*Peter H. Gleick is co-founder and president of the Pacific Institute in Oakland, California, a MacArthur fellow, and member of the U.S. National Academy of Sciences. He is the author of seven books, including the biennial report,* The World's Water *(Island Press).*

# Facing Down the Hydro-Crisis

*Peter H. Gleick*

In March 1997, in rural Hebei and Henan Provinces in China, several hundred farmers from neighboring villages clashed over access to water resources to irrigate their crops, leading to dozens of injuries. The rivers that used to supply all their needs were drying up. Two years later, violent conflicts over water escalated in the same region. Hundreds more villagers were injured and water diversion facilities destroyed.

In 1999, some 700 soldiers were sent to quell fighting that claimed six lives and injured 60 others in clashes that erupted between two Yemeni villages fighting over a local spring.

In 2001, civil unrest in Pakistan over severe water shortages led to protests, riots, and bombings, killing one and injuring dozens. In 2004, a similar dispute in a bordering region of India led to four deaths and more than 30 injuries.

Between 2004 and 2006, at least 250 people were killed and many more injured in Somalia and Ethiopia in fighting over water wells and pastoral lands. Villagers there call it the War of the Well and tell stories of "well warlords, well widows, and well warriors."

Across the globe, these sorts of public protests, disputes, and violence over water are increasingly common as problems of contamination, shortages, and allocation grow.

In rural villages and expanding cities around the world, water is an increasingly scarce and contaminated resource. As populations and water demands continue to expand, the heightened risk of violent conflicts over water use and contamination suggest new calls for fundamental changes in the way we manage and use this precious resource. The world of water is changing—not just how much water is available, or who controls it, but the whole way we think about and manage this precious commodity. The assumptions we made in the last century about the availability and use of water no longer seem to apply. And for water managers, planners, hydrologists, engineers, economists, policy makers, and concerned citizens, the time has come for new thinking and new solutions.

Over the past several centuries, societies have developed different technologies, practices, and institutions for supplying safe and reliable freshwater, dealing with extreme events, as well as collecting, treating, and disposing of wastewater. These tools brought enormous benefits to humankind. But they have also failed to solve some of our most difficult water problems, and in key ways they are unsuited to our new

 

challenges. We need a new approach—movement into what I call the Third Water Era.

### *The First Two Water Eras*

The First Water Era lasted for some millennia, before human civilization evolved out of the most primitive hunter-gatherer existence and struggle for survival. The earliest societies relied on the natural hydrologic cycle to provide water for their use and take away what they didn't want. Put more simply, rivers and streams brought drinking water and fish, and washed away untreated detritus and human wastes. While the population of the planet was still small and dispersed, this worked well. Life was brutish and short for most people anyway, and water-related illnesses were dwarfed by the terrible consequences of childbirth, plagues, pox, and malnutrition.

Over time, this simple approach proved insufficient. As pockets of civilization began to expand and outgrow local water resources, the Second Water Era emerged in the form of intentional manipulation of the water cycle and efforts to apply new technologies, engineering, and institutions to water problems. In the ancient cities of Rome and Greece, the agricultural fields of Mesopotamia and the Indus Valley, and other cradles of civilization, new approaches began to improve on nature's hydrologic cycle. The first dams were built across streams and rivers to divert water to farms for irrigation. The Code of Hammurabi, the judicial code dating back 4,000 years to ancient Babylonia, offers hints of the first laws and regulations governing water use, the design and operation of irrigation canals, and punishments for theft of water. Early engineers built the first canals and aqueducts to move water from places of relative abundance to places of concentrated demand. Wastewater began to be collected and isolated from day-to-day living. These kinds of innovations helped early populations live longer, interact more closely, and create cultures of art, philosophy, and science.

In some ways, however, the Second Water Era truly began in the mid-1800s, when versions of our current approaches to water management and use were developed. Cities in industrializing regions were then outgrowing and contaminating their water supplies; waves of cholera and other water-related diseases were sweeping the world; and human scientific and engineering ingenuity was blossoming. By the middle of the nineteenth century, new tools of observation, statistics, and epidemiology were being tested and there were clues that many health challenges were the result of contaminated water and bad water management.

