4

Rising Temperatures and Rising Seas

As the earth's temperature rises, it alters the entire climate system, affecting all life on earth. It brings more intense heat waves, more destructive storms, lower crop yields, ice melting, and rising seas, and it shrinks the snowfields and glaciers that feed so many of the world's rivers. Among the industries most affected are agriculture, insurance, and tourism.

Intense heat waves are taking a growing human toll. In 1995, 700 residents of Chicago died in a heat wave. In the summer of 1998, 100 Texans died in a prolonged heat spell. At about the same time, some 2,500 people died in a heat wave in India. In May 2002, in a heat wave in India that reached 50 degrees Celsius (122 degrees Fahrenheit), more than 1,000 people died in the state of Andhra Pradesh alone.[1]

Among the various manifestations of rising temperatures, ice melting, in particular, is drawing attention from scientists. They are particularly concerned because of the effect on sea level. Rising seas that encroach on a continent and shrink the habitable land area while population is growing can only exacerbate an already difficult problem.

More frequent and more destructive storms are now a matter of record. The insurance industry is painfully aware of the relationship between higher temperatures and storm intensity. The last few years have brought a flurry of lowered credit ratings, both for insurance companies and the reinsurance companies that back them up by spreading their risks.

Numerous industries are affected, including many smaller ones. For example, as mountain snow cover shrinks, the ski industry also shrinks, losing revenue and jobs. In the United States, the ski industry has launched its own campaign to reduce carbon emissions by buying wind-generated electricity to operate ski lifts. Industry leaders call their campaign "Keep Winter Cool."[2]

The Temperature Record

Scientists at NASA's Goddard Institute for Space Studies gather data from a global network of some 800 climate-monitoring stations to measure changes in the earth's average temperature. Their temperature records go back 123 years, to 1880.[3]

From 1880 to 1930, the global temperature for almost every year was below the norm (which scientists define as the average from 1950 to 1980). During the 1930s, the first decade when there were several years above the norm, this pattern began to change. It brought record temperatures and drought to the U.S. Great Plains, helping to create the Dust Bowl.[4]

Beginning in 1977, the temperature began to climb and it has been above the norm each year since then. During the 1980s, the average global temperature was 0.26 degrees Celsius above; during the 1990s, it averaged 0.40 degrees above the norm. And during the first three years of the new century, the average temperature has been 0.55 degrees above the norm. If the accelerating rise continues, the jump in this decade will substantially exceed that of each of the preceding ones.[5]

Meteorologists note that the 16 warmest years on record have come since 1980. And since the three warmest years on record have come in the last five years, not only is the earth's temperature rising, but the rise is accelerating. (See Figure 4–1.) Against this backdrop of record increases, the projections of the Intergovernmental Panel on Climate Change (IPCC) that the earth's average temperature will rise 1.4–5.8 degrees Celsius (2.5–10.4 degrees Fahrenheit) during the current century seem all too possible. The IPCC upper-end projected increase of 5.8 degrees Celsius during this century is comparable to the change registered between the last Ice Age and today. Whether the world's temperature trend is more likely to follow the lower or the upper projection, no one knows. But given the recent acceleration in the rise, we may now be on a trajectory that is much closer to the upper end of the range.[6]

At a practical level, the projected rise in temperature of 1.4–5.8 degrees Celsius is a global average. In reality,

