from *Plan B 3.0: Mobilizing to Save Civilization*, by Lester R. Brown

4

Emerging Water Shortages

Africa's Lake Chad, once a landmark for astronauts circling the earth, is now difficult for them to locate. Surrounded by Cameroon, Chad, Niger, and Nigeria—all countries with fast-growing populations—the lake has shrunk 96 percent in 40 years. The region's soaring demand for irrigation water coupled with declining rainfall is draining dry the rivers and streams that feed the lake. As a result, Lake Chad may soon disappear entirely, its whereabouts a mystery to future generations.[1]

The shrinkage of Lake Chad is not unique. The world is incurring a vast water deficit—one that is largely invisible, historically recent, and growing fast. Because the deficit comes largely from aquifer overpumping, it is often discovered only when wells go dry.

This global water deficit is the result of demand tripling over the last half-century. The drilling of millions of irrigation wells has pushed water withdrawals beyond recharge rates, in effect leading to groundwater mining. The failure of governments to limit pumping to the sustainable yield of aquifers means that water tables are now falling in countries that contain more than half the world's people, including the big three grain producers—China, India, and the United States.[2]

Beyond these traditional sources of water insecurity, climate change is now affecting water supplies. Rising temperatures are boosting evaporation rates, altering rainfall patterns, and melting the glaciers that feed rivers during the dry season. As the glaciers melt, they are threatening to convert perennial rivers such as the Ganges in India and the Yellow in China into seasonal rivers, increasing both water and food insecurity. With the earth's climate system and its hydrological cycle so intertwined, any changes in climate will alter the hydrological cycle.[3]

Among the more visible manifestations of water scarcity are rivers running dry and lakes disappearing. A politics of water scarcity is emerging between upstream and downstream claimants both within and among countries. Water scarcity is now crossing borders via the international grain trade. Countries that are pressing against the limits of their water supply typically satisfy the growing need of cities and industry by diverting irrigation water from agriculture and then importing grain to offset the loss of productive capacity.

The link between water and food is strong. We each drink on average nearly 4 liters of water per day in one form or another, while the water required to produce our daily food totals at least 2,000 liters—500 times as much. This helps explain why 70 percent of all water use is for irrigation. Another 20 percent is used by industry, and 10 percent goes for residential purposes. With the demand for water growing in all three categories, competition among sectors is intensifying, with agriculture almost always losing. While most people recognize that the world is facing a future of water shortages, not everyone has connected the dots to see that this also means a future of food shortages.[4]

Water Tables Falling

Scores of countries are overpumping aquifers as they struggle to satisfy their growing water needs. Most aquifers are replenishable, but not all are. When most of the aquifers in India and the shallow aquifer under the North China Plain are depleted, the maximum rate of pumping will be automatically reduced to the rate of recharge.

Fossil aquifers, however, are not replenishable. For these—the vast U.S. Ogallala aquifer, the deep aquifer under the North China Plain, or the Saudi aquifer, for example—depletion brings pumping to an end. Farmers who lose their irrigation water have the option of returning to lower-yield dryland farming if rainfall permits. But in more arid regions, such as in the southwestern United States or the Middle East, the loss of irrigation water means the end of agriculture.

Falling water tables are already adversely affecting harvests in some countries, including China, which rivals the United States as the world's largest grain producer. A groundwater survey released in Beijing in August 2001 revealed that the water table under the North China Plain, an area that produces over half of the country's wheat and a third of its corn, is falling fast. Overpumping has largely depleted the shallow aquifer, forcing well drillers to turn to the region's deep aquifer, which is not replenishable.[5]

The survey reported that under Hebei Province in the heart of the North China Plain, the average level of the deep aquifer was dropping nearly 3 meters (10 feet) per year. Around some cities in the province, it was falling twice as fast. He Qingcheng, head of the groundwater monitoring team, notes that as the deep aquifer is depleted, the region is losing its last water reserve—its only safety cushion.[6]

