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Peak Water and Food Scarcity

Although many analysts are concerned about the depletion of oil resources, the depletion of underground water resources poses a far greater threat to our future. While there are substitutes for oil, there are none for water. Indeed, modern humans lived a long time without oil, but we would live for only a matter of days without water.

Not only are there no substitutes for water, but the world needs vast amounts of it to produce food. As adults, each of us drinks nearly 4 liters of water a day in one form or another. But it takes 2,000 liters of water—500 times as much—to produce the food we consume each day.[1]

Since food is such an extraordinarily water-intensive product, it comes as no surprise that 70 percent of world water use is for irrigation. Although it is now widely accepted that the world is facing severe water shortages, not everyone realizes that a future of water shortages will also be a future of food shortages.[2]

The use of irrigation to expand food production goes back some 6,000 years. Indeed, the development of irrigation using water from the Tigris and Euphrates Rivers set the stage for the emergence of the Sumerian civilization, and it was the Nile that gave birth to ancient Egypt.[3]

Throughout most of history, irrigation spread rather slowly. But in the latter half of the twentieth century it underwent a rapid expansion. In 1950, there were some 250 million acres of irrigated land in the world. By 2000, the figure had nearly tripled to roughly 700 million acres. After these several decades of rapid increase, however, the growth in irrigated area has slowed dramatically since the turn of the century, expanding only 9 percent from 2000 to 2009. Given that governments are much more likely to report increases than decreases, the recent net growth in irrigated area may be even smaller. This dramatic loss of momentum in irrigation expansion, coupled with the aquifer depletion that is already reducing irrigated area in some countries, suggests that peak water may now be on our doorstep.[4]

The trend in irrigated land area per person is even less promising. For the last half-century, the irrigated area has been expanding—but not as fast as population. As a result, the irrigated area per person today is 10 percent less than it was in 1960. With so many aquifers being depleted and more and more irrigation wells going dry, this shrinkage in irrigated area per person is likely not only to continue but to accelerate in the years ahead.[5]

Roughly 40 percent of the world grain harvest is grown on irrigated land. The rest is rainfed. Among the big three grain producers—China, India, and the United States—the role of irrigation varies widely. In China, four fifths of the grain harvest comes from irrigated land. For India it is three fifths, and for the United States, only one fifth. Asia, where rice is the staple food, totally dominates the world irrigated area.[6]

Farmers use both surface and underground water for irrigation. Surface water is typically stored behind dams on rivers and then channeled onto the land through a network of irrigation canals. Historically, and notably from

1950 until 1975, when most of the world's large dams were built, this was the main source of growth in world irrigated area. During the 1970s, however, as the sites for new dams diminished, attention shifted from building dams to drilling wells for access to underground water.[7]

Most underground water comes from aquifers that are regularly replenished with rainfall; these can be pumped indefinitely as long as water extraction does not exceed recharge. A small minority of aquifers are fossil aquifers, however, containing water put there eons ago. Since these do not recharge, irrigation ends once they are pumped dry. Among the more prominent fossil aquifers are the Ogallala underlying the U.S. Great Plains, the deep aquifer under the North China Plain, and the Saudi aquifers.[8]

Given a choice, farmers generally prefer having their own wells because it enables them to control the timing and amount of water delivered with a precision that is not possible with large, centrally managed canal irrigation systems. Pumps let them apply water precisely when the crop needs it, thus achieving higher yields than with large-scale, river-based irrigation systems. Forty percent of world irrigated area is now dependent on underground water. As world demand for grain has climbed, farmers have drilled more and more irrigation wells with little concern for how many the local aquifers could support. As a result, water tables are falling and millions of irrigation wells are either going dry or are on the verge of doing so.[9]

As groundwater use for irrigation expands, so does the grain harvest. But if the pumping surpasses the sustainable yield of the aquifer, aquifers are depleted. When this happens, the rate of irrigation pumping is necessarily reduced to the aquifer's natural rate of recharge. At this point, grain production declines too.

The resulting water-based "food bubbles," which create a short-term false sense of security, can now be found in

some 18 countries that contain more than half the world's people. In these countries, food is being produced by drawing down water reserves. This group includes China, India, and the United States.[10] (See Table 6–1.)