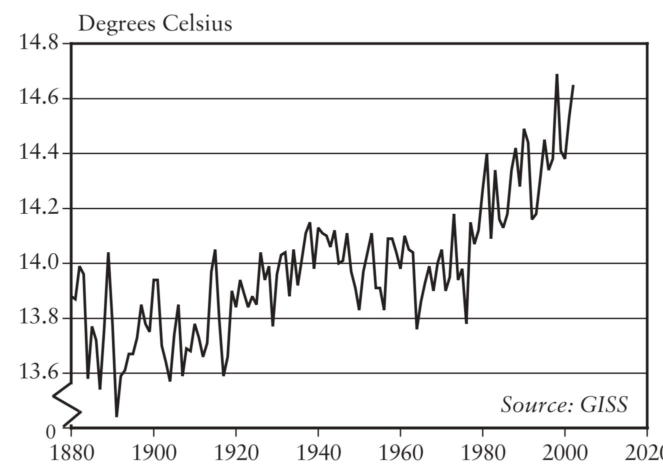

Figure 4–1. *Average Global Temperature, 1880–2002*

the rise will be very uneven. It will be much greater over land than over oceans, in the higher latitudes than over the equator, in the continental interior than in coastal regions. James J. McCarthy, Harvard professor of biological oceanography and co-chair of an IPCC working group, notes that while global average temperature rose roughly 1 degree Fahrenheit during the century that just ended, on Alaska's north slope and in northwestern Canada it rose by 4–7 degrees Fahrenheit (2.2–3.9 degrees Celsius), several times the global average.[7]

The Yield Effect

Among the leading economic trends most sensitive to this warming are crop yields. Crops in many countries are grown at or near their thermal optimum, making them vulnerable to any rise in temperature. Even a minor increase—1 or 2 degrees Celsius—during the growing season can reduce the grain harvest in major food-producing regions, such as the North China Plain, the Gangetic plain of India, or the Corn Belt of the United States.[8]

As noted in Chapter 1, higher temperatures can halt photosynthesis, prevent fertilization, and lead to dehydration. Although the elevated concentrations of atmospheric carbon dioxide (CO_2) that raise temperature can also raise crop yields (absent other constraints, such as soil moisture and nutrient availability), the detrimental effect of higher temperatures on yields appears to be overriding the CO_2 fertilization effect for the major crops.

In a study of local ecosystem sustainability, Mohan Wali and his colleagues at Ohio State University note that as temperature rises, photosynthetic activity increases until the temperature reaches 20 degrees Celsius (68 degrees Fahrenheit). The rate of photosynthesis then plateaus until the temperature hits 35 degrees Celsius (95 degrees Fahrenheit), whereupon it begins to decline, until

at 40 degrees Celsius (104 degrees Fahrenheit), it ceases entirely. At this temperature, the plant is in thermal shock, simply trying to survive.[9]

The most vulnerable part of the plant's life cycle is the period when fertilization occurs. Each of the three food staples—rice, wheat, and corn—is vulnerable at this stage of development. 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 of corn. 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, much as an unfertilized egg moves along the fallopian tube. When temperatures are uncommonly high, the silk strands dry out and quickly turn brown, unable to play their role in the fertilization process.

The effects of temperature on rice fertility have been studied in detail by scientists at the International Rice Research Institute in the Philippines. They report that the fertility of rice falls from 100 percent at 34 degrees Celsius (93 degrees Fahrenheit) to near zero at 40 degrees Celsius, leading to crop failure.[10]

Higher temperatures can also lead to dehydration. While it may take a team of scientists to understand the effects of temperature on the fertilization of the rice plant, anyone can tell when a corn field is suffering from heat stress and dehydration. 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, CO_2 intake is reduced, thereby restricting photosynthesis. The corn plant, which under ideal conditions is so extraordinarily productive, is highly vulnerable to thermal stress.

K. S. Kavi Kumar of the Madras School of Economics and Jyoti Parikh of the Indira Gandhi Institute of Development Research assessed the effect of higher temperatures on wheat and rice yields in India. Basing their model on data from 10 sites, they concluded that in north India a 1-degree Celsius rise in mean temperature did not meaningfully reduce wheat yields, but a 2-degree rise lowered yields at almost all of the sites. When they looked at temperature change alone, a 2-degree Celsius rise led to a decline in irrigated wheat yields ranging from 37 percent to 58 percent. When they incorporated the negative effects of a higher temperature with the positive effects of CO_2 fertilization, the decline in yields among the various sites ranged from 8 percent to 38 percent.[11]