His concerns are mirrored in a World Bank report: "Anecdotal evidence suggests that deep wells [drilled] around Beijing now have to reach 1,000 meters [more than half a mile] to tap fresh water, adding dramatically to the cost of supply." In unusually strong language for a Bank report, it foresees "catastrophic consequences for future generations" unless water use and supply can quickly be brought back into balance.[7]

The U.S. Embassy in Beijing reports that wheat farmers in some areas are now pumping from a depth of 300 meters, or nearly 1,000 feet. Pumping water from this far down raises pumping costs so high that farmers are often forced to abandon irrigation.[8]

Falling water tables, the conversion of cropland to nonfarm uses, and the loss of farm labor in provinces that are rapidly industrializing are combining to shrink China's grain harvest. The wheat crop, grown mostly in semiarid northern China, is particularly vulnerable to water shortages. After peaking at 123 million tons in 1997, the harvest has fallen, coming in at 105 million tons in 2007, a drop of 15 percent.[9]

The World Bank study indicates that China is mining underground water in three adjacent river basins in the north—those of the Hai, which flows through Beijing and Tianjin; the Yellow; and the Huai, the next river south of the Yellow. Since it takes 1,000 tons of water to produce one ton of grain, the shortfall in the Hai basin of nearly 40 billion tons of water per year (1 ton equals 1 cubic meter) means that when the aquifer is depleted, the grain harvest will drop by 40 million tons—enough to feed 120 million Chinese.[10]

As serious as water shortages are in China, they are even more serious in India, where the margin between food consumption and survival is so precarious. To date, India's 100 million farmers have drilled 21 million wells, investing some $12 billion in wells and pumps. In a survey of India's water situation, Fred Pearce reported in the *New Scientist* that "half of India's traditional hand-dug wells and millions of shallower tube wells have already dried up, bringing a spate of suicides among those who rely on them. Electricity blackouts are reaching epidemic proportions in states where half of the electricity is used to pump water from depths of up to a kilometer."[11]

In Tamil Nadu, a state with more than 62 million people in southern India, wells are going dry almost everywhere. According to Kuppannan Palanisami of Tamil Nadu Agricultural University, falling water tables have dried up 95 percent of the wells owned by small farmers, reducing the irrigated area in the state by half over the last decade. As a result, many farmers have returned to dryland farming.[12]

As water tables fall, well drillers are using modified oil-drilling technology to reach water, going as deep as 1,000 meters in some locations. In communities where underground water sources have dried up entirely, all agriculture is rain-fed and drinking water must be trucked in. Tushaar Shah, who heads the International Water Management Institute's groundwater station in Gujarat, says of India's water situation, "When the balloon bursts, untold anarchy will be the lot of rural India."[13]

India's grain harvest, squeezed both by water scarcity and the loss of cropland to non-farm uses, has plateaued since 2000. This helps explain why India reemerged as a leading wheat importer in 2006. A 2005 World Bank study reports that 15 percent of India's food supply is produced by mining groundwater.

Stated otherwise, 175 million Indians are fed with grain produced with water from irrigation wells that will soon go dry.[14]

As water tables fall, the energy required for pumping rises. In both India and China, the rising electricity demand from irrigation is satisfied largely by building coal-fired power plants.[15]

In the United States, the U.S. Department of Agriculture (USDA) reports that in parts of Texas, Oklahoma, and Kansas—three leading grain-producing states—the underground water table has dropped by more than 30 meters (100 feet). As a result, wells have gone dry on thousands of farms in the southern Great Plains, forcing farmers to return to lower-yielding dryland farming. Although this mining of underground water is taking a toll on U.S. grain production, irrigated land accounts for only one fifth of the U.S. grain harvest, compared with close to three fifths of the harvest in India and four fifths in China.[16]

For the seven states that draw on Colorado River water—Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming—the USDA survey shows an irrigated area decline in each from 1997 to 2002. In the two leading irrigation states, California and Colorado, the area dropped by 2 percent and 24 percent respectively. The 2007 survey will likely show further shrinkage in irrigated area.[17]

