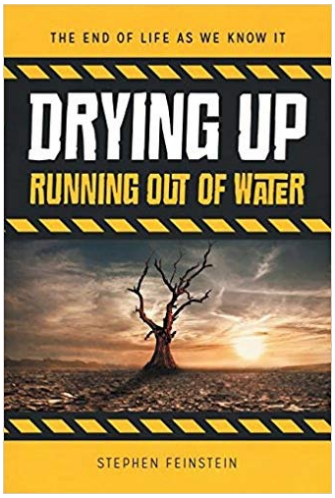


Feinstein, S. (2016). *Drying up: running out of water*. New York: Enslow Publishing.

CHAPTER 2

TOO MANY PEOPLE, NOT ENOUGH WATER

IN 1804 THE NUMBER OF HUMANS INHABITING THE earth reached one billion. It had taken many thousands of years for the world's human population to grow this large. The rate of population growth then began to dramatically increase. By 1927, the world's population had reached two billion. Then, in fewer than fifty years, the population doubled again to four billion in 1975. According to the United Nations (UN), the population of the world reached seven billion in October 2011. The UN estimates that by 2050, the global population will be between eight and eleven billion and could reach fifteen billion by the end of the twenty-first century.

Think about the effects this enormous population will have on the earth's resources. What about freshwater, the most essential resource? Will there be enough of it to go around? Unfortunately, the amount of freshwater is not going to increase. Indeed, billions of people, depending on where they live, already lack access to clean freshwater. And

The Atacama Desert in Chile is one of the driest places on Earth. Scientists have found a way to capture the moisture from fog to help increase the water supply.

water scarcity will continue to be a challenge, often in areas where the greatest numbers of people live. Unequal distribution of rainfall already creates problems. And global warming will disrupt climate patterns, sometimes with destructive results including catastrophic floods in some places and severe and prolonged droughts in others. How will humans survive if there is not enough water to meet the needs of a growing world population?

FOG CATCHERS OF THE ATACAMA DESERT

Imagine what it would be like to live in one of the driest places on Earth. The Atacama Desert, situated on the coast of northern Chile, is just such a place. It hardly ever rains there. Indeed, it is said that in some parts of

this desert it has never rained. But fogs roll in regularly from the cold offshore current of the Pacific Ocean. Residents of the isolated towns along the coast, who rely on fishing for their survival, call the thick, moist fog the *camanchaca*, or creeping fog.

For centuries, people observed how local plants collected tiny water droplets in the fog. In the 1960s, Chilean scientists came up with a way to tap this water source. They invented a system of fog-catchers which are volleyball-style nets that stand upright on the hilltops. As the wind drives the fog through the nets, tiny droplets of water get trapped in the nets' plastic mesh. The droplets then form large drops that run down into a trough that flows to the town below.

In the late 1980s, the Chileans set up their first fog-catching project in the town of Chungungo. Previously, water for the town had to be trucked in from fifty miles away, and the town was dying. The fog-catchers provided the town an average of four thousand gallons of water a day.[1] With a secure water supply, people began to return to Chungungo. Today, fog-catching systems have been set up in many other communities along the Pacific coast of South America.

THE WRONG AMOUNTS OF WATER IN THE WRONG PLACES

According to science writer Marq de Villiers:

> The trouble with water—and there is trouble with water—is that they're not making any more of it. They're not making any less, mind, but no more either. There is the same amount of water on the planet now as there was in prehistoric times. People, however, they're making more of—many more, far