The decline in rice yields was remarkably similar. A separate study in the South Indian state of Kerala, looking at the effect of temperature on rice yields, concluded that for each 1-degree Celsius rise in temperature, rice yields declined 6 percent. These studies are disturbingly relevant given the projected average temperature rise in India of 2.3–4.8 degrees Celsius following the doubling of atmospheric CO_2 over pre-industrial levels.[12]

As rising temperatures become a reality and as the effect of temperature on crop yields becomes clearer, agricultural scientists are becoming concerned. John Sheehy, a crop ecologist and leading researcher on the effects of climate change on crops, offers a scientific rule of thumb for assessing the effect of higher temperature on the yield of rice plants: "For every 1 degree Celsius increase in temperature between 30 and 40 degrees Celsius during flowering, fertility decreases by 10 percent." At 40 degrees, fertility drops to near zero. L. H. Allen, Jr., one of the scientists who is analyzing the temperature-yield relationship at the U.S. Department of Agriculture, concludes that each rise of 2 degrees Fahrenheit (1.1 degrees Celsius) above ideal levels reduces yield by 10 percent.[13]

A recent study by a team of U.S. scientists at the Carnegie Institution goes further. Based on U.S. corn and soybean yield data from more than 400 counties over the last 17 years, they report that a 1-degree Celsius rise in temperature during the June-August growing season reduces yields of both crops by 17 percent. This may help explain why the record U.S. average corn yield—8.7 tons per hectare in 1994—has not been matched during the eight years since then.[14]

With the global average temperature for 2002 at a near-record high, it is not surprising that the 2002 harvest in several countries suffered from high temperatures. As the temperature climbs, more countries are likely to suffer crop-withering heat waves. The May 2002 heat wave in India that claimed more than 1,000 lives in Andhra Pradesh also stressed crops. So, too, did the heat wave in neighboring Pakistan.[15]

In the United States, intense heat in 2002, particularly in the Great Plains states—often 38 degrees Celsius (100 degrees Fahrenheit) or higher—took its toll on the grain harvest. These near-record temperatures at times extended northward into the Great Plains of Canada during the summer, exacerbating drought there and shrinking the wheat harvest. The higher latitudes and continental interiors where the projected temperature rise is to be greatest neatly defines the North American breadbasket—the Great Plains of the United States and Canada and the U.S. Corn Belt.[16]

The North China Plain, China's principal food-producing region, also suffered from high temperatures in 2002. Even in September, temperatures were soaring into the mid-30s and above. Such high temperatures not only stress crops, they also increase soil moisture evaporation, raising the demand for irrigation water.[17]

Plant breeders will undoubtedly be able to develop crop strains that are more heat-resistant, but it is doubtful that they can fully offset the effects of rising temperature. And thus far biotechnology has not had any major success in this strategically important area of plant breeding.

If we permit atmospheric CO_2 levels to continue rising at recent rates, we will be headed for a world far warmer than any since agriculture began some 11,000 years ago—a world in which farmers will be struggling to adjust to an ever-changing climate. They must think about changing to not only new varieties, as they have always done to boost production, but also to new crops in order to adapt to the changing climate. And virtually all the world's farmers will have to change their farming practices, keeping in mind this is not just a one-time adjustment but a continuing change and a guessing game as to whether shifts are aberrations or a lasting change in the local climate. In the past, farmers could deal with aberrations because they knew that sooner or later conditions would return to normal, but now there is no "normal" to return to.

What changes in cropping patterns lie ahead as the earth becomes warmer? Will the decline in production of drought-tolerant crops, such as sorghum and millet, over the last several decades be reversed as they replace wheat in human diets and in rations for livestock and poultry? Will rice give way to more water-efficient wheat in our diets? Will water shortages lead to wheat eventually edging out rice as the dominant food staple in both India and China?