Pakistan, a country with 164 million people that is growing by 3 million per year, is also mining its underground water. In the Pakistani part of the fertile Punjab plain, the drop in water tables appears to be similar to that in India. Observation wells near the twin cities of Islamabad and Rawalpindi show a fall in the water table between 1982 and 2000 that ranges from 1 to nearly 2 meters a year.[18]

In the province of Balochistan, which borders Afghanistan, water tables around the capital, Quetta, are falling by 3.5 meters per year. Richard Garstang, a water expert with the World Wildlife Fund and a participant in a study of Pakistan's water situation, said in 2001 that "within 15 years Quetta will run out of water if the current consumption rate continues."[19]

The water shortage in Balochistan is province-wide. Sardar Riaz A. Khan, former director of Pakistan's Arid Zone Research Institute in Quetta, reports that six basins have exhausted their groundwater supplies, leaving their irrigated lands barren.

Khan expects that within 10–15 years virtually all the basins outside the canal-irrigated areas will have depleted their groundwater supplies, depriving the province of much of its grain harvest.[20]

Future irrigation water cutbacks as a result of aquifer depletion will undoubtedly reduce Pakistan's grain harvest. Countrywide, the harvest of wheat—the principal food staple—is continuing to grow, but more slowly than in the past.[21]

Iran, a country of 71 million people, is overpumping its aquifers by an average of 5 billion tons of water per year, the water equivalent of one third of its annual grain harvest. Under the small but agriculturally rich Chenaran Plain in northeastern Iran, the water table was falling by 2.8 meters a year in the late 1990s. New wells being drilled both for irrigation and to supply the nearby city of Mashad are responsible. Villages in eastern Iran are being abandoned as wells go dry, generating a flow of "water refugees."[22]

Saudi Arabia, a country of 25 million people, is as water-poor as it is oil-rich. Relying heavily on subsidies, it developed an extensive irrigated agriculture based largely on its deep fossil aquifer. After several years of supporting wheat prices at five times the world market level, the government was forced to face fiscal reality and cut the subsidies. Its wheat harvest dropped from a high of 4.1 million tons in 1992 to 2.7 million tons in 2007, a drop of 34 percent.[23]

Craig Smith writes in the *New York Times,* "From the air, the circular wheat fields of this arid land's breadbasket look like forest green poker chips strewn across the brown desert. But they are outnumbered by the ghostly silhouettes of fields left to fade back into the sand, places where the kingdom's gamble on agriculture has sucked precious aquifers dry." Some Saudi farmers are now pumping water from wells that are 4,000 feet deep, nearly four fifths of a mile or 1.2 kilometers.[24]

A 1984 Saudi national survey reported fossil water reserves at 462 billion tons. Half of that, Smith reports, has probably disappeared by now. This suggests that irrigated agriculture could last for another decade or so and then will largely vanish.[25]

In neighboring Yemen, a nation of 22 million, the water table under most of the country is falling by roughly 2 meters a year as water use outstrips the sustainable yield of aquifers. In western Yemen's Sana'a Basin, the estimated annual water extraction of 224 million tons exceeds the annual recharge of 42 million tons by a factor of five, dropping the water table 6 meters per year. World Bank projections indicate the Sana'a Basin—site of the national capital, Sana'a, and home to 2 million people—may be pumped dry by 2010.[26]

In the search for water, the Yemeni government has drilled test wells in the basin that are more than a mile deep—depths normally associated with the oil industry—but they have failed to find water. Yemen must soon decide whether to bring water to Sana'a, possibly by pipeline from coastal desalting plants, if it can afford it, or to relocate the capital. Either alternative will be costly and potentially traumatic.[27]