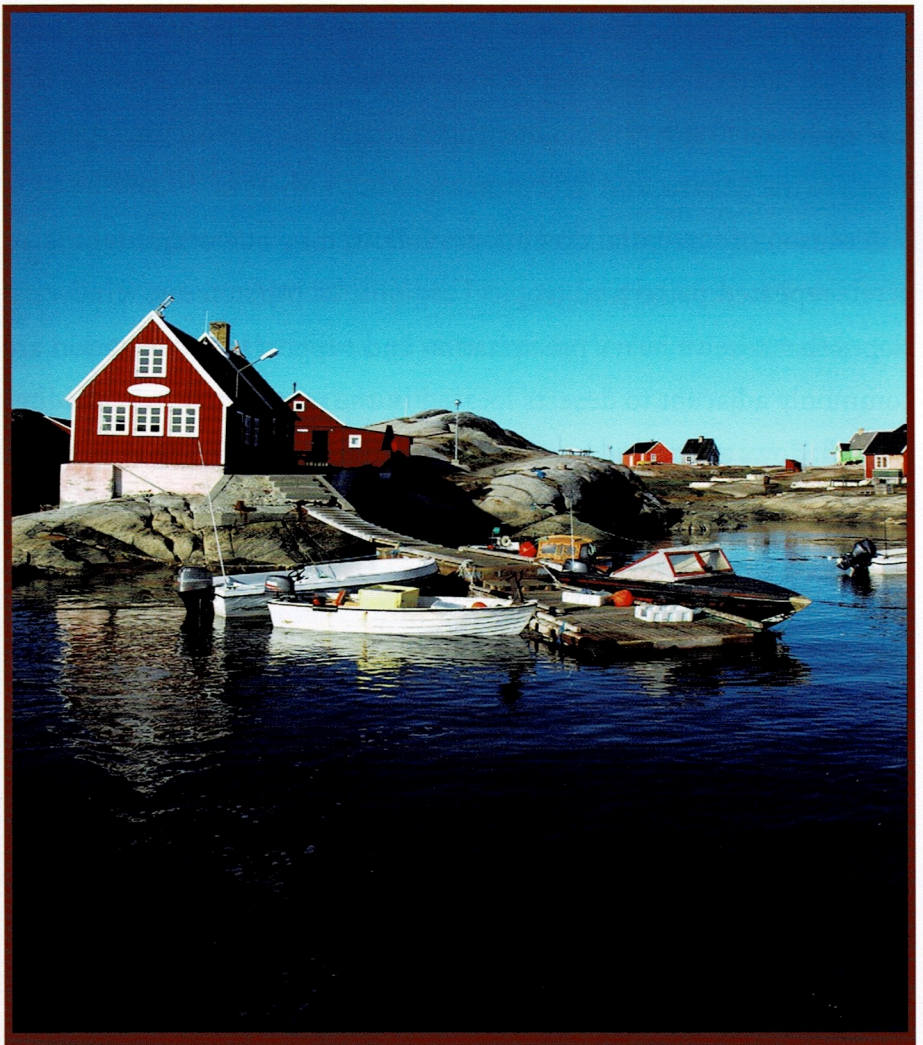
> more than is ecologically sensible—and all those people are utterly dependent on water for their lives (humans consist mostly of water), for their livelihoods, their food, and, increasingly, their industry. Humans can live for a month without food but will die in less than a week without water. Humans consume water, discard it, poison it, waste it, and restlessly change the hydrological cycles, indifferent to the consequences: too many people, too little water, water in the wrong places and in the wrong amounts. The human population is burgeoning, but water demand is increasing twice as fast.[2]

According to the United Nations Population Division, "The vast majority of population growth—95 percent—is occurring in developing countries. Africa has the highest growth rate of any region: 2.4 percent annually. Its population is expected to more than double by 2050, to 2.3 billion."[3]

Some scientists estimate that we will not have enough water to feed ourselves in twenty-five years' time. There will simply not be enough water available for agriculture. They base this on the growing scarcity of freshwater supplies in many parts of the world and on the increasing global population. More and more people will create ever greater demand for the available water.

In the American Southwest, the Colorado River is already under stress from the worst drought conditions in its recorded history. Huge numbers of people from the upper Midwest have been migrating to parched places such as Arizona and Nevada. This will only add to the crisis.

Unfortunately, precipitation and water resources are not uniformly distributed all over the globe. For example, China has less water than



The availability of water varies greatly around the globe. Places such as Greenland, seen here, have an abundance of freshwater to use, while many people in Africa and Asia have almost none.

Canada but forty times more people. Greenland has about eight million gallons of water available for each of its citizens each day.[4] At the other extreme, Kuwait has to make do with only eight gallons per citizen. And while Wadi Halfa, Sudan, gets less than 0.1 inches (0.25 cm) of rain a year, Quibdo, Colombia, gets an average of 354 inches (899 cm).[5]

Some parts of the world with the fastest growing populations—and therefore the greatest need for clean freshwater—have low annual rainfall and are prone to severe droughts. This is true in parts of Africa, especially south of the Sahara, and in certain areas of south Asia.

A season of torrential downpours followed by one of drought is an often-repeated pattern in tropical regions. In other areas, windward slopes that receive heavy precipitation and support lush vegetation are commonly adjacent to deserts located in the mountains' rain shadow. Rain shadows are caused because clouds drop most of their precipitation when they hit one side of the mountain range, and then the mountains act as a shield, which keeps the other side dry. These deserts may go years between rains and average only a few inches per year, which may come all at once during a cloudburst.

THE WORLD IS GETTING WARMER

Many scientists believe global warming will only add to the problem of water scarcity by increasing evaporation rates and decreasing snow packs. They say that certain areas can expect more severe and frequent storms accompanied by disastrous flooding. But in other places, global warming will increase the severity of droughts due to reduced rainfall.