Another response will be to move agriculture northward into Canada and Siberia. Unfortunately, the soils in these regions are not particularly fertile. There is, for example, a world of difference between the deep fertile soils south of the Great Lakes and those north of them.

The U.S. Corn Belt is the world's most productive agricultural region, whereas the thin glaciated soils north of the Great Lakes are far less productive. Despite its vast land area, Canada produces less grain than France does. It is a leading exporter only because its population is so small relative to its vast land area.[18]

Temperature rises in some areas could easily be double the global average. In other areas, there might be little or no change. Such is the world of uncertainty now facing the world's farmers.[19]

Reservoirs in the Sky

Snow/ice masses in mountains are nature's freshwater reservoirs. These "reservoirs in the sky" are nature's way of storing water to feed rivers during the summer dry season. Agriculture is heavily dependent on these snow/ice masses, which are a major source of water for irrigated farming. Now they are being threatened by the rise in temperature.

In some agricultural regions, snowmelt is the leading source of irrigation water. These regions include the southwestern United States, where the Colorado River, the 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, also relies on snowmelt from the Sierra Nevada in the eastern part of the state. Both the Sierra Nevada and the coastal range supply irrigation water to California's Central Valley, the world's fruit and vegetable basket.

Preliminary results of an analysis of the effects of rising temperature on three major river systems in the western United States—the Columbia, the Sacramento, and the Colorado—indicate that the winter snow pack in the mountains feeding them will be dramatically reduced and that winter rainfall and flooding will increase accordingly. John Krist, who writes for California's *Ventura County Star*, says that this "will mean less water flowing into reservoirs from snowmelt during dry months but more pouring in during flood-prone winter months when there is no room to store it." Many of the world's river irrigation systems are plagued with the same prospect.[20]

In Central Asia, the agriculture in several former Soviet republics depends heavily on snowmelt from the Hindu Kush mountain range. Among these are Uzbekistan, Turkmenistan, Kyrgyzstan, Kazakhstan, and Tajikistan. Afghanistan also depends on the Hindu Kush. Iran gets much of its water from the snowmelt in the 6,000-meter Elburz Mountains between Tehran and the Caspian Sea.

Largest of all in world food terms is the snow/ice mass in the Himalayas. Every major river in Asia originates in the Himalayas, including the Indus, the Ganges, the Mekong, the Yangtze, and the Yellow. If rainfall in the Himalayas increases and snowfall decreases, the seasonal flow of these rivers will change, leading to more flooding during the rainy season and less snowmelt to feed rivers during the dry season.[21]

This melting's impact on the Yellow River will affect China's wheat harvest, the largest in the world. Alterations in the flow of the Yangtze River will directly affect China's rice harvest—also the world's largest. And India's wheat harvest, which is second only to China's, will be affected by the flows of both the Indus and the Ganges. Anything that alters the seasonal flow of the Mekong will reduce the rice harvest of Viet Nam, a leading source of rice for importing countries.[22]

There are many more mountain ranges where the snow/ice cover is melting, including the Alps and the Andes. The snow/ice masses in the world's leading mountain ranges and the water they store as ice and snow has been taken for granted simply because it has always been there. Now that is changing. If we continue burning fossil fuels and raising the earth's temperature, we risk losing these reservoirs in the sky.

Melting Ice and Rising Seas

In its landmark third edition report released in early 2001, the IPCC projected that sea level would rise during this century 0.09–0.88 meters (4–35 inches) as a result of thermal expansion and ice melting. New studies released during the two years since then indicate that the earth's ice cover is melting much faster than IPCC scientists assumed.[23]

A 2002 study by two scientists from the University of Colorado's Institute of Arctic and Alpine Research shows that the melting of large glaciers on the west coast of Alaska and in northern Canada is accelerating. Earlier data had indicated that the melting was raising sea level by 0.14 millimeters per year, but new data for the 1990s indicate that the more rapid melting is now raising sea level by 0.32 millimeters a year—more than twice as fast.[24]

