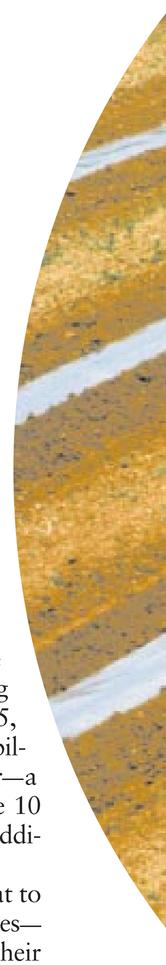
Growing more Food with less Water

by Sandra Postel



DAVID BARNES *Stone*

Six thousand years ago farmers in Mesopotamia dug a ditch to divert water from the Euphrates River. With that successful effort to satisfy their thirsty crops, they went on to form the world's first irrigation-based civilization. This story of the ancient Sumerians is well known. What is not so well known is that Sumeria was one of the earliest civilizations to crumble in part because of the consequences of irrigation.

Sumerian farmers harvested plentiful wheat and barley crops for some 2,000 years thanks to the extra water brought in from the river, but the soil eventually succumbed to salinization—the toxic buildup of salts and other impurities left behind when water evaporates. Many historians argue that the poisoned soil, which could not support sufficient food production, figured prominently in the society's decline.

Far more people depend on irrigation in the modern world than did in ancient Sumeria. About 40 percent of the world's food now grows in irrigated soils, which make up 18 percent of global cropland [*see illustration on page 50*]. Farmers who irrigate can typically reap two or three harvests every year *and* get higher crop yields. As a result, the spread of irrigation has been a key factor behind the near tripling of global grain production since 1950. Done correctly, irrigation will continue to play a leading role in feeding the world, but as history shows, dependence on irrigated agriculture also entails significant risks.

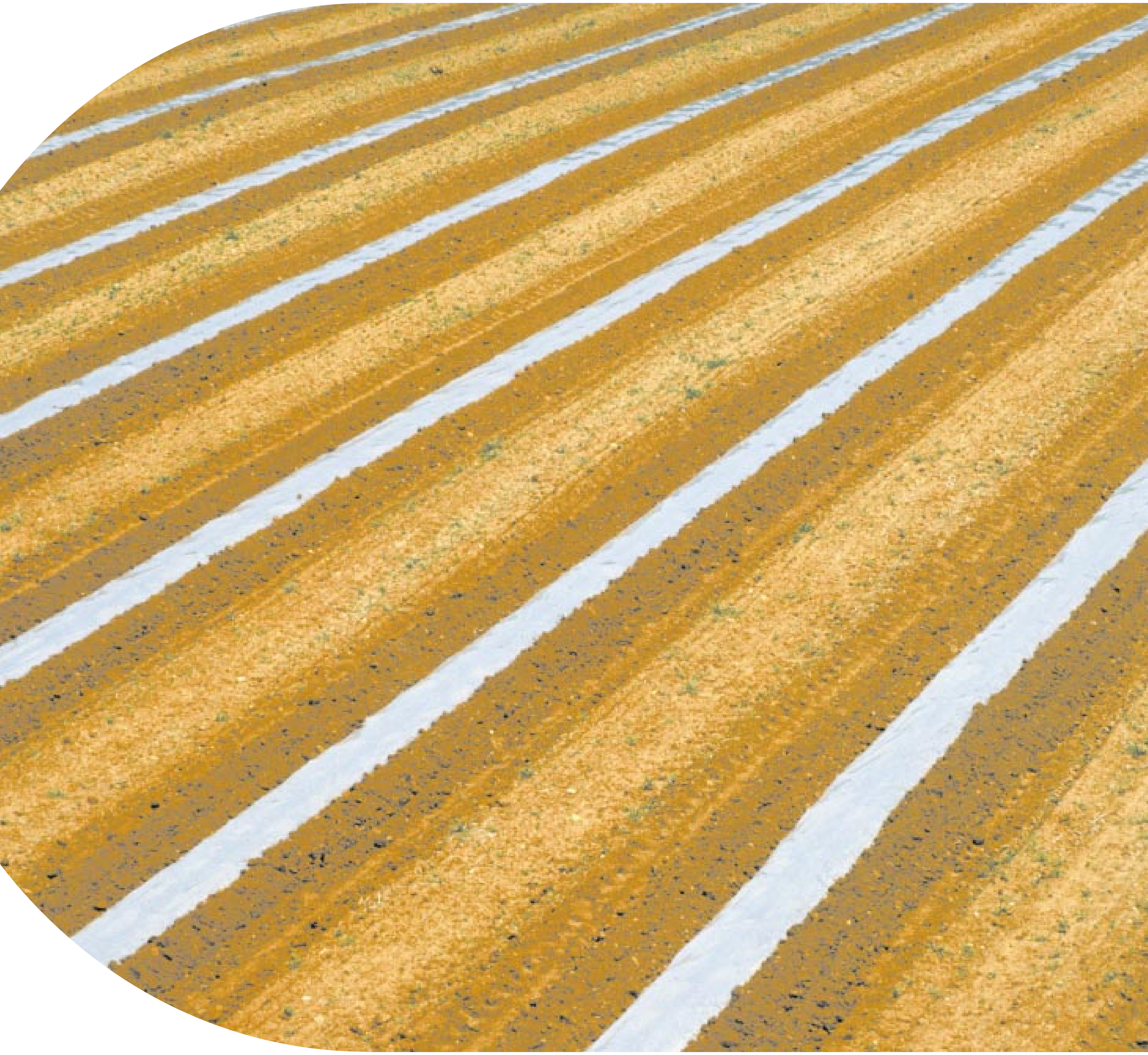
Today irrigation accounts for two thirds of water use worldwide and as much as 90 percent in many developing countries. Meeting the crop demands projected for 2025, when the planet's population is expected to reach eight billion, could require an additional 192 cubic miles of water—a volume nearly equivalent to the annual flow of the Nile 10 times over. No one yet knows how to supply that much additional water in a way that protects supplies for future use.

