CHAPTER 5
IMPLICATIONS FOR PUBLIC POLICY

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Great potential exists for using water more efficiently in agriculture, industries and cities. Increasingly, investments in conservation, efficiency, reuse, and recycling can yield more usable water per dollar than investments in new engineering projects to expand the freshwater supply. By enabling farmers, factories, and households to get more service out of each liter drawn from a river, lake or aquifer, efficiency measures allow more water to remain instream to serve vital ecological functions. They are not only the most cost-effective and environmentally sound water supply options available in most cases, they are now essential to protecting the natural systems upon which we depend.

Unfortunately, the policies and laws that shape water use today more often promote profligacy and waste than conservation and wise use. Moving toward more efficient, ecologically sound and sustainable patterns of water use requires major changes in the way water is valued, allocated, and managed. Appropriate pricing, the creation of markets for buying and selling water, and other economic inducements for better water use have a central role to play in easing the transition to an era of water scarcity.

In addition, protecting the many functions water performs that a marketplace does not adequately value—such as habitat protection, species preservation and maintenance of water quality—requires limiting the amount of water that cities, industries, and agriculture collectively claim. And finally, with the stability of the water cycle so dependent on the land over which water flows, regulations on how we use critical parcels of the earth are also necessary to achieve water security.

PRICING AND INSTITUTIONAL REFORMS

Many of the water shortages emerging around the world stem from the widespread failure to value water at anything close to its worth. Grossly underpricing water perpetuates the illusion that it is plentiful, and that nothing is sacrificed by wasteful practices. Benjamin Franklin once said, “When the well’s dry, we know the worth of water.” (1) A key challenge is to begin valuing it appropriately and using it more wisely so as to avoid learning Franklin’s lesson the hard way.

Pricing water closer to the real cost of supplying it is a central component of any serious water conservation strategy. It is especially important in agriculture, which accounts for two-thirds of the world's total water use and, therefore, the bulk of the water wasted as well. Water subsidies are larger and more pervasive in agriculture than in any other realm of water use. Governments often build, maintain, and operate irrigation systems with public funds, and then charge farmers next to nothing for these expensive services. Irrigators in Mexico, for instance, pay on average just 11 percent of their water's full cost, and those in Indonesia and Pakistan, about 13 percent. In Egypt, a land of extreme scarcity, farmers are not charged directly for their irrigation water at all. (2)

In India, the world's third largest food producer, government spending to operate and maintain medium and large canal projects exceeds the total revenue collected from farmers by 23.5 billion rupees ($816 million). Adding in capital cost subsidies would lift this figure even higher. Irrigation officials set water charges according to the size of farmers' plots and the crops they are growing, so payments bear no relation to the amount actually used on the fields. Moreover, charges are so low—typically amounting to 2-5 percent of the harvest's value—that they have no influence on farmers' management decisions. Water prices have not been raised in most Indian states since the mid-eighties, and in a few, including the Punjab and water-short Tamil Nadu, since the mid-seventies. (3)

Such extreme undercharging not only fosters waste and the planting of water-intensive crops, it also deprives government agencies of the funds needed to maintain canals and other irrigation works adequately. As a result, agriculture usurps far more water than is necessary for the harvest it yields, farmers grow thirsty crops like sugarcane even in water-tight areas, and irrigation works fall into disrepair, which reduces efficiency even further.

The situation is little better in the United States. The Federal Bureau of Reclamation supplies water to a quarter of the West's irrigated land—more than 4 million hectares—under long-term (typically 40-year) contracts at greatly subsidized prices. This practice dates back to the 1902 Reclamation Act, which aimed to settle the western frontier by helping family farmers obtain irrigation water and power. Over time, the degree of federal assistance deepened with the bureau's decision not to charge interest on water project construction costs, to lengthen the repayment period, and to limit repayment to farmers' "ability to pay." (4)

As a result, subsidies expanded greatly over time for farmers, large and small. As of the mid-eighties, irrigators benefiting from California's huge Central Valley Project had repaid only 4 percent of its capital costs: $38 million out of $950 million. U.S. taxpayers have footed the bill for the remainder. (5)

As in poorer countries, this free ride has discouraged farmers from investing in efficiency improvements, led them to choose crops ill-suited to a semidesert, and to devote scarce water to low-value uses. For instance, a third of the water delivered by the Bureau of Reclamation is used to irrigate hay, pasture, and other forage crops destined for livestock. (6) Meanwhile, western cities and industries intent on getting more water drum up plans to dam yet another canyon or divert even more from a distant river.