In Saudi Arabia, pumping is fast depleting the country's major aquifers. After the Arab oil-export embargo in the 1970s, the Saudis realized that since they were heavily dependent on imported grain they were vulnerable to a grain counter-embargo. Using oil-drilling technology, they tapped into aquifers far below the desert to produce irrigated wheat. In a matter of years, the kingdom was self-sufficient in wheat, a food staple.[11]

But after more than 20 years of wheat self-sufficiency, the Saudis announced in January 2008 that their aquifers were largely depleted and they would be phasing out wheat production. Between 2007 and 2011, the wheat harvest of just under 3 million tons dropped by nearly half. At this rate the Saudis likely will harvest their last wheat crop by 2016, as planned, and will then be totally dependent on imported grain to feed nearly 30 million people.[12]

The unusually rapid phaseout of wheat farming in Saudi Arabia is due to two factors. First, in this arid country there is little farming without irrigation. Second, its irrigation depends almost entirely on fossil aquifers. The desalted seawater that Saudi Arabia uses in its cities is far too costly for large-scale irrigation use.[13]

Saudi Arabia's growing food insecurity has even led it to buy or lease land in several other countries, importantly Ethiopia and Sudan. (See Chapter 10.) The Saudis are planning to produce food for themselves with the land and water resources of other countries to augment their fast-growing grain purchases in the world market.[14]

In neighboring Yemen, replenishable aquifers are also being pumped well beyond the rate of recharge, and the deeper fossil aquifers are being rapidly depleted too. As a result, water tables are falling throughout Yemen by some 2 meters per year. In the capital, Sana'a—home to 2 million people—a 2006 report indicated that tap water was available only once every 4 days; in Taiz, a smaller city to the south, it was once every 20 days.[15]

Yemen, where population growth is spiraling out of

Table 6–1. *Countries Overpumping Aquifers in 2012*

Country	Population (million)
Afghanistan	33
China	1,354
India	1,258
Iran	76
Iraq	34
Israel	8
Jordan	6
Lebanon	4
Mexico	116
Morocco	33
Pakistan	180
Saudi Arabia	29
South Korea	49
Spain	47
Syria	21
Tunisia	11
United States	316
Yemen	26
Total	3,599

Source: Earth Policy Institute, with populations from U.N. Population Division.

control, is fast becoming a hydrological basket case. With water tables falling, the grain harvest has shrunk by one half over the last 40 years, while demand has continued its steady rise. As a result, the Yemenis now import more than 80 percent of their grain. With its meager oil exports falling, with no industry to speak of, and with nearly 60 percent of its children physically stunted and chronically undernourished, this poorest of the Middle East Arab countries is facing a bleak and turbulent future.[16]

The likely result of the depletion of Yemen's aquifers, which will lead to further shrinkage of its harvest and spreading hunger, is social collapse. Already a failing state, it may well devolve into a group of tribal fiefdoms, warring over whatever meager water resources remain. For the international community, the risk is that Yemen's internal conflicts could spill over its lengthy, unguarded border with Saudi Arabia.[17]

In addition to the bursting food bubble in Saudi Arabia and the fast-deteriorating water situation in Yemen, two other populous countries in the region—Syria and Iraq—have water troubles. Some of these arise from the reduced flows of the Euphrates and Tigris Rivers, which both countries depend on for irrigation water. Turkey, which controls the headwaters of both these rivers, is in the midst of a massive dam building program that is slowly reducing downstream flows. Although all three countries have discussed water-sharing arrangements, Turkey's ambitious plans to expand both its hydropower generation and irrigated area are being fulfilled partly at the expense of its downstream neighbors.[18]

This is nowhere more evident than in Turkey's massive diversion of water from the Euphrates River by its large southeast Anatolia project. Harald Frederiksen, one of the World Bank's leading water management consultants, says that Turkey's retention of Euphrates and Tigris River

flows has "severely reduced the millennia-old supply to the other riparians." Some analysts estimate that Syria will lose at least 30 percent of its water supply and Iraq, the last country in the Tigris-Euphrates flow, at least 60 percent. Others, who see an even grimmer water future in the region, believe Syria could lose 50 percent and Iraq up to 90 percent. With the loss of irrigation water, many Iraqis are abandoning their land and migrating to cities. Frederiksen notes, "The lower riparians' desperate situation today presents the world community with a highly volatile international security situation."[19]

