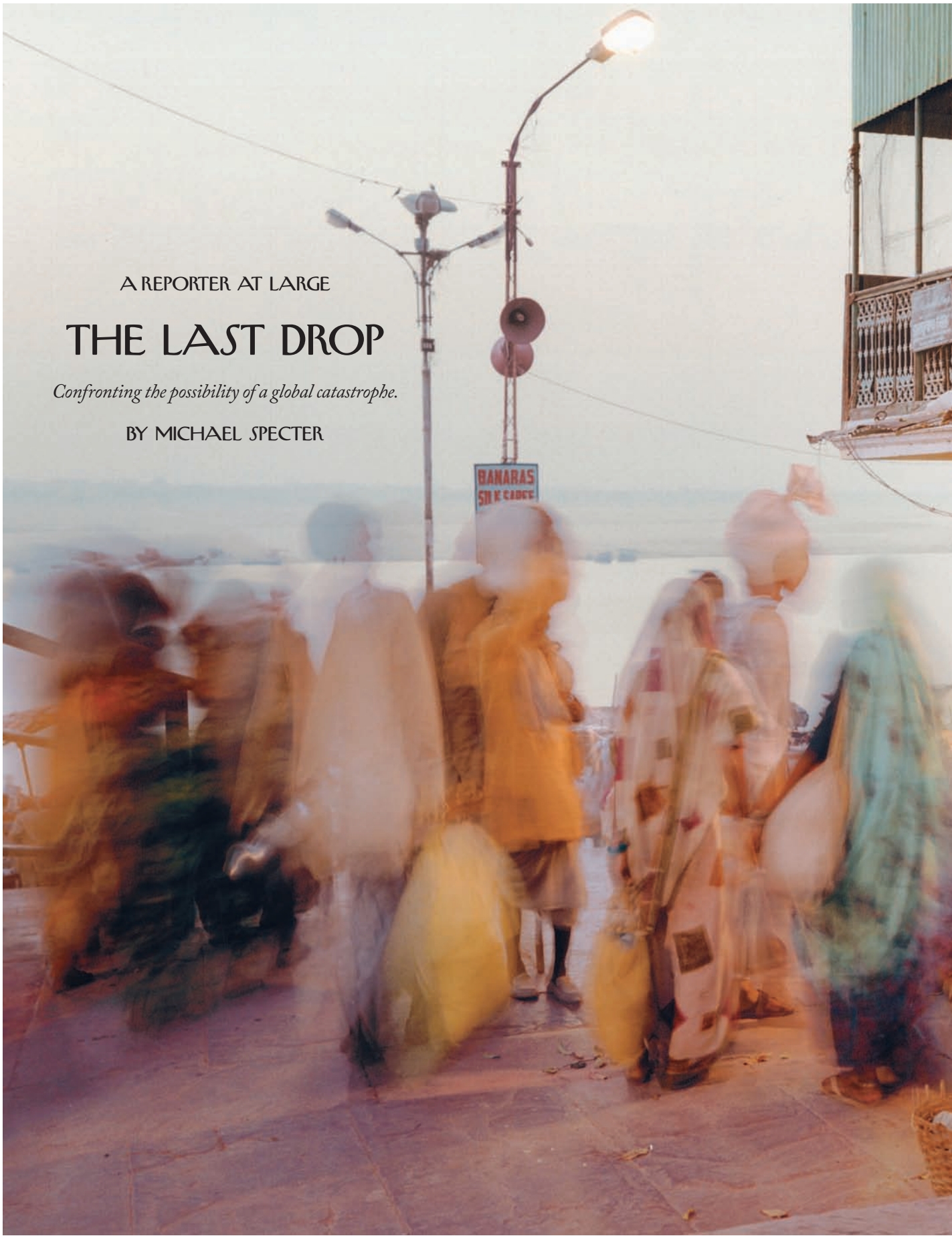
A REPORTER AT LARGE

THE LAST DROP

Confronting the possibility of a global catastrophe.

BY MICHAEL SPECTER



LAIF

A stall in India. Nearly half the people in the world don't have the kind of clean water and sanitation services that were available two

thousand years ago to the citizens of ancient Rome. Photograph by Peter Bialobrzeski.

Most mornings, the line begins to form at dawn: scores of silent women with babies strapped to their backs, buckets balanced on their heads, and in each hand a bright-blue plastic jug. On good days, they will wait less than an hour before a water tanker rumbles across the rutted dirt path that passes for a road in Kesum Purbahari, a slum on the southern edge of New Delhi. On bad days, when there is no electricity for the pumps, the tankers don't come at all. "That water kills people," a young mother named Shoba said one recent Saturday morning, pointing to a row of battered pails filled with thick, caramel-colored liquid. "Whoever drinks it will die." The water was from a community standpipe shared by thousands of the slum's residents. Women often use it to launder clothes and bathe their children, but nobody is desperate enough to drink it. Instead, they take their buckets to a tanker stop, sit in the searing heat, and wait. Shoba found a spot in the shade next to a family of sleeping hogs. She wore a peach-colored sari and, to ward off the sun, a thin purple scarf around her head. Two little girls played happily in piles of refuse that lined the road.

There is no standard for how much water a person needs each day, but experts usually put the minimum at fifty litres. The government of India promises (but rarely provides) forty. Most people drink two or three litres—less than it takes to flush a toilet. The rest is typically used for cooking, bathing, and sanitation. Americans consume between four hundred and six hundred litres of water each day, more than any other people on earth. Most Europeans use less than half that. The women of Kesum Purbahari each hoped to haul away a hundred litres that day—two or three buckets' worth. Shoba has a husband and five children, and that much water doesn't go far in a family of seven, particularly when the temperature reaches a hundred and ten degrees before noon. She often makes up the difference with cups from the city's ubiquitous and unhygienic kiosks, or with bottled water, which costs more than water delivered any other way. Sometimes she just buys milk; it's cheaper. Like the poorest people everywhere, the residents of New Delhi's slums spend a far greater percentage of their incomes on water than anyone

lucky enough to live in a house connected to a municipal system of pipes.