In 1854, Dr. John Snow, a London physician, conducted a simple yet brilliant test that helped to settle the debate about the transmission of cholera. One of the poorest neighborhoods of London—served by central wells and lacking sewage collection—had been beset by a virulent cholera outbreak. He plotted the homes and numbers of people affected and noted the location of the wells that provided water for the hardest hit neighborhoods. He concluded that the source of contamination was the water from one particular well on Broad Street. He received permission from local authorities to remove the pump handle, which forced residents to draw water from other, uncontaminated wells. Within days, the outbreak subsided.

As science and medicine revealed more about the sources and prevention of water-related diseases, a revolution in thinking about water swept through the rapidly industrializing world, leading to sewage systems, innovative water treatment, new piping and distribution investments, and efforts to clean up and protect drinking water sources. This era also saw the first

physical, chemical, and biological treatment systems for large, centralized volumes of waste. The first dams of gigantic scale were built to hold back floods, supply water in dry periods, and produce reliable, clean electricity. The technology was developed and deployed to build aqueducts—not tens of kilometers dug out of dirt, but thousands of kilometers in length, through or over mountains, from glaciers to the deserts. Large-scale irrigation systems were designed to permit farmers to grow food in places and at times never before possible.


©Andreina Schoeberlein

What were the consequences of these advances? Cholera and dysentery, rampant in cities like New Orleans, Philadelphia, Chicago, New York, London, Paris, Moscow, and other major urban centers in the 1800s, were vanquished in developed nations, largely through the use of chlorine, filtration, and other wastewater treatment processes. The Green Revolution, due as much to the modernization of irrigation as to the application of fertilizer and pesticides, helped hundreds of millions of people avoid massive starvations in the twentieth century as the global population quadrupled from 1.5 billion to 6 billion. And nature's fury—unavoidable floods and droughts—are at least partially controlled and less damaging.

## *The Third Water Era*

But despite these enormous advances; despite our better understanding and technology; despite the hundreds of billions of dollars spent by utilities, towns, nations, and the international community; we still face a global water crisis of a magnitude unlike any before in human history. Not only have we not solved all of our traditional water problems, but we are now faced with new and difficult challenges. Today, water is taking center stage as the most critical resource issue facing humanity.

First, there's the complicated question of supply. The total amount of water on the planet is fixed—neither growing nor shrinking. But as the population continues to grow, per-capita water availability is declining. Moreover, while this crisis is global, the impact is felt most acutely on the regional level. Water demands in some regions are rapidly increasing, as economic growth, new industries, and new technologies produce new and higher water demands. Roughly one-third of the world's population still lacks access to the most basic water services, including 1 billion people without any access to safe and afford-

able drinking water and 2.4 billion without access to adequate sanitation. The harsh reality is that there are hundreds of millions of cases of water-related diseases and some 2–5 million deaths per year, largely young children. Most are entirely preventable. At the same time, industrial activities are contaminating water with vast quantities of man-made pollutants—from the gasoline additive MTBE to perchlorate, endocrine disruptors to pharmaceuticals—the effects of which we only poorly understand. As a Kashmiri proverb warns, "It is easy to throw anything into the river, but difficult to take it out again."

As the planet's population surges and a new, global middle class emerges with increased appetites, especially for water-intensive meat, food production has become a critical component of this water crisis. While the area of irrigated land is growing, it is doing so at a declining rate, putting increased pressure on agricultural production. Many regions of the world are suffering from rapid depletion of groundwater resources that are being pumped faster than nature can replenish. By some estimates, as much as 40 percent of our food production comes from such unsustainable water resources.

In our oceans and rivers, a growing number of fish species are threatened or endangered by the human use of water. Some aquatic ecosystems have been completely destroyed or irreversibly modified by human water withdrawals. For example, the Aral Sea, nestled on the frontier between Kazakhstan and Uzbekistan, was once the fourth-largest inland salt-water body. Today, it is barely a quarter of its size a half century ago—thanks to the massive diversion for Soviet irrigation projects of the vast rivers that once fed it. All 24 species of fish found only in the Aral Sea are now extinct. Likewise, nearly one-third of all North American freshwater fauna populations are considered threatened with extinction, a trend mirrored elsewhere around the world. Water flows in average years no longer reach the deltas of many of the world's great rivers, including the Nile, Yellow, Amu Darya, and the Colorado, leading to nutrient depletion, loss of habitat for native fisheries, plummeting populations of birds, erosion of shorelines, and adverse effects on local communities.