The Colorado study is reinforced by a U.S. Geological Survey (USGS) study that indicates glaciers are now shrinking in all 11 of Alaska's glaciated mountain ranges. An earlier USGS study reported that the number of glaciers in Glacier National Park in the United States had dwindled from 150 in 1850 to fewer than 50 today. The remaining glaciers are projected to disappear within 30 years.[25]

Another team of USGS scientists, which used satellite data to measure changes in the area covered by glaciers worldwide, describes an accelerated melting of glaciers in several mountainous regions, including the South American Andes, the Swiss Alps, and the French and Spanish Pyrenees.[26]

The melting of glaciers is gaining momentum throughout the Andes. Lonnie Thompson of Ohio State University reports that the Qori Kalis glacier, which is located on the west side of the Quelccaya ice cap in the Peruvian Andes, shrank three times as fast each year from 1998 to 2000 as it did between 1995 and 1998. And the earlier rate, in turn, was nearly double the annual rate of retreat from 1993 to 1995. Thompson also projects that the large Quelccaya ice cap will disappear entirely between 2010 and 2020. The Antisana glacier in Ecuador, which supplies half of the water for Quito, has retreated nearly 100 meters in the last eight years.[27]

Bernard Francou, research director for the French government's Institute of Research and Development, believes that within the next 15 years, 80 percent of South American glaciers will disappear. For countries like Bolivia, Peru, and Ecuador, which rely on glaciers for water for household and irrigation use, this is not good news.[28]

Lonnie Thompson's studies of Kilimanjaro show that between 1989 and 2000, Africa's tallest mountain lost 33 percent of its ice field. He projects that its snowcap could disappear entirely within the next 15 years.[29]

The vast snow/ice mass in the Himalayas is also retreating. Although data are not widely available, those glaciers that have been studied indicate an accelerating retreat. As one example, representatives of the major mountaineering association, The Union Internationale des Associations d'Alpinisme, report that the glacier that ended at the base camp from which Edmund Hillary and Tenzing Norgay launched their history-making ascent of Everest in 1953 has retreated about 5 kilometers (3 miles). Geologist Jeffrey Kargel, who studies the Himalayas, is not surprised by this. "That fits in with the general picture of what's happening in Nepal, India, Bhutan and, to a smaller extent, Tibet," he says.[30]

Both the North and the South Poles are showing the

effects of rising temperature. While the South Pole is covered by a huge continent, the North Pole is covered by the Arctic Ocean. A flurry of papers presented at the annual conference of the American Geophysical Union (AGU) in December 2002 reported dramatic advances in ice melting. They noted that in summer 2002 the Arctic Ocean ice cover had shrunk to the smallest area seen since 1978, when detailed studies began. Mark Serreze of the National Snow and Ice Data Center in Boulder, Colorado, reported that this was the most abrupt change in the ocean's ice cover that scientists have seen during the 24 years they have been monitoring it.[31]

In addition to shrinking, the Arctic sea ice has thinned by 42 percent over the last 35 years—from an average of 3.1 meters to 1.8 meters. The combination of the shrinking and thinning has reduced the mass of sea ice by half. A team of Norwegian scientists projects that the Arctic Sea could be entirely ice-free during the summer within a matter of decades.[32]

If that happens, it would not affect sea level because the ice is already in the water. But it would alter the Arctic heat balance. When sunlight strikes ice and snow, roughly 80 percent of the light is reflected back into space and 20 percent is absorbed as heat. If, however, sunlight strikes land or open water, only 20 percent is bounced back into space and 80 percent is converted into heat, leading to higher temperatures. This is an example of a positive feedback loop, a situation in which a trend feeds on itself.[33]

The melting of Greenland's ice sheet is a different matter. Another report delivered at the AGU conference—this one by Konrad Steffen, a glaciologist at the University of Colorado—indicated that the ice cover on Greenland is also melting much faster over a 686,000-square-kilometer area (roughly a third of the total area) than at any time on record. Steffen described how he and his colleagues, who were camped on the normally frozen Greenland ice, were flooded under a foot of meltwater and had to be rescued by helicopter.[34]