Given the uncertainty of river water supplies, farmers in Syria and Iraq have drilled many wells for irrigation, leading to overpumping and falling water tables in both countries. With wells going dry, Syria's grain harvest has fallen by one third since peaking at roughly 7 million tons in 2001. In Iraq, the grain harvest has fallen by one sixth since peaking at 4.5 million tons in 2002.[20]

Jordan, with over 6 million people, is also on the ropes agriculturally, due to unsustainable aquifer withdrawals. The Ministry of Water and Irrigation estimates that groundwater withdrawals are nearly twice the sustainable yield, causing the overexploitation and abandonment of both municipal and irrigation wells. Forty or so years ago, the country was producing over 300,000 tons of grain per year. Today, it produces only 55,000 tons and must import over 90 percent of the grain it consumes. In the region, only Lebanon has managed to avoid a decline in grain production.[21]

Thus in the Arab Middle East, where populations are growing fast, the world is seeing the first regional collision between population growth and water supply. For the first time in history, water shortages are shrinking the grain harvest in an entire geographic region—with nothing in sight to arrest the decline. Because of the failure of

governments in the region to mesh population and water policies, each day now brings 9,000 more people to feed and less irrigation water with which to feed them.[22]

A similar prospect of spreading water shortages threatens China. Although surface water is widely used for irrigation, the principal concern is the groundwater situation in the northern half of the country, where rainfall is low and water tables are falling everywhere. This includes the highly productive North China Plain, which stretches from north of Beijing south toward Shanghai and produces half of the country's wheat and a third of its corn.[23]

The scale of overpumping in the North China Plain suggests that some 130 million Chinese are being fed with grain produced with the unsustainable use of water. Farmers in this region are pumping from two aquifers: the so-called shallow aquifer, which is rechargeable but largely depleted, and the deep fossil aquifer. Once the latter is depleted, the irrigated agriculture dependent on it will end, forcing farmers back to rainfed farming.[24]

China has had ample warning. A groundwater survey done more than a decade ago by the Geological Environment Monitoring Institute (GEMI) in Beijing found that under Hebei Province, in the heart of the North China Plain, the average level of the deep aquifer dropped 2.9 meters (nearly 10 feet) in 2000. Around some cities in the province, it fell by 6 meters in that one year alone. He Qingcheng, director of the GEMI groundwater monitoring team, notes that as the deep aquifer under the North China Plain is depleted, the region is losing its last water reserve—its only safety cushion.[25]

In a 2010 interview with *Washington Post* reporter Steven Mufson, He Qingcheng noted that Beijing was drilling down 1,000 feet to reach water—five times deeper than 20 years ago. His concerns are mirrored in the unusually strong language of a World Bank report on China's water situation that foresees "catastrophic consequences for future generations" unless water use and supply can quickly be brought back into balance.[26]

The problem may be even more serious in India, simply because the margin between actual food consumption and survival is so thin. In this global epicenter of well drilling, where farmers have drilled 21 million irrigation wells, water tables are dropping in much of the country. Among the states most affected are Punjab, Haryana, Rajasthan, and Gujarat in the north and Tamil Nadu in the south. The wells, powered by heavily subsidized electricity, are dropping water tables at an accelerating rate. In North Gujarat, the water table is falling by 6 meters, or 20 feet, per year. In some states, half of all electricity is now used to pump water.[27]

In Tamil Nadu, a state of 72 million people, falling water tables are drying up wells. Kuppannan Palanisami of Tamil Nadu Agricultural University says that 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.[28]

As water tables fall, small farmers often lose out because they lack the capital required to drill deeper. Larger farmers in India are using modified oil-drilling technology to reach water, going as deep as 1,000 feet in some locations. Pumping from such depths is energy-intensive and costly. In communities where underground water sources have dried up entirely, all agriculture is rainfed and drinking water is trucked in. Tushaar Shah, a senior fellow at the International Water Management Institute, says, "When the balloon bursts, untold anarchy will be the lot of rural India."[29]

The United States is also depleting its aquifers. In most of the leading U.S. irrigation states, the irrigated area has peaked and begun to decline. In California, historically the irrigation leader, a combination of aquifer depletion

and the diversion of water to fast-growing cities has reduced irrigated area from nearly 9 million acres in 1997 to 8 million acres in 2007. In Texas, the irrigated area peaked in 1978 at 7 million acres, falling to some 5 million acres in 2007 as the thin southern end of the Ogallala aquifer that underlies much of the Texas panhandle was depleted.[30]

