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Water Resources: A Long-Range Global Evaluation

Peter H. Gleick*

INTRODUCTION

My talk today is supposed to be on water resources, but I would also like to also offer some comments on Dante's Inferno, lawyers, the Koran, global climate change, and Walt Disney.

Let me begin with a little review of Dante's Inferno for those of you who haven't read it recently.

In this epic poem, Dante describes his tour of the nine circles of hell. To each circle is condemned a group of sinners, ranging from the top circle, with virtuous pagans, down to the fourth round of the ninth circle, with Satan himself. As Dante descends each circle, he sees that the torments get worse and worse as the sins get worse and worse. Let me give you some of the flavor: going down from the first, relatively mild circle, we pass the carnal, the gluttons, the hoarders, the wasteful, and the heretics. Things get really interesting when we get to Circle 7, which has the violent and the bestial, including murderers, war-makers, blasphemers, perverts, and usurers. Even deeper down, in Circle 8, are the fraudulent and malicious, including seducers, panderers, flatterers, and so on. Now what's the point of all this?

Well, the title of my talk is "Water Resources: a Long-Range Global Evaluation" (a title chosen, by the way, by Professor Buxbaum from the Law School). On level four of Circle 8, way down there, Dante puts the fortune tellers and diviners, which in today's language would include environmental forecasters, climate modelers, and those who stoop to giving "long-range global evaluations." Since each sinner is given a characteristic punishment fitting their sin, perhaps it is appropriate that on this level sinners have their heads turned backwards on their bodies: they move forward in time but are condemned to look backward through eternity.

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My only consolation is that Dante puts certain lawyers even further down in the pits.

With that small disclaimer completed, let me welcome our out-of-town guests to California, which is suffering its sixth consecutive year of drought—one of the most severe in the last century. In the Western United States, we have a saying that the two hardest things to keep out of water are salt and politics. I believe that this is increasingly true for many other parts of the world as well.

I would like to talk this afternoon about water and global environmental politics. I believe that many problems involving fresh water resources are increasing in severity and extent. These problems deserve special attention because, as I will describe, water is a metaphor for many of our other important environmental woes: problems of energy resources, sustainable development, global climate change, and what I call environmental security—conflicts over either global environmental degradation or the inequitable use of resources.

So while I intend to talk mostly about fresh water, I would like to touch on the links to these other environmental problems, many of which you will be tackling during this conference.

FRESH WATER: AN OVERVIEW

Fresh water is wonderful stuff. A little oxygen, a little hydrogen, and bang: water. Without water, the Earth would be a lifeless ball. Yet 97.5% of water on the planet is salt water—it is too salty to drink or grow crops. Of the other 2.5%, the vast majority is locked up out of practical reach in the vast icecaps of Greenland and Antarctica. What is left is unevenly distributed in space and time—so unevenly that we spend billions of dollars every year to move it from wet areas to drier areas, or to store it in wet seasons for coming dry periods.

California is the perfect example of this. All of our rain (when we get any rain) falls in the winter months and none in the summer months when farmers need it most; and the vast majority of our rain falls in Northern California, while the demand is greatest in Southern California.

This maldistribution is evident around the world. Whether measured by how much water there is in a region, or by the amount of water available per capita, there are wide disparities.


Data on the global water cycle are summarized in WATER IN CRISIS: A GUIDE TO THE WORLD'S FRESH WATER RESOURCES (Peter H. Gleick ed., 1993) [hereinafter WATER IN CRISIS].
For example, Iceland, Norway, Canada, and New Zealand all get more than 100,000 cubic meters of water per person per year, whereas the average for all of Africa is under 7,000 cubic meters per person per year. Parts of the Eastern United States receive two or three times the amount of water that California gets, and they get many times the amount received by the arid Southwestern United States.

**POPULATION GROWTH, WATER SUPPLY, AND SANITATION SERVICES**

This issue of the physical maldistribution of water leads to another critical and related environmental issue: population growth. Very simply, the amount of water available per capita in a region depends on how many people reside there. In 1850, the average amount of water available per person worldwide was 43,000 cubic meters per year; today it is under 9,000—a change brought about only by increases in population, not by any change in the hydrologic cycle. Of course, the average water availability per person is rapidly decreasing as populations continue to soar. In regions of the world where water quality or water quantity is a problem, a constantly growing population means having to run just to keep up. And we are failing to keep up.