Global warming, the overall warming of Earth, has accelerated due to human actions. Gases that exist naturally in Earth's atmosphere in the form of water vapor, carbon dioxide, methane, and other trace gases absorb radiation and trap heat in the atmosphere—much as the glass in a greenhouse traps heat, hence the name greenhouse gases. Greenhouse gases make Earth habitable for all forms of life. However, by burning fossil fuels, such as oil, gas, and coal, we have increased the greenhouse gases

in the upper atmosphere, thus disrupting Earth's energy balance (e.g., radiation coming in versus radiation going out). Burning of fossil fuels adds carbon dioxide to the atmosphere, which strengthens the greenhouse effect. Other greenhouse gases, including methane and nitrous oxide, have been building up in the atmosphere and are also contributing to global warming. Agricultural activities and the burning of fossil fuels are responsible for the increased methane. Agriculture and the chemical industry are sources of nitrous oxide.

Earth warmed by an average of 0.5°C (1°F) in the last century. Scientists predict that global temperatures could increase by as much as 4°C (7.2°F) in the twenty-first century. Nearly all scientists agree that global warming will bring about unpredictable changes in climate that will almost certainly result in unpleasant consequences in at least some parts of the world.

According to a study by the US Department of Agriculture (USDA) and the US Climate Change Science Program,

> Warming is very likely to continue in the United States during the next 25 to 50 years, regardless of reductions in greenhouse gas emissions, due to emissions that have already occurred. US ecosystems and natural resources are already being affected by climate system changes and variability.[6]

As ice melts in the polar regions, the sea level around the world will rise. This will inundate some islands and the low coastal areas of many continents. Rising sea levels may contaminate coastal aquifers with salt water. In the North Polar region, the area covered year-round by sea ice,

is diminishing each year at an alarming rate. Scientists believe that by 2016, the Arctic Ocean could be entirely free of ice during the summer months.[7] They also believe there is a link between Arctic sea ice loss and a weakening of the west-to-east jet stream wind. This will result in an increase in extreme weather events, including prolongation of droughts, flooding, cold spells, and heat waves.

Meanwhile, Greenland's massive ice sheet is also melting at a rapid rate. As the freshwater from Greenland's melting glaciers enters the ocean, scientists believe the major ocean current known as the Gulf Stream will be affected. The warm waters of the Gulf Stream flow north along the east coast of North America and then cross the Atlantic to Europe. As it circulates, the Gulf Stream warms the air above it and is responsible for keeping winter temperatures of the northeastern United States and the countries of northern Europe relatively mild. Greenland's melting ice sheet may cause the Gulf Stream current to either slow down or completely shut down. If this happens, the northeast United States and northern Europe will have much colder winters even though the rest of the planet is getting warmer.

On the other side of the globe, scientists believe that the ice of the vast West Antarctic Ice Sheet could disintegrate. This would cause sea levels around the world to rise an average of 10.83 feet (3.3 meters).[8] By 2015, scientists had observed that the disintegration of the ice sheet was already occurring. The Thwaites Glacier, which for thousands of years had held the massive ice sheet together, was starting to collapse. To the scientists, this meant that the West Antarctic Ice Sheet was ultimately doomed. Huge additional areas of melting ice were present in other large Antarctic ice sheets.[9]

Penguins on the Antarctic peninsula stand on a pile of rocks. NASA says the area is losing almost fifty billion tons of ice per year.

Global warming will bring drastic changes in climates around the globe. As the air temperatures rise, evaporation from the oceans will increase. This process will result in storms that are more destructive. In recent years, many parts of the world have been devastated by extremely severe weather events. In the United States, on August 29, 2005, Hurricane Katrina struck New Orleans with winds as high as 174 mph. Katrina caused catastrophic flooding in the city that resulted in the deaths of at least 1,833 people.

On October 29, 2012, Hurricane Sandy, also known as Superstorm Sandy, hit the East Coast. Hardest hit were New York City and coastal New Jersey. In New York City, lower Manhattan, the subways, parts of Brooklyn, and Staten Island were flooded from the intense storm surge. The southern

tip of Manhattan was under fourteen feet of water. Hundreds of homes were destroyed in New York and New Jersey. And at least 186 lives were lost, nearly half killed by drowning.

In May 2015, many parts of Texas were drowned in record-breaking torrential rains. Enough rain fell to cover the entire state to a depth of eight inches. According to the National Weather Service, 37.3 trillion gallons of water fell on Texas during that month.

