EARTH POLICY INSTITUTE
from *Full Planet, Empty Plates: The New Geopolitics of Food Scarcity*, by Lester R. Brown

8

Rising Temperatures, Rising Food Prices

Agriculture as it exists today developed over 11,000 years of rather remarkable climate stability. It has evolved to maximize production within that climate system. Now, suddenly, the climate is changing. With each passing year, the agricultural system is becoming more out of sync with the climate system.[1]

In generations past, when there was an extreme weather event, such as a monsoon failure in India, a severe drought in Russia, or an intense heat wave in the U.S. Corn Belt, we knew that things would shortly return to normal. But today there is no "normal" to return to. The earth's climate is now in a constant state of flux, making it both unreliable and unpredictable.[2]

Since 1970, the earth's average temperature has risen more than 1 degree Fahrenheit. (See Figure 8–1.) If we continue with business as usual, burning ever more oil, coal, and natural gas, it is projected to rise some 11 degrees Fahrenheit (6 degrees Celsius) by the end of this century. The rise will be uneven. It will be much greater in the higher latitudes than in the equatorial regions, greater over land than over oceans, and greater in continental interiors than in coastal regions.[3]

As the earth's temperature rises, it affects agriculture in

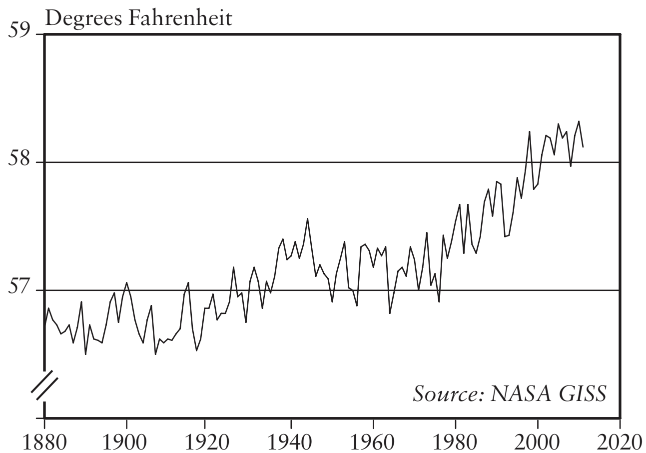

Figure 8–1. *Average Global Temperature 1880–2011*

many ways. High temperatures interfere with pollination and reduce photosynthesis of basic food crops. The most vulnerable part of a plant's life cycle is the pollination period. Of the world's three food staples—corn, wheat, and rice—corn is particularly vulnerable. In order for corn to reproduce, pollen must fall from the tassel to the strands of silk that emerge from the end of each ear. Each of these silk strands is attached to a kernel site on the cob. If the kernel is to develop, a grain of pollen must fall on the silk strand and then journey to the kernel site where fertilization takes place. When temperatures are uncommonly high, the silk strands quickly dry out and turn brown, unable to play their role in the fertilization process.

When it comes to rice, the effects of temperature on pollination have been studied in detail in the Philippines. Scientists there report that the pollination of rice falls from 100 percent at 93 degrees Fahrenheit (34 degrees Celsius) to near zero at 104 degrees, leading to crop failure.[4]

High temperatures can also dehydrate plants. When a

corn plant curls its leaves to reduce exposure to the sun, photosynthesis is reduced. And when the stomata on the underside of the leaves close to reduce moisture loss, carbon dioxide (CO_2) intake is also reduced, further restricting photosynthesis. At elevated temperatures, the corn plant, which under ideal conditions is so extraordinarily productive, goes into thermal shock.