The prospect of much warmer Arctic summers is of concern because Greenland, which is three times the size of Texas, lies partly within the Arctic Circle. An article in *Science* reports that if the entire ice sheet on this huge island were to melt, it would raise sea level 7 meters (23 feet). Such a melting, even under the most rapid warming scenario, would be measured in centuries, not years. Nonetheless, if the Greenland ice sheet does disappear, hundreds of coastal cities will be below sea level, as will the rice-growing river floodplains and deltas of Asia. Many island countries will cease to exist.[35]

At the other end of the earth, the Antarctic ice sheet, which covers a continent the size of the United States and is 2.6 kilometers (1.6 miles) thick on average, contains over 90 percent of the world's fresh water. The immediate concern here is not the ice that covers the continent but the ice shelves that extend from the continent into the surrounding seas, which are beginning to break up at an alarming pace.[36]

The ice shelves surrounding Antarctica are formed by the flow of glaciers from the continent to lower levels. This flow of ice, fed by the continuous formation of new ice on land and culminating in the breakup of the shelves on the outer fringe and the calving of icebergs, is not new. What is new is the pace of this process. When Larsen A, a huge ice shelf on the east coast of the Antarctic Peninsula, broke up in 1995, it was a signal that all was not well in Antarctica. In 2000, a huge iceberg nearly the size of Connecticut—11,000 square kilometers, or 4,250 square miles—broke off the Ross Ice Shelf.[37]

After Larsen A broke up, it was only a matter of time,

given the rise in temperature in the region, before Larsen B would do the same. In November 2001, an alert went out to the scientific community from a researcher at the Instituto Antártico Argentino, who noted the unusually warm spring temperature and the 20-percent acceleration in the flow of the ice shelf. So when the northern part of the Larsen B ice shelf collapsed into the sea in March 2002, it did not come as a surprise. At about the same time, a huge chunk of ice broke off the Thwaite Glacier. Covering 5,500 square kilometers, this iceberg was the size of Rhode Island.[38]

Even veteran ice watchers are surprised at how quickly the disintegration is occurring. "The speed of it is staggering," said Dr. David Vaughan, a glaciologist at the British Antarctic Survey, which has been monitoring the Larsen Ice Shelf closely. Along the Antarctic Peninsula, in the vicinity of the Larsen ice shelf, the average temperature has risen 2.5 degrees Celsius over the last five decades. Higher temperatures lead to ice melting on the surface of the ice shelves. Scientists theorize that as the melted water on the surface penetrates fractures it weakens the ice, making it vulnerable to further fracturing.[39]

As the ice shelves, already in the water, break off from the continental ice mass, this does not affect sea level per se. What is of concern to scientists is that without the ice shelves to impede the flow of glacial ice, typically at a rate of 400–900 meters a year, the flow of ice from the continent could accelerate, leading to a thinning of the ice sheet on the edges of the Antarctic continent. If this were to happen, it would raise sea level. Dr. Neal Young of the Antarctic Cooperative Research Centre at the University of Tasmania in Australia notes that after Larsen A broke off, the upstream rate of glacial flow at least doubled.[40]

Experts now say it is getting harder to avoid the conclusion that there is a link between the buildup of greenhouse gases and the accelerating breakup of Antarctic ice shelves. As Dr. Theodore A. Scambos of the National Snow and Ice Data Center at the University of Colorado observes, “With the disappearance of ice shelves that have existed for thousands of years, you rather rapidly run out of other explanations.”[41]