Let me give you a graphic example of this. In 1980, the United Nations launched the International Drinking Water Supply and Sanitation Decade, with the goal of providing clean drinking water and sanitation services to those without them. At that time, 1.74 billion people in the developing world alone did not have access to adequate sanitation services. Ten years later, in 1990, enormous effort, expense, and progress had provided sanitation services to 748 million of these unserved people, albeit at a pretty minimal level. During that same period, however, the population needing these services grew by 750 million people. In other words, population growth entirely wiped out the progress achieved in this area—1.74 billion people are still without access to sanitation services.

Somewhat better progress was made in providing clean water for drinking. According to the UN, 1.35 billion more people had access to clean water at the end of the decade than at its start, but nearly 1.23 billion still lack such access. Moreover, these overall numbers hide some ugly regional problems. For example, the total populations in urban areas needing both clean water and sanitation grew over the decade,

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3. [The World Resources Institute, World Resources 1990-91, at 330-31 (1990) [hereinafter World Resources Institute]].
6. Id.
reflecting the massive migrations to large, urban centers in developing countries and our inability to provide necessary services there.

Furthermore, the UN estimates that population growth over the period 1990 to 2000 will result in 900 million more people needing these services.\textsuperscript{7} The futility of the situation reminds me of a cartoon I had in my office with a picture of a policeman writing a speeding ticket to a man in a car. The man is saying: "I grant you, I was hurrying, Officer, yes—but not to 'get' somewhere, just to avoid slipping behind."

We are falling further and further behind in our goal of providing even basic clean water and sanitation services to the world's poor.

What are some of the implications of this inability to provide services to all in need? Directly associated with poor sanitation services and unclean drinking water are the severe water-borne diseases: malaria, dysentery, cholera, and the many parasitic diseases found in Africa and Asia, such as schistosomiasis and guinea worm. In 1990, there were 70,000 cases of cholera reported worldwide.\textsuperscript{8} None of these cases were in Latin America, which had been free of cholera for over one hundred years. In 1991, cholera exploded there: over 390,000 new cases were reported in 14 Latin American countries, attributable to the problems I have just described.\textsuperscript{9}

In some regions, the desire to increase water use is coming up against physical limits. Some analysts consider the minimum amount of water required for an efficient industrialized nation to be 1,000 cubic meters per person per year.\textsuperscript{10} Given today's populations, 18 countries simply do not have this quantity of water available. By the year 2025, using the United Nations' mid-range population predictions (I guess we will see some UN officials in the eighth circle of hell, too), 33 countries will be unable to provide this quantity of fresh water, simply due to increases in population. Of these 33 countries, 28 are in Africa and the Middle East; only one is in Europe.\textsuperscript{11}

"What about using desalination to meet this shortfall?" many people ask. After all, 97.5\% of the world's water is salt water. A partial answer is that desalination works—there are over 7,500 desalination plants worldwide, making more than 13 million cubic meters of fresh

\textsuperscript{7} Department of International Economic and Social Affairs, United Nations, World Population Prospects 1990, at 5-10 (1991).
\textsuperscript{8} Letters from Dr. S. J. Simeant, World Health Organization (Geneva, Switz.) (June, 1992).
\textsuperscript{9} Id.
\textsuperscript{10} Id.
\textsuperscript{11} Peter H. Gleick, Effects of Climate Change on Shared Fresh Water Resources, in Confronting Climate Change: Risk, Implications, and Responses 127, 135 (Irving M. Mintzer ed., 1992). The one European nation is Malta. Id.
water every day. But desalination remains out of the question for all but the wealthiest regions and countries because of its high cost, which arises almost entirely from the enormous amount of energy required to strip salt ions out of water. For this reason, the vast majority of desalination facilities are in the Middle East, where the old joke is that every time they sink a well looking for water they find oil.