With its population growing at 3 percent a year and with water tables falling everywhere, Yemen is fast becoming a hydrological basket case. With its grain production falling by two thirds over the last 20 years, Yemen now imports four fifths of its grain supply. Living on borrowed water and borrowed time, Yemen ranks twenty-fourth on *Foreign Policy*'s list of failing states.[28]

Israel, even though it is a pioneer in raising irrigation water productivity, is depleting both of its principal aquifers—the coastal aquifer and the mountain aquifer that it shares with Palestinians. Because of severe water shortages, Israel has banned the irrigation of wheat. Conflicts between Israelis and Palestinians over the allocation of water are ongoing.[29]

In Mexico—home to a population of 107 million that is projected to reach 132 million by 2050—the demand for water is outstripping supply. Mexico City's water problems are well known. Rural areas are also suffering. In the agricultural state of Guanajuato, the water table is falling by 2 meters or more a year. In the northwestern state of Sonora, farmers once pumped water from the Hermosillo aquifer at a depth of 35 feet. Today they pump from more than 400 feet. At the national level, 51 percent of all the water extracted from underground is from aquifers that are being overpumped.[30]

Since the overpumping of aquifers is occurring in many countries more or less simultaneously, the depletion of aquifers and the resulting harvest cutbacks could come at roughly the

same time. And the accelerating depletion of aquifers means this day may come soon, creating potentially unmanageable food scarcity.

Rivers Running Dry

While falling water tables are largely hidden, rivers that are drained dry or reduced to a trickle before they reach the sea are highly visible. Two rivers where this phenomenon can be seen are the Colorado, the major river in the southwestern United States, and the Yellow, the largest river in northern China. Other large rivers that either run dry or come close to doing so during the dry season are the Nile, the lifeline of Egypt; the Indus, which supplies most of Pakistan's irrigation water; and the Ganges in India's densely populated Gangetic basin. Many smaller rivers have disappeared entirely.[31]

As the world's demand for water has tripled over the last half-century and as the demand for hydroelectric power has grown even faster, dams and diversions of river water have drained many rivers dry. As water tables have fallen, the springs that feed rivers have gone dry, reducing river flows.[32]

Since 1950, the number of large dams, those over 15 meters high, has increased from 5,000 to 45,000. Each dam deprives a river of some of its flow. Engineers like to say that dams built to generate electricity do not take water from the river, only its energy, but this is not entirely true since reservoirs increase evaporation. The annual loss of water from a reservoir in arid or semiarid regions, where evaporation rates are high, is typically equal to 10 percent of its storage capacity.[33]

The Colorado River now rarely makes it to the sea. With the states of Colorado, Utah, Arizona, Nevada, and California depending heavily on the Colorado's water, there is little, if any, water left when it reaches the Gulf of California. This excessive demand for water is destroying the river's ecosystem, including its fisheries.[34]

A similar situation exists in Central Asia. The Amu Darya—which, along with the Syr Darya, feeds the Aral Sea—is now drained dry by Uzbek and Turkmen cotton farmers upstream. With the flow of the Amu Darya cut off, only the diminished flow of the Syr Darya keeps the Aral Sea from disappearing entirely.[35]

China's Yellow River, which flows some 4,000 kilometers through five provinces before it reaches the Yellow Sea, has been under mounting pressure for several decades. It first ran dry in 1972, and since 1985 it has often failed to reach the sea.[36]

The Nile, site of another ancient civilization, now barely makes it to the sea. Water analyst Sandra Postel notes in *Pillar of Sand* that before the Aswan Dam was built, some 32 billion cubic meters of water reached the Mediterranean each year. After the dam was completed, however, increasing irrigation, evaporation, and other demands reduced its discharge to less than 2 billion cubic meters.[37]

Pakistan, like Egypt, is essentially a river-based civilization, heavily dependent on the Indus. This river, originating in the Himalayas and flowing southwestward to the Indian Ocean, not only provides surface water, it also recharges aquifers that supply the irrigation wells dotting the Pakistani countryside. In the face of growing water demand, it too is starting to run dry in its lower reaches. With a population of 164 million that is projected to reach 292 million by 2050, Pakistan is in political trouble, ranking twelfth on the 2007 list of failing states.[38]