The accelerated melting of ice, which is consistent with the accelerating rise in temperature that has occurred since 1980, is of great concern in low-lying regions of coastal countries and low-lying island countries. In 2000 the World Bank published a map showing that a 1-meter rise in sea level would inundate half of Bangladesh’s riceland. With a rise in sea level of up to 1 meter forecast for this century, tens of millions of Bangladeshis would be forced to migrate. In a country with 144 million people—already one of the most densely populated on earth—this would be a traumatic experience. Rice-growing river floodplains in other Asian countries would also be affected, including India, Thailand, Viet Nam, Indonesia, and China. With a 1-meter rise in sea level, more than a third of Shanghai would be under water. For China as a whole, 70 million people would be vulnerable to a 100-year storm surge.[42]

The most easily measured effect of rising sea level is the inundation of coastal areas. Donald F. Boesch, with the University of Maryland’s Center for Environmental Sciences, estimates that for each 1-meter rise in sea level, the shoreline will retreat by an average 1,500 meters, or nearly a mile. With such a rise, the United States would lose 36,000 square kilometers (14,000 square miles) of land—with the middle Atlantic and Mississippi Gulf states losing the most. Large portions of Lower Manhattan and the Mall in the center of Washington, D.C., would be flooded with seawater during a 50-year storm surge. New Orleans would be under water.[43]

Thermal expansion of the oceans and ice melting are raising sea level at a measurable rate. It has become an indicator to watch—a trend that could force a human migration of unimaginable dimensions. It also raises questions about responsibility to other nations and to future generations that humanity has never before faced.

More Destructive Storms

Rising seas are not the only threat. Higher temperatures in the surface water in the tropical oceans mean more energy radiating into the atmosphere to drive storm systems, leading to more frequent, more destructive storms. The combination of rising seas, more powerful storms, and stronger storm surges can be devastating. Such a combination would wreck havoc with low-lying coastal cities, such as Shanghai and New Orleans.

In the fall of 1998, Hurricane Mitch—one of the most powerful storms ever to come out of the Atlantic, with winds approaching 200 miles per hour—hit the east coast of Central America. As atmospheric conditions stalled the normal progression of the storm to the north, some 2 meters of rain were dumped on parts of Honduras and Nicaragua within a few days. The deluge collapsed homes, factories, and schools, leaving them in ruins. It destroyed roads and bridges. Seventy percent of the crops and much of the topsoil in Honduras were washed away—topsoil that had accumulated over long stretches of geological time. Huge mudslides destroyed villages, sometimes burying the entire population.[44]

The storm left 11,000 dead and thousands more missing. The basic infrastructure—the roads and bridges in Honduras and Nicaragua—was largely destroyed. President Flores of Honduras summed it up this way: “Overall, what was destroyed over several days took us 50 years to build.” The damage from this storm, exceeding the annual gross domestic product of the two countries, set their economic development back by 20 years.[45]

Munich Re, the world's largest reinsurer, a company that spreads risks among the insurance companies, is worried about the effects of climate change on the financial viability of the industry. It has published a list of storms with insured losses of $1 billion or more. The first such natural disaster came in 1983, when Hurricane Alicia struck the United States, racking up $1.3 billion in insured losses. Of the 34 natural catastrophes with $1 billion or more of insured losses recorded through the end of 2001, two were earthquakes; the other 32 were atmosphere-related—storms, floods, or hurricanes. During the 1980s, there were three such events. But during the 1990s, there were 25.[46]

The two largest events in terms of total damage were Hurricane Andrew in 1992, which took down 60,000 homes and racked up $30 billion worth of damage, and the flooding of China's Yangtze river basin in 1998, which also cost an estimated $30 billion. This sum is equal to the value of the harvest of China's two food staples, wheat and rice, combined. Part of this growth in damage is due to greater development in coastal areas and river floodplains. But part is due to more frequent, more destructive storms.[47]

The regions most vulnerable to more powerful storms are the Atlantic and Gulf coasts of the United States and the Caribbean and Central American countries. In Asia, it is East and Southeast Asia, including countries like the Philippines, Taiwan, Japan, China, and Viet Nam, that are likely to bear the brunt of the powerful storms crossing the Pacific. Further west in the Bay of Bengal, Bangladesh and the east coast of India are particularly vulnerable.