Severe water scarcity presents the single biggest threat to future food production. Even now many freshwater sources—underground aquifers and rivers—are stressed beyond their limits. As much as 8 percent of food crops grows on farms that use groundwater faster than the aquifers are replenished, and many large rivers are so heavily diverted that they don't reach the sea for much of the year. As the number of urban dwellers climbs to five billion by 2025, farmers will have to compete even more aggressively with cities and industry for shrinking resources.

The Author

SANDRA POSTEL directs the Global Water Policy Project in Amherst, Mass., and is a visiting senior lecturer in environmental studies at Mount Holyoke College. She is also a senior fellow of the Worldwatch Institute, where she served as vice president for research from 1988 to 1994.

If the world hopes to feed its burgeoning population, irrigation must become less wasteful and more widespread



FLOODING CROP FURROWS is a traditional but often wasteful irrigation method. Much of the water soaks into the ground or evaporates without assisting the plants.

Despite these challenges, agricultural specialists are counting on irrigated land to produce most of the additional food that will be needed worldwide. Better management of soil and water, along with creative cropping patterns, can boost production from cropland that is watered only by rainfall, but the heaviest burden will fall on irrigated land. To fulfill its potential, irrigated agriculture requires a thorough redesign organized around two primary goals: cut water demands of mainstream agriculture and bring low-cost irrigation to poor farmers.

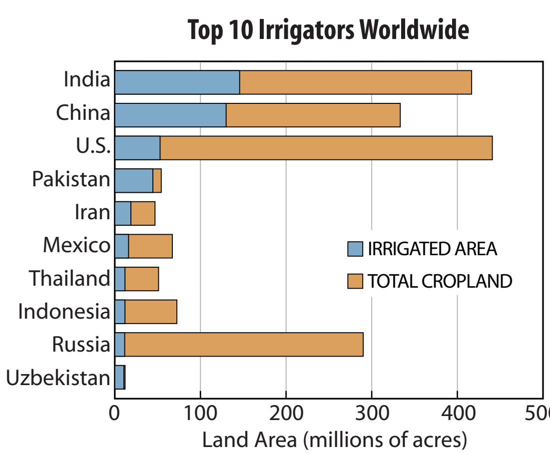
Fortunately, a great deal of room exists for improving the productivity of water used in agriculture. A first line of attack is to increase irrigation efficiency. At present, most farmers irrigate their crops by flooding their fields or channeling the water down parallel furrows, relying on gravity to move the water across the land. The plants absorb only a small fraction of the water; the rest drains into rivers or aquifers, or evaporates. In many locations this practice not only wastes and pollutes water but also degrades the land through erosion, waterlogging and salinization. More efficient and environmentally sound technologies exist that could reduce water demand on farms by up to 50 percent.

