69.60	8,405	8,281	9,815	7,091	9,159	7,599
Qatar	0.05	25	2,000	548	91	739	68
Romania	208.00	16,311	12,752	22,728	9,152	20,381	10,206
Russian Federation	4,498.00	102,192	44,015	148,460	30,298	126,016	35,694
Rwanda	6.30	2,120	2,972	5,184	1,215	12,454	506
Saudi Arabia	4.55	3,201	1,421	18,255	249	40,916	111
Senegal	39.40	2,500	15,760	8,312	4,740	16,270	2,422
Sierra Leone	160.00	1,944	82,305	4,195	38,141	7,833	20,426
Singapore	0.60	1,022	587	3,327	180	3,939	152
Slovakia	30.80	3,463	8,894	5,338	5,770	5,213	5,908
Solomon Islands	44.70	90	496,667	378	118,254	811	55,117
Somalia	13.50	3,072	4,395	9,491	1,422	21,829	618
South Africa	50.00	13,683	3,654	41,465	1,206	67,708	738
South Korea	66.10	20,357	3,247	44,909	1,472	49,802	1,327
Spain	111.30	28,009	3,974	39,627	2,809	36,336	3,063
Sri Lanka	43.20	7,678	5,626	17,928	2,410	21,322	2,026
Sudan	154.00	9,190	16,757	26,707	5,766	44,226	3,482
Suriname	200.00	215	930,233	427	468,384	541	369,686
Swaziland	4.50	264	17,045	857	5,251	1,567	2,872
Sweden	180.00	7,014	25,663	8,788	20,482	8,802	20,450
Switzerland	50.00	4,694	10,652	7,166	6,977	7,160	6,983
Syria	53.69	3,495	15,362	14,203	3,780	24,343	2,206
Tajikistan	101.30	1,532	66,123	5,828	17,382	9,158	11,061
Tanzania	89.00	7,886	11,286	30,026	2,964	60,309	1,476
Thailand	179.00	20,010	8,946	58,242	3,073	63,431	2,822
Togo	12.00	1,329	9,029	4,085	2,938	8,308	1,444
Trinidad and Tobago	5.10	636	8,019	1,287	3,963	1,537	3,318
Tunisia	3.90	3,530	1,105	8,987	434	12,323	316
Turkey	193.10	20,809	9,280	60,838	3,174	78,506	2,460
Turkmenistan	72.00	1,211	59,455	4,075	17,669	6,013	11,974
Uganda	66.00	4,762	13,860	19,689	3,352	41,165	1,603
Ukraine	231.00	36,906	6,259	51,757	4,463	44,081	5,240
United Arab Emirates	1.99	70	28,471	2,210	902	3,098	643
United Kingdom	71.00	50,616	1,403	58,079	1,222	55,522	1,279
United States	2,478.00	157,813	15,702	267,115	9,277	303,132	8,175
Uruguay	124.00	2,239	55,382	3,186	38,920	3,400	36,471
Uzbekistan	129.60	6,314	20,526	22,762	5,694	33,851	3,829
Venezuela	1,317.00	5,094	258,539	21,844	60,291	31,724	41,514
Vietnam	376.00	29,954	12,553	73,793	5,095	100,101	3,756
Yemen	5.20	4,316	1,205	15,027	346	36,535	142
Zaire	1,019.00	12,184	83,634	45,453	22,419	102,760	9,916
Zambia	116.00	2,440	47,541	8,081	14,355	15,510	7,479
Zimbabwe	20.00	2,730	7,326	11,190	1,787	18,156	1,102

2025 Medium Projection		2025 High Projection		2050 Low Projection		2050 Medium Projection		2050 High Projection	
Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)
7,639	22,909	8,453	20,703	8,256	21,197	9,922	17,638	12,437	14,071
22,385	1,452	23,343	1,392	30,189	1,077	34,576	940	39,302	827
238,397	1,175	256,342	1,092	278,732	1,005	338,510	827	403,745	694
30,046	2,230	31,910	2,100	26,513	2,527	32,873	2,038	38,534	1,739
4,662	84,084	4,847	80,875	3,699	105,975	4,694	83,511	5,324	73,629
6,538	295	6,943	278	9,085	212	10,930	177	12,795	151
268,904	1,740	281,063	1,665	306,271	1,528	357,353	1,310	412,787	1,134
3,779	38,105	4,126	34,901	3,536	40,724	4,365	32,990	5,420	26,568
7,546	106,149	7,885	101,585	8,255	97,032	9,637	83,117	11,089	72,234
9,355	33,565	9,482	33,115	9,731	32,268	12,565	24,990	13,678	22,957
35,518	1,126	38,550	1,038	34,184	1,170	42,292	946	51,527	776
105,194	3,071	112,655	2,867	107,785	2,997	130,511	2,475	155,904	2,072
39,973	1,406	43,413	1,295	32,801	1,713	39,725	1,415	49,226	1,142
9,438	7,374	9,768	7,125	7,638	9,112	8,701	7,999	9,755	7,135
782	64	819	61	718	70	861	58	1,009	50
21,098	9,859	22,228	9,358	16,423	12,665	19,009	10,942	22,374	9,297
131,395	34,233	141,293	31,835	96,559	46,583	114,318	39,346	142,136	31,646
12,981	485	13,431	469	14,760	427	16,937	372	19,318	326
42,363	107	43,531	105	52,821	86	59,812	76	66,494	68
16,896	2,332	17,522	2,249	20,473	1,924	23,442	1,681	26,614	1,480
8,200	19,512	8,770	18,244	9,838	16,263	11,368	14,075	13,465	11,883
4,212	142	4,397	136	3,424	175	4,190	143	4,772	126
5,469	5,632	5,765	5,343	4,405	6,992	5,260	5,856	6,172	4,990
844	52,962	878	50,911	1,033	43,272	1,192	37,500	1,362	32,819
23,669	570	25,287	534	30,171	447	36,408	371	42,870	315
71,621	698	75,513	662	77,084	649	91,466	547	107,177	467
52,533	1,258	55,110	1,199	43,608	1,516	52,146	1,268	60,055	1,101
37,500	2,968	38,872	2,863	27,925	3,986	31,755	3,505	35,670	3,120
23,934	1,805	26,674	1,620	20,777	2,079	26,995	1,600	34,251	1,261
46,850	3,287	49,356	3,120	50,722	3,036	59,947	2,569	69,720	2,209
605	330,579	670	298,507	551	362,976	711	281,294	902	221,729
1,675	2,687	1,784	2,522	1,853	2,428	2,228	2,020	2,644	1,702
9,511	18,925	9,837	18,298	7,653	23,520	9,574	18,801	10,743	16,755
7,581	6,595	7,787	6,421	5,665	8,826	6,935	7,210	7,609	6,571
26,303	2,041	28,279	1,899	28,419	1,889	34,463	1,558	41,255	1,301
9,747	10,393	10,344	9,793	10,428	9,714	12,366	8,192	14,537	6,968
62,436	1,425	64,557	1,379	77,960	1,142	88,963	1,000	100,672	884
69,089	2,591	74,714	2,396	57,266	3,126	72,969	2,453	91,527	1,956
8,762	1,370	9,405	1,276	10,656	1,126	12,655	948	15,043	798
1,692	3,014	1,818	2,805	1,475	3,458	1,899	2,686	2,263	2,254
13,524	288	14,618	267	12,725	306	15,907	245	19,289	202
85,791	2,251	91,828	2,103	77,524	2,491	97,911	1,972	116,024	1,664
6,470	11,128	6,937	10,379	6,553	10,987	7,916	9,096	9,464	7,608
44,983	1,467	48,304	1,366	54,099	1,220	66,305	995	79,079	835
45,979	5,024	48,080	4,804	34,531	6,690	40,802	5,661	47,205	4,894
3,297	604	3,496	570	3,045	655	3,668	543	4,368	456
59,535	1,193	61,101	1,162	47,321	1,500	58,733	1,209	64,970	1,093
332,481	7,453	354,649	6,987	272,128	9,106	347,543	7,130	409,479	6,052
3,692	33,586	3,968	31,250	3,230	38,390	4,027	30,792	4,902	25,296
36,500	3,551	39,198	3,306	37,133	3,490	45,094	2,874	54,219	2,390
34,775	37,872	37,514	35,107	33,669	39,116	42,152	31,244	51,257	25,694
110,107	3,415	120,355	3,124	103,671	3,627	129,763	2,898	160,295	2,346
39,589	131	42,307	123	51,195	102	61,129	85	71,515	73
105,925	9,620	114,132	8,928	146,186	6,971	164,635	6,189	196,117	5,196
16,163	7,177	16,816	6,898	18,959	6,118	21,965	5,281	25,193	4,604
19,347	1,034	20,528	974	20,768	963	24,904	803	29,456	679

Endnotes

1. Robert Engelman and Pamela LeRoy, *Sustaining Water: Population and the Future of Renewable Water Supplies* (Washington, DC: Population Action International, 1993).
2. Robert Engelman and Pamela LeRoy, *Sustaining Water: An Update* (Washington, DC: Population Action International, 1995).
3. United Nations Population Division, *World Population Prospects: The 1996 Revision* (New York: The United Nations, 1996).
4. World Resources Institute, *World Resources 1996-1997: A Guide to the Global Environment* (New York: Oxford University Press, 1996).
5. United Nations Population Division, *World Population Prospects: The 1996 Revision*, Population Newsletter, no. 62 (December 1996).
6. Malin Falkenmark and Carl Widstrand, *Population and Water Resources: A Delicate Balance*, Population Bulletin (Washington, DC: Population Reference Bureau, 1992).
7. Falkenmark and Widstrand.
8. Engelman and LeRoy, *Sustaining Water: An Update.*
9. John F. Burns, "Sharing Ganges Waters," *New York Times*, 25 May 1997.
10. Inam Ahmed and Aasha Amin, "Bangladesh, Waiting for a Miracle," *People and the Planet* 5, no. 3 (1996).
11. Burns.
12. Asit K. Biswas, "Sustainable Water Development: A Global Perspective," *Water International* 17, no. 2 (June 1992).
13. George Khroda, "Strain, Social and Environmental Consequences, and Water Management in the Most Stressed Water Systems in Africa," in *Water Management in Africa and the Middle East: Challenges and Opportunities*, ed. Eglal Rached, Eva Rathgeber, and David Brooks (Ottawa: IRDC Books, 1996).
14. *World Population Prospects: The 1996 Revision*, Population Newsletter.
15. Kathy Eales, Simon Forster and Lusekelo Du Mhango, "Strain, Water Demand and Supply Direction in the Most Stressed Water Systems of Lesotho, Namibia, South Africa, and Swaziland," in *Water Management in Africa and the Middle East.*
16. Eales, Forster, and Du Mhango.
17. Judith Matloff, "Southern Africa's Oasis May Turn to Dust," *The Christian Science Monitor*, 22 July 1997.
18. Eales, Forster, and Du Mhango.
19. "Thirst," *The Economist* 344, no. 8024 (1997).
20. Eales, Forster, and Du Mhango.
21. John Kolars and William Mitchell, *The Euphrates River and the Southeast Anatolia Development Project* (Carbondale, IL; Southern Illinois University Press, 1991).
22. Godfrey Jansen, "Euphrates Tussle," *Middle East International*, 16 February 1990.
23. Aaron Wolf, *Middle East Water Conflicts and Directions for Resolution*, Food, Agriculture, and the Environment Discussion Paper 12 (Washington, DC: International Food Policy Research Institute, 1996).
24. Sandra Postel, *Last Oasis: Facing Water Scarcity*, (New York: W.W. Norton, Worldwatch Institute, 1992).
25. Wolf.
26. Amy Docker Marcus, "Water Fight," *Wall Street Journal*, 22 August 1997.
27. Sandra Postel, *Dividing the Waters: Food Security, Ecosystem Health and the New Politics of Scarcity* (Washington, DC: Worldwatch Institute,1996).
28. *World Population Prospects: The 1996 Revision.*
29. Postel, *Dividing the Waters.*
30. Marcus.
31. Marcus.
32. Marcus.
33. *World Population Prospects: The 1996 Revision.*
34. Lammi Guddaa, "Ethiopia: Crisis Over the Nile Waters," *Africa News*, April 1997.
35. UN Press Release SG/SM/6185, 21 March 1997.
36. *UN Development Update*, no. 21, 1997.
37. Marcus.

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Sustaining Water

Population and the Future of Renewable Water Supplies

By Robert Engelman and Pamela LeRoy

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The Earth's Water and Population

Total water on earth:
1.4 billion cubic kilometers (335 million cubic miles), enough to cover the United States to a depth of 150 kilometers (93 miles).

Total renewable water falling on continents and islands each year:
41,000 cubic kilometers (10,000 cubic miles), enough to cover the United States to a depth of 4.4 meters (15 feet).

World population, 1955:
2.8 billion people

World population, 1990:
5.3 billion people

World population, 2025 (projected):
Between 7.9 billion and 9.1 billion people

Water measurement units:
1 cubic kilometer = 1 billion cubic meters = 810 million acre feet
1,000 cubic meters = 264,200 gallons = 0.81 acre feet
1 cubic meter = 1000 liters = 264.2 gallons
1 liter = 1.06 quarts

Introduction

Of all the planet's renewable resources, fresh water may be the most unforgiving.

Difficult to purify, expensive to transport and impossible to substitute, water is essential to food production, to economic development and to life itself. Its importance to human health and well-being was underlined in mid-1993 when the United Nations' new Commission on Sustainable Development made improvement of water quality one of the first priorities for technology transfers from wealthy countries to poorer ones.

Only when taps run dry, as happened for a time in 1993 in places as far apart as Des Moines, Iowa, and Sarajevo, are those who live in the industrialized world reminded how critical access to water is to all aspects of life. In less prosperous countries millions of people, most of them women, need no such reminder. They walk miles each day to find the water they need and carry it home.

Yet water availability has not received the attention it deserves in global discussions of the sustainable use of natural resources. It has been examined even less in the context of population growth. On a planet whose surface is more than two thirds covered by water, the illusion of abundance has clouded the reality that renewable fresh water is an increasingly scarce commodity.

While the world's oceans may seem unbounded, the amount of fresh water actually available to people is finite—and a mere fraction of the water visible from outer space. Over the long term, the water humanity can count on for use year after year is the planet's *renewable* supply. That is the water that falls from the sky, seeps into the ground or collects in rivers and lakes, and flows back to the sea from which it was first drawn up by the sun. To be used sustainably, water cannot be withdrawn from reservoirs and other sources faster than it is replenished through this natural hydrologic cycle.

Our capacity for capturing and storing fresh water has expanded throughout history, and we are learning how to use it more efficiently. But no technology can significantly expand the basic resource. The use of desalination may suggest the world's oceans are potentially inexhaustible sources of fresh water, but the process of extracting salt from seawater remains expensive and dependent on polluting and nonrenewable fossil fuels. The reality is that there is essentially no more fresh water on the planet today than there was 2,000 years ago when the earth's human population was less than three percent its current size of 5.5 billion people.

The finite nature of renewable fresh water makes it a critical natural resource to examine in the context of population growth. Few other resources so essential to daily life are bounded by such fixed limits on supply—limits that in dozens of countries are already constraining efforts to improve health and living standards.

As population grows, the average amount of renewable fresh water available to each person declines. Hydrologists and other water experts agree that when certain ratios of human numbers to renewable fresh water supplies are exceeded, water stress and outright scarcity are all but inevitable.

In recent decades these ratios have been approached or exceeded in more than two dozen countries. And the projected population growth of the next few decades could push yet another two dozen countries and hundreds of millions more people over the brink of water shortage. Moreover, predicted changes in global climate could redistribute or reduce water supplies and intensify storms, adding to the challenge of managing water supply.

Acute water shortages already have required extraordinary measures in some countries. When thousands of refugees from Djibouti, the most water-scarce country in the world, crossed into Ethiopia in the summer of 1993, the Red Cross had to send tankers up to 300 miles to find water for them. During severe droughts in western India, the government brings drinking water to some rural areas by railway.

Life is tied to water as it is tied to air and food. And food is tied to water, since plant growth depends on its flow from roots to foliage. Throughout history, secure access to water has been essential to social and economic development and the stability of cultures and civilizations. Since ancient times agriculture has depended on fortuitous combinations of good soils and predictable water supplies, and

Throughout history, secure access to water has been essential to social and economic development and the stability of cultures and civilizations.

Efforts to encourage water conservation face special challenges not encountered with other natural resources.

dependable sources of abundant water played a prominent role in the industrialization of Europe and North America. Even if less developed nations pursue new development paths that avoid the errors of the past, it is difficult to imagine how sustainable development will proceed if renewable fresh water is in short supply.

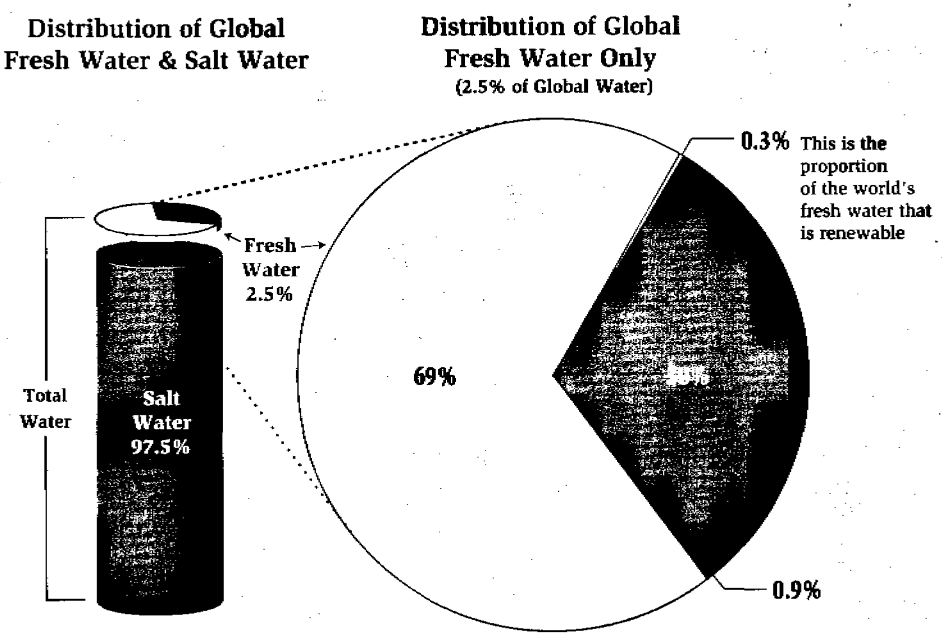
Efforts to encourage water conservation face special challenges not encountered with other natural resources. In much of the world, water is not controlled by market mechanisms because it is either free for the taking or unmetered. Nor is water a global resource that can be traded like petroleum or given in aid like food or medicine. Whether people waste water in one river basin is irrelevant to those who live in another. People need sources of clean water close to home.

This report, the first in a series, examines per capita national water availability and use as indicators for a range of likely economic, social and health risks faced by nations with insufficient fresh water. The 149 nations for which authoritative information is available on renewable water volume are included in an index of water scarcity. The index illustrates annual renewable fresh water available to each person in the country in 1955, in 1990, and in 2025 (based on UN population projections). A graphic version of this index, including a bar chart of the 100 driest countries and a map of projected world water scarcity in 2025, is included in a detachable wall chart in the center of the report. A ranking of all 149 countries based on 1990 per capita water availability per person can be found in Appendix 2. The population and water data used to compile the full index is presented in Appendix 3.

National data, admittedly, masks huge regional differences in many large countries. The water shortages faced in recent years in California and in northeastern Brazil, for example, demonstrate that regional scarcity can occur even in nations generally well endowed with renewable water. A detailed analysis of how population interacts with renewable water at local levels would demand data on regional supply and quality that are currently unavailable. Comparing current and projected population trends with national data on renewable water supplies in 149 countries, however, begins to bring into focus the impact of population growth on this essential natural resource.

Figure 1

The World's Water



- 69% glaciers and permanent snow cover (24,060,000 cubic kilometers)
- 30% fresh groundwater (10,530,000 cubic kilometers)
- 0.3% freshwater lakes and river flows (93,000 cubic kilometers)
- 0.9% other, including soil moisture, ground ice/permafrost and swamp water (342,000 cubic kilometers)

(Note: Percentage figures do not add up to 100% due to rounding.)

Source: Igor Shiklomanov, "World Fresh Water Resources" in Peter H. Gleick, ed., *Water in Crisis: A Guide to the World's Fresh Water Resources*, 1993

While the world's oceans may seem unbounded, the amount of fresh water actually available to people is finite – and a mere fraction of the water visible from outer space.

I. Limits

Between 1940 and 1990, world population more than doubled, from 2.3 billion to 5.3 billion human beings. Simultaneously, per capita use of water doubled, from about 400 to 800 cubic meters per person per year[1]. The practical result of these two trends was that global use of water increased by more than four times in that half century. Given the finite nature of the earth's fresh water resources, such a quadrupling of world water use probably cannot occur again. In many of the regions where world population is growing most rapidly, the needed water is simply unavailable.

Although water remains abundant in many countries, in others the continual subdivision of renewable water resources among more people is leading to unsustainable uses of water or substantial declines in water availability and quality. This is especially true in Africa and the Middle East, but over time the ratio of people to renewable water supply is likely to become a concern in parts of Asia and Latin America, and possibly even in Europe.