Correcting these perverse situations is easier said than done. It requires bucking deeply entrenched and politically influential special interests, instilling irrigation bureaucracies with a broader sense of mission, and decentralizing water management so that local water suppliers and users have more responsibility and accountability for the performance of their operations. In some cases, it even means challenging religious and cultural beliefs. Islamic norms, for instance, hold that water must be free, which has generally precluded governments in Muslim countries from charging anything more than the cost of delivery. (7)

Requiring farmers in developing countries to at least pay for the operation and maintenance of their irrigation systems is often frustrated by the notion that they cannot afford higher prices. Yet those benefiting from irrigation typically earn far more than those cultivating rainfed lands. Lessening irrigation subsidies would free up funds to invest in the productivity of rainfed farming, which accounts for the bulk of the world's cropland and provides the livelihood of most of the rural poor. Moreover, Third World irrigators have shown time and again that they are willing and able to pay more for water that is reliable and over which they can exercise control. With an assured and timely supply, they can invest in fertilizers, high-yielding seeds, and better management practices, often boosting their crop production and income enough to offset any rise in water prices. (8)

Reducing irrigation subsidies would thus tend to promote both efficiency and equity while stemming problems of waterlogging, soil salinization, and other forms of environmental degradation. Precisely how this is done will vary from case to case, and will not always be easy. The canal systems in the Third World often span huge areas; some in India, for instance, cover more than a million hectares and include thousands of farmers. Measuring the exact amount of water each individual irrigator uses and charging for it appropriately would be a costly administrative nightmare.

But practical ways do exist to give farmers an economic incentive to use water more efficiently. In a pilot project in Maharashtra, India, for example, a local nongovernmental organization helped a farmers association and the irrigation bureaucracy craft a workable arrangement for charging farmers according to the volume of water taken from the minor irrigation canal that services their cropland area. It is up to the group to determine how much each individual farmer will pay. Any water they are entitled to but do not use is stored in a reservoir and supplied to them during the dry season, when they otherwise might not get any water at all. This gives the farmers association a powerful motivation to use water sparingly, both because they pay for the amount they take and because their efficiency determines how much they get during the dry season, when irrigation is so critical to the harvest. (9)

Such a scheme shows that with creativity and flexibility, incentives to promote efficiency can be designed. A key in almost all cases is ensuring more local accountability for how irrigation systems perform. At a minimum, setting water fees to cover operation and maintenance costs, collecting them through a local farmers organization that is involved in the system's management, and making irrigation managers accountable for the performance of their project areas could go a long way toward realizing irrigation's potential in developing countries.

Field workers trained in techniques of social organization have fulfilled an important catalytic and coordinating role in the formation of water user associations, especially in many Asian countries. Spearheaded in large part by the International Irrigation Management Institute in Sri

Lanka, this approach has been instrumental in effectively banding farmers together, improving communication between them and irrigation officials, and establishing workable patterns of operating and maintaining irrigation systems. (10)

In Nepal, for instance, “social organizers” began working in 1987 in the Sirsia-Dudhaura Irrigation System, one that had been plagued by many common management problems. Within a year or so, farmers had been mobilized to clean and maintain field channels, water schedules had been prepared, and many breaches in the system had been fixed. As a result, water efficiency increased and the surplus water allowed more land to be planted in wheat the following season. And with more water reaching the tail end of the system, conflicts among the farmers themselves diminished. (11)

In Mexico, the federal government is in the process of turning over the operation, maintenance, and financing of 77 large irrigation districts to autonomous water user associations. By giving farmers more control over their water supplies and direct responsibility for the upkeep and management of irrigation projects, the government hopes to improve the productivity and financial solvency of these systems, which collectively cover some 3.2 million hectares, 62 percent of the nation’s irrigated land. The plan is to turn over some 2 million hectares to water user associations by 1994. It remains to be seen whether farmers will be sufficiently organized and prepared to assume responsibility by this date, but in any case, the Mexican plan is an important test worth watching. (12)