ENERGY RESOURCES

The problem of water resources has other ties to the question of energy resources. Not only does providing clean water require substantial quantities of energy (for desalination, or pumping, or other activities), but providing energy often requires significant quantities of water. The prime example of this is power plant cooling.

Of all human activities, agriculture is the most consumptive of fresh water, but as much water is withdrawn every day and used for power plant cooling as is used for agriculture. Most of this water is put back, a bit hotter, into the original stream or lake from which it was taken. The fundamental fact, however, is that for regions and countries where the absolute amount of water is limited, building many large power plants that require vast quantities of cooling water may simply be out of the question. In this regard, the conventional forms of energy used by industrialized nations, fossil fuel and nuclear power plants, tend to require far more water than do renewable energy sources. This energy-water tie has been ignored for too long, and it deserves a better analysis in the decisions about energy resources that are now being made.

AGRICULTURE

I mentioned that far more water is consumed by the agricultural sector than by any other. Indeed, here in California, over 80% of all water consumed goes to the farm sector, and this is true elsewhere as well. The "Green Revolution" was as much a revolution of irrigation as of crop types, fertilizers, and pesticides. Further expansion of food production thus will require a significant expansion of irrigation. Before such expansion is undertaken, however, we must ask if the water is available. In 1989, only 9 countries in Africa irrigated more than 10% of their cropland. Over 60 countries worldwide fall in this category. In fact, nearly 20 nations in Africa have no irrigation systems at all.

13. See id. at 159-71.
15. Id.
16. Water in Crisis, supra note 2.
17. Id.
While arable land suitable for irrigation often exists, physical or political constraints may hinder any expansion. The political constraints can be just as significant as any physical ones. In Northern Africa, for example, the Sudan is considered to be one of the few nations with great potential for increased irrigation: there is sufficient arable land, and there is, in theory, sufficient water in the Nile. In reality, however, withdrawing additional water from the Nile would require renegotiating or abrogating a treaty signed in 1959 with Egypt, allocating the waters of the Nile between the two countries. This is an action with enormous political ramifications.

INTERNATIONAL SECURITY

There has been a growing discussion over the last few years about the links between resources, the environment, and international security. The changes in the international picture in the last few years have been enormous—almost unimaginable even by the best fortune-tellers. Yet the end of the cold war has been accompanied by an increase in tensions over resources and the environment, culminating in two important events: the Persian Gulf War and the United Nations Conference on Environment and Development (UNCED) meeting in Brazil. The war in the Persian Gulf was a war over oil, fought with the environment as both a target and a military tool. We saw intentional attacks on oil fields, desalination plants, energy facilities, and water supply systems. We saw the deliberate spilling of oil into the Gulf as a weapon, and we heard discussions about cutting off the flow of the Euphrates to Iraq by closing the Ataturk Dam in Turkey.

The potential for future problems in international security to revolve around water is great. Fresh water resources are widely shared internationally. More than half of the land area on Earth drains into rivers shared by two or more nations, and conflicts over these joint resources have occurred in the past—for example in the Middle East over the Jordan River, in South Asia over the Ganges, Brahmaputra, and Indus Rivers, and in the America's over the Colorado and Paraná Rivers. These disputes have usually been resolved in conference rooms over pen and paper, but violent conflicts over water have also arisen. I believe conflicts

20. See CENTRE FOR NATURAL RESOURCES, ENERGY, & TRANSP., DEPARTMENT OF ECON. & SOCIAL AFFAIRS OF THE UNITED NATIONS, UNITED NATIONS REGISTER OF INT'L RIVERS 3 (1978). In 1978, 47% of the world's land area was drained by rivers shared by two or more nations. Id. This percentage has increased significantly due to the dissolution of the Soviet Union and Yugoslavia.
over shared water resources are on the rise, and they will be increasingly violent unless we can work out satisfactory mechanisms to prevent them. These conflicts will be spurred by growing populations that demand more and more water for basic human services, by the need to increase irrigation to provide food for these populations, and by what I see as a disturbing trend toward the use of resources and the environment as weapons of war.