Global warming could also bring about an 8 to 10 percent increase in the amount of water vapor in the atmosphere. That will cause an increase in levels of global rainfall. But these changes in the atmosphere will result in shifts in the paths of rain-producing weather systems. So rainfall patterns will change as rainfall is redistributed. Middle-latitude areas, such as the plains of the western United States, could become drier.[10]

The flows of water in individual rivers around the world will be affected by the changes in precipitation patterns and rates of evaporation. According to the best guesses of scientists, many dry areas will become drier while wet areas will become wetter. As a result, according to writer Fred Pearce:

> Many of the rivers that provide water in the world's most densely populated areas and where water is already in the shortest supply will be in still deeper trouble soon. In northeastern China, the savanna grasslands of Africa, the Mediterranean, and the southern and western coasts of Australia, rains will probably diminish, evaporation will certainly be greater—and the rivers will run dry.[11]

Global warming will affect water in yet another way, which will result in increased scarcity. Mountain glaciers provide flows of water that feed into some of the world's most important rivers. According to Pearce:

> The glaciers of the Himalayas and Tibet feed seven of the greatest rivers in Asia—the Ganges, Indus, Brahmaputra, Salween, Irrawaddy, Mekong, and Yangtze—ensuring reliable water supplies for 2 billion people. But in half a century or so, the glacier flows in many of these rivers will dwindle and be replaced by much more fickle flows from rain in the mountains. That is a serious threat to Asia's future.[12]

Meanwhile, in South America, cities in the Andes face a similar threat. La Paz in Bolivia, Lima in Peru, and Quito in Ecuador also depend on glaciers for their water and hydroelectric power. And the glaciers are disappearing fast.

GLOBAL WARMING: BELIEVE IT OR NOT

Despite all the evidence of its existence, some people continue to deny that global warming is occurring. Some are sincere in their belief, while other deniers support this view because of vested interests in companies that contribute to global warming. Then there are those who acknowledge that Earth is warming but argue that human activities are not responsible for it and therefore there is nothing we can do about it.

Today, a majority of Americans—71 percent, according to a recent Yale/Gallup poll—believe that global warming is really happening. And 57 percent are sure that human activity, such as emitting greenhouse

gases like carbon dioxide is causing it. Another 12 percent think that the warming is at least partly caused by humans.[13]

Unfortunately, many who hold political office refuse to accept the scientific evidence for global warming. In January 2015, NASA and the National Oceanic and Atmospheric Administration (NOAA) declared 2014 the hottest year ever recorded on Earth. Several days later, rejecting the scientific consensus that humans are causing climate change, the Republican-controlled US Senate went on record in a 50–49 vote saying that climate change is not caused by humans. Senator James Inhofe, a Republican from Oklahoma and chairman of the Senate Environment

Senator James Inhofe arrives for work in Washington, DC. For years, Inhofe has fought against the idea that humans have caused climate change and in 2012 wrote a book entitled *The Greatest Hoax: How the Global Warming Conspiracy Threatens Your Future.*

TAKE ACTION!

WRITE TO YOUR GOVERNMENT REPRESENTATIVES

It is obvious that global warming affects what happens to water on our planet. Millions of people in various parts of the world have to endure severe droughts or floods brought about by changes in climate. And since human activity is responsible for climate change, it is important for our representatives in government to regulate the amount of carbon dioxide and other greenhouse gases released into the atmosphere by the burning of fossil fuels such as oil, gas, and coal.

Send an e-mail or letter to your members of Congress in support of legislation to reduce the amount of greenhouse gases spewed into the atmosphere. Write about your concern that water scarcity resulting from climate change can become a huge problem unless something is done to slow down the global warming process.

and Public Works Committee, said that global warming is the "biggest hoax" perpetrated against mankind.[14] According to NASA, 97 percent of scientists now believe that climate change is man-made. But in an apparent lack of common sense, not a single 2016 Republican presidential candidate agreed.

FIGHTING OVER WATER

Water shortages will increase the likelihood of conflicts over a scarce resource. Indeed, access to freshwater has already been a major factor in at least one war. According to Fred Pearce, the Six-Day War in 1967 between Israel and its Arab neighbors was the first modern water war. According to Pearce, Israeli leader Ariel Sharon described in his autobiography how

Syria had begun digging a canal in the Golan Heights to divert the headwaters of the Jordan River away from Israel. Sharon wrote, "The Six-Day War really started on the day Israel decided to act against the diversion of the Jordan. . . . While the border disputes were of great significance, the matter of water diversion was a stark issue of life and death."[15]

But three years earlier in 1964, Israel, without the agreement of Syria or Jordan, had begun pumping water out of the Jordan River. This would eventually deprive Israel's neighbors of the Jordan's waters. For thousands of years, the Jordan River had flowed from the Golan Heights down into the Sea of Galilee and would eventually reach the Dead Sea at the lower end of the Jordan Valley. But Israel constructed a dam, which prevented the Jordan from flowing beyond the Sea of Galilee. A huge pipe, known as the National Water Carrier, was built to lift water 1200 feet (366 meters) out of the valley. Israel now depended on the Water Carrier to supply most of its water. By 1991, no freshwater flowed out of the Sea of Galilee into the lower Jordan Valley.