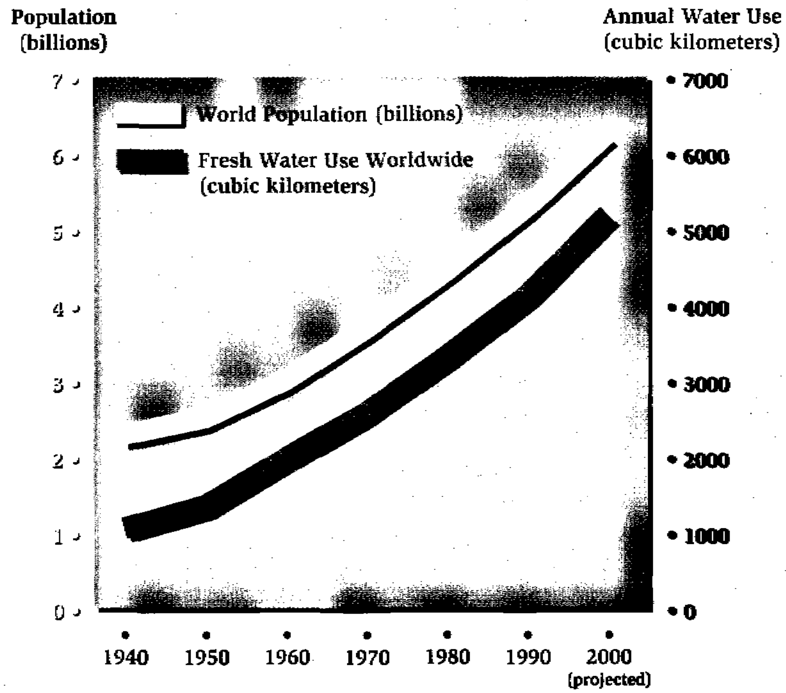
Understanding the limits of renewable fresh water supply requires an appreciation of how little of the planet's 1.4 billion cubic kilometers of water actually fits into that category. Only 2.5 percent is fresh—fit for drinking, growing crops and most industrial uses. Moreover, 69 percent of that is locked in polar ice caps and mountain glaciers or stored in underground aquifers too deep to tap under current and foreseeable technology[2].

In calculating how much fresh water is available for human use, what counts is not the sum total of global fresh water supplies, but the rate at which fresh water resources are renewed or replenished by the global hydrologic cycle. Powered by the sun, this cycle each year deposits about 113,000 cubic kilometers of water on the world's continents and islands as rain and snow. Of that, about 72,000 cubic kilometers evaporates back into the atmosphere. That leaves 41,000 cubic kilometers a year to replenish aquifers or to return by river or other runoff to the oceans[2]. If all the world's water fit into a bathtub, the portion of it that could be used sustainably in any given year would barely fill a teaspoon[3].

Moreover, not all of this 41,000 cubic kilometers can be captured for human use. More than half flows unused to the sea in floodwaters and as much as an eighth falls in areas too far from human habitation to be captured for use. Some water experts suggest the practical upper limit of the world's *available* renewable fresh water lies between 9,000 and 14,000 cubic kilometers per year [1,4]. And a substantial proportion of this amount is needed to sustain natural ecosystems—in and around rivers, wetlands and coastal waters—and the millions of living species they contain.

Figure 2

World Population and Fresh Water Use, 1940 to 2000



Since 1940, the amount of fresh water used by humanity has roughly quadrupled as world population has doubled. Some water experts estimate the practical upper limit of usable renewable fresh water lies between 9,000 and 14,000 cubic kilometers yearly. That suggests a second quadrupling of world water use is unlikely.

Source: Peter H. Gleick, Pacific Institute for Studies in Development, Environment and Security

Definitions of Key Water Terms and Concepts

Hydrologic cycle (also called the water cycle): the cycle by which water evaporates from oceans and other bodies of water, accumulates as water vapor in clouds, and returns to oceans and other bodies of water as rain and snow, or as runoff from this precipitation or as groundwater.

Runoff: water originating as rain or snow that runs off the land in streams, eventually reaching oceans, inland seas, or aquifers unless it evaporates first.

Aquifer: a layer or section of earth or rock that contains groundwater.

Groundwater: any water naturally stored underground in aquifers, or that flows through and saturates soil and rock, supplying springs and wells.

Water withdrawal: removal of water from any natural source or reservoir—such as a lake, stream or aquifer—for human use. If not consumed, the water may later be returned to the same or another natural reservoir.

Water consumption: use of water that allows its evaporation or transpiration (through plants), or leaves it unfit for any subsequent use.

Renewable water: water continuously renewed within reasonable time spans by the hydrologic cycle, such as that in streams, reservoirs or other sources that refill from precipitation or runoff. The renewability of a water source depends both on its natural rate of recharge and the rate at which the water is withdrawn for human ends. To the extent water is withdrawn faster than its source is recharged, it cannot be considered renewable.

Nonrenewable water: water in aquifers and other natural reservoirs that are not recharged, or are recharged so slowly that significant withdrawals will cause depletion.

Desalination: production of fresh water by removing salt from seawater or brackish water through the application of energy, usually oil or other fossil fuels.

Water scarcity: as used in reference to countries by water engineers and in this report, condition in which the annual availability of renewable fresh water is 1,000 cubic meters or less per person in the population.

Water stress: condition in which the annual availability of renewable fresh water is less than 1,667 and greater than 1,000 cubic meters per person in the population.

Sources: Adapted from Robert K. Barnhart, *The American Heritage Dictionary of Science*, 1986; Peter H. Gleick; World Resources Institute

The critical limits, of course, are not at the global level but at regional, national and local levels. In measuring a country's water resources, hydrologists refer to *endogenous*, or internal, and *exogenous*, or external, resources. Internal supply refers to the precipitation that falls on national territory, minus that portion lost through evaporation. External water supply is that which flows into a country from rivers and aquifers originating in other countries—and is vulnerable to the restrictions of those countries. While most of both kinds of renewable water would be available for a country's use under ideal conditions, many countries can only *mobilize*—capture for use—a proportion of their potential water resources, depending on the suitability of their land for water storage in reservoirs and the extent and condition of their infrastructure. Some developing countries can currently mobilize only 20 percent of their potential water resources[5].

Water Availability

Throughout most of human history, the world's fresh water reserves were more than adequate to serve human needs while maintaining the integrity and biological diversity of the earth's ecosystems. But as populations have grown, fresh water has become increasingly less available where and when it is needed.

Fresh water availability is dictated in large part by climate, and particularly by the timing and location of precipitation and by "evaporative demand," a measure of how much moisture the atmosphere can absorb that is chiefly determined by average temperature. Some arid countries in the Middle East and North Africa have such low precipitation and high evaporation that only a small amount of fresh water can be captured for human use. Rainfall in many desert areas amounts to a few millimeters a year—and all of that may fall within a few days. By contrast, nations such as Sweden or Iceland, where precipitation is high and evaporative demand low, enjoy abundant water resources.

Water availability can vary tremendously from season to season, causing distinct wet and dry seasons in well-watered regions. Bangladesh is inundated with rainfall during its two-to-three-month monsoon season, but lacks rainfall for much of the rest of the year. Water availability also varies from year to year, making even semi-arid regions vulnerable to a succession of dry years, such as the drought that gripped 20 sub-Saharan African nations from 1981 to 1984 and California, more recently. To be useful, moreover, fresh water supplies must be close to the populations that need them. Three quarters of Mexico's population lives in its dry central highlands, while four-fifths of the surface water lies in the wetter coastal regions[6].

Socioeconomic factors greatly influence access to water. Developing countries may lack the capital and technology to tap potential water resources. Within a country powerful industrial or agricultural interests may claim a disproportionate share of water

...as populations have grown, fresh water has become increasingly less available where and when it is needed.

Worldwide, agriculture is the single biggest drain on water supplies, accounting for about 69 percent of all water use.

resources. People with the least status and wealth often suffer disproportionately when supplies are limited.

Access is further complicated by conflicts arising over rights to water in river and lake basins shared by two or more countries, and to water in aquifers that cross international borders. Access to water is one of the critical negotiating issues for Israel and its Arab neighbors, who together have among the highest ratios of population to renewable water in the world. Areas of real or potential water conflict also include the valleys of the Nile, the Tigris and Euphrates, and the Indus, Ganges and Brahmaputra rivers.

Among the greatest single influences on fresh water availability, however, is the number of people competing for the resource. Higher population size and standards of living boost demand for finite quantities of water and intensify competition and tension among users. Since much of the world's urbanization, industrialization and irrigation is characterized by unsustainable patterns of fresh water use, the situation threatens to grow worse.

China and Canada, for example, receive similar amounts of precipitation, both in total and per hectare[7]. But with 42 times Canada's population, China can offer each citizen only 2.2 percent of the water each Canadian can claim. As populations grow unevenly in the world, such inequities will increase.

Uses of Water

Worldwide, agriculture is the single biggest drain on water supplies, accounting for about 69 percent of all use. About 23 percent of water withdrawals go to meet the demands of industry and energy, and just 8 percent to domestic or household use[3]. Patterns of use vary greatly from country to country, depending on levels of economic development, climate and population size. Africans, for instance, devote 88 percent of the water they use to agriculture, mostly irrigation, while highly industrialized Europeans allot more than half their water to industry and hydroelectric energy production.

Although much of the world's farming still relies on the renewable water that falls on crops from the sky, irrigation largely explains agriculture's thirst. And the watering of crops has grown in tandem with rising world population. (Livestock production is an agricultural activity, but its use of water is minor compared to irrigation.) In 1990, 250 million hectares (620 million acres) of land were under irrigation worldwide, supplying a third of the world's harvested crops[8], and agriculture was the primary use for water in two out of three countries[3].

Agricultural water use is particularly high in arid areas such as the Middle East, North Africa and the southwestern United States, where rainfall is minimal and evaporation so high that crops must be irrigated most of the year. Afghanistan, and Sudan apply an estimated 99 percent of all the water they use to agriculture.

The area of irrigated land worldwide nearly doubled in the first half of this century to meet the needs of a growing population that was developing economically and consuming more food per capita. Land under irrigation more than doubled again between 1950 and 1990[8]. Only in recent years has the growth of irrigation slowed, reflecting the challenge of finding new sites for dams and reservoirs and of squeezing more water out of already overpumped aquifers. In California and the southwestern United States, water is becoming so valuable that farmers are selling their land—and the accompanying water rights—to ballooning metropolitan areas with huge demand. A few countries, such as Malta and Botswana, have opted to rely on imported food, in part, to save water. This reduces the need for irrigation water, but at the risk of limiting options if imported food becomes expensive.

Domestic water use—including drinking, food preparation, washing, cleaning, gardens and service industries such as restaurants and laundromats—accounts for only a small portion of total use in most countries. The amount of water people apply to household purposes tends to increase with rising standards of living, and variations in domestic water use are substantial. In the United States, each individual typically uses more than 700 liters each day, or 185 gallons, for domestic tasks. In Senegal, the average individual uses just one twentieth of that—29 liters, or 7.6 gallons—to meet household needs[3]. Domestic needs account for a greater share of overall use in countries, rich or poor, that have little agriculture or industry. In both Kuwait and Zambia, nearly two out of every three liters of water are used in households.

Industry, a category that includes energy production, uses water for cooling, processing, cleaning and removing industrial wastes. Nuclear and fossil-fueled power plants are the single largest industrial users, applying staggering amounts of water to the job of cooling[9]. While most of the water used for industrial purposes is returned to the water cycle, it is often contaminated by chemicals and heavy metals, or its temperature is increased to the detriment of water ecosystems. Industrial use varies from less than 5 percent of withdrawals in dozens of developing countries to as much as 85 percent in Belgium and Finland. Only in Europe, where reliance on irrigation is relatively low, does industrial water use equal the sum of water applied to agriculture and domestic uses. The proportion of water used for industrial purposes is often seen as an indicator of economic development.

Water and Sustainable Development

The essence of sustainable development is that natural resources must be used in ways that will not limit their availability to future generations.

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Sustainable development of water resources requires that we respect the hydrologic cycle by using renewable water resources that are not diminished over the long term by that use.

Today, however, most easily accessible renewable fresh water resources—rivers, smaller streams and lakes, and aquifers that recharge quickly—already have been developed. The cost of developing less accessible ones will be high and the process time consuming. The environmental and human costs of projects can also be enormous. Egypt's Aswan Dam—while providing multiple benefits to farmers and others—covered priceless archeological sites, destroyed valuable ecosystems and fishing grounds, eroded beaches and damaged nutrient and sediment balances. China will pay over $3.2 billion to resettle the estimated 1 million farmers and villagers that are expected to be displaced by the planned Three Gorges Dam on the Yangtze River[10,12].

Transfers of water from one river basin to another, used for example to balance regional water supply and demand in the western United States, are generally prohibitively expensive across national borders. Schemes such as one to transport water from rivers in Alaska and Western Canada over the Rocky Mountains to water-poor states in the United States and northern Mexico have stalled because of excessive costs, technological obstacles and environmental risks.

The growing use of fossil fuels to pump water from deep underground aquifers is dramatically expanding access to fresh water today—but at the cost of access in the future. There is nothing inherently unsustainable about the use of groundwater per se; people have been drawing water from wells since the earliest civilizations of the Fertile Crescent. But to ensure that wells provide as generously next year, or next century, water must be drawn at a rate that permits water table levels to remain stable over time. The rate of sustainable water use is determined not by human needs but by the laws of nature.

Although all natural water resources are replenished through the natural hydrologic cycle, their renewal rates range from days to millennia. For rivers, renewal rates average 18 days; for large lakes and deep aquifers they can span thousands of years[11]. The world's oldest water reserves, such as the Nubian aquifer in North Africa, were filled when water infiltrated the earth's subsurface in past geologic ages. Because it is questionable when, if ever, "fossil" water from such aquifers will be replenished, drawing significant amounts of water from them is by definition unsustainable, and their use cannot be more than a temporary solution to water scarcity.

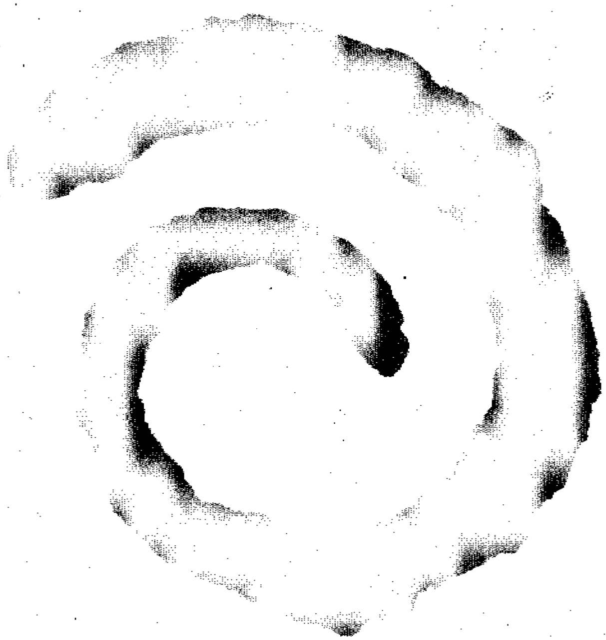
Fresh Water from the Sea

Desalination of seawater could theoretically be a sustainable source of fresh water—at least for wealthy nations with access to seawater—but it falls far short of sustainability today. In

1990 just over 13 million cubic meters of fresh water were being produced per day in some 7,500 facilities around the world through desalination[3]. That represents a 13-fold increase in global capacity over 20 years[11]. Yet desalinated water still supplies barely one thousandth of the fresh water used worldwide, according to calculations by Peter H. Gleick, an expert on water issues with the Pacific Institute for Studies in Development, Environment, and Security in Oakland, California. Between the high capital and energy requirements, desalinated water costs several times more than water supplied by conventional means[3]. To make it affordable, Kuwait and other wealthy countries heavily subsidize the costs of water to their citizens. With world population growing by 1.6 percent a year, it is hard to imagine this technology expanding fast enough to make a major contribution to meeting water needs around the world.

Desalination as currently practiced has a further constraint: It is driven almost entirely by the combustion of fossil fuels. These fuels, in extensive but still finite supply, pollute the air and contribute to the risk of global climate change. At present, solar powered desalination plants—which hold the promise of using renewable energy to take the salt out of seawater—account for only 5,240 cubic meters a day, a negligible proportion of all desalinated water[12].

New sources of fresh water will be developed, and no doubt water will be used with increasing efficiency. Solutions that work over time, however, must respect the limits imposed by the global water cycle. At least until renewable energy can be coupled inexpensively with desalination technologies, sustainable development of water resources means working with the 41,000 cubic kilometers the water cycle provides each year. To allow for flooding and nature's needs, a quarter to a third of that amount may be the upper limit of water available for sustainable human use.



II. Population and Water

At a time when many countries are approaching or exceeding the limits of their renewable fresh water resources, world population is growing by larger increments than ever before. Fertility has declined and the global growth rate has eased slightly since 1970, but due to the unprecedented size and youth of the world's population, 90 million people are added to the planet each year—the equivalent of the population of Mexico. And for each new person, water is among the absolute necessities of life.

Already some 80 countries with 40 percent of the world's population suffer from water shortages at some time during the year[13]. Some of the highest population growth rates are found in arid countries, many of which are already experiencing severe water scarcity. By the turn of the century, chronic fresh 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[4,14].

Population growth not only increases human water needs, it also helps accelerate environmental disturbances of the water cycle as a by-product of the greater production of food and fuel. Among these disturbances are deforestation and other destructive land use practices, the disposal of waste, the use of pesticides and fertilizers, and the release of greenhouse gases that could warm global climate. Many of these activities pollute the water that is available, in addition to limiting the amounts that can be captured.

Population and Water Stress

Malin Falkenmark, a widely respected Swedish hydrologist, pioneered the concept of a "water stress index," based on an approximate minimum level of water required per capita to maintain an adequate quality of life in a moderately developed country in an arid zone. Falkenmark began with the calculation that 100 liters per day (36.5 cubic meters per year) is a rough minimum per capita requirement for basic household needs to maintain good health. The experience even of water-efficient and moderately developed countries shows that roughly 5 to 20 times this amount tends to be needed to satisfy the requirements of agriculture, industry and energy production, she found. Based upon these findings, Falkenmark suggests specific thresholds of water stress and water scarcity[5].

A country whose renewable fresh water availability, on an annual per capita basis, exceeds about 1,700 cubic meters will suffer only occasional or local water problems. Below this threshold countries begin to experience periodic or regular *water stress*. When fresh water availability falls below 1,000 cubic meters per person per year, countries experience chronic *water scarcity*, in which the lack of water begins to hamper economic development and human health and well-being. When renewable fresh water supplies fall below 500 cubic meters per person, countries experience *absolute scarcity*.

These levels should be considered rough benchmarks, not precise thresholds. The exact level at which water stress sets in varies from region to region, a function of climate, level of economic development and other factors. Water stress can also be eased by comprehensive programs of water conservation and more efficient technologies. But the basic concept of scarcity thresholds provides a useful tool for considering how changes in population can affect per capita water supply, and hence abundance on country-wide scales.

The 1,000-cubic-meter benchmark has been accepted as a general indicator of water scarcity by World Bank and other analysts[15]. Gleick, of the Pacific Institute, has called it the "approximate minimum necessary for an adequate quality of life in a moderately developed country."[11] Israel, a relatively prosperous country, is commonly cited for surviving on much less—461 cubic meters of fresh water per person (although Israel also depends on some nonrenewable groundwater). But even countries with high water availability may experience problems because of regional disparities or very high water demand.

Acknowledging such discrepancies, however, hydrologists and water use experts find 1,000 cubic meters serves as a useful benchmark for water scarcity around the world. Falkenmark's higher stress benchmark of about 1,700 cubic meters per capita per year is a "warning light" to nations whose populations continue to grow. In time, in the absence of conditions that lead to population stabilization, most water-stressed nations will fall into the scarcity category.

Countries with less than 1,700 cubic meters per person experience water stress; those with less than 1,000 cubic meters, water scarcity.

...achievable reductions in population growth could cut by half a billion the number of people who will live in countries that are frequently or chronically short of water.

Toward an Index of Water Scarcity

The impact of population growth on water availability can be analyzed by comparing current data on each country's renewable water supply (including river inflow from other countries) with data on past, present and projected population size. The World Resources Institute publishes country-by-country data on water availability and use. These data were recently updated and revised by Gleick in collaboration with Population Action International.

The United Nations periodically publishes projections of future population growth and size for most countries. On the basis of varying assumptions about future fertility, mortality and migration, the UN suggests low and high range scenarios of population growth through 2025, with a medium range projection in between.

By comparing population data for 1955, 1990 and 2025 with the most current data on fresh water availability in 149 countries, an index of country-by-country water scarcity can be constructed using the Falkenmark water availability thresholds for three evenly spaced points in time. Comparison of the best and worst case scenarios for population growth in 2025 illustrates the difference even near term population growth will make to fresh water availability within the lifetimes of most people alive today. (For a detailed explanation of the methodology of the water scarcity index, see Appendix 1. For the complete index, see Appendices 2 and 3. See also detachable wall chart in center of book.)

The water scarcity index makes clear that water is, or is likely to become, a major constraint on development for more than a third of the countries studied, on four of the five major continents. In 1990, 28 countries with populations totaling 335 million experienced water stress or scarcity. By 2025, from 46 to 52 countries will fall into these categories, and the number of people in such countries could be as low as 2.782 billion or as high as 3.290 billion—*depending on rates of population growth over the next three decades*. The difference between these two numbers is one and a half times the number of people living in such conditions in 1990. As early as the first quarter of the 21st century, achievable reductions in population growth could cut by half a billion the number of people who will live in countries that are frequently or chronically short of water.

Water-scarce Countries

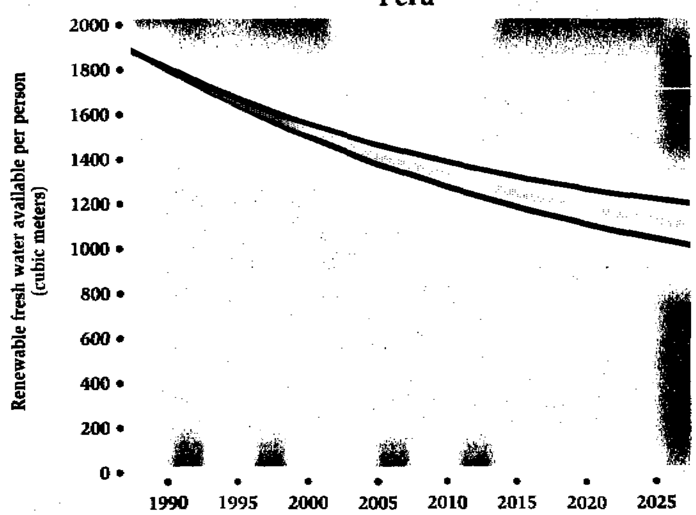
Quantities of renewable fresh water qualified 20 nations in 1990 as water-scarce, 15 of them with rapidly growing populations. By 2025, between 10 and 15 nations will be added to this category. Between 1990 and 2025 the number of people living in countries in which renewable water is a scarce resource will rise from 131 million to somewhere between 817 million under the UN's low projection of population growth and 1.079 billion under the high projection. In this case, the difference between the high and low projections—262 million—is precisely twice the number of people living in water-scarce countries in 1990.