Water is often seen as the most basic and accessible element of life, and seemingly the most plentiful. For every gallon in rivers or lakes, fifty more lie buried in vast aquifers beneath the surface of the earth. Yet at least since the cities of ancient Sumeria went to war over control of their rivers—long before tales of Moses parting the Red Sea or the Flood described in the Bible—water has been a principal source of conflict. (The word "rivals" even has it roots in fights over water, coming from the Latin *rivalis*, for "one taking from the same stream as another.") By 2050, there will be at least nine billion people on the planet, the great majority of them in developing countries. If water were spread evenly across the globe, there might be enough for everyone. But rain often falls in the least desirable places at the most disadvantageous times. Delhi gets fewer than forty days of rain each year—all in less than four months. In other Indian cities, the situation is worse. Somehow, though, the country has to sustain nearly twenty per cent of the earth's population with four per cent of its water. China has less water than Canada—and forty times as many people. With wells draining aquifers far faster than they can be replenished by rain, the water table beneath Beijing has fallen nearly two hundred feet in the past twenty years.

Most of the world's great civilizations grew up around rivers, and few forces have so clearly shaped the destiny of human populations. When full and flowing, rivers have brought prosperity to the cities and nations they feed. Harnessing the power of a major river has been a signature of progress at least since Rome built its first aqueduct, the Aqua Appia, more than two thousand years ago. New York, London, and Rome would have disappeared long ago without the Hudson, the Thames, and the Tiber. In the twenty-first century, though, no river can satisfy the demands of the world's biggest cities. The fourteen million residents of New Delhi consume nine hundred million gallons of freshwater each day; the city supplies nearly seven hundred million gallons from rivers and reservoirs, but more than a third of it is lost to leaks within the ten-thousand-kilometre system of dilapidated pipes and pumping stations. Some of the rest is siphoned off by an increasingly brazen water mafia, which then sells it to people in slums like Kesum Purbahari who are supposed to get it for free.

"I cleared out the case so people can crawl inside and feel what it's like to be a piece of meat."

When you can't get enough water from the surface of the earth, there are really only two alternatives: pray for rain or start to dig. In India, Africa, China, and much of the rest of the developing world, people are digging as they never have before. Nearly two billion people rely on wells for their water, some of which is easily accessible. Far more lies trapped in the pores of rocks, or buried hundreds of metres below tons of ancient shale and metamorphic debris. Sturdy drills and cheap new pumps have made much of that water available—liberating millions of farmers from centuries of dependence on rain. The freedom comes at a cost, though, because once groundwater is gone it is often gone for good.

There were two million wells in India thirty years ago; today, there are twenty-three million. As the population grows, the freshwater available to each resident dwindles, and people have no choice but to dig deeper. Drill too deep, though, and saltwater and arsenic can begin to seep in. When that happens, an aquifer is ruined forever. Wells throughout the country have become useless. Brackish water has even infiltrated parts of Punjab, the northern state that is India's most important agricultural region. As sources dry up and wells are abandoned, farmers have turned on each other and on themselves. Indian newspapers are filled with accounts of fights between states or neighbors over access to lakes and reservoirs, and of "suicide farmers," driven to despair by poverty, debt, and often by drought. There have been thousands of such suicides in the past few years.

Even in the most prosperous neighborhoods of cities like Delhi and Mumbai, water is available for just a few hours each day—and often only as a brown and sludgy trickle—forcing millions of middle-class Indians to stumble out of bed at three or four in the morning to turn on their taps. Then, with the help of electric pumps, they push the water to storage tanks on their rooftops. Battles over the water supply have become so common that Priya Ranjan Dasmunshi, the Minister of Water Resources, sometimes describes himself as the Minister of Water Conflicts.

The fight for water intensifies every day: between rich residents of overcrowded cities and their poorest neighbors, and between cities and the rural

territory that surrounds them. Forty million Indians live in slums—there are more than a thousand in Delhi alone—and almost all are caught in the peculiar logic of Indian bureaucracy: because slums are not considered official settlements, they are not entitled to pipes that would connect them to the municipal water system. In the end, people can do nothing but wait.

Around noon, when a tanker finally arrived in Kesum Purbahari, sounds of shrieking women temporarily drowned out the noise of the jets taking off from the nearby runways of Indira Gandhi International Airport. Neighbors who had sat patiently for hours, swapping stories and sharing cigarettes, erupted in a collective wail. They began pushing each other, trying to grab a ratty green garden hose attached to the tanker's spout and cram it into their buckets. With every jarring tug on the hose, precious drops spilled in rivulets and then torrents, turning the burning summer dirt to mud.

"We speak of our information technology and the advances we have made in our society with justifiable pride," Mahesh Chaturvedi told me one afternoon when I visited him in his quiet New Delhi neighborhood filled with pipal trees and spotted sparrows. Chaturvedi, a hydrologist, has taught at Harvard and for many years was a professor of environmental sciences and engineering at the Indian Institute of Technology. Most mornings, he, too, rises at four to turn on his tap. "We take seriously the discussion of Indians going to the moon," he said. "We have very big dreams. Yet here we are, a deeply backward country peering at modernity from the threshold. It is a fact of the human condition that we can achieve none of our goals without water. Nobody could. People often speak as if that were not a serious problem, or that this is one of those things we have to accept because, after all, this is India. But if we accept it we can't possibly survive. Not this way. One day—and it won't be long—we are going to wake up and it is just going to be too late."

Not even the miraculous scientific achievements of the twentieth century have affected human health and development as profoundly as has the ready availability of clean water. In modern countries, diseases that were responsible for tens of millions of deaths throughout history—cholera, typhoid, malaria—have essentially vanished. Their disappearance is due at least as much to the use of sewers as to any medical advance. Clean water has not only healed humanity but nourished it. Irrigation for agriculture accounts for more than two-thirds of all water use, and sophisticated water-distribution projects have helped increase crop yields to feed the earth's surging population.

Despite those accomplishments, nearly half the people in the world don't have the kind of clean water and sanitation services that were available two thousand years ago to the citizens of ancient Rome. More than a billion people lack access to drinking water, and at least that many have never seen a toilet. Half of the hospital beds on earth are occupied by people with an easily preventable waterborne disease. In the past decade, more children have died from diarrhea than people have been killed in all armed conflicts since the Second World War. Simply providing access to clean water could save two million lives each year. As cities have grown, many rivers have turned into fetid sewers. The amount of fecal bacteria in the Yamuna River, the principal source of water for New Delhi, has increased thousands of times over the past decade. Thirty per cent of the schools in the developing world have no water of any kind. A recent study in Bangladesh found that the addition of a single private toilet could increase the number of girls attending school by as much as fifteen per cent. In 2000, the United Nations established eight Millennium Development Goals aimed at eliminating the world's most desperate poverty. One seeks to cut by half over the next decade the proportion of people without access to clean drinking water. Another sets a similar target for improving access to sanitation facilities. The U.N., which has designated this the decade of "Water for Life," estimates that, if both goals are met, "only" thirty to seventy million people will die in the next fifteen years from preventable water-related diseases. It is already clear that there is little chance of meeting either goal.