All of these problems are likely to be made worse by the world's changing climate, which will have an increasing impact on water resources and the systems we built to manage them. As temperatures rise, the need for water will rise; as precipitation patterns change, water availability will change. Glaciers and snowpacks are diminishing, while the frequencies and intensities of storms are more irregular. Meanwhile, water managers are wholly unprepared to meet the demands of a different climate.

The final issue, of course, is the world's broad and all but total failure to integrate questions of growth, development, and resource use, of which water may be the number one victim. These pressures come at the very moment the competition for limited freshwater is growing among users, threatening local, regional, and potentially, global stability.

### *Non-Traditional Reactions*

The first reaction to our water problems is often a traditional, knee-jerk response—that we just need to pay more attention, and put more effort and more money into addressing this crisis. Doing more of the same, however, will not be enough. In fact, while the tools and methods used in the Second Water Era brought great benefits, they also brought huge and unexpected economic, social, political, and environmental costs. It is high time to look for new ideas and answers. Over the past two decades, with little fanfare and recognition, a new

way of thinking about water has been taking shape. Community-scale sanitation and hygiene projects have been developed, tested, and implemented. New technologies for water treatment are being brought to market. And innovative forms of information and communication are appearing at an astounding rate, permitting successful solutions to be more quickly and widely appreciated and implemented.

This new era requires nothing short of a revolution in thinking about water—a fundamental re-evaluation of water planning, policy, and management. We need to utilize technology, environmental science, economics, and new institutional approaches to address unresolved water challenges and to tackle new threats, such as climate change. We need what the Pacific Institute calls a Soft Path for Water.

> "We need a revolution in thinking—a fundamental re-evaluation of water planning, policy, and management."

First, the top priority is to meet the basic water requirements for all humans and all ecosystems. Governments, international aid organizations, corporations, and private groups at all levels must join forces to meet the goal of providing these basic needs universally. The economic costs of meeting these needs are far less than the economic costs of failing to do so. Some efforts are currently underway. But funding, agreements to transfer technology and information, and institutional efforts on the part of international agencies and local governments are all inadequate. For basic human needs, the efforts of the world community through the Millennium Development Goals are a key beginning. These goals include the targets of expanding access to water and sanitation for the world's poor. For basic ecosystem needs, there are new efforts to identify, define, and satisfy water requirements through policy initiatives. In North America, efforts to provide basic river flows or restore ecosystem health are underway in the Florida Everglades, the Great Lakes, the Sacramento/San Joaquin Delta, and many other places. In South Africa, the constitution guarantees meeting the basic water needs of both humans and the environment. And in Europe and Asia, there are proposals for new standards for environmental management. Just as in battling climate change, the United States has an opportunity to be a player in solving water issues through smarter funding and the utilization of our vast scientific, technological, and educational resources. But we are not yet playing that role to the extent of our ability, either at home or abroad.

Second, we must rethink our approach to both water supply and demand. On the demand side, there is vast potential to become more efficient in how we use water, in every community, in every use—from industry to commerce, from homes to farms. Our societal goals are not the "use" of water, but providing goods and services to society: getting rid of wastes, producing industrial output, washing our clothes and bodies, and growing more food. While most of these steps require water, there is tremendous potential to reduce the amount of water needed to accomplish these goals. If we can do these things with less and less water, we will be better off. We are already making progress in this area: overall water use in the United States is lower today than it was some 35 years ago; China is beginning to raise water prices to encourage conservation and efficiency; Mexico City is beginning a

major effort to find and stop leaks that prevent water from reaching consumers; and Singapore's water conservation programs, coupled with innovative new supply developments, have helped reduce its dependence on imported water from Malaysia.

It is possible to break the assumed connection between economic growth and water use. Indeed, improving efficiency is perhaps the most important new tool in our arsenal.