For several countries varying population scenarios could mark the difference between potentially manageable water stress and outright water scarcity in 2025. In 1990 Peru, for example, had 1,856 cubic meters of renewable water per person per year. Under almost any conditions, that figure will plunge, but the rate of population growth could determine whether Peru crosses into water scarcity or hovers in water stress with nearly 1,200 cubic meters per person in 2025. Similar possibilities face Tanzania, Zimbabwe and Cyprus. For Sri Lanka, Mozambique and Mauritania, the population trajectory will determine whether the threshold is crossed from relative water abundance to stress.

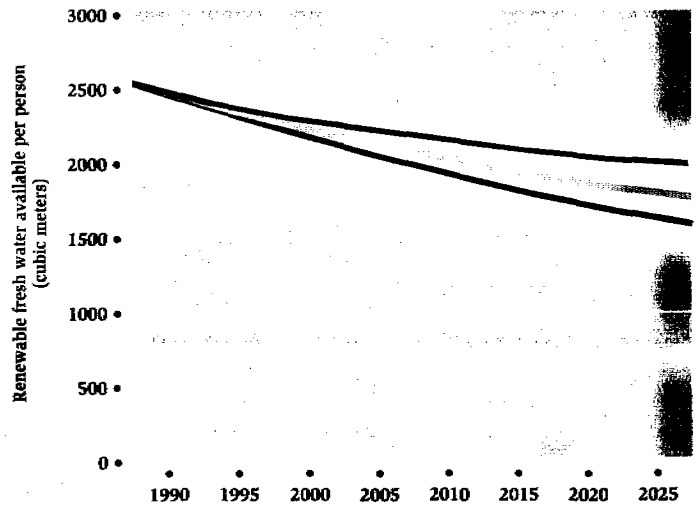
Among the countries projected to fall into the water stress category before 2025 is India (1990 annual per capita water availability: 2,464 cubic meters), currently the second most populous country in the world

Figure 3

Fresh Water Availability in Peru and Sri Lanka Under Three Population Growth Scenarios



The trajectory that Peru's population follows could determine whether it crosses the threshold of water scarcity as early as 2025. Note that the descent of the curves illustrates *lower* per capita water availability as a result of *higher* population growth.



If Sri Lanka realizes the United Nations' high population projection, it could cross the threshold of water stress before 2025.

Table 1

Countries experiencing water scarcity in 1955, 1990 and 2025 (projected), based on availability of less than 1,000 cubic meters of renewable water per person per year

Water-scarce countries in 1955	Countries added to scarcity category by 1990	Countries added to scarcity category by 2025 under all UN population growth projections	Countries added to scarcity category by 2025 only if they follow UN medium or high projections*
Malta	Qatar	Libya	Cyprus
Djibouti	Saudi Arabia	Oman	Zimbabwe
Barbados	United Arab Emirates	Morocco	Tanzania
Singapore	Yemen	Egypt	Peru
Bahrain	Israel	Comoros	
Kuwait	Tunisia	South Africa	
Jordan	Cape Verde	Syria	
	Kenya	Iran	
	Burundi	Ethiopia	
	Algeria	Haiti	
	Rwanda		
	Malawi		
	Somalia		

* *Cyprus will have more than 1,000 cubic meters of renewable fresh water annually per person in 2025 if it follows either the UN low or medium population growth projection. Zimbabwe, Tanzania and Peru will avoid falling below 1,000 cubic meters per capita only if they follow the UN low projection.*

with nearly 900 million people. By 2025, India's population is expected to exceed 1.4 billion under the UN's medium projection, and the chronic water scarcity that already plagues many regions of the country is all but certain to intensify.

China, today's most populous nation (1990 annual per capita water availability: 2,427 cubic meters), only narrowly will miss the water stress benchmark in 2025, according to all three UN projections. In that year, according to the medium scenario, each of China's projected 1.5 billion citizens will have 1,818 cubic meters available. In the North China Plain, however, water shortages are already acute, and demand is expected to outstrip supply by the turn of the century[3].

Oil rich Arab states—Kuwait, Qatar, Bahrain, Saudi Arabia and the United Arab Emirates—make up five of the nine countries with the least water per capita. Every time Saudi Arabians prospect for water, a joke runs, they strike oil. And, in fact, oil is in some ways as close to a substitute for water as one can find, for it provides an energy source both for desalination and the pumping of deep aquifers. Many countries in the Middle East rely heavily on desalination and nonrenewable groundwater supplies to augment their meager renewable fresh water supplies. And with continuing high family size in these countries, renewable water will become increasingly scarce. Populations in the region are currently doubling every two or three decades. It may appear that the wealth these countries now enjoy will enable them to buy their way out of any future water shortages. The key point, however, is that wealthy countries as well as poor ones are now using water unsustainably. Eventually they will have to face the consequences and place their water management on a sustainable path.

Israel and Jordan are high on the list of water-scarce nations, and their placement there says much about the potential for continued conflict in the Jordan River valley. Israel probably uses water more efficiently than any other country, yet its demand has exceeded the sustainable annual yield of its available sources since the mid-1970s. Israel strictly controls Palestinian use of water in the occupied 5,890-square-kilometer West Bank, from which it draws 40 percent of its groundwater and more than 25 percent of its renewable water supplies. Palestinians, noting that Jewish settlers use four times as much water on a per capita basis, charge that deep wells dug for the settlers sap the yields of their own shallower wells[16]. Israel is projected to grow from 4.7 million people in 1990 to about 8 million in 2025.

For Jordan, whose population more than doubled from 1.5 million in 1955 to 4 million in 1990, increasing scarcity means deteriorating water quality and growing reliance on groundwater when water tables are dropping rapidly. In the summer of 1993, water shortages were endemic throughout Amman, the country's capital, despite ongoing water rationing. Jordan (1990 annual per capita water availability: 327 cubic meters) already exploits all its available water resources, and its population is projected to double again before 2015[17].

A dozen or more African nations also are struggling to balance declining per capita water supplies with the demands of rapidly rising populations. Of 20 African countries that have faced food emergencies in recent years, half are either already stressed by water shortage or are projected to fall into the stress category by 2025[18]. Lacking the financial resources and technology to improve management of scarce water or gain access to more renewable supplies, these countries are in desperate need of improvement in the development and management of renewable fresh water resources. They include war torn Somalia as well as Algeria, Kenya, Malawi and Rwanda.

Certain countries currently enjoy adequate per capita renewable fresh water resources but will encounter water scarcity by 2025. Iran, for example, had 2,025 cubic meters a year per capita in 1990; by 2025 the figure is projected to be between 776 and 860. Haiti, with 1,696

...wealthy countries as well as poor ones are now using water unsustainably. Eventually, they will have to face the consequences...

Regional Water Scarcity: India

Based on per capita renewable water availability, India—the second most populous country in the world—has water enough to meet its people's needs. But despite an estimated 2,464 cubic meters per person per year, many of its nearly 900 million people suffer severe water shortages, in part as a result of uneven availability of water. Most rainfall comes during the monsoon season, from June to September, and levels of precipitation vary from 100 millimeters a year in the western parts of Rajasthan to over 9,000 millimeters in the northeastern state of Meghalaya[19]. Floods and droughts are both common throughout the country.

India's vulnerability to regional water scarcity is well illustrated by the case of Rajasthan, a state in northwest India. Situated in one of the most inhospitable arid zones in the world, Rajasthan's northwest corner extends into the vast Thar Desert. With a wide range of temperatures and an unpredictable monsoon climate, drought and desertification are common, and water is a scarce commodity. Home to eight percent of India's population, Rajasthan can claim only one percent of the country's water resources, which come in the form of groundwater, limited rainfall, and a restricted share of waters that straddle state boundaries[20].

Population growth in Rajasthan, as in the rest of India, has been rapid. In 1990, the state's population reached almost 44 million. And with only some 30 percent of couples using contraception, the state's total fertility rate, or average number of children per woman, remains at about 4.5. By the year 2000, Rajasthan's population is projected to increase to almost 55 million. In 1990 per capita water use in the state amounted to 562 cubic meters, a level nearly commensurate with absolute scarcity[20]. With the projected increases in human numbers for the coming decade, acute shortages are imminent.

Even those who live in areas of high rainfall in India often face drought because landscapes have been denuded. Soil is compacted and most rainfall runs off before it can sink into the ground, increasing flooding. The region of Cheerapunji in Meghalaya, for example, receives among the highest levels of mean rainfall recorded in the world. Yet because of intense seasonal rainfall and the fact that the area's forests have been cleared in the past few decades to meet growing demands for agricultural land and housing, much of the runoff cannot be captured. The region now suffers from excessive flooding for three or four months and frequent droughts the rest of the year[21]. With a rapidly growing population of 1.8 million, Cheerapunji's water shortages and desertification will likely worsen.

cubic meters in 1990, could have anywhere from 761 to 981 per person in 2025, depending on population growth. Libya, close to scarcity already with 1,017 cubic meters per capita in 1990, is projected to have between 329 and 377 cubic meters in 2025.

Other Indicators of Unsustainability

Some countries are using more fresh water, in effect, than they have—or at least have in the form of renewable resources. A ratio of actual water withdrawals, or water *use*, to renewable supply that exceeds 100 percent is a key indicator of unsustainable water use, for nonrenewable water in deep aquifers can only be used once[22]. In 1990, nine countries used water in amounts more than 100 percent of their renewable supplies, with Libya's water withdrawals equal to nearly four times its renewable water resources.

Despite Libya's increasing use of desalination and water recycling, rapid growth in the country's demand for water have led it to rely on groundwater mining. The country's southern area, a desert region with few inhabitants, overlies two of the largest groundwater basins in the world. Libya's government has used oil revenues to fund one of the world's largest water engineering projects, in which a giant pipeline will ship water from those reserves to the more densely populated north. But with Libya's 1990 population of 4.5 million expected to increase to 12.9 million by 2025, water demand could outstrip the groundwater reserves of the southern desert within the next few decades.

Water Imports

Dependence on imported surface waters is another indicator of a population's susceptibility to water shortage[22]. Reliance on water that flows across their borders from other nations makes countries more vulnerable to forces outside their control, and this vulnerability is exacerbated

Table 2

Countries whose water use exceeds 100 percent of their renewable water supplies, with population doubling times

Country	Water withdrawals as a percentage of renewable water supplies, late 1980s	Years required for population to double at current rate of natural increase*
Libya	374%	20.4
Qatar	174%	33.0
United Arab Emirates	140%	24.8
Yemen	135%	21.7
Jordan	110%	19.3
Israel	110%	46.2
Saudi Arabia	106%	21.7
Kuwait	more than 100%	23.1
Bahrain	more than 100%	28.9

**Excludes rates of migratory flows, which are significant in some of these countries*

Sources: Adapted from Peter H. Gleick, "Water and Conflict," 1992; Population Reference Bureau, *1993 World Population Data Sheet*

Table 3

Countries depending on river inflow from other countries for more than half their renewable water

Country	Percentage of renewable water supplies originating outside borders*	Years required for population to double at current rate of natural increase
Egypt	97%	30.1
Netherlands	89%	138.6
Cambodia	82%	27.7
Syria	79%	18.2
Sudan	77%	22.4
Iraq	66%	18.7

**Excludes rates of migratory flows*

Source: Adapted from Peter H. Gleick, "Effects of Climate Change on Shared Fresh Water Resources," in *Confronting Climate Change: Risks, Implications and Responses*, 1992; Population Reference Bureau, *1993 World Population Data Sheet*

by growing water demand. Egypt, dependent on the waters of the Nile for 97 percent of its renewable water supply, is the country most dependent on imported surface water. Egypt's reliance on the waters of the Nile, the longest river in the world, places it in an extremely vulnerable position. Composed of the Blue and White Nile rivers, which join in Sudan, the Nile passes through nine countries, and Egypt is last in line. As UN Secretary General Boutros Boutros-Ghali told the U.S. Congress in 1989 when he was Egypt's minister of state for foreign affairs, "The national security of Egypt is in the hands of the eight other African countries in the Nile basin."[4]

In 1959, Egypt and Sudan signed an agreement allocating the waters of the Nile, but Ethiopia and other upstream countries are not party to it. Ethiopia, source of the Blue Nile, is considering developing sections of the Nile watershed, and Kenya and Tanzania both plan to use Lake Victoria, the source of the White Nile, for irrigation projects. Burundi, Tanzania and Uganda have joined forces to develop the Kagera River, which feeds into Lake Victoria[12]. Egypt's growing population of 58 million is projected to reach between 86 million and 101 million in 2025, yet the country is already approaching water scarcity (1990 annual per capita availability: 1,017) and its demand for water approaches 100 percent of renewable supply. Egypt is justifiably alarmed by the likelihood its supplies will be diminished as countries upstream demand a greater share of the Nile's waters. U.S. Vice President Al Gore recently noted that all of the nations in the Nile Basin have high rates of population growth, with populations that will double in 20 to 30 years, yet "the amount of water in the Nile is no more than when Moses was found in the bulrushes."[23]

The continual fall of water tables and lake levels is a warning signal to governments that their countries are passing the limits of sustainable use of their water resources. As populations continue to grow, the signals blink more urgently.

Regional Water Scarcity: California

Compared to countries experiencing water stress or scarcity on a national level, the United States has abundant renewable water resources that average almost 10,000 cubic meters per person per year. Yet even in the United States, regional water demand often exceeds supply. California, a semi-arid state with the largest and among the most rapidly growing populations in the country, epitomizes the conflicts over water that are developing elsewhere in the United States—and around the world.

In the last century, California experienced very rapid urban growth and at the same time developed large tracts of irrigated agriculture. Urban growth and agricultural development both were made possible by massive federal, state and local investments in dams, aqueducts, pumping plants and water distribution systems. Vast amounts of water are now transferred from water-rich to water-poor areas around the state. San Francisco gets water from the Sierra Nevada a few hundred miles away; Los Angeles depends on waters from faraway Mono Lake, the Central Valley Project and the Colorado River. But with the best dam sites gone, and the only undeveloped sources of water far from population centers, fresh water is increasingly scarce.[12]

In addition, the environmental effects of California's water use are increasingly evident. Water quality has declined in many areas of the state and numerous important aquatic ecosystems have been destroyed or severely altered. The state suffered one of the worst droughts in its history from 1987 to 1992, and the damage was severe. Water quality deteriorated, threatened and endangered species dwindled to perilously low numbers, and entire populations of fish were eliminated when several streams and lakes went completely dry. And California's 1990 population of just under 30 million is projected to exceed 63 million by 2040.[24]

Because of local opposition to the development of new water supplies, demands for water from California's growing population probably will have to be met through more efficient use of existing supplies and the reallocation of water from the agricultural sector, which uses 80 percent of the state's water but pays a fraction of what urban water consumers do. Californians are only beginning to debate the policy implications of such shifts, but the state's predicament holds a lesson for other regions and countries. Ultimately, the need to balance the conflicting water interests of urban residents, farmers, industry and natural ecosystems now evident in California will have to be faced worldwide.

III. Implications for Health and Development

Alone among living species, human beings have learned to make water work for them on a massive scale, capturing rain in cisterns, damming rivers, drilling wells and desalinating seawater. Yet our record is a mixed one. The pressures of modern agriculture, industry and urban lifestyles — multiplied by growing populations and rising standards of living—are causing water tables and river levels to fall and contamination to spread. In many cases, water supplies are becoming unusable and aquatic ecosystems are disappearing. In others, water quality is declining or reliance on nonrenewable water is growing precariously. These trends are evident in our growing dependence on deep underground aquifers to water cropland and supply rapidly growing urban areas.

The results of overuse of groundwater are visible throughout the world. In China's northern provinces, where 10 large cities rely on water from underground, water tables have been dropping as much as one meter a year in wells serving Beijing, Xian and Tianjin[15]. Overexploitation of groundwater in Bangkok is causing the city to sink two to four inches a year, leading to cracked pavements, broken sewer and water pipes, seawater intrusion and flooding.[25] In the early 1980s, water tables in Texas were falling by as much as six inches a year, although that rate has since moderated.[8]

Lakes and rivers have also proven vulnerable to unsustainable use. The level of Lake Naivasha in Kenya is dropping as farmers tap its waters to irrigate their fields. The diversion for irrigation of the rivers that feed the Aral Sea in central Asia reduced it to 40 percent its former surface area[4]. Once they are seriously polluted, groundwater reserves and lakes are essentially lost to

Population and Water Availability:

An Index of the 100 Countries With the Least Annual Renewable Fresh Water Available Per Person, 1955, 1990 and 2025

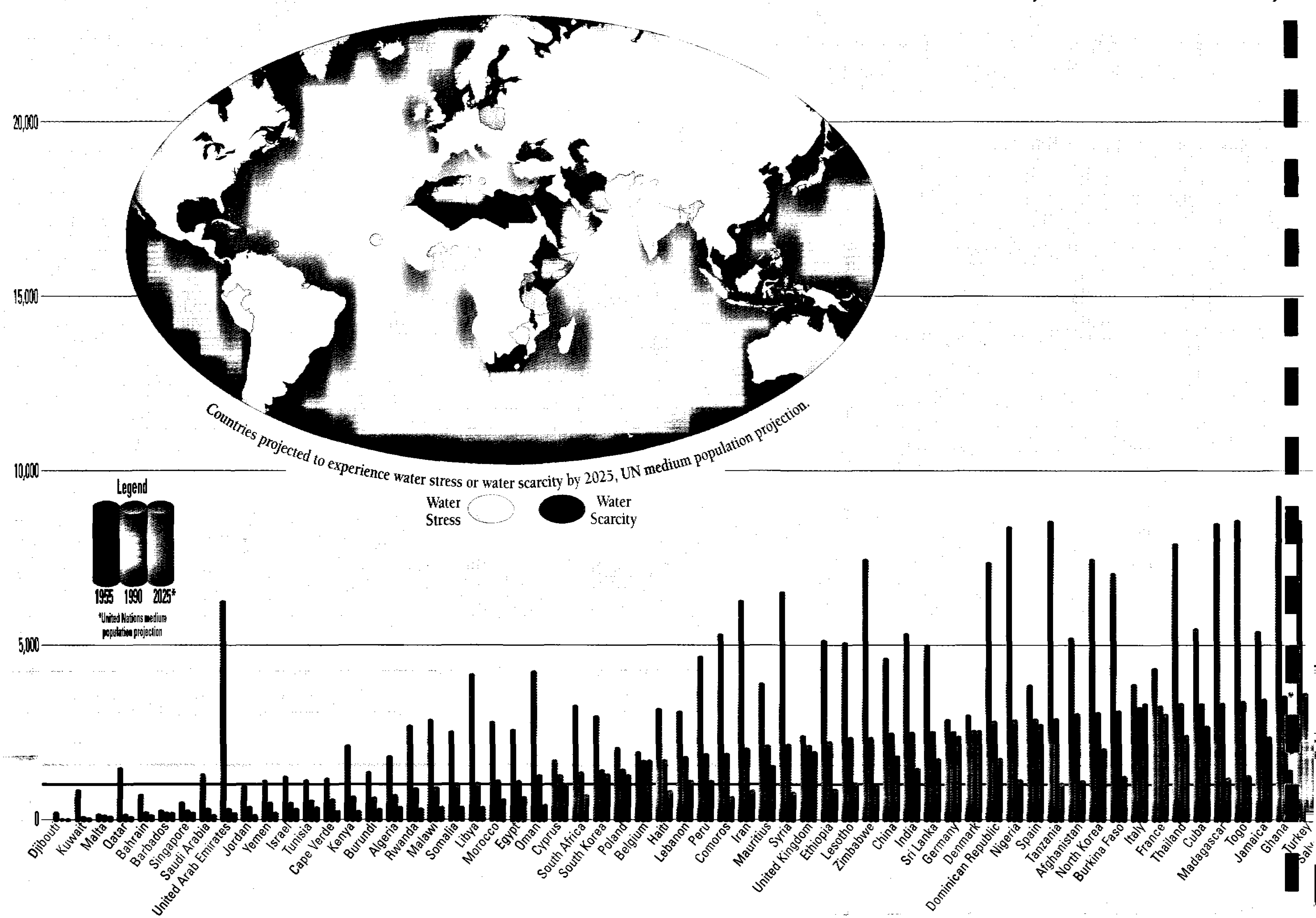
Population and Environment Program

Population Action International

POPULATION AND WATER AVAILAB

AN INDEX OF THE 100 COUNTRIES WITH THE LEAST ANNUAL RENEWABLE FRESH WATER

Countries Ranked by 1990 Fresh Water Availability



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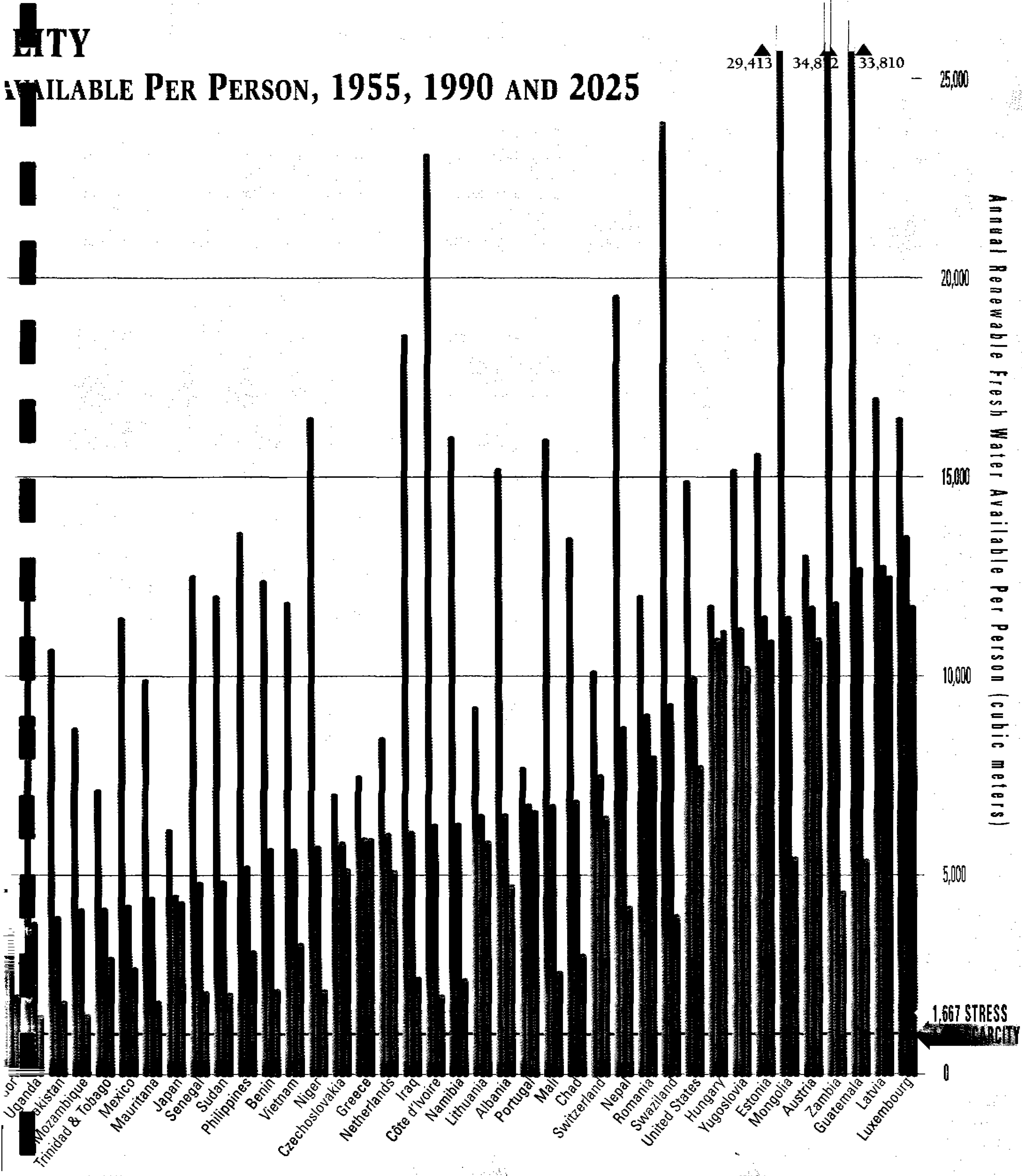

Fresh water that is continually renewed through the global water cycle is a finite natural resource in each country. Water engineers and planners consider a country to have reached a point of water scarcity when it has fewer than 1,000 cubic meters of renewable fresh water available annually for each person in its population. A higher and less severe benchmark is water stress, when a country has between 1,000 and 1,667 cubic meters of annual water availability per person. Since renewable freshwater resources are essentially constant in each nation, per capita availability falls as population rises, pushing some countries over time into water stress and water scarcity.