"Is there a more egregious example of the failure of governments and leaders than our inability to meet basic human standards for clean water and sanitation?" Peter Gleick, the president of the Pacific Institute for Studies in Development, Environment and Security, asked me recently when I visited him at his office in Oakland, California. Gleick, who is forty-nine, has studied the connections between water, development, and human health for nearly three decades. He argues that management failures and political myopia are at least as responsible for water problems as shortages and population growth. "Providing enough water to grow food for the planet is and will continue to be a challenge," he said. "So is limiting the damage pollution has caused. Still, how can any government that cares for its people let them die of something so simple as a lack of clean water? But they do, in numbers that are staggering. This problem is so fundamental and so widespread, yet it's not like curing AIDS or eradicating malaria. It is not scientifically challenging. It's just a matter of whether or not we care about the most vulnerable people on our planet."

Nearly every country subsidizes the cost of water, but those subsidies rarely achieve the intended goal of improving services for the poor. In India, most people who are connected to the municipal water system pay less than a tenth of what it costs to deliver that water. The poor are supposed to pay nothing, but they rarely have the pipes that would permit them to take advantage of the subsidy.

India's situation is extreme, but other countries have had similar problems. In the nineteenth century, when piped water was first introduced in the United States and in many European cities, municipal utilities rarely installed meters in private homes or small businesses, and, as a result, few customers paid their fair share of costs. Water was seen as a right that automatically deserved subsidies, and it was so plentiful and cheap that restricting its flow, or charging customers for how much they used, seemed to make little sense. New York City began to require water meters less than twenty years ago.

Because the global supply of freshwater is widely regarded as a collective resource, most people feel entitled to

claim a share. No politician in India (or in almost any other country) can win votes by suggesting an increase in prices. So water remains free for many people and is sold at absurdly low cost to the rest. The same is true for the energy required to pump that water from the ground. Without sufficient revenues, utilities cannot maintain or replace their antiquated systems—or deliver water to the people who need it most.

"This is a problem everywhere in the world," Peter P. Rogers, a professor of environmental engineering at Harvard, told me. "People will not pay for water. They consider it immoral. You can live without food for forty days and water for five at the most. Nobody is ever going to consciously die of thirst. And what is the most obvious result? The poor will suffer. But the poor always do."

Philosophers and economists at least since Copernicus have noted that, although no substance is more valuable than water, none is more likely to be free. In "The Wealth of Nations," Adam Smith called this the "diamond-water paradox": although water is essential for life, and the value of diamonds is mostly aesthetic, the price of water has always been far lower than that of diamonds. Economists often argue that water should be considered a commodity, like housing or food. But water possesses an intangible, even mystical, quality that transcends the principles of economics; people simply don't think about it in the way that they think about transportation or clothing—and they never have. Water is precious, but not like oil, which, once burned, is gone forever. While there is almost no human activity that doesn't depend on water in some way, it never actually disappears: when water leaves one place, it simply goes somewhere else.

Water that dinosaurs drank is still consumed by humans, and the amount of freshwater on earth has not changed significantly for millions of years. But that doesn't mean it's available when or where it is needed. Nearly all of the earth's water is in the ocean. Only three per cent is even theoretically available for humans to drink. Most of that is locked in polar ice caps and glaciers, or deeply embedded in layers of rock. If a large bucket were to represent all the seawater on the planet, and a coffee cup the amount of freshwater frozen in glaciers, only a teaspoon would remain for us to drink.

The earth's population has increased exponentially in the two hundred years since Thomas Malthus predicted that the demand for food would soon exceed the supply. In fact, the rate of growth has been far more punishing than Malthus could have imagined. The human population more than tripled in the twentieth century alone (and water use grew sixfold). Within the next fifty years, demographers expect the population to grow again by as much as fifty per cent. There have always been predictions that such increases would present humanity with insurmountable obstacles, and those predictions have always been wrong. Yet even if the population of the earth stopped rising tomorrow—and no demographer considers that possible—the number of people facing water shortages will continue to grow for decades. There are simply too many people who lack access to clean water; even the slightest improvement in the standard of living for hundreds of millions of them would increase demand immensely.

This puts countries like India in a nearly impossible position, caught between a desire for economic growth and a need for dependable sources of freshwater. Industrialization and the economic success that it brings often have unforeseen implications. Agrarian societies have traditionally consumed little meat. But in China and other East Asian nations where income has been growing rapidly this is no longer true. In India, sixty-five per cent of the population work on farms. Nonetheless, the country now has more than two hundred and eighty million urban residents, and the shift to city life, which began more than a hundred years ago as rural residents fled famine and drought, con tinues. By 2020, more than a third of the population will have made the move.

As people migrate to cities, they invariably start to eat more meat, adding to the pressure on water resources. The amount of water required to feed cattle and to process beef is enormous: it takes a thousand tons of water to grow a ton of grain and fifteen thousand to grow a ton of cow. Thirteen hundred gallons of water go into the production of a single hamburger; a steak requires double that amount. Every day, a hundred thousand people join India's middle class, and many have become affluent enough to eat out every week. Early one evening in Bangalore, India's particularly vibrant version of Silicon Valley, I wandered into the Kobe Sizzlers, which is on the top floor of the Garunda Mall. I rode the escalator up past a Dior boutique, a collection of Sony flat-screen televisions, and a demonstration area for the new Nokia Internet phones. Each store was packed with families who couldn't seem to buy these products fast enough. At Sizzlers, people stood in line to order garlic pepper steaks and French fries. The vast majority of Indians are Hindus, who don't eat beef (and many of the rest are Muslims, who don't eat pork). McDonald's, Sizzlers, and most of their fast-food competitors have been careful to serve food that does not offend Indian habits. Maharaja Macs, which were first made with lamb and now only with chicken, sell by the millions. As does the vegetarian version, McAloo Tikki. So many people are taking advantage of their new social and economic status that the Indian fast-food industry is growing even more rapidly than its technology businesses.