Since farmers relying on groundwater typically operate their own wells, direct water subsidies to them are much lower than to farmers benefiting from government-run surface schemes. But many governments greatly undercharge for energy, and, since pumping is a large share of total groundwater costs, this effectively amounts to a large irrigation subsidy. India’s rural electricity subsidies, for instance, totaled some 14.6 billion rupees ($507 million) per year in the mid-eighties, contributing to the pervasive and worsening problem of falling water tables. Where groundwater is used for irrigation, eliminating energy subsidies can thus be as critical to water conservation as charging more for water. (13)

In the United States, meaningful reform of the Bureau of Reclamation’s irrigation policies has repeatedly fallen victim to the powerful western agricultural lobby and the politicians beholden to them. With hundreds of federal irrigation contracts coming up for renewal this decade, a timely opportunity exists to establish new rules for what has become a very different water game. A first step is to reduce the subsidies that give farmers water for a small fraction of the price cities and industries pay. Prices could be raised gradually, say over five years, to avoid sudden disruptions. Once farmers know that water prices will be much higher in the next round of contracts, the government could induce them to renegotiate sooner by offering to help pay for conservation investments undertaken immediately. (14)

An important step forward was taken in the United States in late 1992 with passage of a law that overhauls operation of the Central Valley Project in California. The act establishes a tiered pricing system that should encourage more-efficient water use by farmers with contracts under the federal project. It also allows irrigators to voluntarily transfer a portion of their supplies to other water users in the state, thereby creating additional market incentives for conservation. And it dedicates a significant amount of water to the protection and restoration of fisheries, wetlands, and other aspects of the aquatic environment. It could be a precedent-setting law that spurs reform of other federal water projects in the western United States. (15)

Raising the price of water to better reflect its true cost is one of the most important steps cities, too, can take to encourage conservation. Proper pricing gives households and businesses an accurate signal about just how costly water is, and allows them to respond accordingly. Studies in a number of countries, including Australia, Canada, Israel, and the United States, suggest that household water use drops 3-7 percent with a 10-percent increase in water prices. (16)

Unfortunately, as in agriculture, water is consistently undervalued by both public and private urban water suppliers. Even worse, not only do water prices typically fail to promote efficiency, but the water rate structures of many utilities actually reward waste by charging less per liter the more that is consumed. Seven out of ten residents in Manitoba, Canada, for instance, are charged according to this perverse “declining block” pricing policy, as are one out of three in Alberta and Ontario. Water charges for most British households are linked to the value of their home, and have nothing to do with actual consumption.(17)

Many residences in both industrial and Third World cities are not equipped with water meters, which precludes even the possibility of charging people appropriately for their water use. Metering is not only a prerequisite to the success of most conservation measures, it encourages savings in and of itself simply by tying the water bill to the amount used. In Alberta, the city of Edmonton meters all residential users, and its per capita water use is half that of Calgary, which is only partially metered. The areas of Calgary that are metered, however, register water use rates similar to Edmonton’s. Trials in the United Kingdom have shown that metering can cut household use there by 10-15 percent.(18)

Raising water prices can often be politically difficult to do. But if accompanied by public outreach explaining the need for the price hike and the steps consumers can take to keep their water bill down, they can have a strong positive effect. When faced with dire water supply conditions in the mid-seventies, for instance, officials in Tucson, Arizona, raised water rates sharply to make them better reflect the true cost of service. At about the same time, they ran a public education campaign (called “Beat the Peak”) with a goal of curbing water use on hot summer afternoons, when the supply was most in danger of running short of demand. The result was a 16-percent drop in per capita use within a few years, which, along with the lowered peak demand, allowed the Tucson water utility to cut its water supply expansion costs by $75 million. (19)