Western Europe, traditionally experiencing a heavily damaging winter storm perhaps once in a century, had its first winter storm to exceed a billion dollars in 1987—one that wreaked $3.7 billion in destruction, $3.1 billion of which was covered by insurance. Since then, it has had seven winter storms with insured losses ranging from $1.3 billion to $5.9 billion.[48]

Andrew Dlugolecki, a senior officer at the CGMU Insurance Group, the largest insurance company in the United Kingdom, notes that damage from atmospherically related events has increased by roughly 10 percent a year. "If such an increase were to continue indefinitely," he notes, "by 2065 storm damage would exceed the gross world product. The world obviously would face bankruptcy long before then." In the real world, few trends continue at a fixed rate over a period of several decades, but Dlugolecki's basic point is that climate change can be destructive, disruptive, and enormously costly.[49]

Insurance companies are convinced that with higher temperatures and more energy driving storm systems, future losses will be even greater. They are concerned about whether the industry can remain solvent under this onslaught of growing damages. So, too, is Moody's Investors Services, which in early 2002 downgraded the credit-worthiness of four of the world's leading reinsurance companies.[50]

Subsidizing Climate Change

At a time of mounting public concern about climate change driven by the burning of fossil fuels, the fossil fuel industry is still being subsidized by taxpayers to the tune of $210 billion per year. Fossil fuel subsidies belong to another age, a time when development of the oil and coal industries was seen as a key to economic progress—not as a threat to our future. Once in place, subsidies lead to special interest lobbies that fight tooth and nail against eliminating them, even those that were not appropriate in the first place.[51]

In the United States, oil and gas companies are now perhaps the most powerful lobbyists in Washington. Between 1990 and 2002, they amassed $154 million in campaign contributions in an effort to protect special tax rates worth billions. In testimony before the House Ways and Means Committee in 1999, Donald Lubick, U.S. Treasury Assistant Secretary for Tax Policy, said in reference to the oil and gas industry, "This is an industry that probably has a larger tax incentive relative to its size than any other industry in the country." That such profitable investments are possible is a measure of the corruption of the U.S. political system, and of the capacity of those with money to shape the economy to their advantage.[52]

Subsidies permeate and distort every corner of the global economy. Germany's coal mining subsidy was initially justified in part as a job protection measure, for example. At the peak, the government was subsidizing the industry to the tune of nearly $90,000 per year for each worker. In purely economic terms, it would have made more sense to close the mines and pay miners not to work.[53]

Many subsidies are largely hidden from taxpayers. This is especially true of the fossil fuel industry, which includes such things as a depletion allowance for oil production in the United States. Even more dramatic are the routine U.S. military expenditures to protect access to Middle Eastern oil, which are calculated by analysts at the Rand Corporation to fall between $30 billion and $60 billion a year, while the oil imported from the region is worth only $20 billion.[54]

A 2001 study by Redefining Progress shows U.S. taxpayers subsidizing automobile use at $257 billion a year, or roughly $2,000 per taxpayer. This means that taxpayers who do not own automobiles, including those too poor to afford them, are subsidizing those who do.[55]

Another hidden subsidy is that provided in the form of free parking for employees, including even those who work for government agencies. Free parking encourages the use of automobiles and thus the use of gasoline. It is a form of income, but it is not taxed.[56]

One of the bright spots about this subsidization of fossil fuels is that it provides a reservoir of funding that can be diverted to climate-benign, renewable sources of energy, such as wind, solar, and geothermal energy. Shifting these subsidies from fossil fuels to the development of renewable sources would be a win-win situation, as described in Chapter 11. To subsidize the use of fossil fuels is to subsidize rising temperatures, which lead to crop-withering heat waves, melting ice, rising seas, and more destructive storms. Perhaps it is time for the world's taxpayers to ask if this is how they want their tax monies to be used.