Other states with shrinking irrigated area include Arizona, Colorado, and Florida. Colorado has watched its irrigated area shrink for the last few decades. Researchers there project a loss of up to 700,000 acres of irrigated land between 2010 and 2050, which is roughly one fifth of the state's total. All three states are suffering from both aquifer depletion and the diversion of water to urban centers. And now that the growth in irrigated area in the states where it has rapidly expanded over the last decade or so, such as Nebraska and Arkansas, is starting to level off, the prospects for any national growth in irrigated area have faded. With water tables falling as aquifers are depleted under the Great Plains and California's Central Valley, and with fast-growing cities in the Southwest taking more and more water, U.S. irrigated area appears to have peaked and begun a long-term decline.[31]

In Mexico, a largely semiarid country that is home to 116 million people, the demand for water is outstripping supply. Mexico City's water problems are well known, but rural areas are also suffering. In the agricultural state of Guanajuato, the water table is falling by 6 feet or more a year. In the northwestern wheat-growing state of Sonora, farmers once pumped water from the Hermosillo aquifer at a depth of 40 feet. Today, they pump from over 400 feet. With 58 percent of all water extraction in Mexico coming from aquifers that are being overpumped, Mexico's food bubble may burst soon.[32]

In many of the world's river basins, tensions are building as competition for scarce water intensifies. Egypt, at

the lower reaches of the Nile River, with a population of 84 million people in a country where it rarely rains, is highly vulnerable. Egypt either imports its wheat or imports the water to produce it via the Nile River. And since Egypt is a nation of bread eaters, what happens to its wheat supply is a matter of intense public interest.[33]

The Nile Waters Agreement, which Egypt and Sudan signed in 1959, allocated 75 percent of the river's flow to Egypt, 25 percent to Sudan, and none to Ethiopia. However, this agreement has largely become void in practice, in the face of wealthy foreign governments and international agribusiness firms who are snatching up large swaths of arable land in the upper Nile basin. While these deals are typically described as land acquisitions, they are also, in effect, water acquisitions.[34]

Unfortunately for Egypt, both Ethiopia and the two Sudans—the upstream countries that together occupy three fourths of the Nile River basin—are among the principal targets of land acquisitions. In South Sudan, a full 4 percent of the country's land area had already been acquired by foreign investors when it achieved independence. Demands for water in the Nile basin are such that there is little of the river left when it eventually reaches the Mediterranean.[35]

When competing for Nile water, Cairo now must deal with a number of governments and commercial interests that were not party to the 1959 agreement. Moreover, Ethiopia has announced plans to build a huge hydroelectric dam on its branch of the Nile, which would reduce the water flow to Egypt even more.[36]

Because Egypt's wheat yields are already among the world's highest, it has little potential to raise its land productivity further. With its population projected to reach 101 million by 2025, finding enough food and water is an imminent and daunting challenge.[37]

Egypt's plight could become part of a larger, more troubling scenario. Its upstream Nile neighbors—Sudan and South Sudan, with 46 million people, and Ethiopia, with 87 million—are growing even faster, increasing the need for water to produce food. Projections by the United Nations show the combined population of these four Nile-basin countries increasing from 216 million at present to 272 million by 2025.[38]

The Nile is not the only river whose waters are fully allocated. In the southwestern United States, the Colorado River originates in the Rocky Mountains of Colorado and flows to the southwest, theoretically entering the Gulf of California. But now in fact it rarely reaches the Gulf. It is the principal source of irrigation water in the southwestern part of the United States, supplying water to Colorado, Utah, Nevada, Arizona, and California. Major cities such as Phoenix, San Diego, and Los Angeles also depend on its water.[39]

A similar situation is unfolding in the Mekong River basin. China, which controls the headwaters of the Mekong, is building a number of dams, many of them for power generation. Although the water flows through these dams, each dam and the reservoir behind it reduces the amount of water reaching the countries in the lower part of the basin, such as Viet Nam, Thailand, Cambodia, and Laos, simply because of the evaporation factor. The rule of thumb for reservoirs is that each year 10 percent of the water they store evaporates. This loss of Mekong flow plus that from diversion in China threaten the downstream ecosystems, reducing fish populations and depriving many river dwellers of their livelihoods.[40]