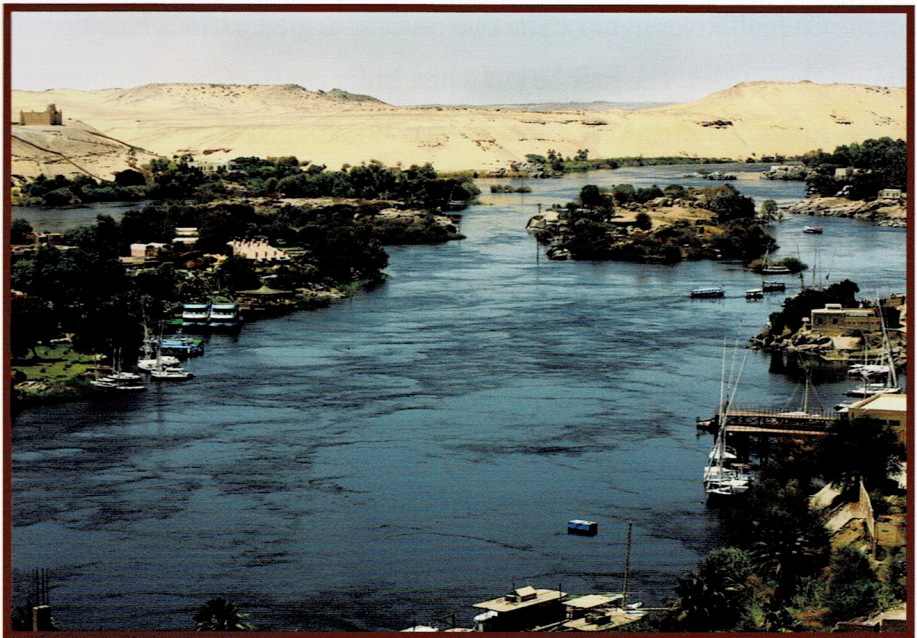
In many other parts of the world, disputes over access to water may be setting the stage for future conflicts. In some of these situations, a river forms the boundary between two or more countries. In others, a country through which a river flows may build dams, which prevents the waters from reaching the nations downstream. The possibilities for trouble become clear when you consider that the Danube and Rhine in Europe and the Niger and Congo in Africa each pass through nine countries. The Zambezi in Africa flows through eight countries. In most of these places, there are no treaties for sharing water.

A dangerous source of potential conflict over water developed between India and Pakistan when India began construction of the Baglihar Dam

on the Chenab River in 1999. The two nuclear-armed nations had already fought three wars. The first began when India cut the flow of tributaries of the Indus River in Kashmir—water Pakistan relied on. In 1960 both countries signed the Indus Waters Treaty, which obliged them to share the flow of the Indus River. Each nation was to take water from three tributaries of the Indus. But the Chenab is one of the tributaries. India claimed the purpose of the dam was to provide hydroelectric power, and that water would still flow to Pakistan. But Pakistan feared that in a future crisis, India could cut off the flow of the Chenab with disastrous results for Pakistan. So Pakistan viewed the dam as a dangerous breach of the Indus Waters Treaty. Fortunately, after the dam was completed in 2008, India and Pakistan resolved the issue peacefully.

In Africa, the Nile flows northward through ten countries, including Ethiopia, Sudan, Egypt, Uganda, Kenya, Tanzania, Burundi, Rwanda, the Democratic Republic of Congo, and Eritrea. At the downstream end lies Egypt, which gets 97 percent of its water from its upstream neighbors. The current water treaty dates from the days when Great Britain ruled the region. It grants most of the Nile's flow to Egypt. Some of the Nile's waters are for Sudan. But none are allocated for Ethiopia or any of the other countries upstream. In a part of the world that receives almost no rainfall, the Nile is obviously a vital resource. Someday, one of the countries through which the Nile flows may decide it absolutely must have some of that water. But Egypt has warned that it would go to war if any of the upstream countries, such as Ethiopia, starts diverting the Nile's water.

The Tigris and Euphrates rivers are the major water bodies sustaining agriculture for thousands of years in Turkey, Syria, and Iraq. Water



Egypt benefits enormously from the Nile River, while some other African countries upstream are prohibited from using any of its waters.

development projects on the Euphrates have been the cause of armed conflict between Turkey, Syria, Iraq, and the Kurds. The construction of the Ataturk Dam (1983–1990) on the Euphrates in Turkey led to feuding with Iraq. Water bound for Iraq was diverted to southern Turkey by a tunnel from the dam. The completion of new dams in Turkey will result in Iraq's losing 80 to 90 percent of its allotment of Euphrates water. And the conflict between the two countries is expected to intensify.