Drip systems rank high among irrigation technologies with significant untapped potential. Unlike flooding techniques, drip systems enable farmers to deliver water directly to the plants' roots drop by drop, nearly eliminating waste. The water travels at low pressure through a network of perforated plastic tubing installed on or below the surface of the soil, and it emerges through small holes at a slow but steady pace. Because the plants enjoy an ideal moisture environment, drip irrigation usually offers the added bonus of higher crop yields. Studies in India, Israel, Jordan, Spain and the U.S. have shown time and again that drip irrigation reduces water use by 30 to 70 percent and increases crop yield by 20 to 90 percent compared with flooding methods.

Sprinklers can perform almost as well as drip methods when they are designed properly. Traditional high-pressure irrigation sprinklers spray water high into the air to cover as large a land area as possible. The problem is that the more time the water spends in the air, the more of it evaporates and blows off course before reaching the plants. In contrast, new low-energy sprinklers deliver water in small doses through nozzles positioned just above the ground. Numerous farmers in Texas who have installed such sprinklers have found that their plants absorb 90 to 95 percent of the water that leaves the sprinkler nozzle.

Technologies exist that could reduce water demand on farms by up to 50 percent

Despite these impressive payoffs, sprinklers service only 10 to 15 percent of the world's irrigated fields, and drip systems account for just over 1 percent. The higher costs of these technologies (relative to simple flooding methods) have been a barrier to their spread, but so has the prevalence of national water policies that discourage rather than foster efficient water use. Many governments have set very low prices for publicly supplied irrigation, leaving farmers with little motivation to invest in ways to conserve water or to improve efficiency. Most authorities have also failed to regulate groundwater pumping, even in regions where aquifers are overtapped. Farmers might be inclined to conserve their own water supplies if they could profit from selling the surplus, but a number of countries prohibit or discourage this practice.



SOURCE: UN FAO AGROSTAT database, 1998

JUST FOUR COUNTRIES account for half the world's 670 million acres of irrigated cropland.

Efforts aside from irrigation technologies can also help reduce agricultural demand for water. Much potential lies in scheduling the timing of irrigation to more precisely match plants' water needs. Measurements of climate factors such as temperature and precipitation can be fed into a computer that calculates how much water a typical plant is consuming. Farmers can use this figure to determine, quite accurately, when and how much to irrigate their particular crops throughout the growing season. A 1995 survey conducted by the University of California at Berkeley found that, on average, farmers in California who used this tool reduced water use by 13 percent and achieved an 8 percent increase in yield—a big gain in water productivity.

An obvious way to get more benefit out of water is to use it more than once. Some communities use recycled wastewater [see "Waste Not, Want Not," by Diane Martindale, on page 55]. Treated wastewater accounts for 30 percent of Israel's agricultural water supply, for instance, and this share is expected to climb to 80 percent by 2025. Developing new crop varieties offers potential as well. In the quest for higher yields, scientists have already exploited many of the most fruitful agronomic options for growing more food with the same amount of water. The hybrid wheat and rice varieties that spawned the green revolution, for example, were bred to allocate more of the plants' energy—and thus their water uptake—into edible grain. The widespread adoption of high-yielding and early-maturing rice varieties has led to a roughly threefold increase in the amount of rice harvested per unit of water consumed—a tremendous achievement. No strategy in sight—neither conventional breeding techniques nor genetic engineering—could repeat those gains on such a grand scale, but modest improvements are likely.

Yet another way to do more with less water is to reconfigure our diets. The typical North American diet, with its large share of animal products, requires twice as much water to produce as the less meat-intensive diets common in many Asian and some European countries. Eating lower on the food chain could allow the same volume of water to feed

JOHNNY JOHNSON

two Americans instead of one, with no loss in overall nutrition.