Pricing was the main tool of a conservation strategy adopted by the water utility serving Bogor, Indonesia, as well. With a proposed new water project estimated to cost twice as much per unit of water as existing supplies, the utility opted to try to reduce demand through more effective pricing. It tripled or quadrupled water prices, depending on the amount used, to encourage households to conserve. Between June 1988 and April 1989, average monthly residential water use dropped nearly 30 percent, which will allow the utility to connect more households to the urban water system at a lower cost. (20)

WATER MARKETS

As it becomes more costly and environmentally damaging to build new projects to expand the water supply, meeting new demands will increasingly require reallocating water among the different users—irrigators, industries, cities, and the natural environment. In many parts of the world, competition for water is already evident and is intensifying as cities and farmers vie for limited regional supplies. In most cases, it is agriculture that will lose water, since its value in food production is typically less than in industrial or household use.

In north China, for instance, reservoirs originally built to serve farmers now supply growing urban areas and industries which yield more economic value per unit of water than crop production does. Israeli officials plan to shift more than a third of agriculture's fresh water over to cities during the coming decades. Water constraints around Delhi, Madras, and other Indian cities are breeding competition there as well. (21)

Water markets—mechanisms for buying and selling water and water rights—can encourage transfers between different users. Freer trading of scarce water also provides an additional incentive to use the resource more efficiently, since markets give water a tangible opportunity cost—its value to a willing buyer.

In the western United States, competition for scarce supplies has spawned an active market that is fostering transfers of water from farms to cities. Where farmers have clear property rights to water, as they do in much of the West, they have the option of selling those rights to a willing buyer. If an irrigator can earn more by selling water to a nearby city than by spreading it on alfalfa, cotton, or wheat, transferring that water from farm to city use is economically beneficial. If it prevents the city from damming another river to increase its supplies, the transfer can also benefit the environment. In this way, marketing can be an effective means of reallocating a finite pool of water.

Farmers can free up supplies for sale in three ways: by irrigating more efficiently and selling the conserved water, by switching to less thirsty crops and selling the water they no longer need, or by taking land out of irrigation entirely and either producing dryland crops or retiring the land from agriculture. Irrigators may also choose among several different types of transactions. For example, they can sell their water rights directly, which permanently transfers control to the buyer. They can lease some or all of their water for an agreed-upon period, while keeping the rights. Or they can swap supplies with another water user.

During 1991, 127 water transactions of various kinds were reported in 12 western U.S. states, up slightly from the 121 reported in 1990. Almost all of the water sold or leased in 1991 came from irrigation, and two-thirds of the trades resulted in cities getting more water for immediate or future use. Prices varied greatly. In Colorado, where half of the transactions took place, water traded for about $2,140 per acre-foot ($1.73 per cubic meter), nearly twice the average trading price in 1989. Much of the price run-up is attributed to the Environmental Protection Agency's veto of the Two Forks Dam, which would have increased supplies for the Denver area. (22)

Exactly how far U.S. water trading ultimately will go in reallocating supplies remains unclear. According to some estimates, redirecting 7 percent of western agriculture's water to cities would be sufficient to meet the growth in urban demand projected for the end of the decade. After that, larger shifts would be needed. Unless cities stabilize their water use through conservation, reuse, and, where necessary, limits on the size of their populations and economies, agriculture ultimately could lose more water—and land—than is socially desirable, given the challenge that lies ahead of feeding a much larger world population. (23)

To the extent that agricultural supplies are freed up by increasing irrigation efficiency or by switching crops, land need not come out of production. For instance, the Metropolitan Water District (MWD) of Southern California—water wholesaler for roughly half the state's 30 million residents—is financing the lining of canals and other conservation projects in the neighboring Imperial Irrigation District in exchange for the 100,000 acre-feet of water per year the investments will save. The annual cost per acre-foot conserved is estimated at $128, far lower than MWD's best new-supply option. Enough water is being traded this way to meet the annual needs of 200,000 households, yet no cropland is being taken out of production. Since the irrigation district keeps control of the water rights, however, MWD is only assured of these supplies for the 35 years covered by the agreement. (24)