"We are emulating America, and not always in ways that make sense for Indians," Sunita Narain said when I visited her at the Centre for Science and the Environment in New Delhi. Narain, who in 2005 won the Stockholm Water Prize, a sort of Nobel for people attempting to conserve aquatic resources, is perhaps the best known of the many activists in India who focus on issues relating to water. She believes that, by abandoning native dietary traditions—which incorporated a variety of grains—India has compounded its environmental problems. "We don't want a culture with a single type of food," she said. "That serves no one but the companies that sell it. But that is where we are heading. You can call it McDonald's or McIndia. They are the same. You can eat the same thing in Kashmir as you do in Kerala, and that is seen as an achievement. It doesn't mat-

ILL WIND

Two red birds
high on a wire
one said love
one said fire

Two black birds
deep in a tree
one said you
one said me

But wind came up
and tossed them away
no one hears
what they say

—Michael Ryan

ter what environment in which you grow the food." She added that even the crops promoted most heavily by the Indian government—rice and wheat—are two that use the most water. "Almost all rice is consumed by humans, so it's at least better than growing grains just to feed cattle," she said. "But now we are either wasting our water on too much rice or wasting it by growing cattle feed. Neither makes sense. We still have nearly three-quarters of the people in rural settings, but the diversity of our agriculture has been lost completely."

Government leaders concede that India's current agricultural policies encourage farmers to waste water. "It's a disgrace, a complete mess," Montek Singh Ahluwalia told me one day when we met in his large, immaculate office adjacent to the Parliament in New Delhi. Ahluwalia, an urbane and contemplative man, is one of the country's most respected officials. He is the deputy chairman of India's planning commission but has also served as Finance Secretary and for many years worked as a senior economist at the World Bank. "Historically, the perception has been that farmers are the weaker end of society, that they need special support and that water should be as cheap for them as possible," he said. "Obviously, we must make certain that the needy have access to water. But just as obviously, when people are growing rice and only rice, the system isn't working. When farmers have water to waste, other people get nothing." His voice rising sharply, Ahluwalia continued, "Water has value. We are going to have to price the damn thing. Because, if we don't, people will continue to use it wantonly. That much we know. I am afraid that if water costs nothing it is worth nothing."

K. Ganasekemon owns a small farm in the village of Vellavedu, along the main coastal highway to Bangalore. He has no idea how much water gushes into his rice paddies every day, but his two-hectare plot looks more like a pond than a farm. An electric pump, protected by a thatched hut, draws water from a well beneath his land, assuring him of a ceaseless flow for months at a time. Scores of ducks bob along the surface, and, when I visited, several women were tending to the rice shoots that had begun to poke through. Ganasekemon, a small man in a white T-shirt and blue sari, has farmed the same way for twenty years, pouring as much water onto his rice as he can. "Last year, the monsoon was perfect," he told me. "So there is plenty of water in the wells here. We don't even have to go too deep, and the rice gets what it needs."

The city of Chennai, just an hour's drive away, has the opposite problem. Chennai, which until ten years ago was known as Madras, lies on the Bay of Bengal, along the thermal equator, and it is quickly becoming one of the largest cities in Asia. It is also one of the most desperate for water. The city is the capital of India's automobile industry and has nearly six million residents, but no significant river or lake. Nor does it get enough rain. People seem to be in motion at all times—on rickshaws, bikes, motorcycles, and overcrowded buses, or on foot. Just as, during Soviet times, no Muscovite would leave home without a string bag in which to carry any product that might suddenly appear in a shop-window, when the citizens of Chennai venture out they often carry pails. Lacking surface water, Chennai relied for decades on wells. Southern India suffered through several intense droughts in the eighties and nineties, and then again over the past few years. As the aquifers were drained of freshwater, many large wells were infiltrated by the sea, making them useless. The city became dependent on monsoons, which almost never fulfill the needs of a large city. Weeks of heavy rains flood roads and railways, disrupt business, and destroy homes. The constant rainfall is usually more than reservoirs, the soil, and local aquifers can absorb, so much of it runs toward the sea and is lost.

Chennai has tried to be inventive. It was the first city in the country to mandate rainwater harvesting, an ancient practice that passed out of fashion during the British Raj. The idea is simple enough. Since ninety per cent of the city's rain falls in just two months, it is essential to capture and store as much of it as possible. Residents and businesses are encouraged to place funnels on their roofs, which shunt rainwater down pipes and into cisterns that are lined with sand and pebbles, to filter impurities. The system is cheap and efficient, and, when used widely, helps many people survive the dry seasons. But it only works when there is enough rain. "When the monsoon fails, we become desperate, and when we have rains it's fine," Sekar Raghavan, the director of Chennai's Rain Centre, said. "It has always been like that. We have had some really hard times, but I don't think the memory of even the worst disaster lasts very long. We try to harvest our water, but it is a big city and a big job, and not everyone understands how much we could save. We simply need more."

Chennai is the largest city in Tamil

Nadu, one of the country's most important agricultural regions. Common sense and a rural tradition of coöperation would suggest that farmers who live near the city share their water and use it sparingly. The agricultural policies of India's government insure the opposite. Rice is the most popular grain in the world, but it requires far more water than any other crop—typically twice as much as wheat and up to ten times more than lettuce. Yet rice and wheat are the two crops that the Indian government supports through price guarantees, so farmers have little incentive to grow anything else or to use less water. On the same amount of land that Chinese farmers grow four thousand kilograms of rice each year, Indians grow no more than sixteen hundred, and they use ten times more water to do it than is necessary. Near Chennai, rice is all that farmers grow.

I visited Ganasekemon's village with N. Parasuraman, a water specialist who works at the M. S. Swaminathan Research Foundation, which is dedicated to preserving the region's environmental resources. Swaminathan is eighty-one and a national hero. In the nineteen-sixties, the country experienced several nearly catastrophic famines. Swaminathan, a plant geneticist, was the head of the Indian Agricultural Research Institute at the time. By combining seeds developed by Norman Borlaug, an American agriculture expert, with local strains of rice and wheat, he helped launch the Green Revolution. The results astonished the world. Yields improved so dramatically that India, which would not have survived without massive imports of grain from the United States, soon became one of the world's biggest exporters. Swaminathan's sophisticated hybrids benefitted greatly from the targeted use of pesticides and fertilizer. More than that, though, the Green Revolution was driven by an almost limitless use of water.