Population and
Environment Program
Director: Robert Engelman

Population Action International

1993

Annual Renewable Fresh Water Available Per Person in 100 Countries, Ranked by 1990 Availability

(cubic meters)

Country	1955	1990	2025 medium
Djibouti	147	23	9
Kuwait	808	75	57
Malta	96	85	69
Qatar	1,427	117	68
Bahrain	672	179	89
Barbados	221	195	164
Singapore	459	221	181
Saudi Arabia	1,266	306	113
United Arab Emirates	6,195	308	176
Jordan	906	327	121
Yemen	1,098	445	152
Israel	1,229	461	264
Tunisia	1,127	540	324
Cape Verde	1,184	551	258
Kenya	2,087	636	235
Burundi	1,339	655	269
Algeria	1,770	689	332
Rwanda	2,636	897	306
Malawi	2,839	939	361
Somalia	2,500	980	363
Libya	4,105	1,017	359
Morocco	2,763	1,117	590
Egypt	2,561	1,123	630
Oman	4,240	1,266	410
Cyprus	1,698	1,282	996
South Africa	3,249	1,317	683
Korea, South	2,940	1,452	1,253
Poland	2,053	1,467	1,279
Belgium	1,906	1,696	1,706
Haiti	3,136	1,696	838
Lebanon	3,088	1,818	1,113
Peru	4,612	1,856	1,071
Comoros	5,256	1,878	620
Iran	6,203	2,025	816
Mauritius	3,854	2,047	1,575
Syria	6,500	2,087	732
United Kingdom	2,344	2,090	1,992
Ethiopia	5,073	2,207	842
Lesotho	5,039	2,290	1,057
Zimbabwe	7,061	2,312	1,005
China	4,597	2,427	1,818
India	5,277	2,464	1,496
Sri Lanka	4,930	2,498	1,738
Germany	2,843	2,516	2,384
Denmark	2,928	2,529	2,529
Dominican Rep.	7,306	2,789	1,747
Nigeria	8,304	2,838	1,078
Spain	3,801	2,849	2,733
Tanzania	8,525	2,924	1,025
Afghanistan	5,137	3,020	1,091
Korea, North	7,386	3,077	2,010
Burkina Faso	6,980	3,114	1,237
Italy	3,845	3,243	3,325
France	4,260	3,262	3,044
Thailand	7,865	3,274	2,477
Cuba	5,454	3,299	2,694
Madagascar	8,476	3,331	1,185
Togo	8,485	3,398	1,280
Jamaica	5,383	3,430	2,365
Ghana	9,204	3,529	1,395
Turkey	8,509	3,626	2,186
El Salvador	8,583	3,674	1,952
Uganda	11,880	3,759	1,437
Pakistan	10,590	3,962	1,803
Mozambique	8,601	4,085	1,598
Trinidad and Tobago	7,073	4,126	2,867
Mexico	11,396	4,226	2,597
Mauritania	9,855	4,387	1,778
Japan	6,091	4,428	4,306
Senegal	12,451	4,777	2,049
Sudan	11,899	4,792	1,993
Philippines	13,507	5,173	3,072
Benin	12,316	5,625	2,105
Vietnam	11,746	5,638	3,215
Niger	16,362	5,691	2,067
Czechoslovakia	6,950	5,810	5,078
Greece	7,406	5,828	5,840
Netherlands	8,371	6,023	5,093
Iraq	18,441	6,029	2,356
Côte d'Ivoire	22,974	6,177	1,950
Namibia	15,900	6,254	2,399
Lithuania	9,130	6,433	5,804
Albania	15,120	6,462	4,711
Portugal	7,665	6,688	6,519
Mali	15,853	6,729	2,522
Chad	13,389	6,843	2,944
Switzerland	10,040	7,449	6,492
Nepal	19,596	8,686	4,244
Romania	11,895	8,963	7,918
Swaziland	23,918	9,268	4,002
United States	14,934	9,913	7,695
Hungary	11,704	10,897	11,062
Yugoslavia	15,126	11,130	10,161
Estonia	15,517	11,371	10,804
Mongolia	29,413	11,416	5,454
Austria	12,955	11,670	10,892
Zambia	34,872	11,797	4,576
Guatemala	33,810	12,613	5,354
Latvia	16,874	12,654	12,350
Luxembourg	16,394	13,405	11,682

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Mining Groundwater: Saudi Arabia and the United States

With no rivers and lakes and only 100 millimeters of annual rainfall Saudi Arabia has come to rely on the unsustainable mining of one of its less well known natural resources: groundwater. Rapid industrial and urban growth and improved standards of living in the prosperous country have resulted in annual demand for fresh water that exceeds its renewable resource by 6 percent. The Kingdom now relies on groundwater to meet 75 percent of its water needs[4].

Mining groundwater refers to the withdrawal of water from underground at rates that greatly exceed recharge rates. Ninety percent of the water Saudi Arabia uses comes from underground reserves, virtually all of which were filled thousands of years ago and have negligible annual recharge today[26]. The Saudi government nonetheless encourages groundwater mining by subsidizing large-scale domestic production of several crops, because it places a higher priority on self-sufficiency in food production than on the sustainable use of water. In 1992, the government spent more than $2 billion in subsidies for the domestic production of four million tons of wheat, which could have been purchased on the world market for a fifth of that price[4].

Estimates of the lifespan for Saudi water reserves vary widely, with one estimate suggesting they could run out early in the next century[26]. The country's population of 17.5 million is projected to climb past 40 million by 2025, by which time groundwater mining may no longer be a realistic option. Food self-sufficiency may be a priority in the short-term, but it cannot be sustained indefinitely with nonrenewable water.

Another example of unsustainable use of groundwater supplies occurs in the United States. The High Plains aquifer, actually a network of aquifers in the midwestern United States, covers 174,000 square miles (450,000 square kilometers) from South Dakota to Texas. The system is frequently called the Ogallala for the formation that dominates it. Water from this aquifer system helped transform the prairies of the plains into one of the country's most productive agricultural areas, and the aquifer network remains the basic water source for much of the grain belt from Texas to Minnesota. But signs of scarcity and contamination have been emerging in recent years.

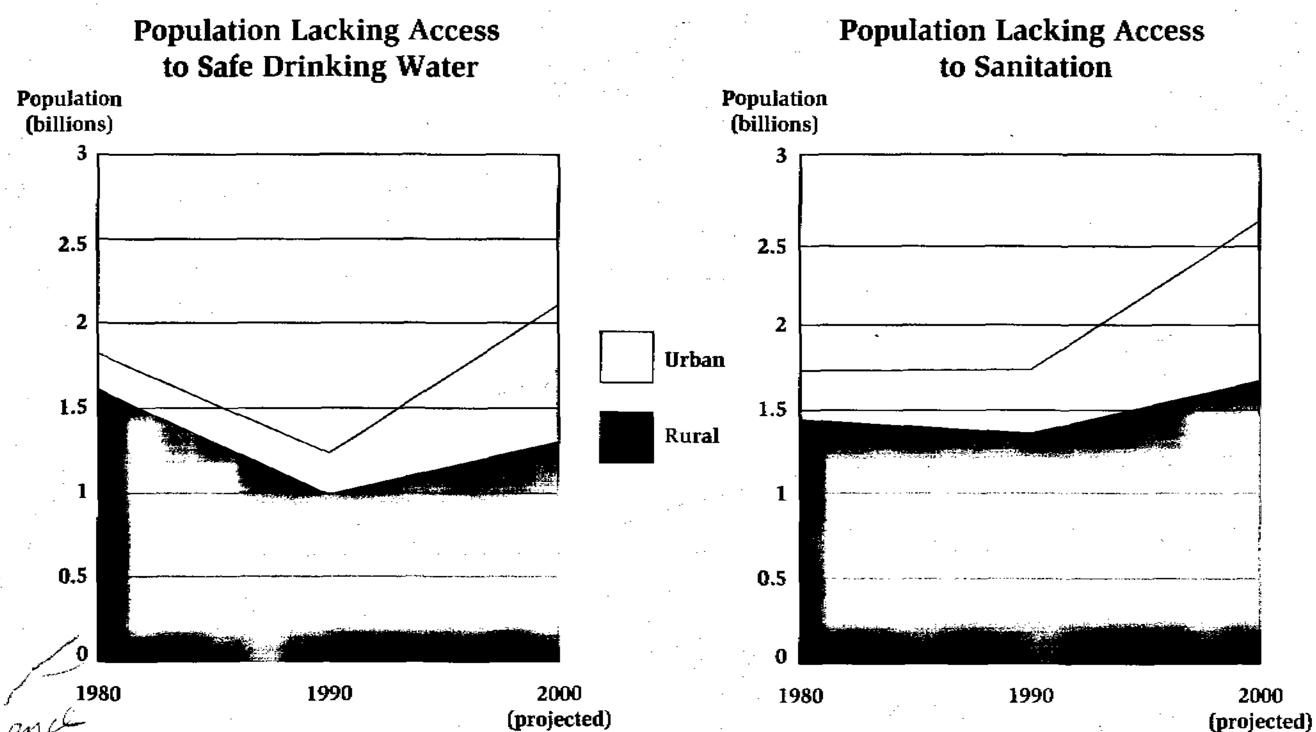
Situated in a semi-arid region with little rainfall and few perennial streams, the Ogallala recharges very slowly. As farmers use advanced irrigation technology to pump water out faster than it can be naturally replenished, some are now removing a gallon (roughly four liters) for every teacupful restored by the natural processes of aquifer recharge. As a result, water tables are falling, pumping costs are escalating, and irrigated lands are being pushed out of production.

Between the 1940s and 1980, the average water level in the aquifer dropped almost 10 feet (3 meters), with declines exceeding 100 feet (30 meters) in some parts of Texas. Between 1974 and 1989, falling water tables caused pumping costs to escalate to the point that irrigated areas in northwest Texas shrank from 6 million to 4 million acres (2.4 million to 1.6 million hectares). By 1990, estimates of depletion of the Texas portion of the aquifer reached 24 percent—a loss of 164 billion cubic meters, or the equivalent of almost six years of the entire state's water use[4].

While improved management practices have eased some of the pressures on the Ogallala, concern for its long-term future remains.

Figure 4

Access to Safe Drinking Water and Sanitation in Developing Countries, 1980 to 2000



difference in opinion with Safe Water 2000 (New York, UN, 1990)

While the number of people with access to safe and sufficient water and adequate sanitation increased between 1980 and 1990, population growth erased any substantial gain, especially in urban areas. Between 1990 and 2000 an additional 900 million people are projected to be born in regions without access to safe water and sanitation.

Source: Peter H. Gleick, ed., *Water in Crisis: A Guide to the World's Fresh Water Resources*, 1993.

use as drinking water. Treatment of contaminated water, and particularly groundwater, can be prohibitively expensive and time consuming.

Pollution and Disease

Deteriorating water quality is a particular threat in developing countries, where hundreds of millions of people lack access to clean drinking water and the vast majority of sewage is discharged into surface waters without wastewater treatment[1]. In many urban areas in poorer countries, people compete for access to polluted water to satisfy their drinking needs.

In 1980, 1.8 billion people lacked access to clean drinking water and 1.7 billion lacked access to adequate sanitation services. The United Nations declared the 1980s the Drinking Water Supply and Sanitation Decade, and the next 10 years saw 1.3 billion people supplied with new water sources and 750 million with sanitation. Yet at the end of the decade, 1.2 billion people still lacked safe water and 1.7 billion lacked sanitation services.

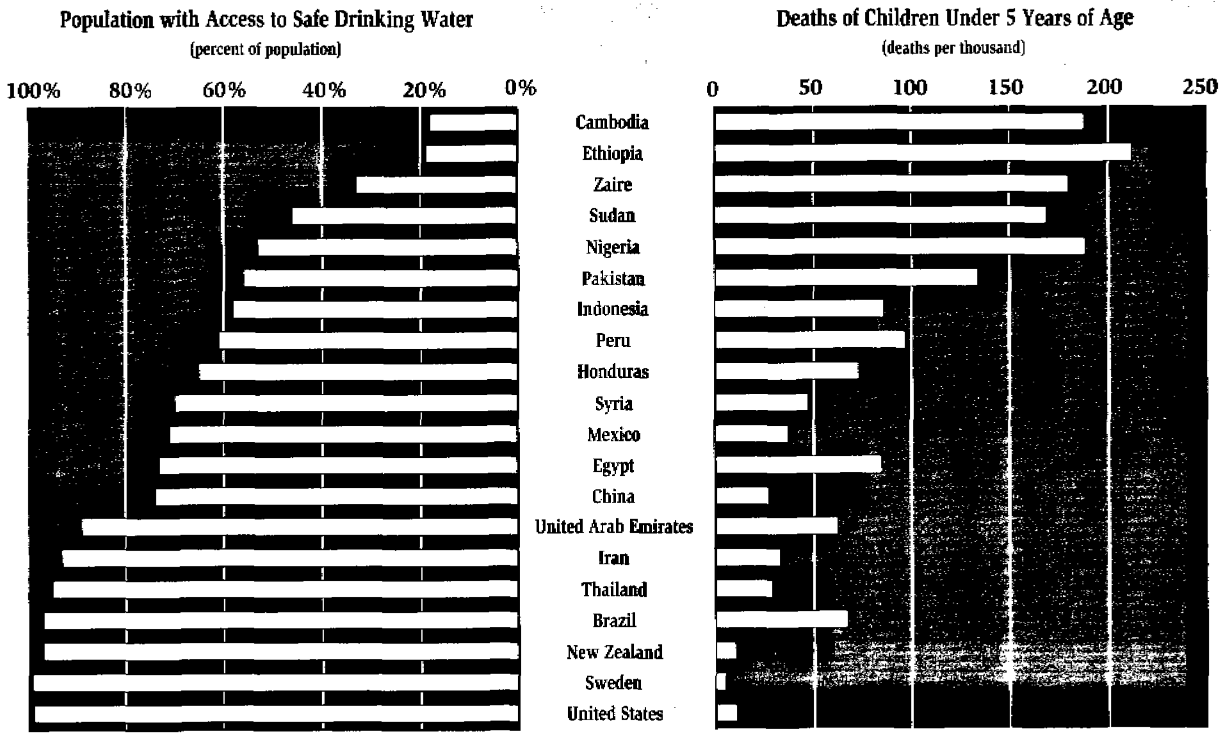
The UN estimated in 1990 that population growth alone would add nearly 900 million people to these categories in the coming decade, with investments in infrastructure unlikely to keep pace[11].

In many developing countries, river pollution from raw sewage reaches levels thousands of times higher than the recommended safe limits for drinking and bathing[1]. With no sewage disposal system, Bangkok alone discharges an estimated 10,000 metric tons of raw sewage and municipal wastes daily into nearby rivers and canals[3]. In India bathers, cremated corpses and millions of tons of sewage can all be found in the holy waters of the Ganges[27].

Drinking and bathing in polluted water supplies are among the most common routes for the spread of infectious disease, and nearly half the world's population suffers from water related diseases[1]. Most of those affected are poor, and almost all live in developing countries[28]. Such diseases are the single largest killers of infants in developing countries—diarrhea alone causes 4 million deaths a year[11]—and access to

Figure 5

Water Quality and Child Survival



Sources: United Nations Children's Fund, *The State of the World's Children 1993*; Worldwatch Institute, *Worldwatch Paper 64: Investing in Children*, June 1985.

...urban infrastructures can take years to develop, and today that development is failing to keep pace with population growth.

safe water correlates strongly with the survival of children under five years old.

With many water-short households forced to rely on contaminated water supplies, waterborne diseases like schistosomiasis and cholera are on the rise. An epidemic of cholera swept Latin America in 1991, causing thousands of deaths. An overwhelming majority of the hundreds of thousands of cases of cholera worldwide have been reported in disadvantaged communities lacking water and waste disposal facilities[29]. Lima, where the cholera epidemic is believed to have begun, is among the fastest growing cities in the region, with most of this growth occurring in just such communities. A top official of the Asian Development Bank in mid-1993 warned that without improved sanitation the megacities of Asia face the threat of cholera epidemics similar to Peru's.

Modern urbanization concentrates large numbers of human beings as never before in history, demanding dependable sources of water and adequate sanitation services on unprecedented scales. By the beginning of the next decade, more than half of the world's people will live in metropolitan areas, and these areas will be home to 90 percent of the absolute poor in Latin America and the Caribbean, 45 percent of those in Asia and 40 percent of those in Africa[30]. But urban infrastructures can take years to develop, and today that development is failing to keep pace with population growth.

The changes in land use patterns brought about by urbanization also affect renewable water supply, by altering and accelerating natural patterns of runoff, eroding soils and speeding evaporation. Urban runoff—collecting toxic compounds from sewage, vehicle exhaust and industrial pollution—severely degrades water quality.

Beyond the urban fringe, the expanding development of rural land is also cutting into the availability of renewable fresh water. Deforestation and the degradation of agricultural soil can accelerate or otherwise alter the water cycle, threatening the continuity of river and groundwater recharge. The dominant hazard is flooding, which can wash away topsoil and slowly choke rivers, dams and reservoirs with deposited sediment. Rapid population growth, which contributes to unsustainable farming practices and deforestation in countries like Nepal and India, has so reduced the water-absorbing capacity of the land in the Himalayan watershed that floods are devastating Bangladesh downstream on the Ganges and Brahmaputra rivers, with increasing frequency[21].

Urban Demand for Water: Mexico and China

In recent years unprecedented levels of migration and high urban birth rates have contributed to record population increases in many of the cities in Africa, Latin America and Asia. Many are now growing too fast to plan and develop the water and sanitation systems that are critical to human health. Urban population growth, coupled with increasing contamination of existing water supplies, threatens to make the provision of safe drinking water and sanitation in urban areas a critical issue for the next several decades.

Mexico City, whose population reached 15 million in 1990, is one of many cities where demand for water and sanitation services already exceeds supply. Mexico City relies on groundwater for more than 80 percent of its water supplies. But overpumping of the nearby Mexico Valley aquifer has been severe, resulting in shifting and subsiding land, falling water tables, and deteriorating water quality. With use of that aquifer restricted, city planners must look farther afield for new sources at a significantly higher expense. The city is currently pumping water from the Cutzamala River through a 180 kilometer (112 mile) pipeline that scales mountains hundreds of meters high.

Halfway around the world in China, more than 200 major cities already lack adequate water, and a fourth of them face acute shortages[4]. Beijing has been plagued by chronic water shortages since the 1970s, and the city finds itself searching for badly needed new water supplies from a source over 1,000 kilometers (621 miles) away. With water tables under the city dropping three to six feet each year, most of the region's water resources have already been tapped[31]. In Shanghai, water intakes have already been moved upstream about 40 kilometers at a cost of about $300 million, because excessive withdrawals at the mouths of streams has allowed the penetration of saltwater from the East China Sea[15]. And the costs of the city's water supply will increase even more dramatically when the need for adequate drainage and sanitation facilities is addressed. By the year 2000, China will need an estimated 2,000 additional wastewater treatment plants[11].