In a study of local ecosystem sustainability, Mohan Wali and his colleagues at Ohio State University noted that as temperature rises, photosynthetic activity in plants increases until the temperature reaches 68 degrees Fahrenheit. The rate of photosynthesis then plateaus until the temperature reaches 95 degrees Fahrenheit. Beyond this point it declines, until at 104 degrees Fahrenheit, photosynthesis ceases entirely.[5]

All of these changes affect crop yields. Crop ecologists in several countries have been focusing on the precise relationship between temperature and crop yields. Their findings suggest a rule of thumb that a 1-degree-Celsius rise in temperature above the norm during the growing season lowers wheat, rice, and corn yields by 10 percent. Some of the most comprehensive research on this topic comes from the International Rice Research Institute in the Philippines. Crop yields from experimental field plots of irrigated rice dropped by 10 percent with a 1-degree-Celsius rise in temperature. The scientists concluded that "temperature increases due to global warming will make it increasingly difficult to feed Earth's growing population."[6]

Stanford University scientists David Lobell and Gregory Asner conducted an empirical analysis of the effect of temperature on U.S. corn and soybean yields. They found that higher temperatures during the growing season had an even greater effect on yields of these crops than many scientists had reckoned. Using data for 1982–98 from 618 counties for corn and 444 counties for soybeans, they concluded that for each 1-degree-Celsius rise in temperature, yields of each crop declined by 17 percent. This study suggests that the earlier rule of thumb that a 1-degree-Celsius rise in temperature would reduce yields by 10 percent could be conservative.[7]

The earth's rising temperature also affects crop yields indirectly via the melting of mountain glaciers. As the larger glaciers shrink and the smaller ones disappear, the ice melt that sustains rivers, and the irrigation systems dependent on them, will diminish. In early 2012, a release from the University of Zurich's World Glacier Monitoring Service indicated that 2010 was the twenty-first consecutive year of glacier retreat. They also noted that glaciers are now melting at least twice as fast as a decade ago.[8]

Mountain glaciers are melting in the Andes, the Rocky Mountains, the Alps, and elsewhere, but nowhere does melting threaten world food security more than in the glaciers of the Himalayas and on the Tibetan Plateau that feed the major rivers of India and China. It is the ice melt that keeps these rivers flowing during the dry season. In the Indus, Ganges, Yellow, and Yangtze River basins, where irrigated agriculture depends heavily on rivers, the loss of glacial-fed, dry-season flow will shrink harvests and could create unmanageable food shortages.[9]

In China, which is even more dependent than India on river water for irrigation, the situation is particularly challenging. Chinese government data show that the glaciers on the Tibetan Plateau that feed the Yellow and Yangtze Rivers are melting at a torrid pace. The Yellow River, whose basin is home to 153 million people, could experience a large dry-season flow reduction. The Yangtze River, by far the larger of the two, is threatened by the disappearance of glaciers as well. The basin's 586 million people rely heavily on rice from fields irrigated with its water.[10]

Yao Tandong, one of China's leading glaciologists, predicts that two thirds of China's glaciers could be gone by 2060. "The full-scale glacier shrinkage in the plateau region," Yao says, "will eventually lead to an ecological catastrophe."[11]

The world has never faced such a predictably massive threat to food production as that posed by the melting mountain glaciers of Asia. China and India are the world's top two wheat producers, and they also totally dominate the rice harvest.[12]

Agriculture in the Central Asian countries of Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan depends heavily on snowmelt from the Hindu Kush, Pamir, and Tien Shan mountain ranges for irrigation water. Nearby Iran gets much of its water from the snowmelt in the 18,000-foot-high Alborz Mountains between Tehran and the Caspian Sea. The glaciers in these ranges also appear vulnerable to rising temperatures.[13]

In the Andes, a number of small glaciers have already disappeared, such as the Chacaltaya in Bolivia and Cotacachi in Ecuador. Within a couple of decades, numerous other glaciers are expected to follow suit, disrupting local hydrological patterns and agriculture. For places that rely on glacial melt for household and irrigation use, this is not good news.[14]