Before the nineteen-sixties, groundwater played no real role in farming, and wells were rarely used to irrigate crops. When the amount of rainfall decreased by twenty per cent, so did the grain harvest. By the late eighties, however, this, too, had changed. In 1987, a year in which rainfall was thirty per cent below normal, the production of grains fell by only five per cent. The difference was due to groundwater. "We couldn't possibly exist without a good well," Ganasekemon said to me. "I don't know how anyone ever did." Ganasekemon's use of water is excessive but not unusual: whoever owns land also owns the groundwater beneath it. The water is free, and the electricity needed to pump the water to the surface is extremely cheap. The electrical subsidy for agriculture makes up nearly half of Tamil Nadu's large deficit.

Everything is for sale in the gray area between urban India and its farmlands. Hawkers offer banana chips, old shoes, and cellular-telephone service. In many parts of the country, the roads are lined with fruit merchants selling fat yellow mangoes or pyramids of limes. Around Chennai, though, water is the ripest fruit. I counted more than a dozen brightly painted twelve-thousand-litre water tankers, each bearing a different company name: Indira Water Supply, Thiramlu Water Supply, Mahindra, Shree Krishna Sharashine, Beven, High Class, Hrahana. As we drove along the dusty roads, Parasuraman, who grew up near Chennai, explained why there were so many tankers: "Indian farmers are good capitalists, and, when a good capitalist has a product that everybody wants, he sells it." These days, water earns more than rice. A local farmer told me, "I have three acres of land, and spend around seven thousand rupees"—about a hundred and fifty dollars—"an acre. My entire family works on the farm for six months of the year, at the end of which I might get twelve thousand rupees per acre. Most of it goes toward paying interest on loans. I have a two-hundred-square-foot well, and it gives me more income than farming does."

Permitting farmers to exploit the nation's most valuable resource has led to inequities that are even more striking than those in the cities: rich men plunder their land at will, installing powerful bore wells driven by engines that can draw the water not only from their farms but also from the land of their neighbors—to whom they then sell that water. The day before I went to Vellavedu, I had visited S. Janakarajan in his office at the Madras Institute of Development Studies. Janakarajan, an intense man with bunches of white shooting through his mop of black hair, has written widely on the water conflicts between Indian cities and the rural areas surrounding them. "This is just a mad race," he said. "I call it 'competitive deepening.' You deepen your well and suck my water out, so I have to deepen my well even further to get yours. You went down sixty feet, so I will go to seventy feet. This is going on all the time, but it cannot continue indefinitely. There is one chance to get this water. If you win, somebody else loses."

He stood up, shook his head, and walked to a map of Tamil Nadu. "If there is an aquifer that should be shared by only four people, it is shared by ten. That way, nobody benefits. But who stops it? There is no law against it. No real property laws. You just have millions of farmers trying to drain the same wells. The entire irrigation system is based on competition, not on sharing. And certainly not on the idea of conservation." The ponds, lakes, and reservoirs around Chennai have been badly neglected. In many cases, as the city has spread, real-estate developers have simply built over the reservoirs, or used them as toxic dumps. "Chennai does not really have a water crisis," Janakarajan said. "This is a man-made crisis, a policy crisis. Politicians love to talk about architecture and new buildings. Water bores them. They don't want to plan for growth, so growth makes its own rules."

Many of the new wells in the area were drilled on the edge of the road, like gas stations, which makes it easier for the trucks to gain access. I stopped in front of the V.B.R. Drinking Water company—a single tanker that sells water to people in Chennai after buying it from local farms. The truck makes a dozen trips each day, and the proprietor, whose name was Selvaraj, assured me that he turns a nice profit. He said that he had been running the business for two years, but he wasn't eager to elaborate. "We sell what people buy," he said with a shrug. The G.M.R. Water Supply company was just a hundred metres down the road. A giant hose snaked from the back of a shed and into the tanker. The heat muffled all sound except the furious banging of a pump in the field.

Parasuraman and I drove on, to a

farm next to the local Coca-Cola bottling plant. When Indians complain about water, they complain about Coke, which has become a symbol of the intrusiveness of foreign companies. "They come here and take what they want," one of the farmworkers told me. "As much water as they can get." It is one of the farmers' most firmly held convictions, but it happens not to be true. Unlike local farmers, Coca-Cola pays for its electricity at market rates. "The Indian approach is that industry should just pay, pay, pay," John Briscoe told me when I met with him in Washington, D.C. Briscoe, the World Bank's country director in Brazil, was for many years the bank's senior water adviser. "Industry uses a small fraction of the water, and it is supposed to pay a hundred per cent of the bill," he said. "It's legalized madness."

Any call for change is greeted by farmers saying that they will die without their human right to water. "If it's a human right for farmers, shouldn't it also be a human right for people in the slums, or poor people on the land in villages?" Briscoe said. "I am a hugely optimistic person, and I think that most problems are overblown, they can be corrected and prevented. The problem with groundwater is that it actually can become irreversible. If you wait too long and waste too much, there is no way back. I worry that that is happening in India. They need innovation. More conservation, more variation in crops. They need to harvest their water and charge for its use. And of course they must have more storage. Much more storage. You can't live on the amount of water they store in India." In the world of hydrology, storage is a code word. It means "dam," and nobody wants to talk about dams.

The Chinese character for "political order" is based on the symbol for "water," and the meaning has always been clear: those who control water control people. For centuries, the most effective way to control water has been to build a dam. No public works have had greater impact on their environments than the world's many colossal dams, and the largest by far were built in the twentieth century. It took sixty-six million tons of concrete to construct the

SKETCHBOOK BY ROZ CHAST

"Howard! I thought you'd run off with another woman!"

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Hoover Dam, which tamed the Colorado River and formed Lake Mead, a reservoir that holds more than nine trillion gallons of water. In Egypt, the Aswan High Dam required twenty times more stone than was used in the Great Pyramid of Giza. When the Three Gorges Dam, on the Yangtze River, is completed, in 2009, it will be the biggest hydroelectric dam in the world. "One of the things Hoover set in motion was a change in the character of the world's waterways, permanently altering the ecosystems of entire drainage basins," Marq de Villiers wrote in his compelling cultural history, "Water." "And in at least one case, the Nile, permanently changing a flow pattern that had sustained civilization for five thousand years."