Throughout the world, urban areas lose staggering amounts of water through leaks and breaks in water supply systems, and much of this water could be saved through targeted efficiency and conservation efforts. More than stopgap programs are clearly needed, however. With 90 percent of future population growth expected to occur in urban areas, the demand for water for domestic and industrial use and waste treatment will soar worldwide.

Whole freshwater ecosystems are disappearing as rivers and coastlands are developed around the world.

Ecosystems, Climate and the Global Environment

Among the casualties of the expanding human use and abuse of water resources are freshwater ecosystems and the plant and animal species they sustain.

Although fresh water represents only a fraction of the earth's water, it supports an exceptional number of animal species. Most are feeling the impacts of increased human intervention in natural systems. Dams block the return of salmon to spawning areas, for example; toxic pollution and acid precipitation kill fish; toxic metals deform waterfowl; and leaching of fertilizers promotes the growth of algal blooms in surface waters. In China, the growth of algae stemming from human, agricultural and industrial wastes has reduced oxygen levels in rivers to the point that only 5 of 15 river stretches sampled recently near large cities could support fish[15]. The heavy metals expelled into water by industry accumulate in fish and shellfish, concentrating in those higher up in the food chain.

Whole freshwater ecosystems are disappearing as rivers and coastlands are developed around the world. In the United States, Florida Bay, most of which lies within the boundaries of Everglades National Park, has undergone dramatic changes since a rapid influx of people into South Florida began in the 1940s. The bay has been transformed from a healthy estuary and sports fishing paradise to a nearly lifeless, hyper-saline lagoon[32].

Looming over questions of future water supply and use is the likelihood that human beings are inadvertently changing climate worldwide through the heat-trapping greenhouse gases their activities increasingly release into the air. The impact of the predicted global warming on renewable water supplies and demand for water is unknown, but it is likely to change rainfall, storm patterns and sea levels. Preliminary studies have suggested as much as a 25 percent decrease in the runoff of the Nile and similar losses in the rivers of the southwestern United States[1,22]. Moreover, some climatologists predict global warming will intensify the extremes of the water cycle, exacerbating drought and bringing more rainfall in deluges that ultimately are lost in floods. The midwestern United States' swing from searing drought in 1988 to record-breaking flooding five years later illustrates how damaging climate extremes can be. The risk of substantial changes in climate over the coming decades, coupled with the other threats posed by growing human pressures, underlines the uncertainty about future water supply—and the need for cautious, flexible and innovative planning.

Water and Development

Although the lack of abundant fresh water clearly limits the ability of countries to maintain public health and develop industry and agriculture, the exact relation of water use to economic development is unclear. Nations with money or sources of energy can often buy their way out of water shortages in the short run, investing in costly technologies powered by fossil fuels. But the poorest developing nations, many of them mired in debt and poverty, lack that option. Given the high population growth rates of many of the most water-scarce developing nations, they are likely to suffer either limits on their use of water, hindering economic progress, or reliance on contaminated and untreated water, fostering disease.

Although the exact correlation between gross national product and rates of water use is uncertain, it appears that countries' greatest needs for water may come in the early phases of development. As development proceeds, people find ways to economize on water by conserving and recycling it. A 1985 UNESCO study found that water withdrawals rose with GNP to a certain point, and then fell as GNP continued to rise[33]. Water use in the United States in 1990 was below its level in 1975, for example, although it is now increasing again[12]. It is clear, however, that countries now moving toward development and industrialization will markedly increase their demand for water.

Water and Conflict

Resource scarcity can exacerbate preexisting tensions or invite new ones, and water is no exception. Although it was global concerns about oil supplies that helped internationalize the 1991 Gulf War, water resources were not spared in the conflict. Using every tactic at his limited disposal, Saddam Hussein ordered his troops to dismantle the desalination plants of Kuwait, and the oil spills that fouled the Persian Gulf also damaged desalination sites in Saudi Arabia—demonstrating both the importance and the vulnerability of these facilities. Tensions over water permeate every region of the world, ranging from clashes between urban and agricultural water users in the western United States to outright warfare in the Middle East.

With over 200 river and lake basins bordered by two or more countries and aquifers crossing international borders, the potential for increased regional tensions over shared resources as population pressures escalate is substantial, particularly in arid and semi-arid regions where water is already scarce[3]. At least 10 rivers flow through a half dozen or more countries. The Danube River leads the list, touching the territory of more than a dozen. Most Middle Eastern countries share aquifers[34]. Where water constitutes an international border, as it does on all five major continents, changes of land due to erosion and sedimentation can also cause disputes, as occurred in the 1966 border war between China and the Soviet Union[35].

Few countries voluntarily consider the impact of their water usage on neighboring countries. To date, countries have forged more than 300 treaties to deal with specific international water issues, and 2,000 treaties have water provisions[11]. Yet coordinated management of international river basins is still the exception rather than the rule.

Resource scarcity can exacerbate preexisting tensions or invite new ones, and water is no exception.

Within a decade water could overshadow oil as a scarce and precious commodity at the center of conflict and peacemaking.

Fresh water scarcity has been a particular source of conflict in the Middle East in recent decades, with relations between most of the countries in the Jordan River basin marked by military conflict over its waters. During the 1967 war, the Israelis attacked a joint Jordanian-Syrian dam site on the Yarmuk River, a tributary of the Jordan. Since the war, Israel has controlled most of the Jordan River's headwaters and basin, leaving insufficient water for Jordan's growing needs[36].

Although Jordan's per capita water consumption of 83 liters per day is the lowest among Middle Eastern countries, it already consumes 15 percent more water than it can harvest from its low rainfall and from the Yarmuk[36]. With a population of 4 million, which recently absorbed hundreds of thousands of migrant workers and refugees from the Persian Gulf War, Jordan's water shortage is now chronic. In 1975, meanwhile, Syria and Iraq came close to war after Syria and Turkey drew down the level of the Euphrates River by filling reservoirs behind two new dams. "The next war in the Middle East will be fought over water, not politics," warned UN Secretary General Boutros Boutros-Ghali in 1985 when he was Egypt's minister of state for foreign affairs[34].

Tensions over control and use of water resources are mounting around the globe. After heavy flooding killed more than 2,000 people in South Asia in the summer of 1993, the government of Bangladesh renewed demands that India and Nepal build dams to control the Ganges and Brahmaputra rivers upstream from Bangladesh. In arid Central Asia, shared waters could quickly become the catalyst for conflicts between the newly independent nations of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. Unfortunately, international water law offers little guidance for resolving these conflicts. As the demands of growing populations approach the limits of renewable resources, water could provide the flash point for conflict in regions with longstanding ethnic and political rivalries. Indeed, some analysts have suggested that within a decade water could overshadow oil as a scarce and precious commodity at the center of conflict and peacemaking.

IV. Strategies

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.

—Agenda 21, endorsed by leaders of 178 nations at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro

At the Earth Summit the governments of the world agreed that water resources must be managed sustainably, with full recognition of their limits. Yet discussion of strategies to fulfill the pledge made in Rio has scarcely begun. Policymakers and planners can no longer direct engineers simply to "find more water" and must shift to prudent management of the renewable water resources that exist within national borders. Long-term solutions will also require them to confront the realities of population growth.

Water is a regional rather than a global resource. A farmer in Jordan can take no comfort from the fact that the Amazon River, which carries some 15 percent of global runoff, remains largely untapped. But water scarcity is becoming a global issue. Few countries are so well-endowed with water or so thinly settled with people that they are completely immune to water quantity and quality problems. As such problems increase in scale and intensity, countries cannot isolate themselves entirely from the problems of water deprivation in other parts of the world. Escalating scarcity demands a sense of urgency that is still largely missing as well as a combination of strategies at the international, national and local levels.

Because prospects for finding major new sources of water are relatively dim in most regions of the world, strategies for improved efficiencies and conservation of water use are an increasingly critical component of any country's water management plans. Water recycling, improved efficiencies in water use, and reallocation of water rights offer substantial potential for stretching water supplies. Japan and Singapore have been using reclaimed wastewater to flush toilets in commercial and residential buildings for years.

...the most effective long-term strategies for dealing with water scarcity include conservation and more efficient water use.

Some Kansas and Nebraska towns have set up a trade: the farmers provide the town with fresh water; the towns provide the farmers with treated waste-water with which to irrigate their crops. During California's recent six year drought, implementation of municipal restrictions on water use, changes in industrial processes and stricter standards for new construction yielded 20 percent reductions in state water use at little economic cost[37].

Perhaps the most hopeful aspect of humanity's use of water, ironically, is that it is now so wasteful that tremendous savings can be realized through more efficient water management. Only a small fraction of the water that covers a farm field ever enters the root of a cultivated plant. That simple fact suggests tremendous reductions could be made in the two thirds of all water use that is now devoted to agriculture. These savings alone could perhaps meet the domestic water needs of the world's current population[38]. Israeli farmers, whose drip-irrigation techniques achieve up to 95 percent efficiency, have more than doubled their food production in the last 20 years without increasing their use of water[34]. Even more dramatic increases are possible where improved irrigation techniques are coupled with careful selection of less water-intensive crops and use of terracing and contour farming.

Slowing down the expansion of land under irrigation could take considerable pressure off the world's renewable water supplies. The yearly volume of water used to irrigate the world's crops is 3,300 cubic kilometers, an impressive portion of the planet's 41,000 cubic kilometers of annual renewable fresh water[8]. Irrigation also degrades water by allowing it to dissolve salts and toxic selenium from the land, which are then concentrated on soil surfaces as the water evaporates in the sun. Much of the world's irrigated land–at least a fifth in the United States, for example–is supported by water extracted from aquifers and lakes thousands of times faster than it can be recharged, and thus literally stolen from the future.

Although the potential for increased efficiency in irrigation is massive, the need for increased agricultural production is also urgent. Public and private investment in agriculture in the developing world is failing to keep up with population growth, and the global expansion of food production is slowing[39]. The world's growing population desperately needs more water, but it also needs more food, and these two needs are colliding.

Combining Conservation and Population Strategies

Water experts increasingly agree that the most effective long-term strategies for dealing with water scarcity include conservation and more efficient water use. Water shortages are already forcing many people to use and re-use water more efficiently. And the efficiency of water use can be further improved—in many cases dramatically. Over the longer term, however, human populations will need to come into balance with available renewable water supplies.

Realizing relatively easy gains through efficiency is essential today while populations grow rapidly. In many nations, conservation and efficiency efforts can buy time that could spell the difference between getting by and suffering a crisis in fresh water supply. A "Blue Revolution" in water supply and sanitation is needed as much today as the "Green Revolution" in food production was needed to feed the billions of people added to world population after 1950. But nations cannot afford to make the mistake some made in the Green Revolution, convincing themselves gains in food production would continue indefinitely and that no efforts to slow population growth were needed. Just as gains in per-capita grain production now show signs of leveling off, new approaches to water supply and management will ultimately reach their own limits.

It is true that great civilizations evolved in conditions where water was anything but abundant. And human ingenuity will undoubtedly continue to produce and refine innovations in resource development and management. But until very recently, our numbers were so low that the merest fraction of the earth's renewable fresh water supplies sufficed to meet our needs. Today, with 5.5 billion people and well-drilling technologies capable of reaching water buried deep in the earth, human populations for the first time are capable of depleting and polluting fresh water supplies on a massive scale. Governments must act now to prepare for inevitable increases in population that will further strain their fresh water supplies. And they need to help create conditions that will encourage the stabilization of population while there is still time to bring human needs and natural resources into a sustainable balance.

Alternative Futures

More than any hydrologist or urban planner, it is women in the developing world—the drawers, carriers and household managers of water—who understand what water scarcity is and what its implications are for families and communities. What is needed is better opportunities for women to translate their knowledge and their energies into action and personal control—over natural resources such as water, and over their own lives. Real opportunities for women—in education, in economic and political life, and in family decisionmaking—could vastly improve the management of water and women's own well-being. Women also need the opportunity to make decisions about their own fertility and the capacity to put those decisions into effect. Efforts to improve the lives, health and status of women can be justified on their own merits, and together they would act powerfully to reduce fertility.

Over the last 30 years, a number of countries have demonstrated that rapid declines in birth

A "Blue Revolution" in water supply and sanitation is needed as much today as the "Green Revolution" in food production was needed... after 1950.

Availability of and access to clean water and sanitation are among the most important determinants of the health of individual human beings.

rates are possible through a combination of relatively inexpensive measures, especially widespread provision of high quality, voluntary family planning services.

Because record numbers of people will be moving into their childbearing years over the next two decades, the impact of lower birthrates will not be fully felt until well into the next century. But the momentum of population growth is such that policies and programs contributing to eventual population stabilization must be initiated *today*—at the same time that improved water management technologies, programs and projects are being developed to meet higher future levels of water demand.

Access to family planning services already has had a dramatic impact. Fertility has declined much faster in parts of Asia and Latin America than it ever did in Europe and North America in earlier decades. It took the United States, for example, nearly six decades to move from an average family size of 6.5 to 3.5 children. In Colombia the change occurred in just 15 years, while Thailand reached replacement fertility of two children per couple after only 17 years. If the number of births per woman averaged five today, as it did in the early 1960s, world population would be growing today by 160 million people each year. Instead, with fertility averaging 3.3 births per women, the annual population increment is 90 million.

World population is lower today by an estimated 400 million than it would have been if organized family planning programs had never been initiated[40]. In many parts of the world, water problems are today more manageable than they otherwise would be because demand for and access to family planning began rising so dramatically 30 years ago. Economic and social development, especially improved opportunities for women, also have made a significant contribution to reductions in population growth. Policies that extend and accelerate these trends today could have an even more dramatic impact on fresh water availability in the next century and beyond.

The importance of large differences in alternative population scenarios to the mid-21st century can be seen in their effect on per capita renewable fresh water availability in India and China. These are the only two countries for which projections to 2150 are currently available, but together they account for more than a third of the world's population. Only the beginnings of a divergence in water availability are evident in each country in 2025, but between 2050 and 2075 the per capita water availability paths diverge dramatically. The path of greatest fertility decline leads to water abundance and increasing per capita supply, while the path of least decline pushes the countries into scarcity by 2050, in the case of India, or 2125, in the case of China.

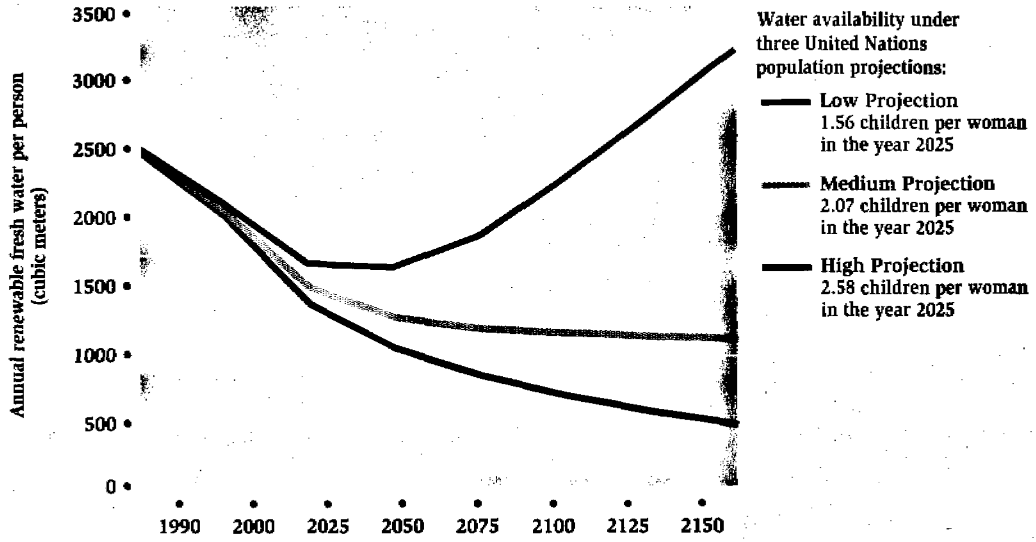
A nation's per capita renewable water supply is not just an accounting measure of an important natural resource. Availability of and access to clean water and

Figure 6

Annual Renewable Fresh Water Available Per Person Under Three Long-range United Nations Population Projections: India and China

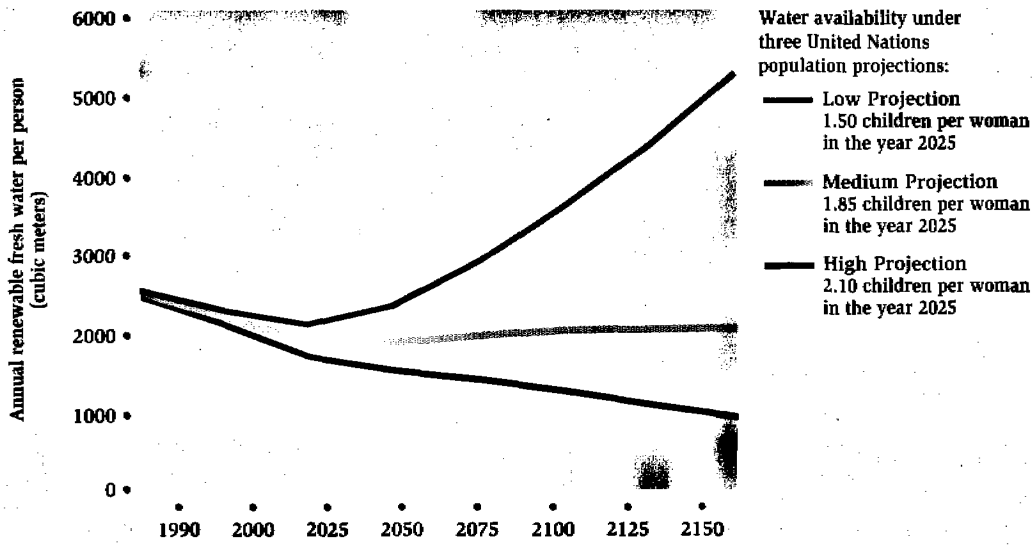
According to long-range United Nations population projections, India's population could, under the low-growth projection, stabilize and eventually shrink in size after 2025, which would actually increase per capita water availability. Under the medium and high projections, however, the country would move into conditions of water stress and water scarcity, respectively.

India



China, too, could see its population size peak and then gradually decrease under the low projection of population growth to 2150. Under the medium projection, China's population would stabilize shortly after 2025, with just enough water per person to avoid water stress. Under the high projection, China's population would continue to grow, pushing the nation into water stress in 2025 and water scarcity around 2140, based on per capita annual availability.

China



Without sufficient water, economic development becomes virtually impossible and conflict over scarce resources virtually inevitable.

sanitation are among the most important determinants of the health of individual human beings. Without sufficient water, economic development becomes virtually impossible and conflict over scarce resources virtually inevitable. Long-term sustainability requires a shift from nonrenewable to renewable supplies of fresh water, a new sense of urgency about water conservation, and ultimately stabilization of population size.

Substantial worldwide experience has demonstrated that making high quality, voluntary family planning widely available to men and women of reproductive age can bring down fertility rates independently of other social and economic factors. Recent research also suggests how powerfully family planning programs work in concert with improved opportunities for women—especially secondary-school education for girls. Efforts in family planning and education may seem far from the concerns of hydrologists and engineers, but they may matter just as much—and over the long term even more—to the future of water availability around the world.

If sustainable development is not a mere platitude, if the nations of the world take seriously the Earth Summit's charge that natural resources must be used in ways that ensure their availability to future generations, then early stabilization of population size is vital to any strategy. We need to develop water supplies in ways that assure every human being abundant, renewable quantities of clean and healthful water for life, prosperity and well-being. And we need to stabilize our numbers at a level that respects not just the quantities of water we can produce today, but that the earth can provide forever.

Appendix 1:

Data Sources and Methodology

For population data this report relies principally on the national and world population estimates and projections of the Population Division of the United Nations, especially the division's projections of country-by-country population through 2025. Some global, regional and country data are taken from the division's long-range population projections through 2150.

The projections are neither forecasts nor predictions, but rather calculations of future changes in population size given specific assumptions about trends in fertility, mortality and migration. Plugging into mathematical formulas what UN demographers believe to be the plausible range of future demographic trends, the analysts calculate a high and low projection, with a middle projection occupying the growth trajectory roughly midway between. All these projections assume declining fertility. The UN population data are broadly consistent with those available from the World Bank and other organizations that conduct demographic analysis. This report also uses some population figures for 1993 from data published annually by the Population Reference Bureau in Washington, D.C.

The report relies on water data collected by experts from the United States, France and the former Soviet Union, which was gathered and assessed by the World Resources Institute in *World Resources 1992-93*. The data was modified and revised for this report, based on the latest and most reliable information as recently compiled by Dr. Peter H. Gleick of the Pacific Institute for Studies in Development, Environment, and Security in Oakland, Calif. Many of the data were drawn from Gleick's 1993 book *Water in Crisis*. All figures on water availability are based on measurements of stream flow within countries, with evaporation calculated based on local climate and subtracted from the total.

The thresholds of water stress and water scarcity used in this report were refined from the hydrological engineering field by Dr. Malin Falkenmark, a professor of international hydrology associated with the Swedish Natural Science Research Council and a pioneer in the field of population and renewable water supply. Falkenmark expresses the thresholds as the number of people per "flow unit" of water, a unit equal to one million cubic meters per year. She uses 600 or more persons per flow unit as an indicator of *water stress*, 1,000 or more persons per flow unit as an indicator of *water scarcity*, and 2,000 or more persons per flow unit as an indicator of *absolute scarcity*. As other commentators have done in the past, this report reverses the ratio of people per flow unit, expressing the figure as the amount of water available per capita. Reversing the first two equations yields fewer than 1,667 cubic meters per person as an indicator of water stress (approximated as 1,700 cubic meters or fewer in the text) and 1,000 or fewer cubic meters per person as an indicator of scarcity.