According to *New York Times* journalist Thomas Friedman, water scarcity was a major cause of the current war in Syria. "The Syrian revolution started in some of the driest places in the country," he reported. When the Syrian revolution began in 2011, among the stressors that ignited the population was an extreme drought that had affected the country since 2006.[16]

Many other water hot spots exist between nations and even within nations. In southern India, the Cauvery River has been the source of a feud between Karnataka and Tamil Nadu. The two states have been arguing for decades over water rights.

In the American Southwest, the states in the region all have claims on the waters of the Colorado River. The Colorado is a totally managed system with more than twenty dams along its 1,470-mile (2,365-kilometer) length. The largest of these are the Hoover Dam and Glen Canyon Dam. Water from Lake Havasu (Parker Dam) is transferred to California through an aqueduct running 242 miles (389 kilometers) from the Colorado River. California accounts for just 1.6 percent of the 242,000-square-mile (626,780 square-kilometer) Colorado basin.[17] Although it inputs nothing to the river, California uses one-fourth of the Colorado River's water. The management of the Colorado River made phenomenal growth possible in Southern California. But it is estimated that evaporation causes the loss of one cubic mile of water from Lake Havasu each year. By the time the Colorado River reaches Mexico, there is barely a drop of water left. Naturally, Mexico—which is supposed to get 1.5 million acre-feet by treaty—is not pleased. (One acre-foot of water is equal to 325,851 gallons. This is the amount of water required to cover an area of one acre to a depth of one foot.)

In 1869, Major John Wesley Powell made a voyage of exploration along the Colorado River. He explored the Grand Canyon, the immense gash in the earth carved by the river. Powell saw that the Colorado could provide enough water to sustain future development of the region. But he was aware that there were limits to making the desert bloom. In 1893 he said, "I wish to make it clear to you, there is not sufficient water to irrigate all

the lands which could be irrigated, and only a small portion can be irrigated. . . . I tell you, gentlemen, you are piling up a heritage of conflict."[18]

By the late 1890s, the rapidly growing city of Los Angeles needed new sources of water to provide for further development. The city secretly bought land and water rights in the Owens Valley, a couple of hundred miles to the north. Writer Vandana Shiva notes:

> This clandestine agreement to transfer water from the farms to the city led to intense conflict between Owens Valley residents and Los Angeles water users. . . . In 1924, Owens Valley residents blasted an aqueduct to prevent water diversion to Los Angeles. The water war had begun. After 12 more blasts, armed guards were stationed on the aqueduct with orders to kill. . . . During the drought of 1929, groundwater pumping began but quickly dried up the 75-square mile Owens Lake. New scarcity had bred new conflicts. In 1976, the aqueduct was bombed again.[19]

Recently it has occurred to managers of water resources that dams make tempting targets for would-be terrorists. In September 2004, the Chinese military responded to rumors of a terrorist attack on the Three Gorges Dam on the Yangtze River. Three Gorges, completed in 2007, is the world's largest hydroelectric dam. Some ten million people who had been living in the Yangtze River Valley were displaced by its construction. The giant dam holds back a reservoir 300 miles (483 kilometers) long. The reservoir contains 32 million acre-feet of water. If the dam were to be destroyed, the water would sweep downstream most likely create the worst man-made disaster in history.[20]

The privatization of water resources is creating yet another type of water conflict. Around the globe, major corporations seek to control and profit from the sale of water. Among the biggest players are the French companies Vivendi Environment and Suez Lyonnaise des Eaux, the Spanish company Aguas de Barcelona, and the British companies Thames Water, Biwater, and United Utilities. Arguments for privatization are based on the poor performance of public water utilities. The World Bank and the International Monetary Fund (IMF) have provided funding for privatization projects known as public-private partnerships. The name is misleading because it suggests public participation, democracy, and accountability. But in reality, such projects usually mean that public funds are made available for the privatization of public goods, such as water. Such projects often lack accountability, have poor track records, and result in price gouging.

According to Vandana Shiva:

> In Chile, Suez Lyonnaise des Eaux insisted on a 35 percent profit. In Casablanca, consumers saw the price of water increase threefold. In Britain, water and sewage bills increased 67 percent between 1989–90 and 1994–95. The rate at which people's services were disconnected rose by 177 percent. In New Zealand, citizens took to the streets to protest the commercialization of water. In South Africa, Johannesburg's water supply was overtaken by Suez Lyonnaise des Eaux. Water soon became unsafe, inaccessible, and unaffordable. Thousands of people were disconnected and cholera infections became rampant.[21]

In April 2000, the people of Cochabamba, Bolivia, won a victory against the powerful Bechtel Corporation. The year before, the World Bank had recommended privatization. The government of Bolivia then passed a drinking water and sanitation law, which allowed privatization of the water utility. Bechtel stepped in. Unfortunately for the residents of Cochabamba—many of whom earned less than sixty dollars a month—water bills skyrocketed. With charges of twenty dollars a month, most people could not afford water. Twenty dollars was the cost of feeding the average family of five for two weeks.[22]

The citizens of Cochabamba formed an alliance called the Coalition in Defense of Water and Life. They held mass protests and a general strike. In their Cochabamba Declaration, the protesters stated that the water rights of every citizen must be protected. They demanded that the government repeal the drinking water law. The government refused. Protests continued with thousands of marchers using slogans such as "Water Is Life" and "Water Is God's Gift and Not a Merchandise." Activists were arrested, protesters killed, and the media censored. Finally, the government had had enough. On April 10, 2000, it issued an order for Bechtel to leave the country. The citizens of Cochabamba had proved that corporate takeover of water supplies could be prevented by the democratic will of the people.