SUSTAINABLE DEVELOPMENT

The last connection I would like to draw is to the issue of sustainable development, symbolized in part by the UNCED conference in Brazil. "Sustainable development" is the new mantra of the international environmental community, yet there has been insufficient attention to actually understanding what such development means, particularly in the area of water resources. In the Brandt Commission report, water resources are hardly mentioned; in the famous Brundtland Commission report, Our Common Future, there are chapters on climate change, forests, land, and endangered species, but not on water, which receives barely a page of discussion in its own right. Even the UNCED did not initially have a session on water, though one was eventually added.

This casual treatment of water is surprising when one considers that some of the greatest constraints placed on true sustainable development may be due to problems related to water quantity and water quality and the ties between water, population, agriculture, energy, and global change. This conference in Berkeley should be commended for its attention to the issue of water.

CONCLUSIONS

Let me close with some observations about solutions and necessary actions:

1. In some regions of the world, fundamental improvements in water supply are needed. I described the large and growing numbers of people without access to clean drinking water or sanitation services. Improving water supply will have a direct effect on improving the quality of life in developing countries. In some places, such improvements may even mean new large water supply projects, which are typically the focus of considerable environmental controversy and opposition. Given the way such large projects have been built in the past, such controversy and opposition is well deserved. Prior to undertaking more projects that
may have severe environmental impacts, we must learn how to evaluate a project's true costs and benefits, including its ecological ones.

2. In the industrialized countries, where water use is very high, intense efforts at increasing the efficiency with which water is used is vitally important. The same effort that has gone into energy efficiency should also go into water use efficiency; and more effort ought to go into both. This will involve new technology, changes in the way we price water, and innovative governmental policies. A moral justification for conservation and efficiency is not difficult to find. For example, I note that the Holy Koran says: "Be not prodigal. Lo! He loveth not the prodigal." and "The squanderers were even brothers to the Devil." One author even states that a proper Muslim is required to develop a positive attitude to the rational use of water—a sentiment that echoes Dante's Inferno, which puts wasters way down in Circle 6, just above the murderers and warmakers, but below the gluttons and hoarders.

3. The issue of global change, in particular global climate change, should be considered a fundamental part of our future. Far more progress on this has been made in Europe than in the United States. The basic fact is that global climate change will affect water availability and water quality in ways that we do not yet fully understand, but that could affect us enormously. For example, we must consider the implications of a 25% decrease or increase in the average flow of the Nile or the Rhine or the Brahmaputra—changes that are quite plausible given what we know about the dynamics of climate change.

4. I have already discussed population growth. Let me just say that if we cannot get this under control, everything else becomes exponentially more difficult.

5. The great scope of shared international rivers and the growing risks of conflict over them necessitates the development of better international agreements and principles. International water law has a long history, but it remains somewhat immature: broad principles of agreement have yet to be adopted, though I note that progress has recently been made by the International Law Commission. Individual river treaties, which have been more

23. Surah Al Isra 27.
successful (though on a more limited geographical basis), should begin to include provisions for the uncertainties induced by the greenhouse effect and by growing demands for water. All parties to a river basin should be parties to a treaty. We can no longer afford to have a situation like the one on the Nile River, where the 1959 treaty between Egypt and the Sudan excludes the other seven nations that belong to the basin.\textsuperscript{26} Agreements regarding the rivers of Europe can provide good examples, though I note that even in developed regions such as Europe, issues of water quality and water supply are far from fully resolved.

Finally, a comment on Walt Disney is appropriate, believe it or not. Many of you know that Disney recently opened a new amusement park in France—EuroDisney. Water plays a prominent role in such theme parks—it provides innumerable forms of entertainment, including exciting rides and beautiful fountains, not to mention its use in the more mundane aspects of maintaining and operating the parks. In these parks, water appears to be available and used in unlimited amounts, not unlike the old Villa d’Este in Italy. But try to remember that unlimited fresh water, like much of what Disney itself offers, is only a fantasy.

\textsuperscript{26} Sudan-Egypt Agreement, \textit{supra} note 18, 453 U.N.T.S. at 72.