Peru, which stretches some 1,100 miles along the vast Andean mountain range and is the site of 70 percent of the earth's tropical glaciers, is in trouble. Its glaciers, which feed the many Peruvian rivers that supply water to the cities in the semiarid coastal regions, have lost 22 percent of their area. Ohio State University glaciologist Lonnie Thompson reported in 2007 that the Quelccaya Glacier in southern Peru, which was retreating by 6 meters per year in the 1960s, was by then retreating by 60 meters annually. In an interview with *Science News* in early 2009, he said, "It's now retreating up the mountainside by about

18 inches a day, which means you can almost sit there and watch it lose ground."[15]

Many of Peru's farmers irrigate their wheat, rice, and potatoes with the river water from these disappearing glaciers. During the dry season, farmers are totally dependent on irrigation water. For Peru's 30 million people, shrinking glaciers could mean shrinking harvests.[16]

Throughout the Andean region, climate change is contributing to water scarcity. Barbara Fraser writes in *The Daily Climate* that "experts predict that climate change will exacerbate water scarcity, increasing conflicts between competing users, pitting city dwellers against rural residents, people in dry lands against those in areas with abundant rainfall and Andean mining companies against neighboring farm communities."[17]

In the southwestern United States, the Colorado River—the region's primary source of irrigation water—depends on snowfields in the Rockies for much of its flow. California, in addition to depending heavily on the Colorado, relies on snowmelt from the Sierra Nevada range in the eastern part of the state. Both the Sierra Nevada and the coastal range supply irrigation water to California's Central Valley, the country's fruit and vegetable basket.[18]

With the continued heavy burning of fossil fuels, global climate models project a 70-percent reduction in the amount of snow pack for the western United States by mid-century. The Pacific Northwest National Laboratory of the U.S. Department of Energy did a detailed study of the Yakima River Valley, a vast fruit-growing region in Washington State. It projected progressively heavier harvest losses as the snow pack shrinks, reducing irrigation water flows.[19]

Even as the melting of glaciers threatens dry-season river flows, the melting of mountain glaciers and of the Greenland and Antarctic ice sheets is raising sea level and thus threatening the rice-growing river deltas of Asia. If the Greenland ice sheet were to melt entirely, it would raise sea level 23 feet. The latest projections show sea level rising by up to 6 feet during this century. Such a rise would sharply reduce the rice harvest in Asia, home to over half the world's people. Even half that rise would inundate half the riceland in Bangladesh, a country of 152 million people, and would submerge a large part of the Mekong Delta, a region that produces half of Viet Nam's rice, leaving the many countries that import rice from it looking elsewhere.[20]

In addition to the Gangetic and Mekong Deltas, numerous other rice-growing river deltas in Asia would be submerged in varying degrees by a 6-foot rise in sea level. It is not intuitively obvious that ice melting on a large island in the far North Atlantic could shrink the rice harvest in Asia, but it is true.[21]

Scientists also expect higher temperatures to bring more drought—witness the dramatic increase in the land area affected by drought in recent decades. A team of scientists at the National Center for Atmospheric Research in the United States reported that the earth's land area experiencing very dry conditions expanded from well below 20 percent from the 1950s to the 1970s to closer to 25 percent in recent years. The scientists attributed most of the change to a rise in temperature and the remainder to reduced precipitation. The drying was concentrated in the Mediterranean region, East and South Asia, mid-latitude Canada, Africa, and eastern Australia.[22]

A 2009 report published by the U.S. National Academy of Sciences reinforced these findings. It concluded that if atmospheric CO_2 climbs from the current level of 391 parts per million (ppm) to above 450 ppm, the world will face irreversible dry-season rainfall reductions in several regions. The study likened the conditions to those of the U.S. Dust Bowl era of the 1930s. Physicist Joe Romm, drawing on recent climate research, reports that "levels of aridity comparable to those in the Dust Bowl could stretch from Kansas to California by mid-century."[23]