Transactions in Arizona, on the other hand, have caused great controversy, since Phoenix, Tucson, and other rapidly expanding cities have taken to "water ranching." State law makes it difficult to buy rights to water independent of the land, so cities have purchased farmland for the water that comes with it. This elimination of farming has threatened to deprive rural communities of tax revenue and income needed to keep them viable. Passage of a new state law in 1991 limits future farm water exports to land already acquired by cities, along with two other groundwater basins. It also requires cities to pay a sum equal to the property taxes that would have been assessed on those farms had they not been sold. So while irrigated agriculture will continue to shrink in Arizona, it will likely do so to a lesser degree and at a slower pace as a result of the new law (25)

In parts of Bangladesh, India, and Pakistan, marketing has emerged as an effective way of distributing water more equitably, particularly in areas where irrigation relies on groundwater. Often the poorest villagers cannot afford the pumps and other machinery needed to extract underground water for their crops. But if they are able to buy supplies from wealthier farmers, they can still receive some of irrigation's benefits—including higher and more reliable yields, and more certain income. The resulting expansion of irrigation would also create more stable employment opportunities for landless people in the vicinity, since more dry-season cropping would occur.

In one irrigated area of Bangladesh, each owner of a shallow groundwater well sells water to an average of 14 other farmers. For each hectare irrigated by a well owner there, two other hectares are irrigated by farmers purchasing water. Indian agricultural economist Tushaar Shah notes that evidence from a number of Indian states, including Andhra Pradesh, Gujarat, and Tamil Nadu, suggests that where a poorer farmer can buy enough water to grow an additional crop, water selling "can have dramatic beneficial impacts on the incomes of water buyers and the economy of the community as a whole." (26)

In some cases, buyers pay cash for the water, but often they pay in kind, either by lending their labor, sharing a portion of their harvest with the seller, or some combination of these two approaches. Where electricity is priced according to a flat fee geared to the horsepower of the pump, as is common in many areas, a farmer has an extra incentive to sell water, since there is no real cost to the extra pumping. Although this makes relatively inexpensive water available to poorer farmers, it also creates a strong inducement to overpump the resource, especially because tubewell owners often have de facto ownership rights to as much groundwater as they can extract. To serve the goals of efficiency, equity, and sustainable resource use simultaneously, water marketing would need to be accompanied by limits on groundwater pumping, the elimination of energy subsidies, and assurances that markets do not further concentrate water rights in the hands of the rich. (27)

REGULATIONS AND TAXES

Wherever pricing and marketing fail to take into account the full social, environmental, and intergenerational costs of water use, some additional correction is needed. This will usually take the form of regulations on some specific aspect of water use or taxes to ensure that the full cost of water is being paid by users. While regulations are sometimes viewed as a competing policy alternative to economic incentives, they often provide a necessary and effective complement to a water efficiency strategy.

For example, setting water efficiency standards for common fixtures—including toilets, showerheads, and faucets—can be a critical component of urban conservation. Standards establish technological norms that ensure a certain level of efficiency is built into new products and services.

In this way, water savings build over time, and they are reliable and predictable.

In 1989, the Mexican government adopted a strict set of nationwide efficiency standards for household plumbing fixtures and appliances. They require toilets—the biggest water user in the home—to use no more than 6 liters per flush, and they set maximum limits for showers, faucets, dishwashers, and washing machines as well.28 The Canadian province of Ontario has also established efficiency standards for new water fixtures, which will take effect in 1993. By 1996, new toilets throughout the province must meet a 6-liter standard. (29)

In the United States, legislation setting national standards was signed into law in October 1992. It requires that showerheads and faucets manufactured after January 1, 1994 use no more than 9.5 liters per minute; domestic toilets manufactured after that date are to use no more than 6 liters per flush. According to estimates by Boston-based water conservation consultant Amy Vickers, the standards will cause average U.S. indoor residential water use to fall gradually from 291 liters per person per day to 204, a 30-percent reduction. (30)

Regulations can also be effective in limiting the overpumping of groundwater, a pervasive problem in may parts of the world. In the United States, Arizona pioneered this approach in 1980 with passage of a law requiring that groundwater basins undergoing depletion achieve a balance between pumping and recharge by the year 2025. Unfortunately, many cities affected by this legislation have not met their conservation targets, and, as noted earlier, have sought to buy land and water rights from farms. (31)