Information on renewable fresh water resources is less than uniform. Data on rainfall and river flow are not available in some regions of the world. Indeed there is as yet no international consensus on how to define and measure renewable fresh water resources. Some analysts define the term to include only water that originates within a country's borders as rain or groundwater. Others include river and groundwater flow from neighboring countries. While downstream countries cannot depend on waters that upstream neighbors could some day capture for use, the practical result of an "internal-origin" definition of renewable water is to make some countries appear far more water-poor than they really are. Egypt, for example, could claim only 30 cubic meters of renewable fresh water per person per year if inflow from the Nile River were not credited to the country—compared to 1,123 cubic meters per capita when Nile inflow is included. And if the waters of the Rhine were not included in tallying the Netherlands' supplies, the country's per capita availability would decrease eightfold, suggesting scarcity. Accordingly, this report combines internal renewable water resources and, where available, inflow from rivers.

Combining renewable internal and imported sources of water necessarily exaggerates the availability of water in multi-state river basins. Rivers that flow through many countries, such as the Danube and the Nile, carry water that may be counted several times. The water accounting method used here thus can suggest an abundance that only accords with reality to the extent upstream countries return the water they use to the river from which it is withdrawn.

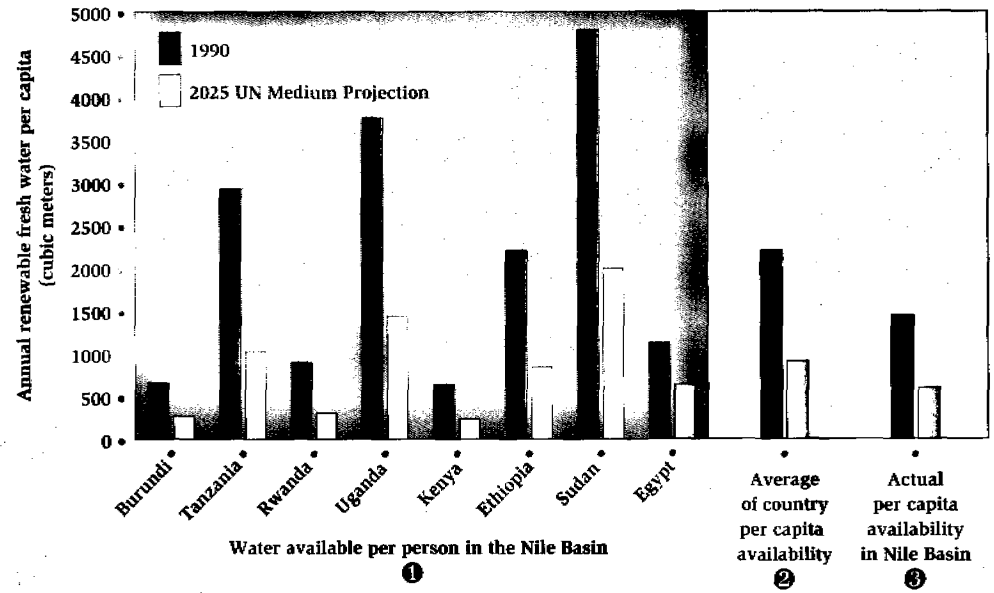
The potential discrepancies this accounting method may produce are illustrated in a country-by-country breakdown of per capita availability in eight of the nine countries of the Nile River basin. (Zaire is excluded because its territory is dominated by the Zaire River rather than the Nile River.) Under this accounting method, average per capita availability among the countries is 2,204 cubic meters in 1990, and 908 cubic meters in 2025 under the UN's medium population projection. But the true average for the eight nations as a basin, with Nile River water counted only once, is 1,449 cubic meters per person in 1990 and 597 cubic meters in 2025. Many of these per capita figures should accordingly be considered optimistic assessments or best-case scenarios that assume minimal development of major river resources by nations in multi-state basins. As populations continue to grow, that assumption will become less tenable.

A further complication is the uncertainty of estimates of groundwater reserves, including water that may cross international borders. Estimates of global groundwater vary from 4 million

Figure 7

Renewable Fresh Water Availability Per Person in the Countries of the Nile River Basin: Two Methodologies

1990 and 2025



❶ Attributing river inflow to a country's total renewable fresh water supply can paint an overly optimistic picture of the water actually available to countries that share a river basin with many neighbors, since the same water is counted multiple times. In the index of water scarcity presented in this report, half of the eight countries in the Nile River basin appear to have had relatively abundant per capita renewable water resources in 1990.

❷ On average, when the countries' apparent renewable fresh water supplies are added together, each person within the basin appears to have had 2,204 cubic meters of renewable fresh water annually in 1990, with a projected 908 cubic meters in 2025.

❸ In fact, however, the Nile basin had only 1,449 cubic meters of renewable water available per capita in 1990—below the threshold of water stress—and will have a projected 597 cubic meters in 2025.

Note: The 2025 figures are based on the United Nations medium projection. A small section of Zaire also lies within the Nile basin, but that country is excluded from this calculation.

Source: Peter H. Gleick, Pacific Institute for Studies in Development, Environment and Security to 60 million cubic kilometers, at either extreme a vast amount[41]. But most of this groundwater lies too deep to be accessible, and groundwater is only renewable to the extent it is withdrawn no faster than it recharges. Some water moves across international borders underground, but the extent and quality are difficult to quantify, and hydrologists do not believe this underground inflow is likely to make a major difference to renewable water supply in most countries.

Ideally, data on renewable fresh water supply would be specific to time and location within each country. Since accurate data are not available for many areas, the figures used in this report are based on best available estimates that take into account averages over time and area. The combination of the most recent data on internal renewable water resources and river inflow for 149 nations presents a reasonably fair, if optimistic, picture of water availability that allows for comparisons among nations, and within nations as populations change over time.

These measures of water supply, of course, say little about water quality. Population size and distribution can have a substantial impact on the cleanliness and security of fresh water supplies. A 1991 study by the New York Botanical Garden's Institute of Ecosystem Studies of nitrate pollution in 42 major rivers concluded that "human population density in a watershed is the best predictor of river nitrate concentrations and export." (Nitrate is a water pollutant originating in human sewage, agriculture and deforestation.) But reliable data on water quality is currently only available for specific areas in a select group of countries. A comprehensive study of population's impact on water quality would require improved data and complex analysis that remains to be done.

It is important to recognize that water can be *withdrawn* and *used* without being *consumed*. Water that irrigates a field can flow back into the river—with losses from evaporation and crop intake and some decline in quality—and drawn again downstream to irrigate another field. In contrast, water that is consumed, such as drinking water, cannot be recycled (without expensive treatment) for subsequent human use. The distinction can be important, because in some countries water withdrawals already exceed water supply, while water consumption does not. Where hydrologists speak of water use, they generally mean withdrawals.

Unfortunately, data on water consumption and nonconsumptive uses of water are also unavailable except as estimates in some industrialized countries. Data on annual water withdrawals, by contrast, are available for most countries. A considerable proportion of withdrawals are in fact consumptive withdrawals, and to the extent withdrawn water is returned to water sources it is all but inevitably degraded in quality. For these reasons, most discussions of water resources work with available data on water withdrawals.

Those who analyze water resources desperately need improved data on where and when water is available and how it is used. A call for better data was one of the major products of a 1992 international conference on water supply held in Dublin. Only in recent years have fairly complete data on renewable water resources on a country-by-country basis become available. Without such data, an examination of population's relationship to renewable water supply would scarcely be possible at all.

Appendix 2: Annual Renewable Fresh Water Available Per Person

149 Countries, Ranked by 1990 Fresh Water Availability

(Complete population and water data for each country, see Appendix 3.)

Country	1990 annual renewable fresh water available per person (cubic meters)
Water-scarce Countries	
Djibouti	23
Kuwait	75
Malta	85
Qatar	117
Bahrain	179
Barbados	195
Singapore	221
Saudi Arabia	306
United Arab Emirates	308
Jordan	327
Yemen	445
Israel	461
Tunisia	540
Cape Verde	551
Kenya	636
Burundi	655
Algeria	689
Rwanda	897
Malawi	939
Somalia	980
Water-stressed Countries	
Libya	1,017
Morocco	1,117
Egypt	1,123
Oman	1,266
Cyprus	1,282
South Africa	1,317
South Korea	1,452
Poland	1,467
Water-abundant Countries	
Belgium	1,696
Haiti	1,696
Lebanon	1,818
Peru	1,856
Comoros	1,878
Iran	2,025
Mauritius	2,047
Syria	2,087
United Kingdom	2,090
Ethiopia	2,207
Lesotho	2,290
Zimbabwe	2,312
China	2,427
India	2,464
Sri Lanka	2,498
Germany	2,516
Denmark	2,529
Dominican Republic	2,789
Nigeria	2,838
Spain	2,849
Tanzania	2,924
Afghanistan	3,020
North Korea	3,077
Burkina Faso	3,114
Italy	3,243
France	3,262
Thailand	3,274
Cuba	3,299
Madagascar	3,331
Togo	3,398

Country	1990 annual renewable fresh water available per person (cubic meters)
Jamaica	3,430
Ghana	3,529
Turkey	3,626
El Salvador	3,674
Uganda	3,759
Pakistan	3,962
Mozambique	4,085
Trinidad and Tobago	4,126
Mexico	4,226
Mauritania	4,387
Japan	4,428
Senegal	4,777
Sudan	4,792
Philippines	5,173
Benin	5,625
Vietnam	5,638
Niger	5,691
Czechoslovakia (both republics)	5,810
Greece	5,828
Netherlands	6,023
Iraq	6,029
Côte d'Ivoire	6,177
Namibia	6,254
Lithuania	6,433
Albania	6,462
Portugal	6,688
Mali	6,729
Chad	6,843
Switzerland	7,449
Nepal	8,686
Romania	8,963
Swaziland	9,268
United States	9,913
Hungary	10,897
Yugoslavia (former)	11,130
Estonia	11,371
Mongolia	11,416
Austria	11,670
Zambia	11,797
Guatemala	12,613
Latvia	12,654
Luxembourg	13,405
Indonesia	13,729
Ireland	14,273
Botswana	14,540
Angola	17,185
Cameroon	18,049
USSR (former)	19,428
Honduras	19,852
Australia	20,075
Bangladesh	20,733
Sweden	21,013
Finland	22,682
Bulgaria	22,801
Malaysia	25,488
Gambia	25,552
Myanmar	25,870
Zaire	27,253
Ecuador	29,771
Argentina	30,753
Costa Rica	31,301
Guinea-Bissau	32,158
Colombia	33,127
Chile	35,527
Sierra Leone	38,545
Guinea	39,270
Fiji	39,945
Uruguay	40,078
Bolivia	41,835
Brazil	46,631
Central African Republic	46,875
Nicaragua	47,606
Panama	59,553
Cambodia	59,741
Bhutan	61,728
Laos	64,255
Venezuela	68,164
Paraguay	73,416
Belize	84,656
Equatorial Guinea	85,227
Liberia	90,097
Norway	97,268
Canada	108,900
New Zealand	117,040
Solomon Islands	140,625
Gabon	141,501
Papua New Guinea	206,710
Guyana	302,764
Congo	359,803
Suriname	473,934
Iceland	666,667

Appendix 3:

Population, Annual Renewable Fresh Water Availability, 1955, 1990 and 2025

(Population figures are in thousands; per capita water availability figures are in cubic meters.)

		1955		1990		2025 UN Low Projection		2025 UN Medium Projection		2025 UN High Projection	
Country	Total annual renewable fresh water available by country (millions of cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)
Afghanistan	49,999	9,734	5,137	16,556	3,020	41,879	1,194	45,832	1,091	49,317	1,014
Albania	21,002	1,389	15,120	3,250	6,462	4,086	5,140	4,458	4,711	4,907	4,280
Algeria	17,197	9,715	1,770	24,960	689	47,914	359	51,830	332	55,659	309
Angola	157,999	4,437	35,609	9,194	17,185	24,265	6,511	26,619	5,936	28,721	5,501
Argentina	993,998	18,928	52,515	32,322	30,753	42,887	23,177	45,505	21,844	48,901	20,327
Australia	343,001	9,240	37,121	17,086	20,075	22,820	15,031	25,210	13,606	27,335	12,548
Austria	89,999	6,947	12,955	7,712	11,670	7,693	11,699	8,263	10,892	8,748	10,288
Bahrain	90	134	672	503	179	943	95	1,014	89	1,087	83
Bangladesh	2,357,010	45,486	51,818	113,684	20,733	210,714	11,186	223,252	10,558	236,042	9,986
Barbados	50	227	221	257	195	277	181	305	164	324	154
Belgium	16,904	8,868	1,906	9,967	1,696	9,178	1,841	9,908	1,706	10,367	1,630
Belize	16,000	78	205,128	189	84,656	290	55,172	290	55,172	342	46,784
Benin	25,999	2,111	12,316	4,622	5,625	11,337	2,293	12,354	2,105	13,245	1,963
Bhutan	94,999	789	120,405	1,539	61,728	3,154	30,120	3,395	27,982	3,593	26,440
Bolivia	299,999	3,072	97,656	7,171	41,835	13,207	22,715	14,096	21,283	15,096	19,873
Botswana	18,001	433	41,572	1,238	14,540	2,688	6,696	2,853	6,309	3,020	5,960
Brazil	6,949,978	62,567	111,081	149,042	46,631	212,756	32,667	219,673	31,638	238,154	29,183
Bulgaria	205,004	7,499	27,337	8,991	22,801	8,209	24,973	8,802	23,290	9,436	21,725
Burkina Faso	28,004	4,012	6,980	8,993	3,114	20,853	1,343	22,633	1,237	24,154	1,159
Burundi	3,597	2,687	1,339	5,492	655	12,336	292	13,392	269	14,295	252
Cambodia	498,001	4,840	102,893	8,336	59,741	14,661	33,968	16,716	29,792	17,451	28,537
Cameroon	207,997	4,843	42,948	11,524	18,049	28,121	7,397	29,262	7,108	30,394	6,843
Canada	2,900,987	15,736	184,354	26,639	108,900	32,830	88,364	38,356	75,634	43,659	66,447
Cape Verde	200	169	1,184	363	551	720	278	774	258	893	224

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Central African Republic	141,000	1,414	99,717	3,008	46,875	6,459	21,830	7,046	20,011	7,551	18,673
Chad	37,999	2,838	13,389	5,553	6,843	11,851	3,206	12,907	2,944	13,817	2,750
Chile	467,997	6,776	69,067	13,173	35,527	19,305	24,242	19,774	23,667	20,595	22,724
China	2,799,472	609,005	4,597	1,153,470	2,427	1,417,065	1,976	1,539,758	1,818	1,642,230	1,705
Colombia	1,070,002	13,759	77,767	32,300	33,127	47,532	22,511	49,359	21,678	51,295	20,860
Comoros	1,020	194	5,256	543	1,878	1,493	683	1,646	620	1,783	572
Congo	802,001	889	902,138	2,229	359,803	5,295	151,464	5,757	139,309	6,153	130,343
Costa Rica	94,999	1,025	92,681	3,035	31,301	5,400	17,593	5,608	16,940	5,829	16,298
Côte d'Ivoire	74,000	3,221	22,974	11,980	6,177	34,693	2,133	37,942	1,950	40,795	1,814
Cuba	34,996	6,417	5,454	10,608	3,299	11,896	2,942	12,993	2,694	13,363	2,619
Cyprus	900	530	1,698	702	1,282	839	1,073	904	996	977	921
Czechoslovakia (both republics)	90,996	13,093	6,950	15,662	5,810	16,481	5,522	17,919	5,078	18,972	4,797
Denmark	12,999	4,439	2,928	5,140	2,529	4,816	2,699	5,140	2,529	5,424	2,397
Djibouti	10	69	147	440	23	1,065	9	1,159	9	1,240	8
Dominican Republic	19,997	2,737	7,306	7,170	2,789	10,845	1,844	11,447	1,747	12,615	1,585
Ecuador	313,995	3,806	82,500	10,547	29,771	17,173	18,285	18,643	16,843	20,973	14,972
Egypt	58,874	22,990	2,561	52,426	1,123	86,483	681	93,536	630	100,797	584
El Salvador	19,002	2,214	8,583	5,172	3,674	8,969	2,118	9,735	1,952	10,697	1,776
Equatorial Guinea	30,000	238	126,050	352	85,227	732	40,984	798	37,594	854	35,129
Estonia	18,000	1,160	15,517	1,583	11,371	1,557	11,561	1,666	10,804	1,769	10,175
Ethiopia	109,977	21,680	5,073	49,831	2,207	119,618	920	130,674	842	140,381	784
Fiji	29,000	336	86,310	726	39,945	881	32,917	974	29,774	1,067	27,179
Finland	113,002	4,235	26,683	4,982	22,682	4,788	23,601	5,173	21,844	5,482	20,613
France	185,014	43,428	4,260	56,718	3,262	57,394	3,223	60,785	3,044	63,782	2,901
Gabon	164,000	477	343,815	1,159	141,501	2,541	64,542	2,869	57,163	3,203	51,202
Gambia	22,000	313	70,288	861	25,552	1,799	12,229	1,875	11,733	1,951	11,276
Germany	199,969	70,326	2,843	79,479	2,516	75,520	2,648	83,877	2,384	93,587	2,137
Ghana	53,006	5,759	9,204	15,020	3,529	36,575	1,449	37,988	1,395	41,123	1,289
Greece	58,997	7,966	7,406	10,123	5,828	9,514	6,201	10,103	5,840	10,679	5,525
Guatemala	116,002	3,431	33,810	9,197	12,613	19,435	5,969	21,668	5,354	24,004	4,833

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Guinea	225,999	2,826	79,971	5,755	39,270	13,726	16,465	15,088	14,979	16,204	13,947
Guinea-Bissau	31,000	522	59,388	964	32,158	1,815	17,080	1,978	15,672	2,107	14,713
Guyana	241,000	486	495,885	796	302,764	1,009	238,850	1,141	211,218	1,280	188,281
Haiti	11,000	3,508	3,136	6,486	1,696	11,208	981	13,128	838	14,463	761
Honduras	102,000	1,640	62,195	5,138	19,852	10,160	10,039	11,510	8,862	14,265	7,150
Hungary	114,996	9,825	11,704	10,553	10,897	9,663	11,901	10,396	11,062	11,094	10,366
Iceland	170,000	158	1,075,950	255	666,667	309	550,162	344	494,186	363	468,320
India	2,085,015	395,096	5,277	846,191	2,464	1,290,364	1,616	1,393,871	1,496	1,498,803	1,391
Indonesia	2,530,021	86,552	29,231	184,283	13,729	249,910	10,124	283,318	8,930	314,891	8,035
Iran	117,991	19,021	6,203	58,267	2,025	137,166	860	144,625	816	152,072	776
Iraq	109,004	5,911	18,441	18,080	6,029	44,166	2,468	46,260	2,356	49,050	2,222
Ireland	49,998	2,921	17,117	3,503	14,273	3,237	15,446	3,583	13,955	3,784	13,214
Israel	2,148	1,748	1,229	4,660	461	7,318	294	8,146	264	9,058	237
Italy	187,001	48,633	3,845	57,663	3,243	51,982	3,597	56,237	3,325	59,580	3,139
Jamaica	8,301	1,542	5,383	2,420	3,430	3,063	2,710	3,509	2,365	3,994	2,078
Japan	547,022	89,815	6,091	123,537	4,428	120,121	4,554	127,034	4,306	134,499	4,067
Jordan	1,311	1,447	906	4,009	327	10,299	127	10,807	121	11,342	115
Kenya	15,000	7,189	2,087	23,585	636	60,830	247	63,826	235	66,870	224
Kuwait	161	199	808	2,143	75	2,596	62	2,789	57	3,771	42
Laos	270,000	1,944	138,889	4,202	64,255	8,429	32,032	9,411	28,690	10,315	26,175
Latvia	34,001	2,015	16,874	2,687	12,654	2,568	13,240	2,753	12,350	2,918	11,652
Lebanon	4,981	1,613	3,088	2,740	1,818	4,028	1,236	4,476	1,113	4,936	1,009
Lesotho	4,001	794	5,039	1,747	2,290	3,617	1,106	3,783	1,057	3,953	1,012
Liberia	232,000	914	253,829	2,575	90,097	6,598	35,162	7,234	32,071	7,772	29,851
Libya	4,622	1,126	4,105	4,545	1,017	12,257	377	12,873	359	14,036	329
Lithuania	24,002	2,629	9,130	3,731	6,433	3,849	6,235	4,135	5,804	4,405	5,448
Luxembourg	5,000	305	16,394	373	13,405	401	12,469	428	11,682	454	11,013
Madagascar	40,005	4,720	8,476	12,010	3,331	31,117	1,285	33,746	1,185	36,005	1,111
Malawi	8,997	3,169	2,839	9,582	939	22,588	398	24,923	361	27,025	333
Malaysia	456,006	7,000	65,144	17,891	25,488	28,525	15,986	31,274	14,581	34,101	13,372
Mali	62,001	3,911	15,853	9,214	6,729	22,413	2,766	24,580	2,522	26,384	2,350
Malta	30	314	96	354	85	392	77	432	69	453	66
Mauritania	8,879	901	9,855	2,024	4,387	4,597	1,932	4,993	1,778	5,340	1,663