In Southeast Asia, the flow of the Mekong is being reduced by the dams being built on its upper reaches by the Chinese. The downstream countries, including Cambodia, Laos, Thailand, and Viet Nam—countries with 172 million people—complain about the reduced flow of the Mekong, but this has done little to curb China's efforts to exploit the power and the water in the river.[39]

The same problem exists with the Tigris and Euphrates Rivers, which originate in Turkey and flow through Syria and Iraq en route to the Persian Gulf. This river system, the site of Sumer and other early civilizations, is being overused. Large dams erected in Turkey and Iraq have reduced water flow to the once "fertile crescent," helping to destroy 80 percent of the vast wetlands that formerly enriched the delta region.[40]

In each of the river systems just discussed, virtually all the water in the basin is being used. Inevitably, if people upstream get more water, those downstream will get less. Allocating water among competing interests, within and among societies, is part of an emerging politics of resource scarcity.

Lakes Disappearing

As river flows are reduced or even eliminated entirely and as water tables fall from overpumping, lakes are shrinking and in some cases disappearing. As my colleague Janet Larsen notes, the lakes that are disappearing are some of the world's best known—including Lake Chad in Central Africa, the Aral Sea in Central Asia, and the Sea of Galilee (also known as Lake Tiberias).[41]

Reuters reporter Megan Goldin writes that "walking on the Sea of Galilee is a feat a mere mortal can accomplish," as a result of its receding shores. When I first saw the Jordan River as it enters Israel from Syria, its fragility was obvious. Indeed, in many places it would be called a creek. And yet it has the primary responsibility for supplying water to the Sea of Galilee, which it enters at the north end and exits on the south end. It then continues southward some 105 kilometers before emptying into the Dead Sea.[42]

With the Jordan's flow further diminished as it passes through Israel, the Dead Sea is shrinking even faster than the Sea of Galilee. Over the past 40 years, its water level has dropped by some 25 meters (nearly 80 feet). It could disappear entirely by 2050.[43]

Of all the shrinking lakes and inland seas, none has gotten as much attention as the Aral Sea. Its ports, once centers of commerce, are now abandoned, looking like the ghost mining towns of the American West. Once one of the world's largest freshwater bodies, the Aral has lost four fifths of its volume since 1960. Ships that once plied its routes are now stranded in the sand of the old seabed—with no water in sight.[44]

The seeds for the Aral Sea's demise were sown in 1960, when Soviet central planners in Moscow decided the region embracing the Syr Darya and Amu Darya basins would become a vast cotton bowl to supply the country's textile industry.[45]

As cotton planting expanded, so too did the diversion of water from the two rivers that fed the Aral Sea. And as the sea shrank, the salt concentrations climbed until the fish died. The thriving fishery that once yielded 50,000 tons of seafood per year disappeared, as did the jobs on the fishing boats and in the fish processing factories.[46]

With the 65-billion-cubic-meter annual influx of water from the two rivers now down to 1.5 billion cubic meters a year, the prospect for restoring the sea is not good, though some local successes have been recorded. With the sea's shoreline now up to 250 kilometers (165 miles) from the original port cities, there is a vast area of exposed seabed. Each day the wind lifts thousands of tons of sand and salt from the dry seabed, distributing the airborne particles on the surrounding grasslands and croplands, reducing their fertility.[47]

At a 1990 Soviet Academy of Sciences conference on the future of the Aral Sea, there was an aerial tour for foreign guests. Flying in what seemed to be a World War II-vintage single-engine biplane a few hundred feet above the dry, salt-covered seabed, I noted that it looked like the surface of the moon. There was no vegetation, no sign of life, only total desolation.