Another option is to tax groundwater pumping that exceeds natural replenishment. A 1991 Arizona law moves toward this approach in the Phoenix area, requiring those who have overdrawn their groundwater accounts to pay a “replenishment tax” or to purchase credits from someone who has pumped less than the allowable level. The tax rate reflects the cost of supplying enough water to balance the whole district’s account, and is thus high enough to induce conservation. (32)

In the case of fossil aquifers, such as the Ogallala in the U.S. High Plains, or the deep desert aquifers in Saudi Arabia and Libya, this approach could take the form of a “depletion tax” on all groundwater extractions. In this way, those profiting from the draining of one-time reserves would at least partially compensate society for the loss of these supplies, which will be valued far more highly by future generations faced with feeding a much larger world population. Besides helping promote equity among generations—a basic tenet of a sustainable society—a groundwater depletion tax would encourage greater water use efficiency, and thereby slow the rate of aquifer depletion.

PROTECTING NATURAL WATER SYSTEMS

Some form of public intervention is also needed to ensure that ecological systems get the water they need to remain healthy. Incentives to promote greater efficiency need to be complemented with regulations or other mechanisms for protecting aquatic environments from excessive water diversions.

Open markets that allow water to be purchased and dedicated to ecological functions can help. For instance, 11 of the 127 water transactions in the western United States in 1991 were aimed at securing more water for rivers, wetlands, and nature reserves. (33)

But environmental protection needs are far larger than private conservation initiatives alone can handle through the marketplace. According to Defenders of Wildlife, a U.S. conservation group, in 1989 (a drought year) wildlife refuges in California’s Central Valley got less than 8 percent of the water needed for migrating waterfowl to winter there successfully. (34)

Private action simply cannot secure the large volumes of water needed to serve the public’s interest. Collecting money from the millions of people who are willing to pay for protection of these ecological values is far too difficult and costly. Economists call this a problem of excessively high “transaction costs” and it is one of the important reasons why the market fails to protect the environment adequately.

In such instances, regulations are needed to preserve and restore ecological health. The water laws and practices of most countries are heavily biased toward the individual’s right to withdraw water for private gain, and against the public’s common interest in leaving water “instream” to maintain fisheries, recreational values, and the integrity of ecosystems. Where water is plentiful, the consequences of this bias may be negligible; but where it is scarce, severe ecological damage results, as is now so evident in many parts of the world.

One way of protecting water's life-support functions is simply to limit the total amount that can be diverted from a river, lake, or stream. Until fairly recently, this was difficult in the western United States, since water rights had to be put to "beneficial use", which was interpreted as removing water from its natural channel for some productive purpose. Most states, however, now recognize that water left "instream" to protect ecological functions is a legitimate beneficial use to which water rights can be attached. Only a few allow individuals and private entities to hold "instream" rights; in most cases, a state agency must acquire them. Montana, for instance, passed a law in 1973 that allows the state and federal governments to reserve water for instream uses. As a result, about 70 percent of the average annual flow in the upper basin of the Yellowstone River and one half to two-thirds of the lower basin flow have been reserved to protect aquatic life, water quality, and other ecological services. (35)

Where excessive diversions have already caused ecological damage, as with central Asia's Aral Sea, California's Mono Lake, or Florida's Everglades, new laws and regulations will be needed to restore ecosystems to health. One such instrument is a legal principle called the "public trust doctrine", which asserts that governments hold certain rights in trust for the public and can take action to protect those rights from private interests. Widespread application of this doctrine could have sweeping effects, since even existing water rights could be revoked in order to prevent violation of the public trust.