Few people understood the power of a dam to influence the life of a nation better than Jawaharlal Nehru, India's first Prime Minister. Dedicating the Bhakra Dam, in 1963, he said, "Bhakra-Nangal Project is something tremendous, something stupendous, something which shakes you up when you see it. Bhakra, the new temple of resurgent India, is the symbol of India's progress." Dams, and the large projects that often come with them—pipelines, aqueducts, water-filtration plants—have benefitted billions of people. By the middle of the twentieth century, they had become a defining symbol of man's attempt to govern nature, an effort that was nowhere more vigorous than in the United States, where there are more than seventy-five thousand dams. "That is a new dam nearly every day since we signed the Declaration of Independence," Peter Rogers, the Harvard professor, pointed out. "The environmental impact of these things cannot be ignored." Large swaths of the American West wouldn't be habitable if not for the dams along the Colorado River. In 1933, poverty in much of the Tennessee Valley was acute, crop yields were low, and there was no electricity. Then President Franklin Delano Roosevelt created the Tennessee Valley Authority. The T.V.A. built forty-two dams and reservoirs, which harnessed enough water to generate electricity for tens of thousands of farms, enabling thousands of people to use modern appliances. Clean water became widely available, and so did electricity. In India, the dam at Bhakra helped increase crop yields and double the income of agricultural laborers in the region. In 2000, a typical year, Bhakra produced thirty million tons of the grain purchased by Indian government agencies—eighty-five per cent of the total.

Dams have made it possible for the United States and Australia to store five thousand cubic metres of water per person. Middle-income countries like Morocco, Mexico, and China each store about a thousand. The per-capita figure for India is two hundred cubic metres—not much better than that for the poorest countries in Africa. Without sufficient water storage, irrigation becomes nearly impossible, and the relationship between irrigation and prosperity is absolute: if your land is fed by water, you are far less likely to be poor and far more likely to be educated.

In the past few decades, however, large dams have fallen out of favor in many places. One reason is that sixty per cent of the world's biggest rivers have already been dammed. But public opposition to dams has been growing for years, and in 2000 the World Bank joined the World Conservation Union to publish a definitive study of their value and impact. It was a remarkable decision on the part of both groups, since the bank has played a central role in developing dams, and the Conservation Union, based near Geneva, has often expressed doubt that they are worth the money or the ecological and human disruption they cause. The groups' joint report was thorough and largely negative. While "dams have made an important and significant contribution to human development, and benefits derived from them have been considerable," it stated, "in too many cases an unacceptable and often unnecessary price has been paid to secure those benefits, especially in social and environmental terms, by people displaced, by communities downstream, by taxpayers and by the natural environment." The report found that often, despite investments of tens of billions of dollars, dams do not achieve their goals for irrigation, power generation, or flood control. In the twentieth century alone, dams displaced as many as eighty million people, in addition to destroying forests and decimating fisheries.

Today, India has at least three thousand large dams and a thousand more under construction. The most bitterly opposed of them lie along the Narmada River in the state of Gujarat, which borders Pakistan and the Arabian Sea. These dams were conceived in the nineteen-forties, but construction didn't begin for thirty years. When the Narmada project is finished, the dams are supposed to bring irrigation to more than eighteen thousand square kilome-

tres of drought-prone land. But many local residents will be flooded from their homes, and activists, infuriated that the government has offered little in the way of compensation, have chained themselves to boulders and gone on hunger strikes in an effort to stop construction. Narmada has set off a national debate, not just over dams but over the environmental future of the country, as well as the conventional view of progress.

By far the most eloquent and extreme voice of opposition has been that of Arundhati Roy, the author of the Booker Prize-winning novel "The God of Small Things." "For over half a century, we've believed that Big Dams would deliver the people of India from hunger and poverty," she says. "The opposite has happened." In 1999, Roy published an inflammatory and highly influential essay, "The Greater Common Good," in which she argued that the most important of the Narmada dams, Sardar Sarovar, had raised doubts about the nature of Indian democracy. "Big Dams are obsolete," she wrote. "They're a Government's way of accumulating authority . . . a brazen means of taking water, land and irrigation away from the poor and gifting it to the rich." The issue is so controversial that in April, when Aamir Khan, one of India's best-known movie stars, appeared at Sardar Sarovar to say that the government should do more to help the people it is displacing there, theatre owners in Gujarat responded by refusing to show Khan's most recent film, "Fanaa." Khan, who says that he is opposed not to the dam but only to the way local residents have been treated, has been denounced by state officials, and effigies of the actor have been burned. Although Prime Minister Manmohan Singh released a statement defending Khan's right to speak out, leaders in Gujarat have demanded that he apologize for his public stance. Khan has refused. "I want the people of Gujarat to get water," he said. "I love the people of Gujarat … but there should be justice for the displaced people, too."

Opponents of dams argue that conservation is a better way to protect resources, while supporters insist that without them successful development is impossible. "We can always tell people in other countries not to build dams," Rogers told me. "It's easy to say. You have to remember we had many more years to construct this infrastructure in Europe and America than they have had in the developing world. They are doing in India in a few decades what took us two hundred years. They are doing it in a noisy democracy, not secretly or without debate, as in China. Now, dams have flaws, but sometimes people forget they don't only have flaws. For India, with millions of hectares of crops and rain that falls for only a few months every year, you have to store water. Dams are simply a hydrological and geophysical must."

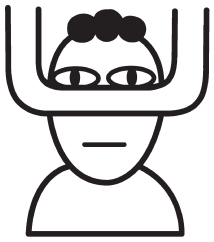
When people suggest that pollution, population growth, waste, and bad policy have already placed unacceptable burdens on the global supply of freshwater, or that industrial development in places like India and China can only hasten inevitable environmental catastrophe, Peter Gleick likes to remind them about the Cuyahoga River. On June 22, 1969, the Cuyahoga caught fire outside Cleveland, Ohio. Flames rose five stories high, and fireboats rushed from Lake Erie to bring the blaze under control. It wasn't the first time that a river in a heavily industrial region of the United States had burst into flames. But no environmental disaster has had a more visceral impact on the national consciousness. *Time* described the Cuyahoga as the river that "oozes rather than flows," and in which a person "does not drown. He decays." "It was a very important day for this country," Gleick told me in his office at the Victorian mansion that houses the main offices of the Pacific Institute. "Before that, we were doing stupid things with water. Industries could dump whatever crap they wanted into rivers. There were no controls, no constraints. The Cuyahoga was coated with a sheet of flammable waste. And when it caught fire we passed the Clean Water Act, the Safe Drinking Water Act, and other measures, too. Everything began to change."