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Mauritius	2,201	571	3,854	1,075	2,047	1,287	1,709	1,397	1,575	1,515	1,452
Mexico	357,038	31,330	11,396	84,486	4,226	129,029	2,767	137,483	2,597	155,180	2,301
Mongolia	25,001	850	29,413	2,190	11,416	4,341	5,759	4,584	5,454	4,829	5,177
Morocco	27,993	10,132	2,763	25,061	1,117	43,865	638	47,477	590	50,977	549
Mozambique	58,007	6,744	8,601	14,200	4,085	33,510	1,731	36,290	1,598	38,693	1,499
Myanmar	1,082,013	19,561	55,315	41,825	25,870	70,636	15,318	75,604	14,311	80,531	13,436
Namibia	9,000	566	15,900	1,439	6,254	3,409	2,640	3,751	2,399	4,054	2,220
Nepal	169,994	8,675	19,596	19,571	8,686	37,878	4,488	40,055	4,244	42,273	4,021
Netherlands	90,002	10,751	8,371	14,943	6,023	16,172	5,565	17,673	5,093	18,659	4,823
New Zealand	397,000	2,136	185,861	3,392	117,040	4,019	98,781	4,279	92,779	4,502	88,183
Nicaragua	175,000	1,287	135,975	3,676	47,606	8,199	21,344	9,079	19,275	10,809	16,190
Niger	43,997	2,689	16,362	7,731	5,691	19,363	2,272	21,287	2,067	22,944	1,918
Nigeria	308,042	37,094	8,304	108,542	2,838	274,613	1,122	285,823	1,078	297,019	1,037
North Korea	66,989	9,070	7,386	21,771	3,077	29,531	2,269	33,339	2,010	36,472	1,837
Norway	413,000	3,427	120,514	4,246	97,268	4,528	91,210	4,916	84,011	5,188	79,607
Oman	1,929	455	4,240	1,524	1,266	4,551	424	4,705	410	4,869	396
Pakistan	467,999	44,194	10,590	118,122	3,962	246,744	1,897	259,562	1,803	272,560	1,717
Panama	143,999	1,011	142,432	2,418	59,553	3,633	39,637	3,862	37,286	4,185	34,409
Papua New Guinea	801,001	1,744	459,290	3,875	206,710	7,366	108,743	7,770	103,089	8,167	98,078
Paraguay	314,000	1,552	202,320	4,277	73,416	8,063	38,943	9,182	34,197	10,275	30,560
Peru	39,997	8,672	4,612	21,550	1,856	34,150	1,171	37,350	1,071	40,687	983
Philippines	322,987	23,913	13,507	62,437	5,173	96,932	3,332	105,147	3,072	113,278	2,851
Poland	56,010	27,281	2,053	38,180	1,467	39,796	1,407	43,788	1,279	47,449	1,180
Portugal	65,997	8,610	7,665	9,868	6,688	9,429	7,000	10,125	6,519	10,793	6,115
Qatar	50	35	1,427	427	117	689	73	731	68	774	65
Romania	208,004	17,486	11,895	23,207	8,963	23,433	8,876	26,270	7,918	28,297	7,350
Rwanda	6,303	2,391	2,636	7,027	897	18,844	334	20,595	306	22,156	284
Saudi Arabia	4,550	3,593	1,266	14,870	306	38,844	117	40,426	113	42,082	108
Senegal	35,001	2,811	12,451	7,327	4,777	16,386	2,136	17,078	2,049	17,715	1,976
Sierra Leone	160,000	2,081	76,886	4,151	38,545	8,944	17,889	9,800	16,327	10,484	15,261
Singapore	599	1,306	459	2,710	221	3,070	195	3,309	181	3,485	172
Solomon Islands	45,000	102	441,176	320	140,625	805	55,901	844	53,318	883	50,963

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Somalia	8,503	3,401	2,500	8,677	980	21,379	398	23,401	363	25,239	337
South Africa	49,992	15,385	3,249	37,959	1,317	68,927	725	73,211	683	77,590	644
South Korea	62,983	21,422	2,940	43,377	1,452	47,053	1,339	50,289	1,253	52,679	1,196
Spain	110,994	29,199	3,801	38,959	2,849	37,359	2,971	40,613	2,733	43,037	2,579
Sri Lanka	43,008	8,723	4,930	17,217	2,498	22,031	1,952	24,738	1,738	27,589	1,559
Sudan	120,773	10,150	11,899	25,203	4,792	58,584	2,062	60,602	1,993	65,402	1,847
Suriname	200,000	250	800,001	422	473,934	591	338,409	668	299,401	749	267,023
Swaziland	6,960	291	23,918	751	9,268	1,661	4,190	1,739	4,002	1,817	3,830
Sweden	179,997	7,262	24,786	8,566	21,013	8,848	20,344	9,529	18,890	9,967	18,060
Switzerland	49,998	4,980	10,040	6,712	7,449	7,233	6,913	7,702	6,492	8,182	6,111
Syria	25,785	3,967	6,500	12,355	2,087	34,072	757	35,250	732	37,638	685
Tanzania	76,004	8,915	8,525	25,993	2,924	68,002	1,118	74,172	1,025	79,540	955
Thailand	179,012	22,762	7,865	54,677	3,274	65,525	2,732	72,264	2,477	77,039	2,323
Togo	11,998	1,414	8,485	3,531	3,398	8,522	1,408	9,377	1,280	10,063	1,192
Trinidad and Tobago	5,100	721	7,073	1,236	4,126	1,592	3,204	1,779	2,867	1,972	2,586
Tunisia	4,351	3,860	1,127	8,057	540	11,934	365	13,425	324	15,019	290
Turkey	203,023	23,859	8,509	55,991	3,626	84,537	2,401	92,881	2,186	101,393	2,002
Uganda	66,008	5,556	11,880	17,560	3,759	41,677	1,584	45,933	1,437	49,736	1,327
United Arab Emirates	489	79	6,195	1,589	308	2,656	184	2,792	176	2,994	164
United Kingdom	119,989	51,199	2,344	57,411	2,090	57,013	2,105	60,251	1,992	63,231	1,898
United States	2,478,002	165,932	14,934	249,975	9,913	301,716	8,213	322,007	7,695	345,605	7,170
Uruguay	124,001	2,372	52,277	3,094	40,078	3,599	34,454	3,691	33,595	3,776	32,839
USSR (former)	5,465,950	190,356	28,714	281,344	19,428	308,631	17,710	344,457	15,868	368,605	14,829
Venezuela	1,316,997	6,148	214,215	19,321	68,164	31,457	41,867	32,665	40,318	34,173	38,539
Vietnam	375,987	32,009	11,746	66,688	5,638	108,113	3,478	116,958	3,215	125,484	2,996
Yemen	5,199	4,734	1,098	11,684	445	33,104	157	34,237	152	35,397	147
Yugoslavia (former)	264,994	17,519	15,126	23,809	11,130	24,210	10,946	26,081	10,161	27,157	9,758
Zaire	1,019,017	13,604	74,906	37,391	27,253	95,323	10,690	104,530	9,748	112,627	9,048
Zambia	96,004	2,753	34,872	8,138	11,797	20,246	4,742	20,981	4,576	21,716	4,421
Zimbabwe	22,997	3,257	7,061	9,947	2,312	21,625	1,064	22,889	1,005	24,157	952

Endnotes

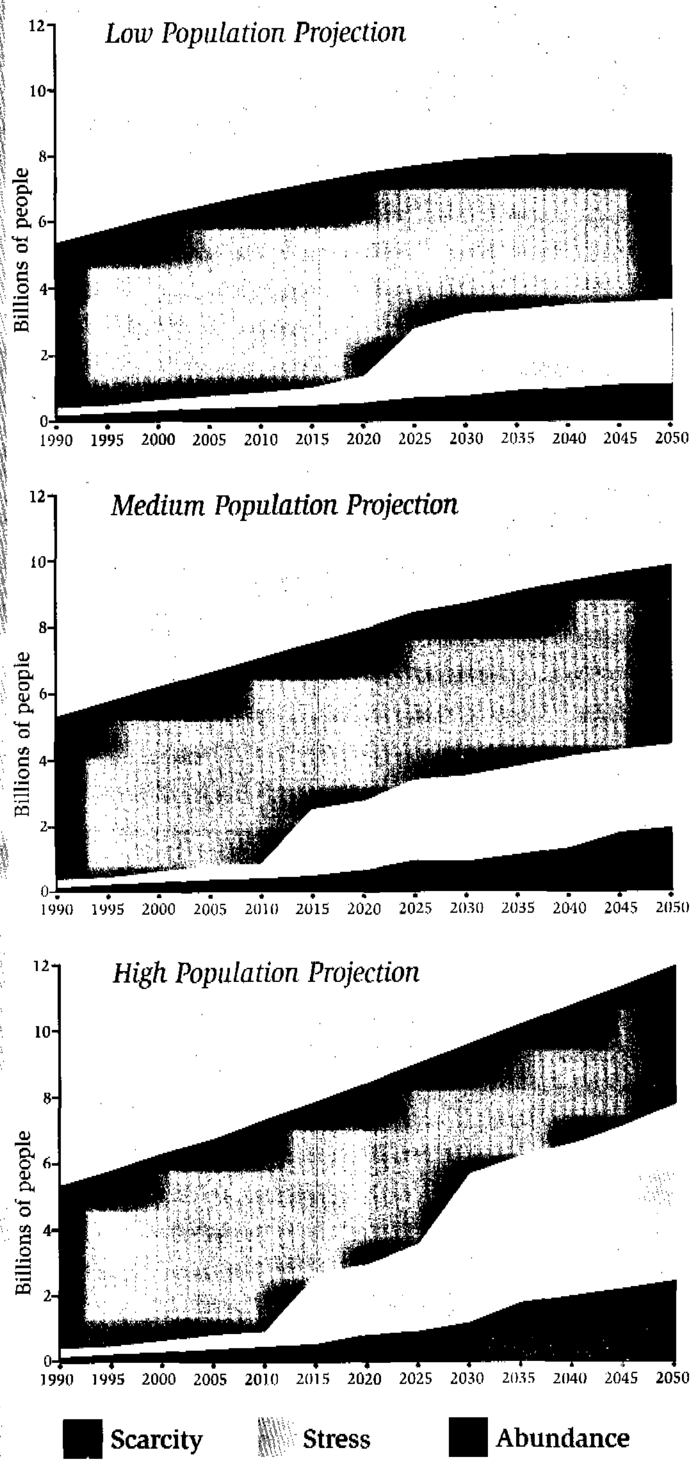
1. Robin Clarke. 1993. *Water: The International Crisis*. Cambridge: MIT Press.
2. Igor A. Shiklomanov. 1993. "World Fresh Water Resources," in Peter H. Gleick, ed., *Water in Crisis: A Guide to the World's Fresh Water Resources*. New York: Oxford University Press.
3. World Resources Institute. 1993. *World Resources 1992-93*. New York: Oxford University Press.
4. Sandra Postel. 1992. *Last Oasis: Facing Water Scarcity*. Worldwatch Institute. New York: W.W. Norton.
5. Malin Falkenmark and Carl Widstrand. 1992. "Population and Water Resources: A Delicate Balance." *Population Bulletin*. Population Reference Bureau.
6. Bruce Stokes. 1983. "Water Shortages: The Next Energy Crisis." *The Futurist*, 17(2).
7. World Resources Institute. 1988. *World Resources 1988-89*. New York: Oxford University Press.
8. Sandra Postel. 1990."Saving Water For Agriculture." *State of the World 1990*. Worldwatch Institute. New York: W.W. Norton.
9. Sandra Postel. 1985. "Managing Fresh Water Supplies." *State of the World 1985*. Worldwatch Institute. New York: W.W. Norton.
10. Nicholas Kristof. 1993. "China Breaks Ground for World's Largest Dam." *New York Times*, June 22, 1993.
11. Peter H. Gleick, ed. 1993. *Water in Crisis: A Guide to the World's Fresh Water Resources*. New York: Oxford University Press.
12. Personal communication with Dr. Peter H. Gleick, Pacific Institute.
13. G. Tyler Miller, Jr. 1991. *Environmental Science: Sustaining the Earth*. California: Wadsworth.
14. Arun Elhance. "Central Asia's Looming Water Wars." *The Christian Science Monitor*, January 11, 1993.
15. World Bank. 1992. *World Development Report 1992*. New York: Oxford University Press.
16. Miriam Lowi. 1992. "West Bank Water Resources and the Resolution of Conflict in the Middle East." *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.

17. Amy Henderson. "No Easy Solution to Jordan's Endemic Water Shortage." *The (Amman) Star*, July 15-21, 1993.
18. United Nations Food and Agriculture Organization, cited in Charles J. Hanley, "20 African Nations Risk Somalia's Fate." *The Washington Times*, March 1, 1993.
19. M.S. Reddy. 1992. Country Paper prepared by India for International Conference on Water and Environment, Dublin, January 1992.
20. Institute of Development Studies. 1990. "Priorities of Research in Water Management for Water-Scarce Regions." Jaipur: Jaipur Printers P. Ltd.
21. Radharkrishna Rao. 1989. "Water Scarcity Haunts World's Wettest Place." *Ambio*, 18(5).
22. Peter H. Gleick. 1992. "Water and Conflict." *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.
23. Senator Al Gore. 1992. *Earth in the Balance*. Boston: Houghton Mifflin Company.
24. U.S. Census Bureau. Official population projection, Demographic Research Unit.
25. Jae-Bok Young. "Asia's Rapid Urbanization Brings Economic Fruits." *The Christian Science Monitor*, April 20, 1993.
26. World Resources Institute. 1990. *World Resources 1990-91*. New York: Oxford University Press.
27. John Ward Anderson. "The Great Cleanup of the Holy Ganges." *The Washington Post*, September 25, 1992.
28. *Our Planet, Our Health: Report of the WHO Commission on Health and the Environment*. 1992. Geneva: World Health Organization.
29. Fred M. Reiff. 1992. "Cholera in Peru." *World Health*, July-August 1992. Geneva: The World Health Organization.
30. *The State of World Population 1993*. New York: United Nations Population Fund, 1993.
31. Sandra Postel. "Crisis on Tap: A World Without Water." *The Washington Post*, October 29, 1989.
32. Dave Lear. "Florida Bay: In Trouble." *Salt Water Sportsman*, June 1993.
33. J. Orloci, K. Szesztay and L. Varkonyi. 1985. "National Infrastructure in the Field of Water Resources." Paris: UNESCO.
34. Priit J.Vesilind. "Middle East Water—Critical Resource." *National Geographic*, May, 1993.
35. Malin Falkenmark. 1989. "Fresh Waters as a Factor in Strategic Policy and Action." *Population and Resources in a Changing World*. Stanford University: Morrison Institute.
36. "The Drying Game." *Utne Reader*, May/June 1993. (Reprinted from the German magazine *Der Spiegel*, May 25, 1992.)
37. Peter H. Gleick and Linda Nash. 1991."The Societal and Environmental Costs of the Continuing California Drought." Report to Congress.
38. Sandra Postel. 1989. "Water for Agriculture: Facing the Limits." Worldwatch Paper 93. Worldwatch Institute.
39. Lester Brown, Hal Kane, and Ed Ayres. 1993. *Vital Signs 1993: The Trends that are Shaping our Future*. Worldwatch Institute.
40. John Bongaarts, W. Parker Mauldin, and James F. Phillips. 1990. "The Demographic Impact of Family Planning Programs." *Studies in Family Planning*, 21:6.
41. World Resources Institute and the International Institute for Environment and Development. 1986. *World Resources 1986*. New York: Basic Books.

Sustaining Water: An Update

Revised Data for the Population Action International Report,
Sustaining Water: Population and the Future of Renewable Water Supplies

Population Experiencing Fresh Water Scarcity, 1990–2050



The figures presented in these pages, projecting annual per capita availability of renewable fresh water in 149 countries through 2050, update and extend those presented in Population Action International's 1993 report *Sustaining Water: Population and the Future of Renewable Water Supplies.* The update was made possible by the mid-1994 publication of new population estimates and projections for the period from 1990 to 2050 by the Population Division of the United Nations.[1] These revisions suggest most countries would experience slightly lower growth rates between 1990 and 2025 than the division had projected in 1992. And, for the first time, the UN extended projections for country populations in five-year increments from 2025 to 2050.

This update is designed to accompany *Sustaining Water.* Since the data are based on more recent population projections, they

Cont. on page 8

[1]United Nations Population Division. 1994. *World Population Prospects: The 1994 Revision.* New York: The United Nations.

Appendix 3 Update:

Population, Annual Renewable Fresh Water Availability, 1955, 1990, 2025 and 205

(Population figures are in thousands; per capita water availability figures are in cubic meters.)

Country	Total annual renewable fresh water available by country (cubic kilometers)	1955		1990		2025 UN Low Projection	
		Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)
Afghanistan	50.00	9,734	5,137	15,045	3,323	41,387	1,208
Albania	21.00	1,389	15,119	3,289	6,385	4,254	4,937
Algeria	17.20	9,715	1,770	24,935	690	40,347	426
Angola	158.00	4,437	35,610	9,194	17,185	24,265	6,511
Argentina	994.00	18,928	52,515	32,547	30,540	41,751	23,808
Australia	343.00	9,201	37,279	16,888	20,310	21,860	15,691
Austria	90.00	6,947	12,955	7,705	11,681	7,782	11,565
Bahrain	0.09	134	672	490	184	858	105
Bangladesh	2,357.00	45,486	51,818	108,118	21,800	181,036	13,020
Barbados	0.05	227	220	257	195	282	177
Belgium	16.90	8,868	1,906	9,951	1,698	9,642	1,753
Belize	16.00	80	200,000	189	84,656	350	45,714
Benin	26.00	2,111	12,316	4,633	5,612	11,240	2,313
Bhutan	95.00	789	120,406	1,544	61,528	2,889	32,883
Bolivia	300.00	3,006	99,800	6,573	45,641	11,930	25,147
Botswana	18.00	433	41,570	1,276	14,107	2,812	6,401
Brazil	6,950.00	62,567	111,081	148,477	46,809	206,086	33,724
Bulgaria	205.00	7,499	27,337	8,991	22,801	7,487	27,381
Burkina Faso	28.00	4,012	6,979	8,987	3,116	19,938	1,404
Burundi	3.60	2,687	1,340	5,503	654	12,388	291
Cambodia	498.00	4,840	102,893	8,841	56,328	17,815	27,954
Cameroon	208.00	4,843	42,949	11,526	18,046	28,035	7,419
Canada	2,901.00	15,736	184,354	27,791	104,386	32,596	88,999
Cape Verde	0.20	169	1,183	341	587	682	293
Central African Rep.	141.00	1,414	99,717	2,927	48,172	5,821	24,223
Chad	38.00	2,838	13,390	5,553	6,843	11,851	3,206
Chile	468.00	6,747	69,364	13,154	35,579	17,918	26,119
China	2,800.00	609,005	4,598	1,155,305	2,424	1,363,000	2,054
Colombia	1,070.00	13,759	77,767	32,300	33,127	46,703	22,911
Comoros	1.02	194	5,258	543	1,878	1,493	683
Congo	802.00	889	902,137	2,232	359,319	5,220	153,640
Costa Rica	95.00	1,025	92,683	3,035	31,301	5,331	17,820
Côte d'Ivoire	74.00	3,221	22,974	11,974	6,180	33,656	2,199
Cuba	35.00	6,417	5,454	10,598	3,303	11,381	3,075
Cyprus	0.90	530	1,698	702	1,282	848	1,061
Czechoslovakia (both republics)	91.00	13,100	6,947	15,562	5,848	15,005	6,065
Denmark	13.00	4,439	2,929	5,140	2,529	4,771	2,725
Djibouti	0.01	69	145	517	19	998	10
Dominican Republic	20.00	2,737	7,307	7,110	2,813	10,348	1,933
Ecuador	314.00	3,862	81,305	10,264	30,592	16,269	19,301
Egypt	58.90	24,692	2,385	56,312	1,046	87,080	676
El Salvador	19.00	2,214	8,582	5,172	3,674	8,271	2,297
Equatorial Guinea	30.00	238	126,050	352	85,227	732	40,984
Estonia	18.00	1,160	15,517	1,575	11,429	1,345	13,383

2025 UN Medium Projection		2025 UN High Projection		2050 UN Low Projection		2050 UN Medium Projection		2050 UN High Projection	
Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)	Population (thousands)	Per capita water availability (cubic meters)
45,262	1,105	48,796	1,025	48,990	1,021	59,960	834	71,686	697
4,668	4,499	5,071	4,141	4,212	4,986	5,265	3,989	6,456	3,253
45,475	378	50,362	342	43,168	398	55,674	309	69,542	247
26,619	5,936	28,721	5,501	33,630	4,698	41,182	3,837	49,183	3,212
46,133	21,546	50,673	19,616	41,909	23,718	53,121	18,712	66,327	14,986
24,667	13,905	27,233	12,595	19,764	17,355	26,060	13,162	31,983	10,724
8,262	10,893	8,490	10,601	6,419	14,021	7,811	11,522	8,609	10,454
922	98	985	91	864	104	1,046	86	1,251	72
196,128	12,018	211,589	11,140	195,189	12,075	238,512	9,882	288,574	8,168
309	162	331	151	254	197	325	154	388	129
10,407	1,624	10,774	1,569	8,028	2,105	10,068	1,679	11,307	1,495
386	41,451	422	37,915	396	40,404	499	32,064	618	25,890
12,252	2,122	13,138	1,979	15,370	1,692	18,649	1,394	22,049	1,179
3,136	30,293	3,345	28,401	3,573	26,588	4,329	21,945	5,093	18,653
13,131	22,847	13,927	21,541	13,568	22,111	16,967	17,681	19,955	15,034
2,980	6,040	3,150	5,714	3,383	5,321	3,996	4,505	4,673	3,852
230,250	30,185	253,393	27,428	205,082	33,889	264,349	26,291	330,689	21,017
7,768	26,390	8,302	24,693	6,090	33,662	7,091	28,910	8,625	23,768
21,654	1,293	23,118	1,211	27,492	1,018	33,365	839	39,364	711
13,490	267	14,448	249	15,716	229	19,065	189	22,501	160
19,686	25,297	21,323	23,355	21,083	23,621	26,272	18,956	31,768	15,676
29,173	7,130	30,301	6,864	37,371	5,566	43,100	4,826	49,196	4,228
38,266	75,811	42,338	68,520	28,345	102,346	39,870	72,761	48,932	59,286
735	272	785	255	795	252	959	209	1,134	176
6,360	22,170	6,815	20,690	7,261	19,419	8,907	15,830	10,580	13,327
12,907	2,944	13,817	2,750	15,174	2,504	18,450	2,060	21,835	1,740
19,775	23,666	21,433	21,835	17,685	26,463	22,450	20,846	27,547	16,989
1,526,106	1,835	1,666,589	1,680	1,199,919	2,333	1,605,991	1,743	1,979,157	1,415
49,359	21,678	54,202	19,741	47,738	22,414	56,402	18,971	70,639	15,147
1,646	620	1,783	572	2,008	508	2,484	411	2,988	341
5,677	141,272	6,067	132,191	7,249	110,636	8,774	91,406	10,330	77,638
5,608	16,940	6,075	15,638	5,905	16,088	6,902	13,764	8,398	11,312
36,817	2,010	39,590	1,869	50,206	1,474	61,441	1,204	73,169	1,011
12,658	2,765	13,811	2,534	9,743	3,592	12,907	2,712	15,944	2,195
927	971	1,011	890	800	1,125	1,006	895	1,255	717
16,636	5,470	17,868	5,093	12,976	7,013	17,217	5,285	20,824	4,370
5,081	2,559	5,385	2,414	3,935	3,304	4,819	2,698	5,683	2,288
1,055	9	1,110	9	1,202	8	1,403	7	1,616	6
11,164	1,791	12,370	1,617	10,870	1,840	13,167	1,519	16,624	1,203
17,792	17,648	19,632	15,994	17,142	18,318	21,189	14,819	26,498	11,850
97,301	605	107,876	546	91,456	644	117,398	502	147,994	398
9,735	1,952	11,206	1,696	9,069	2,095	12,485	1,522	16,530	1,149
798	37,594	854	35,129	941	31,881	1,144	26,224	1,355	22,140
1,422	12,658	1,536	11,719	1,134	15,873	1,368	13,158	1,682	10,702