In a landmark decision handed down in February 1983, the California Supreme Court declared that the water rights of Los Angeles, which permit diversions from the Mono Lake basin, are subject to the public trust doctrine. Mono Lake—a hauntingly beautiful water body on the eastern side of the Sierra Nevada whose algae and brine shrimp support hundreds of migratory bird species—has had its volume halved and its salinity doubled because of excessive diversions from its major tributaries. Since 1989, the courts have prevented the Los Angeles Department of Water and Power from siphoning off any Mono basin water, which had previously accounted for some 15 percent of the urban utility's supply. With a final determination of the city's rights to Mono water not expected until 1993, Judge Terrence Finney called Mono Lake "a national environmental, ecological and scenic treasure [that] should not be experimented with even for a few brief years." (36)

Protecting water systems also depends on regulating the use of those critical areas of land that help moderate water's cycling through the environment. Degradation of the watershed—the sloping land that collects, directs, and controls the flow of rainwater in a river basin—is a pervasive problem in rich and poor countries alike. Besides contributing to flash floods and loss of groundwater recharge, which can exacerbate the effects of drought, it leads to soil erosion that prematurely fills downstream reservoirs with silt, shortening the useful life of these expensive water projects.

When the Ubolratana dam in Thailand was completed in 1965, for instance, 90 percent of the upper catchment area was forested. Less than two decades later, forest cover was down to 40 percent, which, ironically, was partly due to the fact that people living on the reservoir site were relocated there. Erosion rates sharply increased, greatly reducing the useful storage area of the reservoir. Worldwide, the replacement cost of reservoir capacity lost to siltation is estimated to total about $6 billion a year. (37)

With today's population pressures and the need for greater food production, keeping entire watersheds forested is no longer possible in most places. About half of Asia, for example, is technically watershed, defined as land sloping at an angle of at least 8 degrees. Much of this land is, and needs to be, used for agriculture. Yet in sensitive regions, governments may now need to require cultivation practices that protect basic watershed functions, especially in the steeply sloping upper basin areas. (38)

Fortunately, many of the measures that can help safeguard water supplies also enhance crop production in upland areas. Terracing, mulching, agroforestry (the combined production of crops and trees), and planting vegetative barriers on the contour are just a few of the ways soil and water can be conserved while improving agricultural output. Cultivation on the contour, for instance, on slopes up to 30 degrees has produced yields 6-66 percent higher than traditional cultivation up and down the slope. On lands not suitable for cultivation, revegetating deforested slopes, reducing grazing pressures, and altering timber practices are among the options for watershed protection. The challenge for local and national governments is to plan the use of watershed lands with soil and water conservation in mind, recognizing that the way uplands are managed greatly affects the livelihood of people and the integrity of water systems downstream. (39)

Land-use planning in and around cities and suburbs can be equally important for the protection of local water supplies. Unplanned development can end up paving over rainwater's main point of entry into a key drinking-water source. Especially in areas dependent on local groundwater, protecting these critical aquifer recharge areas is essential to ensure that water sources are replenished. Suffolk County, Long Island, recently spent $118 million to acquire 3,440 hectares of open space in order to preclude development in recharge zones vital to the region's underground water supply, its sole source of drinking water. To fund the land purchases, voters approved a one-quarter cent increase in the county sales tax which will remain in effect until the end of the decade. (40)

Local ordinances can also set landscaping requirements with an eye to protecting water supplies. Across the United States, cultivated lawns cover 10-12 million hectares, an area about the size of Kentucky. Not only do lawns fail to promote recharge effectively in many cases, the fertilizers and pesticides used to maintain them are troubling sources of pollution. The town of Southampton, Long Island, requires that at least 80 percent of each home lot situated in a critical aquifer zone be kept in its natural (typically wooded) state and that no more than 15 percent be turned into lawns or vegetation requiring fertilizer. (41)

A number of states—including Connecticut, Georgia, New York, and North Carolina—have adopted laws and regulations specifically designed to control land use in watersheds. North Carolina passed a law in 1989, for instance, requiring the development of minimum statewide standards for watershed protection, which were due to enter into effect by July 1992. Cities and towns are required to develop land use plans and ordinances that are at least as strict as the state's standards, which include, for example, limits on impervious surface areas and certain agricultural practices. (42)

Here and there, pricing, marketing, and regulatory actions are being used effectively to promote conservation, efficiency, and sustainable water use. But nowhere have all the elements been brought together into a strategy ensuring that human use of water remains within ecological bounds and that the integrity of water systems overall is protected. The technologies and know-how exist to support a major transformation in water use toward greater efficiency and environmental integrity. The challenge now is to adopt the policies that will spur a rapid unfolding of that transformation.

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