Every week, scholars, governments, ecological activists, and hydrologists produce thick reports about water scarcity and its relationship to irrigation, urban decay, and human health. Perhaps no one is more prolific or authoritative than Gleick, whose biennial report, "The World's Water," is a selective encyclopedia of the world's aquatic resources. Gleick is a reserved, tweedy-looking man with thinning hair, a short, graying beard, and, behind his circular wire-rimmed glasses, the searching eyes of an East Bay idealist. Although he received a Ph.D. in hydrology from Berkeley and studied engineering as an undergraduate at Yale, he knew by the end of his senior year that he didn't want to build dams for a living. He has spent his professional life searching through obscure collections of data for patterns of water use. He lectures frequently, and can cite dreary statistics, evidence of governmental inaction, and worrisome trends with great rhetorical force. But his central message, which is often ignored by both planners and environmentalists, is surprisingly hopeful. "It is a little-known fact that the United States today uses far less water per person, and less water in total, than we did twenty-five years ago," he said. "It's a shocker. People don't believe it, but it's true. This is an indication that things are not the way people think they are. It is not really because we are trying to cut our water use, although that is true in some regions of the United States, and particularly in the West. But we have changed the nature of our economy, and we have become more efficient at doing what we want to do."

The amount of water that Americans used for nearly all purposes rose steadily from the beginning of the twentieth century, through the Second World War, and into the seventies. Every projection indicated that the growth would continue. Yet, in 1980, the amount of water we withdrew from rivers, lakes, and reservoirs reached its peak and then began to subside. Despite increases in wealth, industrial productivity, and the size of the American population, the decline has accelerated.

There are several methods to assess the way we use water. Withdrawals measure how much we actually take from the earth. Some of the water used in factories or homes can be recycled. On the other hand, once water is consumed by agriculture or polluting industries, it is gone—at least until it rises to the clouds, evaporates, and returns as rain or snow. In the United States, total water withdrawals now stand at levels

not seen since the end of the fifties; per-capita withdrawals—the amount each of us uses every day—have fallen by twenty-five per cent. This is true even though the population has grown by more than a hundred million. Among the reasons are higher energy costs, which force consumers and industries to become more efficient in their use of water. (More freshwater is used to produce electricity than for any purpose other than farming.) Environmental laws, enacted in the seventies, forced factories to cut back on the amount of wastewater they discharged into American rivers. Many industries quickly realized that the cheapest way to meet the new requirements was to use less water. Conservation is another reason for the changes; federal and state laws now require efficiency improvements for many American appliances. (Toilets, for instance, use more water than any other domestic appliance. Over the past decade, the average amount of water in a standard flush has fallen from six gallons to 1.6.) Most important, perhaps, growing pressure on water resources—particularly for farmers in the West—has forced dramatic improvements in how much food we are able to grow with every gallon of water.



Finland, parts of Australia, much of Europe, and even Hong Kong also have experienced decreases in per-capita water consumption. As countries become more industrialized, pollution and economic inequality increase—often dramatically—and so does the use and abuse of natural resources. Eventually, though, as the gross domestic product of a nation rises, technologies mature, efficiency improves, and so does the amount of attention paid to human welfare and the environment. (This general phenomenon is known as the Kuznets Curve, after the Nobel Prize-winning economist Simon Kuznets.) In 1965, Japan needed fifty million litres of water to produce a million dollars' worth of goods. By 1989, the figure, after adjusting for inflation, had dropped to thirteen million litres. Such statistics suggest a fundamental change in how people live, and Gleick, among others, has argued that, in order to abandon what he calls the "hard path," planners, economists, and public officials must begin to address water use in an entirely new way. "The hard path treats our water problems as a simple issue of getting more from the environment, of finding new ways to take water from rivers and lakes and aquifers and move it farther and farther and farther away, completely independent of any analysis of how we are moving that water or how we are using it," Gleick said. "That is what the World Bank guys and traditional water engineers were trained to do. That is what we did in the twentieth century. It brought great benefits, but it has not solved all our water problems, and it is not going to.

"People who build dams don't understand the concept of efficiency, and neither do water managers," he continued. "I am a hydrologist. I was taught how to satisfy the needs of a hundred thousand people by making a dam. I can design a dam on a virgin river to meet those needs. I was never taught in engineering school to think about how people actually use water."

Dams are the principal instrument of the hard path. Desalination plants are another. If, through some alchemy, we could wring enough freshwater from the sea, our water problems would be solved. The concept is ancient, and, oddly enough, it arose at a time when salt, not water, was the more valuable commodity. Thomas Jefferson, seeking a way to provide freshwater to ships at sea, was the first advocate of desalination in America, and in the sixties John F. Kennedy strongly supported the idea, saying that desalination "can do more to raise men and women from lives of poverty and desperation than any other scientific advance."

There are two main ways to separate freshwater from salty seawater. Distillation, the traditional method, relies on heat to evaporate water and remove salt and impurities. It requires a lot of fuel and can be prohibitively expensive. A technology like reverse osmosis uses a more modern approach: water is forced at high pressure through a series of tightly wrapped membranes so that the water molecules, which are smaller than impurities and salt, pass through. The rest is then discharged as brine into the sea, where it can cause serious ecological damage. There are nearly twenty thousand desalination plants in operation today, most in countries with little water but no shortage of either oil or money. In the Persian Gulf, desalination accounts for nearly forty per cent of municipal water supplies.

Reverse osmosis has become significantly more efficient in the last few years, and in many places the cost of producing potable water has fallen by half or more, making it a valuable tool. In Singapore, for example, ten per cent of the water is produced by Asia's biggest and most economical desalination plant. Yet for developing countries such solutions are unlikely to be affordable soon. In India, water produced by desalination plants would cost a hundred times as much as water taken from a well. Nonetheless, the government of Tamil Nadu is about to build a plant that would provide a hundred million gallons of water to the city of Chennai each day. That would make it one of the largest such facilities in the world. "This is complete rubbish," Janakarajan, the water-policy expert from the Madras Institute of Development Studies, told me. "Desalination is a five-star solution for a one-star country. We are poor. We need to capture our rain and store it. But that would be too easy, and it would make too much sense." Like most of his colleagues, Janakarajan argues that recycling industrial wastewater, achieving greater agricultural efficiencies, cutting the leaks on pipelines (most Indian cities lose at least forty per cent of their water to leaks), and repairing neglected ponds and misused reservoirs would provide the city with all the water it needs. "Everyone wants to solve this problem with smart technology," he said. "We are more likely to solve it by simply being smart."