The disappearance of lakes is perhaps most pronounced in China. In western China's Qinhai province, through which the Yellow River's main stream flows, there were once 4,077 lakes. Over the last 20 years, more than 2,000 have disappeared. The situation is far worse in Hebei Province, which surrounds Beijing. With water tables falling throughout this region, Hebei has lost 969 of its 1,052 lakes.[48]

Population is also outgrowing the water supply in Mexico. Lake Chapala, the country's largest, is the primary source of water for Guadalajara, which is home to 4 million people. Expanding irrigation in the region has reduced water volume in the lake by 80 percent.[49]

Lakes are disappearing on every continent and for the same reasons: excessive diversion of water from rivers and overpumping of aquifers. No one knows exactly how many lakes have disappeared over the last half-century, but we do know that thousands of them now exist only on old maps.

Farmers Losing to Cities

Water tensions among countries are more likely to make the headlines, but it is the jousting for water between cities and farms within countries that preoccupies local political leaders. The economics of water use do not favor farmers in this competition, simply because it takes so much water to produce food. For example, while it takes only 14 tons of water to make a ton of steel worth $560, it takes 1,000 tons of water to grow a ton

of wheat worth $200. In countries preoccupied with expanding the economy and creating jobs, agriculture becomes the residual claimant.[50]

Many of the world's largest cities are located in watersheds where all available water is being used. Cities in such watersheds, such as Mexico City, Cairo, and Beijing, can increase their water consumption only by importing water from other basins or taking it from agriculture. Increasingly the world's cities are meeting their growing needs by taking irrigation water from farmers. Among the U.S. cities doing so are San Diego, Los Angeles, Las Vegas, Denver, and El Paso.[51]

The competition between farmers and cities for underground water resources is intensifying throughout India. Nowhere is this more evident than in Chennai (formerly Madras), a city of 7 million on the east coast of south India. As a result of the city government's inability to supply water for some of the city's residents, a thriving tank-truck industry has emerged that buys water from farmers and hauls it to the city's thirsty residents.[52]

For farmers surrounding the city, the price of water far exceeds the value of the crops they can produce with it. Unfortunately, the 13,000 tankers hauling the water to Chennai are mining the underground water resources. Water tables are falling and shallow wells have gone dry. Eventually even the deeper wells will go dry, depriving these communities of both their food supply and their livelihood.[53]

Chinese farmers along the Juma River downstream from Beijing discovered in 2004 that the river had suddenly stopped flowing. A diversion dam had been built near the capital to take river water for Yanshan Petrochemical, a state-owned industry. Although the farmers protested bitterly, it was a losing battle. For the 120,000 villagers downstream from the diversion dam, the loss of water could cripple their ability to make a living from farming.[54]

Literally hundreds of cities in other countries are meeting their growing water needs by taking the water that farmers count on. In western Turkey, for example, the historic city of Izmir now relies heavily on well fields (a network of wells connected by pipe) from the neighboring agricultural district of Manisa.[55]

In the U.S. southern Great Plains and Southwest, where virtually all water is now spoken for, the growing water needs of cities and thousands of small towns can be satisfied only by taking water from agriculture. A monthly publication from California, *The Water Strategist*, devotes several pages to a listing of water sales that took place in the western United States during the preceding month. Scarcely a working day goes by without another sale. A University of Arizona study of over 2,000 of these water transfers from 1987 to 2005 reported that at least 8 out of 10 were by individual farmers or irrigation districts to cities and municipalities.[56]

Colorado has one of the world's most active water markets. Fast-growing cities and towns in a state with high immigration are buying irrigation water rights from farmers and ranchers. In the upper Arkansas River basin, which occupies the southeastern quarter of the state, Colorado Springs and Aurora (a suburb of Denver) have already bought water rights to one third of the basin's farmland. Aurora has purchased rights to water that was once used to irrigate 9,600 hectares (23,000 acres) of cropland in the Arkansas valley.[57]