At the same time, we must also rethink our water supply alternatives. The traditional approach of building dams, aqueducts, and central irrigation systems to take more water from vulnerable ecosystems and watersheds is unsustainable. New approaches must be developed. In many countries, new water management infrastructure is still needed, but it will have to be built to better economic, social, and environmental standards. The days of misleading and incomplete cost-benefit analyses—ecosystems ignored, social impacts hidden, and communities left out of the decision-making process—must be brought to an end.

But we should also expand the definition of what we consider new "supply." Water supply must also include increased use of recycled and reclaimed water, rainwater harvesting, desalination (where appropriate), and innovative blended use of surface and groundwater. In Namibia, Singapore, and California, wastewater is increasingly treated to a very high standard and reused for industrial or commercial purposes, even for drinking. And in India, traditional rainwater harvesting is once again restoring groundwater and stream flows, reviving communities and giving new options to struggling farmers.

Third, we must do a better job of protecting water quality and matching requirements to demands. Why is expensive potable water still widely used to make our golf courses green or flush our toilets, when other water is readily available? In the western United States and other regions, where water is scarce, lower quality alternatives are already being used. In developing nations, new technologies are beginning to offer better, cheaper, and more reliable water-quality monitoring to protect human health. But governments must improve and strengthen standards for water quality and more aggressively enforce those standards. Greater attention to water quality will not only save lives and protect ecosystem health, it will also expand the amount of water resources available for use. In China, for example, as much as 40 percent of water is too contaminated to use for domestic and agricultural purposes. Accelerating the construction of modern wastewater collection and treatment systems and enforcing laws against polluters can help stop the needless sickness and death that result from the consumption of dirty water, while simultaneously increasing the volume of water that can be used to meet agricultural requirements—and that now simply goes to waste.

Fourth, global climate changes are coming; indeed, they are already upon us. Humans are altering the composition of the atmosphere in a way that is guaranteed to alter the climate for centuries to come. The scientific evidence that climate change is already affecting our water resources is rapidly accumulating. We are seeing the loss of snowpack in the world's mountain ranges. The glaciers of the Rockies, Himalayas, and Andes are fast disappearing, which will affect downstream communities that depend on the water stored in these mountains. The timing of rainfall and runoff is shifting. Billions of people and the coastal infrastructures on which they depend are vulnerable to storms and rising sea levels. These risks impel legislation to reduce greenhouse gas emissions and plans for adapting and mitigating the impacts that are now, sadly, unavoidable. With regard to building the facilities required for sustainable water

management, climate change must be considered. Wastewater treatment plants and desalination facilities along coastlines must take into account sea levels of the future, not of yesterday. And ongoing projects to dam rivers and tap into groundwater aquifers must consider how future climatic conditions will affect operations and hydrology. In short, we must manage our water systems for tomorrow's climate or face the reality that they might be obsolete before the final brick is laid.

Finally, we must improve institutions that manage our water resources, including utilities, planning agencies, government bureaucracies, and companies. Charles Darwin observed that "if the misery of our poor be caused not by the laws of nature, but by our institutions, great is our sin." Well, we must then repent. The failure to solve our water problems is not the result of a lack of water, money, or knowledge. Ultimately, it is the failure of our institutions. Universities will have to broaden what they teach about water—expanding beyond simple engineering to smart economics, sociology, and political science. Water utilities must devise innovative environmental management systems that permit them to sustainably satisfy the needs of both human and natural ecosystems. Government planning agencies must make real efforts to integrate growth, planning, and water resource issues by prohibiting development in regions with inadequate water resources or limiting the kinds of development to "green," low-water-use design and construction. New collaborations are required among farmers, environmentalists, industry, and water agencies to reduce the risks of violence over diminished water resources. And an innovative set of economic tools must begin to set reasonable pricing incentives to encourage efficient and sustainable use of water and eliminate subsidies that promote bad practices.

> "Why is expensive potable water still widely used to make our golf courses green or flush our toilets?"

What will the future bring? Are we as humans condemned to a perpetual water crisis and growing conflicts over water? This unwanted and dangerous path can now be seen far more clearly than ever before, and at this critical juncture, every step we make will affect the course we follow. As population growth and development pushes us even closer to the limits of our water supply, our focus must shift to a new way of thinking. Water is a precious, scarce, and vital resource and our use of it must be thoughtful, sustainable, and carefully planned. ●