One way to be smarter about water is to take better advantage of the global economy. It makes no sense to measure water use solely by how many times we flush the toilet, wash our cars, or take a bath. Those things matter, of course, but far more water is used to manufacture food, paper, and cotton. When a Toyota sedan or a cotton sweater is imported into the United States, the water it took to make those products is imported along with them. When we sell our grain, processed food, or other manufactured products on international markets, the United States is also ex-

porting the water that is contained within those products. Economists use the concept, known as "virtual water," to illustrate a simple fact: it is often cheaper to import something like grain or cotton than it is to transport water. The amount of virtual water contained in ordinary products is often surprisingly large: a recent study from the Netherlands found that a standard cup of coffee required a hundred and forty litres of water, most of which is used to grow the coffee plant. This means that it takes more than a thousand drops of water to make one drop of coffee. Most of the water used to make that coffee is not actually Dutch, because the coffee is grown in Latin America, Africa, and Asia. Virtual water is one way to use less water on agriculture in a place where it is needed for other purposes.

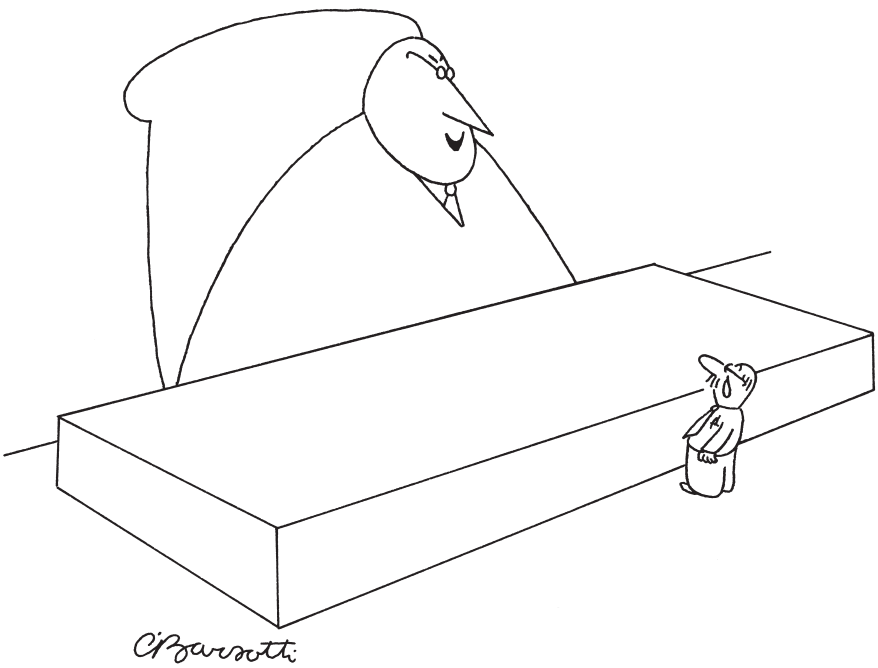
Since the nineteen-seventies, nearly all water-demand forecasts issued by governments and international agencies have grossly overestimated future needs. This has led engineers and planners to continue pushing for giant public-works projects. "These are the nuclear people from the seventies, the big-dam people from the sixties, and now they are the desalination people," Gleick said, stressing that, in theory, he was opposed to none of them. "All these people seek large magic bullets to solve the world's problems. They all have this very strong belief that there is one solution out there and if only we could build enough of it or find it our problems would be over. It drives me crazy."

In many parts of the world, there is now almost as much talk about dismantling dams as there is of building them. People in San Francisco have debated the fate of the Hetch Hetchy dam, the city's principal source of freshwater, for fifty years. Hetch Hetchy is a valley in Yosemite National Park carved by glaciers and surrounded by sheer granite walls and waterfalls. The dam provides two hundred and sixty million gallons of nearly pristine water each day to more than two and a half million residents of the San Francisco Bay Area.

The creation of Hetch Hetchy, in 1913, outraged the newly formed Sierra Club. Its founder, John Muir, led the opposition to flooding the valley, which gave rise to the modern American environmental movement. "Dam Hetch Hetchy!," Muir wrote in 1908. "As well dam for water-tanks, the people's cathedrals and churches, for no holier temple has ever been consecrated by the heart of man." In July, California Governor Arnold Schwarzenegger released a report suggesting that Hetch Hetchy may no longer be necessary—several new reservoirs have been developed in the past twenty years—although the cost of tearing it down and building a plant to filter the new sources of water would be enormous. "I think Hetch Hetchy is going to go," Adam Werbach, a former president of the Sierra Club, told me. Werbach is one of five members of the San Francisco Power Utility Commission, which regulates water for the city. "The question is really when and how," he said, pointing out that it is technically feasible to dismantle the dam now, though it is unlikely to happen soon. "This was one of the most beautiful places on earth, and you have to ask yourself, 'Do you want your grandchildren to hike through the lost valley of the Gods, or do you want that old six-gallon flush toilet?'"

Until recently, nobody bothered to ask such questions—and nobody needed to. But the biggest potential new source of water, not just in Delhi or Dar es Salaam but in Tokyo and San Francisco as well, is us. By conserving water and pricing it more realistically, we can dramatically reduce our needs. Agriculture will always require more water than any other human endeavor, but that doesn't mean it has to be wasted. Until the sixties, none of the vineyards in California used drip irrigation, which applies minimal amounts of water directly to the roots of crops. Today, seventy per cent of them do, using less water to produce the same yield (or the same amount of water to produce more). Some farmers have begun to level their fields with lasers, making irrigation even more precise. And although genetically modified crops remain controversial, researchers have produced several strains of rice that require only a fraction of the water most farmers use today.

"I would argue that almost everything we do on earth we could do with less water," Gleick told me. "And that is the soft path. This is a different way of thinking than in the twentieth century, when the simple answer to every demand was 'Let's go get some water.' That is what led to the destruction of the Aral Sea, the dewatering of the Colorado River basin in Mexico and the Yellow River, in China." He stopped for a moment and stared at his hands. "This is really good news, you know. Because it means we can do better. We don't need to run out of water. We just need to think more seriously about how we can avoid using it." ♦



"You're out, Hodges—it's time to make way for a younger loser."