Far larger purchases are being made by cities in California. In 2003, San Diego bought annual rights to 247 million tons (200,000 acre-feet) of water from farmers in the nearby Imperial Valley—the largest farm-to-city water transfer in U.S. history. This agreement covers the next 75 years. In 2004, the Metropolitan Water District, which supplies water to 18 million southern Californians in several cities, negotiated the purchase of 137 million tons of water per year from farmers for the next 35 years. Without irrigation water, the highly productive land owned by these farmers is wasteland. The farmers who are selling their water rights would like to continue farming, but city officials are offering far more for the water than the farmers could possibly earn by irrigating crops.[58]

Whether it is outright government expropriation, farmers being outbid by cities, or cities simply drilling deeper wells than farmers can afford, the world's farmers are losing the water war. They are faced with not only a shrinking water supply in many situations but also a shrinking share of that shrinking supply. Slowly but surely, fast-growing cities are siphoning water from the world's farmers even as they try to feed some 70 million more people each year.[59]

Scarcity Crossing National Borders

Historically, water scarcity was a local issue. It was up to national governments to balance water supply and demand. Now this is changing as scarcity crosses national boundaries via the international grain trade. Since it takes 1,000 tons of water to produce one ton of grain, as noted earlier, importing grain is the most efficient way to import water. Countries are, in effect, using grain to balance their water books. Similarly, trading in grain futures is in a sense trading in water futures.[60]

After China and India, there is a second tier of smaller countries with large water deficits—Algeria, Egypt, Mexico, and Pakistan. Algeria, Egypt, and Mexico already import much of their grain. With its population outgrowing its water supply, Pakistan too may soon turn to world markets for grain.[61]

The Middle East and North Africa—from Morocco in the west through Iran in the east—has become the world's fastest-growing grain import market. The demand for grain is driven both by rapid population growth and by rising affluence, much of the latter from the export of oil. With virtually every country in the region pressing against its water limits, the growing urban demand for water can be satisfied only by taking irrigation water from agriculture.[62]

Egypt, with some 75 million people, has become a major importer of wheat in recent years, vying with Japan—traditionally the leading wheat importer—for the top spot. It now imports close to 40 percent of its total grain supply, a dependence that reflects a population that is outgrowing the grain harvest produced with the Nile's water. Algeria, with 34 million people, imports well over half of its grain.[63]

Overall, the water required to produce the grain and other farm products imported into the Middle East and North Africa last year approached the annual flow of the Nile River at Aswan. In effect, the region's water deficit can be thought of as another Nile flowing into the region in the form of imported food.[64]

It is often said that future wars in the Middle East will more likely be fought over water than oil, but in reality the competition for water is taking place in world grain markets. The countries that are financially the strongest, not necessarily those that are militarily the strongest, will fare best in this competition.

Knowing where grain deficits will be concentrated tomorrow requires looking at where water deficits are developing today. Thus far, the countries importing much of their grain have been smaller ones. Now we are looking at fast-growing water deficits in both China and India, each with more than a billion people.[65]

As noted earlier, overpumping is a way of satisfying growing food demand that virtually guarantees a future drop in food production when aquifers are depleted. Many countries are in essence creating a "food bubble economy"—one in which food production is artificially inflated by the unsustainable mining of groundwater. At what point does water scarcity translate into food scarcity?

David Seckler and his colleagues at the International Water Management Institute, the world's premier water research group, summarized this issue well: "Many of the most populous countries of the world—China, India, Pakistan, Mexico, and nearly all the countries of the Middle East and North Africa—have literally been having a free ride over the past two or three decades by depleting their groundwater resources. The penalty for mismanagement of this valuable resource is now coming due and it is no exaggeration to say that the results could be catastrophic for these countries and, given their importance, for the world as a whole."[66]

Since expanding irrigation helped triple the world grain harvest from 1950 to 2000, it comes as no surprise that water losses can shrink harvests. With water for irrigation, many countries are in a classic overshoot-and-decline mode. If countries that are overpumping do not move quickly to raise water use efficiency and stabilize water tables, then an eventual drop in food production may be inevitable.[67]