Rising temperatures also fuel wildfires. Anthony Westerling of Scripps Institution and colleagues found that the average wildfire season in the western United States has lengthened by 78 days from the period 1970–86 to 1987–2003 as temperatures increased an average 1.6 degrees Fahrenheit. Looking forward, researchers with the U.S. Department of Agriculture's Forest Service drew on 85 years of fire and temperature records to project that a 2.9-degree-Fahrenheit rise in summer temperature could double the area of wildfires in the 11 western states.[24]

In addition to more widespread drought and more numerous wildfires, climate change brings more extreme heat waves. One of the most destructive of these came in the U.S. Midwest in 1988. Combined with drought, as most heat waves are, this one dropped the U.S. grain harvest from an annual average of 324 million tons in the preceding years to 204 million tons. Fortunately, the United States—the world's dominant grain supplier—had substantial stocks at that time that it could draw upon, allowing it to meet its export commitments. If such a drop were to occur today, when grain stocks are seriously depleted, there would be panic in the world grain market.[25]

Another extreme heat wave came in Western Europe in the late summer of 2003. It claimed some 52,000 lives. France and Italy were hit hardest. And London experienced its first 100-degree-Fahrenheit temperature reading in its history. Fortunately the wheat crop was largely harvested when this late-summer heat wave began, so the losses in that sector were modest.[26]

In the summer of 2010, Russia experienced an extraordinary heat wave unlike anything it had seen before. The

July temperature in Moscow averaged a staggering 14 degrees Fahrenheit above the norm. High temperatures sparked wildfires, which caused an estimated $300 billion worth of damage to the country's forests. In addition to claiming nearly 56,000 lives, this heat wave reduced the Russian grain harvest from nearly 100 million tons to 60 million tons. Russia, which had been an exporting country, suddenly banned exports.[27]

Close on the heels of these unprecedented high temperatures in Russia was the 2011 heat wave in Texas, a leading U.S. agricultural state. In Dallas, located in the Texas heartland, the average temperature reached 100 degrees Fahrenheit for 40 consecutive days, shattering all records. It also forced many farmers into bankruptcy. More than a million acres of crops were never harvested. Many ranchers in this leading cattle-producing state had to sell their herds. They had no forage, no water, and no choice. The heat and drought in Texas broke almost all records in the state's history for both intensity and duration. Agricultural damage was estimated to exceed $7 billion.[28]

As the earth's temperature rises, scientists expect heat waves to be both more frequent and more intense. Stated otherwise, crop-shrinking heat waves will now become part of the agricultural landscape. Among other things, this means that the world should increase its carryover stocks of grain to provide adequate food security.[29]

The continuing loss of mountain glaciers and the resulting reduced meltwater runoff could create unprecedented water shortages and political instability in some of the world's more densely populated countries. China, already struggling to contain food price inflation, could well see spreading social unrest if food supplies tighten.[30]

For Americans, the melting of the glaciers on the Tibetan Plateau would appear to be China's problem. It is. But it is also a problem for the entire world. For low-income grain consumers, this melting poses a nightmare scenario. If China enters the world market for massive quantities of grain, as it has already done for soybeans over the last decade, it will necessarily come to the United States—far and away the leading grain exporter. The prospect of 1.35 billion Chinese with rapidly rising incomes competing for the U.S. grain harvest, and thus driving up food prices for all, is not an attractive one.[31]

In the 1970s, when tight world food supplies were generating unacceptable food price inflation in the United States, the government restricted grain exports. This is probably not an option today where China is concerned. Each month when the U.S. Treasury Department auctions off securities to cover the U.S. fiscal deficit, China is one of the big buyers. Now holding close to $1 trillion of U.S. debt, China has become the banker for the United States. Like it or not, Americans will be sharing their grain harvest with Chinese consumers. The idea that shrinking glaciers on the Tibetan Plateau could one day drive up food prices at U.S. supermarket checkout counters is yet another sign of how integrated our global civilization has become.[32]

Data, endnotes, and additional resources can be found at Earth Policy Institute, www.earth-policy.org.