Reducing the water demands of mainstream agriculture is critical, but irrigation will never reach its potential to alleviate rural hunger and poverty without additional efforts. Among the world's approximately 800 million undernourished people are millions of poor farm families who could benefit dramatically from access to irrigation water or to technologies that enable them to use local water more productively.

Most of these people live in Asia and Africa, where long dry seasons make crop production difficult or impossible without irrigation. For them, conventional irrigation technologies are too expensive for their small plots, which typically encompass fewer than five acres. Even the least expensive motorized pumps that are made for tapping groundwater cost about $350, far out of reach for farmers earning barely that much in a year. Where affordable irrigation technologies have been made available, however, they have proved remarkably successful.

I traveled to Bangladesh in 1998 to see one of these successes firsthand. Torrential rains drench Bangladesh during the monsoon months, but the country receives very little precipitation the rest of the year. Many fields lie fallow during the dry season, even though groundwater lies less than 20 feet below the surface. Over the past 17 years a foot-operated device called a treadle pump has transformed much of this land into productive, year-round farms.

To an affluent Westerner, this pump resembles a StairMaster exercise machine and is operated in much the same way. The user pedals up and down on two long bamboo poles, or treadles, which in turn activate two steel cylinders. Suction pulls groundwater into the cylinders and then dispenses it into a channel in the field. Families I spoke with said they often treadled four to six hours a day to irrigate their rice paddies and vegetable plots. But the hard work paid off: not only were they no longer hungry during the dry season, but they had surplus vegetables to take to market.

Costing less than $35, the treadle pump has increased the average net income for these farmers—which is often as little as a dollar a day—by $100 a year. To date, Bangladeshi farmers have purchased some 1.2 million treadle pumps, raising the productivity of more than 600,000 acres of farmland. Manufactured and marketed locally, the pumps are injecting at least an additional $350 million a year into the Bangladeshi economy.

In other impoverished and water-scarce regions, poor farmers are reaping the benefits of newly designed low-cost drip and sprinkler systems. Beginning with a $5 bucket kit for home gardens, a spectrum of drip systems keyed to different income levels and farm sizes is now enabling farmers with limited access to water to irrigate their land efficiently. In 1998 I spoke with farmers in the lower Himalayas of northern India, where crops are grown on terraces and irrigated with a scarce communal water supply. They expected to double their planted area with the increased efficiency brought about by affordable drip systems.

Bringing these low-cost irrigation technologies into more widespread use requires the creation of local, private-sector supply chains—including manufacturers, retailers and installers—as well as special innovations in marketing. The treadle pump has succeeded in Bangladesh in part because local businesses manufactured and sold the product and marketing specialists reached out to poor farmers with creative techniques, including an open-air movie and village demonstrations. The challenge is great, but so is the potential payoff. Paul Polak, a pioneer in the field of low-cost irrigation and president of International Development Enterprises in Lakewood, Colo., believes a realistic goal for the next 15 years is to reduce the hunger and poverty of 150 million of the world's poorest rural people through the spread of affordable small-farm irrigation techniques. Such an accomplishment would boost net income among the rural poor by an estimated $3 billion a year.

Over the next quarter of a century the number of people living in water-stressed countries will climb from 500 million to three billion. New technologies can help farmers around the world supply food for the growing population while simultaneously protecting rivers, lakes and aquifers. But broader societal changes—including slower population growth and reduced consumption—will also be necessary. Beginning with Sumeria, history warns against complacency when it comes to our agricultural foundation. With so many threats to the sustainability and productivity of our modern irrigation base now evident, it is a lesson worth heeding. SA

LOW-COST TREADLE PUMPS have helped more than a million Bangladeshi farmers irrigate for the first time.

COURTESY OF INTERNATIONAL DEVELOPMENT ENTERPRISES

Further Information

Salt and Silt in Ancient Mesopotamian Agriculture. Thorkild Jacobsen and Robert M. Adams in *Science*, Vol. 128, pages 1251–1258; November 21, 1958.

Pillar of Sand: Can the Irrigation Miracle Last? Sandra Postel. W. W. Norton, 1999.

Groundwater in Rural Development. Stephen Foster et al. Technical Paper No. 463. World Bank, Washington, D.C., 2000.

Irrigation and land-use databases are maintained by the United Nations Food and Agriculture Organization at http://apps.fao.org