Water Scarcity Yields Political Stresses

We typically measure well-being in economic terms, in income per person, but water well-being is measured in cubic meters or tons of water per person. A country with an annual supply of 1,700 cubic meters of water per person is well supplied with water, able to comfortably meet agricultural, industrial, and residential needs. Below this level, stresses begin to appear. When water supply drops below 1,000 cubic meters per person, people face scarcity. Below 500 cubic meters, they face acute scarcity. At

this level people are suffering from hydrological poverty—living without enough water to produce food or, in some cases, even for basic hygiene.[68]

The world's most severe water stresses are found in North Africa and the Middle East. While Morocco and Egypt have fewer than 1,000 cubic meters per person per year, Algeria, Tunisia, and Libya have fewer than 500. Some countries, including Saudi Arabia, Yemen, Kuwait, and Israel, have less than 300 cubic meters per person per year. A number of sub-Saharan countries are also facing water stress, including Kenya and Rwanda.[69]

While national averages indicate an adequate water supply in each of the world's three most populous countries—China, India, and the United States—regions within these countries also suffer from acute water shortages. Water is scarce throughout the northern half of China. In India, the northwestern region suffers extreme water scarcity. For the United States, the southwestern states from Texas to California are experiencing acute water shortages.[70]

Although the risk of international conflict over water is real, so far there have been remarkably few water wars. Water tensions tend to build more within societies, particularly where water is already scarce and population growth is rapid. Recent years have witnessed conflicts over water in scores of countries. Perhaps the most common of these is the competition described earlier between cities and farmers, particularly in countries like China, India, and Yemen. In other countries the conflicts are between tribes, as in Kenya, or between villages, as in India and China, or upstream and downstream water users, as in Pakistan or China. In some countries local water conflicts have led to violence and death, as in Kenya, Pakistan, and China.[71]

In Pakistan's arid southwest province of Balochistan, water tables are falling everywhere as a fast-growing local population swelled by Afghan refugees is pumping water far faster than aquifers can recharge. The provincial capital of Quetta, as noted earlier, is facing a particularly dire situation. Naser Faruqui, a researcher at Canada's International Development Research Centre, describes the situation facing Quetta: "With over a million people living there now, many of whom are Afghan refugees, the possibility of confrontation over decreasing water resources, or even mass migration from the city, is all too real."[72]

Not far to the west, Iraq is concerned that dam building on the Euphrates River in Turkey and, to a lesser degree, Syria will leave it without enough water to meet its basic needs. The flow into Iraq of the Euphrates River, which gave birth to the ancient Sumerian civilization, has shrunk by half over the last few decades.[73]

Another water flash point involves the way water is divided between Israelis and Palestinians. A U.N. report notes that "nowhere are the problems of water governance as starkly demonstrated as in the Occupied Palestinian Territories." Palestinians experience one of the highest levels of water scarcity in the world. But the flash point is as much over inequity in the distribution of water as it is over scarcity. The Israeli population is roughly double that of the Palestinians, but it gets seven times as much water. As others have noted, peace in the region depends on a more equitable distribution of the region's water. Without this, the peace process itself may dry up.[74]

At the global level, most of the projected population growth of nearly 3 billion by 2050 will come in countries where water tables are already falling. The states most stressed by the scarcity of water tend to be those in arid and semiarid regions, with fast-growing populations and a resistance to family planning. Many of the countries high on the list of failing states are those where populations are outrunning their water supplies, among them Sudan, Iraq, Somalia, Chad, Afghanistan, Pakistan, and Yemen. Unless population can be stabilized in these countries, the continually shrinking supply of water per person will put still more stress on already overstressed governments.[75]

Although spreading water shortages are intimidating, we have the technologies needed to raise water use efficiency, thus buying time to stabilize population size. Prominent among these technologies are those for more water-efficient irrigation, industrial water recycling, and urban water recycling, as discussed in Chapters 9 and 10.