The struggle over water continues in other countries. Even in the United States, there are people who have had to fight for their right to have water. Thousands of Detroit's poor residents, struggling to survive in a difficult economy, were unable to pay their water bills. The Detroit Water Department responded by shutting off their water. In many cases, water bills had gone up 119 percent in the past decade.

The city of Cochabamba saw a huge increase in the cost of water after the Bolivian government decided to allow privatization of the water supply. Residents organized protests and strikes, and after a tough fight, the government ultimately reversed its decision.

In October 2014, the residents took their fight to the United Nations. On July 28, 2010, the UN General Assembly had adopted a resolution recognizing the human right to safe and clean drinking water as essential for the full enjoyment of the right to life. UN officials were shocked by the mass water shutoffs in Detroit. Declaring Detroit's actions to be contrary to human rights, the UN called for Detroit to restore water service to the poor. But the water crisis in Detroit continues to this day.

STRATEGIES FOR DEALING WITH WATER SCARCITY

Faced with shortages of freshwater, communities in various parts of the world have tried a number of different strategies for supplying the much-needed water. Rain harvesting was once a worldwide technology on which hundreds of millions of people depended. Today, all across India groups are harvesting the rain either for direct use or to revive underground water reserves. Scattered across the country are about one hundred forty thousand tanks. Most of these are shallow mud-walled reservoirs in valley bottoms. They cover a couple of acres at most and can irrigate up to fifty acres. As farmers are having to pump from ever greater depths to retrieve underground water, the old tanks are starting to be restored.

Some two million people in the desolate Gansu region of western China also get most of their water for drinking and growing crops by harvesting rain. They collect rainwater in bell-shaped cisterns. The cisterns can hold about sixteen thousand gallons (sixty-one thousand liters) of water. Every household in the region has one cistern.

Elsewhere, people have resorted to a more ancient method of making rain. According to Fred Pearce:

> Some have even suggested using sound to capture moisture from the air. On a cool, still night, the air can be so

> saturated with moisture that modest air movements, such as sound waves, can condense the moisture and produce raindrops. In the mountains of Yunan in southern China, villagers have a tradition of yelling loudly in the hope that it will stimulate rain. The louder they shout, it is said, the more it rains. This gives interesting scientific credence to the African notion of the rain dance, once seen as the epitome of superstition.[23]

Another approach involves the use of purification systems for recycling wastewater. Wastewater has been used in many places for agriculture. Now, increasingly, recycled wastewater is being promoted as perfectly safe for cooking and drinking. Such wastewater can be a good source of water for industrial use in the workplace or garden, toilets, and cleaning in the home. But there are real concerns about bathing, drinking, or cooking with recycled water. Treated water has often been found to contain many toxic substances. According to cancer expert Dr. Steven Oppenheimer, "the 'toilet to tap' process should only be considered as a last resort."[24] At current treatment levels, Oppenheimer compared drinking recycled water to playing Russian roulette with human life.

What about the oceans as a source of water? After all, the oceans contain most of Earth's water. Sometimes oceans are considered to be available water, but what about all the salt? Is desalination a solution to water scarcity? The possibility of converting an unlimited quantity of seawater to freshwater certainly seems a promising solution. But the amount of energy needed to convert salt water to drinkable freshwater is costly. A small fraction of the world's water supply currently comes from desalination. Nevertheless, as the global water crisis grows worse,

DOES CLOUD SEEDING WORK?

Some people believe that seeding the clouds to make rain can solve the water crisis. Scientists fly a plane into the clouds and spray billions of silver iodide crystals into the clouds. The tiny particles become the nuclei around which water droplets form and become raindrops. At least ten American states, from Texas to North Dakota, and twenty-four countries around the world currently practice cloud seeding. All claim varying degrees of success. But how could you scientifically prove that any rain that falls would not have fallen anyway without the cloud seeding?

Assuming that cloud seeding works, there could still be problems. Suppose you were to succeed in condensing enough water above a particular area to produce precipitation. You would be depriving locations downwind from receiving rain. This could heighten political tensions. For example, Israel has claimed great success with its cloud-seeding programs. According to the Israelis, spraying the winter clouds over the hills of Galilee raises rainfall by 15 percent and produces forty thousand acre-feet of water a year. But the Israelis may be harvesting water that would have crossed the Jordan Valley into Jordan.[25]

managers of water resources are increasingly looking to desalination as the answer to their problems.