Country	Total annual renewable fresh water available by country (cubic kilometers)	1955 Population (thousands)	1955 Per capita water availability (cubic meters)	1990 Population (thousands)	1990 Per capita water availability (cubic meters)	2025 UN Low Projection Population (thousands)	2025 UN Low Projection Per capita water availability (cubic meters)
Ethiopia	110.00	20,418	5,387	47,423	2,320	116,131	947
Fiji	29.00	336	86,310	726	39,945	1,065	27,230
Finland	113.00	4,235	26,682	4,986	22,663	4,869	23,208
France	185.00	43,428	4,260	56,718	3,262	57,334	3,227
Gabon	164.00	477	343,816	1,146	143,106	2,389	68,648
Gambia	22.00	313	70,288	923	23,835	1,977	11,128
Germany	200.00	70,326	2,844	79,365	2,520	74,112	2,699
Ghana	53.00	5,759	9,203	15,020	3,529	36,574	1,449
Greece	59.00	7,966	7,406	10,238	5,763	9,597	6,148
Guatemala	116.00	3,431	33,809	9,197	12,613	19,435	5,969
Guinea	226.00	2,826	79,972	5,755	39,270	13,726	16,465
Guinea-Bissau	31.00	522	59,387	964	32,158	1,815	17,080
Guyana	241.00	486	495,885	796	302,764	1,009	238,850
Haiti	11.00	3,508	3,136	6,486	1,696	12,455	883
Honduras	102.00	1,610	63,354	4,879	20,906	10,081	10,118
Hungary	115.00	9,825	11,705	10,365	11,095	8,727	13,177
Iceland	170.00	158	1,075,949	255	666,667	315	539,683
India	2,085.00	395,096	5,277	850,638	2,451	1,286,318	1,621
Indonesia	2,530.00	86,552	29,231	182,812	13,839	247,289	10,231
Iran	118.00	19,020	6,204	58,946	2,002	112,672	1,047
Iraq	109.00	5,911	18,440	18,078	6,029	40,631	2,683
Ireland	50.00	2,921	17,117	3,503	14,273	3,572	13,998
Israel	2.15	1,748	1,230	4,660	461	7,088	303
Italy	187.00	48,633	3,845	57,023	3,279	50,633	3,693
Jamaica	8.30	1,542	5,383	2,366	3,508	2,880	2,882
Japan	547.00	89,815	6,090	123,537	4,428	116,320	4,703
Jordan	1.31	1,447	905	4,259	308	11,496	114
Kenya	15.00	7,190	2,086	23,613	635	60,432	248
Kuwait	0.16	199	804	2,143	75	2,550	63
Laos	270.00	1,944	138,889	4,202	64,255	8,666	31,156
Latvia	34.00	2,015	16,873	2,671	12,729	2,201	15,448
Lebanon	4.98	1,613	3,087	2,555	1,949	3,991	1,248
Lesotho	4.00	794	5,038	1,792	2,232	3,982	1,005
Liberia	232.00	914	253,829	2,575	90,097	6,604	35,130
Libya	4.62	1,126	4,103	4,545	1,017	12,406	372
Lithuania	24.00	2,629	9,129	3,711	6,467	3,454	6,948
Luxembourg	5.00	305	16,393	381	13,123	405	12,346
Madagascar	40.00	4,747	8,426	12,571	3,182	32,840	1,218
Malawi	9.00	3,169	2,840	9,367	961	21,390	421
Malaysia	456.00	7,000	65,143	17,891	25,488	28,791	15,838
Mali	62.00	3,911	15,853	9,212	6,730	22,525	2,752
Malta	0.03	314	96	354	85	384	78
Mauritania	8.88	901	9,856	2,003	4,433	4,239	2,095
Mauritius	2.20	571	3,853	1,057	2,081	1,371	1,605
Mexico	357.00	31,755	11,242	84,511	4,224	122,500	2,914
Mongolia	25.00	850	29,412	2,177	11,484	3,476	7,192
Morocco	28.00	10,132	2,764	24,334	1,151	36,342	770
Mozambique	58.00	6,744	8,600	14,187	4,088	32,442	1,788
Myanmar	1,082.00	19,561	55,314	41,813	25,877	70,086	15,438
Namibia	9.00	562	16,014	1,349	6,672	2,921	3,081
Nepal	170.00	8,675	19,597	19,253	8,830	38,454	4,421
Netherlands	90.00	10,751	8,371	14,952	6,019	15,547	5,789
New Zealand	397.00	2,136	185,861	3,360	118,155	4,075	97,423

2025 UN Medium Projection Population (thousands)	2025 UN Medium Projection Per capita water availability (cubic meters)	2025 UN High Projection Population (thousands)	2025 UN High Projection Per capita water availability (cubic meters)	2050 UN Low Projection Population (thousands)	2050 UN Low Projection Per capita water availability (cubic meters)	2050 UN Medium Projection Population (thousands)	2050 UN Medium Projection Per capita water availability (cubic meters)	2050 UN High Projection Population (thousands)	2050 UN High Projection Per capita water availability (cubic meters)
126,886	867	136,338	807	159,403	690	194,203	566	230,547	477
1,161	24,978	1,277	22,709	1,109	26,150	1,377	21,060	1,720	16,860
5,407	20,899	5,628	20,078	4,066	27,791	5,373	21,031	6,103	18,515
61,247	3,021	64,530	2,867	49,339	3,750	60,475	3,059	70,134	2,638
2,697	60,808	3,011	54,467	3,087	53,126	3,975	41,258	5,000	32,800
2,102	10,466	2,229	9,870	2,344	9,386	2,762	7,965	3,238	6,794
76,442	2,616	80,968	2,470	56,388	3,547	64,244	3,113	76,505	2,614
37,988	1,395	40,676	1,303	47,944	1,105	54,868	966	64,946	816
9,868	5,979	10,407	5,669	7,598	7,765	8,591	6,868	10,111	5,835
21,668	5,354	24,004	4,833	23,359	4,966	29,353	3,952	36,888	3,145
15,088	14,979	16,204	13,947	18,348	12,317	22,607	9,997	26,905	8,400
1,978	15,672	2,107	14,713	2,262	13,705	2,766	11,208	3,262	9,503
1,141	211,218	1,280	188,281	969	248,710	1,279	188,428	1,657	145,444
13,128	838	13,904	791	16,198	679	18,564	593	21,779	505
10,656	9,572	11,413	8,937	11,867	8,595	13,921	7,327	16,588	6,149
9,397	12,238	10,159	11,320	7,309	15,734	9,223	12,469	11,339	10,142
337	504,451	360	472,222	298	570,470	365	465,753	431	394,432
1,392,086	1,498	1,501,507	1,389	1,345,936	1,549	1,639,863	1,271	1,979,932	1,053
275,598	9,180	304,068	8,321	247,252	10,232	318,802	7,936	401,549	6,301
123,549	955	137,481	858	132,473	891	163,108	723	203,161	581
42,656	2,555	45,440	2,399	49,906	2,184	57,691	1,889	67,581	1,613
3,882	12,880	4,152	12,042	3,266	15,309	4,103	12,186	4,859	10,290
7,808	275	8,718	247	7,167	300	8,927	241	11,211	192
52,324	3,574	55,441	3,373	38,266	4,887	43,630	4,286	51,872	3,605
3,301	2,514	3,758	2,209	2,810	2,954	3,755	2,210	4,938	1,681
121,594	4,499	130,287	4,198	93,990	5,820	110,015	4,972	133,409	4,100
12,039	109	12,581	104	14,564	90	16,874	78	19,364	68
63,360	237	66,308	226	79,146	190	92,194	163	106,392	141
2,805	57	3,070	52	2,714	59	3,384	47	4,168	38
9,688	27,870	10,565	25,556	10,281	26,262	13,001	20,768	15,820	17,067
2,335	14,561	2,503	13,584	1,861	18,270	2,272	14,965	2,749	12,368
4,424	1,126	4,877	1,021	4,089	1,218	5,189	960	6,484	768
4,172	959	4,365	916	5,068	789	5,856	683	6,709	596
7,240	32,044	7,779	29,824	9,002	25,772	10,997	21,097	13,041	17,790
12,885	359	13,375	345	16,725	276	19,109	242	21,664	213
3,816	6,289	4,031	5,954	2,965	8,094	3,912	6,135	4,586	5,233
439	11,390	459	10,893	332	15,060	420	11,905	481	10,395
34,419	1,162	36,025	1,110	43,919	911	50,926	785	58,562	683
22,348	403	23,313	386	29,472	305	33,658	267	38,150	236
31,577	14,441	34,387	13,261	30,649	14,878	38,089	11,972	46,586	9,788
24,575	2,523	26,378	2,350	30,300	2,046	36,817	1,684	43,603	1,422
422	71	453	66	341	88	439	68	523	57
4,443	1,999	4,665	1,904	5,246	1,693	6,077	1,461	7,034	1,262
1,481	1,485	1,646	1,337	1,350	1,630	1,654	1,330	2,115	1,040
136,594	2,614	154,372	2,313	126,328	2,826	161,450	2,211	209,112	1,707
3,827	6,533	4,322	5,784	3,713	6,733	4,649	5,378	5,981	4,180
40,650	689	44,928	623	37,317	750	47,858	585	59,885	468
35,139	1,651	37,466	1,548	43,382	1,337	52,145	1,112	61,192	948
75,564	14,319	81,111	13,340	77,794	13,909	94,569	11,441	113,275	9,552
3,049	2,952	3,179	2,831	3,629	2,480	4,163	2,162	4,743	1,898
40,693	4,178	42,971	3,956	45,117	3,768	53,272	3,191	62,287	2,729
16,276	5,530	17,216	5,228	13,009	6,918	15,275	5,892	17,891	5,030
4,376	90,722	4,775	83,141	3,836	103,493	4,667	85,065	5,811	68,319

Country	Total annual renewable fresh water available by country (cubic kilometers)	1955 Population (thousands)	1955 Per capita water availability (cubic meters)	1990 Population (thousands)	1990 Per capita water availability (cubic meters)	2025 UN Low Projection Population (thousands)	2025 UN Low Projection Per capita water availability (cubic meters)
Nicaragua	175.00	1,287	135,975	3,676	47,606	8,199	21,344
Niger	44.00	2,689	16,363	7,731	5,691	21,085	2,087
Nigeria	308.00	37,094	8,303	96,154	3,203	217,953	1,413
North Korea	67.00	9,070	7,387	21,774	3,077	29,678	2,258
Norway	413.00	3,427	120,514	4,241	97,383	4,289	96,293
Oman	1.93	503	3,837	1,751	1,102	5,580	346
Pakistan	468.00	44,194	10,590	121,933	3,838	270,915	1,727
Panama	144.00	977	147,390	2,398	60,050	3,538	40,701
Papua New Guinea	801.00	1,744	459,289	3,839	208,648	7,151	112,012
Paraguay	314.00	1,552	202,320	4,317	72,736	8,260	38,015
Peru	40.00	8,672	4,613	21,588	1,853	33,604	1,190
Philippines	323.00	23,913	13,507	60,779	5,314	96,353	3,352
Poland	56.00	27,281	2,053	38,119	1,469	37,601	1,489
Portugal	66.00	8,610	7,666	9,868	6,688	9,358	7,053
Qatar	0.05	35	1,429	485	103	753	66
Romania	208.00	17,486	11,895	23,207	8,963	19,986	10,407
Rwanda	6.30	2,391	2,635	6,986	902	14,574	432
Saudi Arabia	4.55	3,593	1,266	16,048	284	41,251	110
Senegal	35.00	2,811	12,451	7,327	4,777	16,240	2,155
Sierra Leone	160.00	2,081	76,886	3,999	40,010	7,993	20,018
Singapore	0.60	1,306	459	2,705	222	3,154	190
Solomon Islands	45.00	102	441,176	320	140,625	805	55,901
Somalia	8.50	3,401	2,499	8,677	980	19,428	438
South Africa	50.00	15,385	3,250	37,066	1,349	66,867	748
South Korea	63.00	21,422	2,941	42,869	1,470	48,657	1,295
Spain	111.00	29,199	3,802	39,272	2,826	36,511	3,040
Sri Lanka	43.00	8,723	4,929	17,225	2,496	22,287	1,929
Sudan	120.78	10,150	11,900	24,585	4,913	56,365	2,143
Suriname	200.00	250	800,000	400	500,000	529	378,072
Swaziland	6.96	291	23,918	744	9,355	1,532	4,543
Sweden	180.00	7,262	24,787	8,559	21,030	8,951	20,109
Switzerland	50.00	4,980	10,040	6,834	7,316	7,269	6,879
Syria	25.79	3,967	6,501	12,348	2,089	30,871	835
Tanzania	76.00	8,915	8,525	25,600	2,969	60,144	1,264
Thailand	179.00	22,762	7,864	55,583	3,220	63,066	2,838
Togo	12.00	1,414	8,487	3,531	3,398	8,522	1,408
Trinidad and Tobago	5.10	721	7,074	1,236	4,126	1,596	3,195
Tunisia	4.36	3,860	1,130	8,080	540	11,802	369
Turkey	203.00	23,859	8,508	56,098	3,619	82,583	2,458
Uganda	66.00	5,556	11,879	17,949	3,677	43,458	1,519
United Arab Emirates	0.49	79	6,203	1,671	293	2,787	176
United Kingdom	120.00	51,199	2,344	57,411	2,090	56,607	2,120
United States	2,478.00	165,932	14,934	249,924	9,915	300,434	8,248
Uruguay	124.00	2,372	52,277	3,094	40,078	3,422	36,236
USSR (former)	5,466.00	190,356	28,715	280,407	19,493	289,495	18,881
Venezuela	1,317.00	6,230	211,396	19,502	67,532	31,602	41,675
Vietnam	376.00	32,009	11,747	66,689	5,638	109,098	3,446
Yemen	5.20	4,734	1,098	11,311	460	30,922	168
Yugoslavia (former)	265.00	17,519	15,126	22,945	11,549	22,648	11,701
Zaire	1,019.00	13,604	74,904	37,436	27,220	95,423	10,679
Zambia	96.00	2,753	34,871	8,150	11,779	18,237	5,264
Zimbabwe	23.00	3,257	7,062	9,903	2,323	18,033	1,275

2025 UN Medium Projection Population (thousands)	2025 UN Medium Projection Per capita water availability (cubic meters)	2025 UN High Projection Population (thousands)	2025 UN High Projection Per capita water availability (cubic meters)	2050 UN Low Projection Population (thousands)	2050 UN Low Projection Per capita water availability (cubic meters)	2050 UN Medium Projection Population (thousands)	2050 UN Medium Projection Per capita water availability (cubic meters)	2050 UN High Projection Population (thousands)	2050 UN High Projection Per capita water availability (cubic meters)
9,079	19,275	10,809	16,190	9,769	17,914	12,211	14,331	16,837	10,394
22,385	1,966	23,724	1,855	29,538	1,490	34,576	1,273	40,131	1,096
238,397	1,292	256,342	1,202	275,941	1,116	338,510	910	403,745	763
33,386	2,007	37,302	1,796	28,519	2,349	37,198	1,801	47,648	1,406
4,719	87,519	4,913	84,063	3,690	111,924	4,791	86,203	5,452	75,752
6,094	317	6,543	295	8,228	235	10,005	193	11,847	163
284,827	1,643	298,756	1,566	326,935	1,431	381,488	1,227	440,273	1,063
3,767	38,227	4,166	34,566	3,631	39,658	4,290	33,566	5,493	26,215
7,532	106,346	7,913	101,226	8,188	97,826	9,614	83,316	11,136	71,929
9,017	34,823	9,758	32,179	9,465	33,175	11,666	26,916	14,115	22,246
36,692	1,090	39,611	1,010	35,543	1,125	43,820	913	52,895	756
104,522	3,090	112,593	2,869	105,627	3,058	129,532	2,494	156,081	2,069
41,542	1,348	44,543	1,257	32,827	1,706	43,154	1,298	51,844	1,080
9,685	6,815	10,242	6,444	7,966	8,285	9,140	7,221	10,740	6,145
799	63	845	59	739	68	889	56	1,060	47
21,735	9,570	23,232	8,953	15,809	13,157	20,389	10,202	24,619	8,449
15,797	399	16,794	375	17,964	351	21,755	290	25,501	247
42,651	107	44,103	103	53,999	84	60,897	75	68,355	67
16,896	2,071	17,556	1,994	20,430	1,713	23,442	1,493	26,675	1,312
8,690	18,412	9,291	17,221	9,938	16,100	12,090	13,234	14,312	11,179
3,355	179	3,507	171	2,720	221	3,304	182	3,773	159
844	53,318	883	50,963	1,025	43,902	1,191	37,783	1,373	32,775
21,276	400	22,948	370	26,265	324	32,062	265	38,140	223
70,951	705	75,111	666	76,005	658	90,129	555	105,790	473
54,418	1,158	57,257	1,100	42,335	1,488	56,456	1,116	65,358	964
37,571	2,954	39,691	2,797	28,165	3,941	31,765	3,494	37,376	2,970
25,031	1,718	27,921	1,540	21,871	1,966	28,350	1,517	36,133	1,190
58,388	2,069	60,340	2,002	74,823	1,614	84,829	1,424	95,220	1,268
599	333,890	673	297,177	537	372,439	706	283,286	909	220,022
1,647	4,226	1,766	3,941	1,806	3,854	2,176	3,199	2,591	2,686
9,751	18,460	10,438	17,245	7,895	22,799	9,991	18,016	11,880	15,152
7,786	6,422	8,092	6,179	6,027	8,296	7,422	6,737	8,374	5,971
33,505	770	36,182	713	38,647	667	47,212	546	56,836	454
62,894	1,208	65,657	1,158	78,858	964	91,132	834	104,373	728
73,584	2,433	85,123	2,103	59,514	3,008	81,913	2,185	110,142	1,625
9,377	1,280	10,063	1,192	11,101	1,081	13,704	876	16,286	737
1,808	2,821	2,033	2,509	1,579	3,230	2,085	2,446	2,701	1,888
13,290	328	14,816	294	12,026	363	15,607	279	19,750	221
90,937	2,232	99,228	2,046	84,833	2,393	106,284	1,910	130,869	1,551
48,056	1,373	52,184	1,265	58,194	1,134	72,131	915	86,971	759
2,958	166	3,147	156	2,860	171	3,423	143	4,088	120
61,476	1,952	65,024	1,845	48,674	2,465	61,635	1,947	72,155	1,663
331,152	7,483	364,422	6,800	272,065	9,108	348,966	7,101	430,895	5,751
3,691	33,595	4,014	30,892	3,282	37,782	4,013	30,900	5,005	24,775
308,244	17,733	331,944	16,467	263,756	20,724	318,868	17,142	387,998	14,088
34,775	37,872	38,011	34,648	33,538	39,269	42,152	31,244	52,152	25,253
118,151	3,182	127,419	2,951	118,336	3,177	143,620	2,618	172,324	2,182
33,676	154	36,175	144	41,068	127	49,280	106	57,927	90
24,582	10,780	26,595	9,964	19,219	13,788	24,441	10,842	29,952	8,847
104,639	9,738	112,745	9,038	134,487	7,577	164,433	6,197	195,804	5,204
19,130	5,018	20,028	4,793	23,300	4,120	27,173	3,533	31,380	3,059
19,631	1,172	21,232	1,083	21,675	1,061	26,622	864	32,188	715

supersede those presented in the report's Appendix 3. The figures for water availability by nation have not changed, but they are rounded and expressed in cubic kilometers rather than the millions of cubic meters used in the report. (A cubic kilometer contains 1 billion cubic meters.) Also, in the table on p. 5 of the report, 1 cubic kilometer and 1 billion cubic meters should have been described as equal to 810,000 acre feet.

As noted in the report, the water figures include only the renewable water available to each country—that which falls on its territory or flows in from neighboring countries. This finite supply is all the water countries can use sustainably. For detailed information about data methodology and the significance of ratios of people to renewable water availability, please refer to the report.

What do the revised data on national per capita fresh water availability reveal? The UN's 1994 medium population projection suggests that by the middle of the coming century, 4.4 billion of the nearly 10 billion people projected to inhabit the planet will live in 58 countries experiencing either water scarcity (less than 1,000 cubic meters of renewable water per capita per year) or water stress (between 1,000 and roughly 1,700 cubic meters). Under the high projection, the proportion of the world's population living in 66 water-short nations would be 65 percent, or 7.7 billion out of a total world population of 11.9 billion. Under the low projection, by contrast, the proportion would be 44 percent, or 3.5 billion people living in 51 water-short countries out of a total world population of 7.9 billion. Clearly, the extent of water shortages will depend to a large degree on which trajectory world population follows. The projections of the per capita availability of renewable water through 2050 make even clearer the urgent need for policies that will lead to population stabilization while efforts are made to ensure access to clean fresh water for all.

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—Robert Engelman and Pamela LeRoy
January 1995

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