Another major river with a potential source of conflict is the Indus. Though a large part of the Indus water flow originates in India, most of the water is actually used in Pakistan because of geography and the 1960 Indus Water Treaty. The Indus, flowing west from the Himalayas to the Indian Ocean, supplies water not only for Pakistan's Indus basin irrigation system, the world's largest, but also for the country's other needs. For much of the year, like the Colorado River, it now barely reaches the ocean.[41]

Pakistan, with a population of 180 million people that is projected to reach 275 million by 2050, is facing trouble. Water expert John Briscoe writes in a World Bank study, "Pakistan is already one of the most water-stressed countries in the world, a situation which is going to degrade into outright water scarcity due to high population growth." He then notes that "the survival of a modern and growing Pakistan is threatened by water."[42]

At the international level, water conflicts among countries dominate the headlines. But within countries it is the competition for water between cities and farms that preoccupies political leaders. Neither economics nor politics favors farmers. They almost always lose out to cities.

Indeed, in many countries farmers now face not only a shrinking water supply but also a shrinking share of that shrinking supply. In large areas of the United States, such as the southern Great Plains and the Southwest, virtually all water is now spoken for. The growing water needs of major cities and thousands of small towns often can be satisfied only by taking water from agriculture. As the value of water rises, more farmers are selling their irrigation rights to cities, letting their land dry up.[43]

In the western United States, hardly a day goes by without the announcement of a new sale. Half or more of all sales are by individual farmers or their irrigation districts to cities and municipalities. Felicity Barringer, writing in the *New York Times* from California's Imperial Valley, notes that many fear that "a century after Colorado River water allowed this land to be a cornucopia, unfettered urban water transfers could turn it back into a desert."[44]

Colorado, with a fast-growing population, has one of the world's most active water markets. Cities and towns of all sizes are buying irrigation water rights from farmers and ranchers. In the 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 19,000 acres of cropland in the Arkansas valley. The U.S. Geological Survey estimates that 400,000 acres of farmland dried up statewide between 2000 and 2005.[45]

Colorado is not alone in losing irrigation water. Farmers in India are also losing water to cities. This is strikingly evident in Chennai (formerly Madras), a city of 9 million on the east coast. As a result of the city government's inability to supply water to many of its residents, a thriving tank-truck industry has emerged that buys water from nearby farmers and hauls it to the city's thirsty residents.[46]

For farmers near the city, the market price of water far exceeds the value of the crops they can produce with it. Unfortunately, the 13,000 tankers hauling water to Chennai are mining the region's underground water resources. Water tables are falling and shallow wells have gone dry. Eventually even the deeper wells will go dry, depriving rural communities of both their food supply and their livelihood. The intensifying competition for water at the local level led India's Minister of Water Resources to quip that he is actually the Minister of Water Conflicts.[47]

In the competition for water between farmers on the one hand and cities and industries on the other, the economics do not favor agriculture. In countries such as China, where industrial development and the jobs associated with it are an overriding national economic goal, agriculture is becoming the residual claimant on the water supply.

In countries where virtually all water has been claimed, as in North Africa and the Middle East, cities can typically get more water only by taking it from irrigation. Countries then import grain to offset the loss of grain production. Since it takes 1,000 tons of water to produce 1 ton of grain, importing grain is the most efficient way to import water. Similarly, trading in grain futures is, in a sense, trading in water futures. To the extent that there is a world water market, it is embodied in the world grain market.[48]

We live in a world where more than half the people live in countries with food bubbles based on overpumping. The question for each of these countries is not whether its bubble will burst, but when. And how will the government cope with it? Will governments be able to import grain to offset production losses? For some countries, the bursting of the bubble may well be catastrophic. For the world as a whole, the near-simultaneous bursting of several national food bubbles as aquifers are depleted could create unmanageable food shortages.

Given the sheer geographic scale of overpumping, the simultaneous fall of water tables among countries, and the accelerating rate of their drop, the need to stabilize water tables is urgent. Although falling water tables are historically recent, they now threaten the security of water supplies and, hence, of food supplies not only in the countries where this is occurring but throughout the world.

The gap between rising water use and the sustainable yield of aquifers grows larger each year, which means the drop in water tables each year is greater than the year before. Underlying the urgency of dealing with the fast-tightening water situation is the sobering realization that not a single country has succeeded in arresting the fall in its water. The fast-unfolding water crunch has not yet translated into food shortages at the global level. But if it is not addressed, it may do so soon.