Desalination is actually an old technology. It involved distilling seawater by boiling it and collecting the water vapor. In the fourth century BC, the Greek philosopher Aristotle wrote that "saltwater, when it turns into vapor, becomes sweet and the vapor does not form saltwater again when it condenses."[26]

President John F. Kennedy strongly believed in the importance of desalination. In a speech in June 1961, he said:

> Before this decade is out we will see more and more evidence of man's ability at an economic rate to secure freshwater from saltwater, and when that day comes, then we will literally see the deserts bloom. This is a work . . . more important than any other scientific enterprise in which this country is now engaged. . . . It can do more to raise men and women from lives of poverty than any other scientific advance.[27]

Today more than three hundred million people rely on desalinated water for some or all of their daily needs. As of 2013, there are more than seventeen thousand desalination plants worldwide in one hundred fifty

Desalination, or salt removal, of ocean water is one possible solution to the world's water crisis, but the process is costly and the energy involved contributes to global warming.

countries. These plants produce a combined total of more than 21.1 billion gallons of drinking water a day.[28] Most of these plants are small. In oil-rich Saudi Arabia, there are seventeen desalination plants, which make up one-quarter of the world's desalinated water production. Eventually, all of Saudi Arabia's freshwater will come from desalinated seawater. Saudi Arabia, Israel, and other Middle Eastern countries, as well as certain Caribbean islands, are among the few places where desalination provides a substantial portion of the water supply. The International Desalination Association predicts that demand around the world for desalinated water will grow by about 25 percent per year.

Israel, Singapore, and Australia are just three of the countries in which large desalination plants are currently being built. In Israel, the world's largest desalination plant, call Sorek, recently began operating. Sorek and Israel's three other desalination plants provide 40 percent of Israel's water supply.[29] More than a dozen large-scale ocean desalination plants are being planned in California. One of these, just north of San Diego will be the largest of its kind in the Western Hemisphere. It will provide enough water for three hundred thousand people.

During the Second World War, the US Navy developed a modern distillation technology to provide freshwater on remote Pacific islands. Today, distillation is still being used in about four fifths of the world's desalination plants. But another technology, known as reverse osmosis, has grown in popularity since the 1970s.

There are two methods of reverse osmosis. In one, seawater is forced through a membrane. The membrane is semipermeable. As the seawater passes through the membrane, the salt molecules in the water are filtered out by the membrane. So the water passing through the membrane

has become freshwater. In the other type of reverse osmosis, salt ions in the water are moved through the membrane by electrical currents. The water left behind has become freshwater. This process is known as electrodialysis. Both methods rely on sophisticated membranes specially developed for the reverse osmosis process. Unfortunately, desalination technologies require huge amounts of energy. Most of the energy comes from burning coal, oil, and other fossil fuels. And energy derived from fossil fuels uses water to produce it. So not only does desalinated water cost about a hundred times more than conventional water in most places, but the technology used to produce it also emits greenhouse gases that contribute to global warming.

On the horizon, the use of alternative types of energy promises to address these problems. According to Leon Awerbuch of the Bechtel Corporation, "In the long run, sustainable [desalination] development requires us to look at renewable sources like solar energy and its derivatives, wind, ocean thermal, waves, and alternative energy like nuclear, because of limits of supply of fossil fuel and the potential impact of [the] greenhouse effect."[30] The International Atomic Energy Agency is enthusiastically promoting the use of nuclear reactors as the source of energy for desalination.

But there are other serious environmental problems with desalination. All desalination plants have to dispose of a huge stream of concentrated brine. This is what remains when the salt is extracted from the seawater. The desalination plants also have to get rid of various chemicals and heavy metals. These substances are used to clean and maintain the reverse osmosis membranes and prevent salt erosion. The chemicals and metals are mixed with the brine. Most desalination plants pump this

lethal mixture back into the sea, which pollutes the nearby waters. In countries that discharge their waste into the ocean, much of the water available to an offshore desalination plant is polluted.

There are other problems yet. Environmentalists are concerned that widespread adoption of desalination technologies may lead people to believe that freshwater is no longer scarce because there is no danger of the oceans running out of water. Also, desalination plants close to coral reefs in warm tropical seas could cause harm to these important ecosystems. Coral reefs, according to writer Jeffrey Rothfeder, "provide habitat and nutrients for about four thousand species of fish, many of which feed a large part of the world's population—one billion people in Asia alone."[31] Even so, to many desalination appears to be an excellent technology fix. Many factors should be weighed before desalination is adopted as a water source.