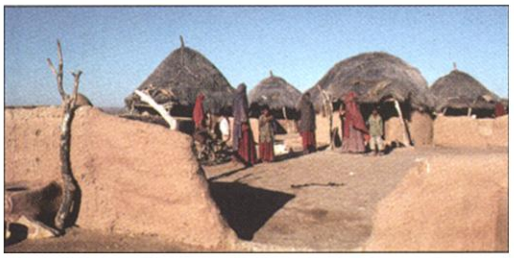
A Bountiful Harvest of Rainwater

OVER THOUSANDS OF YEARS, SOCIETIES HAVE developed a diversity of local water harvesting and management regimes that continue to survive in South Asia, Africa, and other parts of the world (*1*). Such systems are often integrated with agroforestry (*2*) and local forest management practices (*3*). In their Policy Forum "Managing water for people and nature" (*Science*'s Compass, 11 May, p. 1071), Nels Johnson and co-authors discuss several market mechanisms for sustainable water management, including taxing users to pay commensurate costs of supply and distribution and costs of integrated watershed management, and charging polluters for effluent treatment. Although such measures are indeed essential, I would argue that they are insufficient: They should be complemented with policy innovations to promote rainwater harvesting (*4*).

Revival of local practices of rainwater harvesting could provide substantial amounts of water. For example, a hectare of land in Barmer, one of India's driest places, with 100 millimeters of rainfall annually, could yield 1 million liters of water per year from harvesting rainwater. Even with simple technology such as ponds and earthen embankments called tanks, at least half a million liters a year can be harvested from rain falling over 1 hectare of land, as is being done in the Thar Desert, making it the most densely populated desert in the world. Indeed, there are 1.5 million village tanks in use and sustaining everyday life in the 660,000 villages in India.

In the Negev Desert, decentralized harvesting of water in microcatchments from rain falling over a 1-hectare watershed yielded 95,000 liters of water per hectare per year, whereas collection efforts from a single large unit from a 345-hectare watershed yielded only 24,000 liters per hectare per year (*5*). Thus, 75% of the collectible water was lost as a result of the longer distance of runoff. Indeed, this is consistent with local knowledge distilled in an Indian proverb, "Capture rain where it rains."

In the cities, rainwater could be harvested from building rooftops for residential use, and any surplus could be channeled through bore wells to replenish the groundwater, avoiding loss to runoff. However, if tanks and other rain harvesting technology are to be used to their full potential, policy innovations must include institutional changes so that such common-pool resources are effectively managed (*6*). Also, all forms of government subsidies need to be removed to allow market mechanisms, such as the ones Johnson *et al.* discuss, to run their course. Users would then find it prudent not only to make efficient use of priced water, but they would also have the incentive to collect the gift that Mother Nature has to offer in the form of rain.



Villages in the Thar Desert in India, the world's most densely populated desert, rely heavily on the harvesting of rainwater for their daily needs.

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References and Notes
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Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the previous 6 months or issues of general interest. They can be submitted by e-mail (science_letters@aaas.org), the Web (www.letter2science.org), or regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged upon receipt, nor are authors generally consulted before publication. Whether published in full or in part, letters are subject to editing for clarity and space.

Long-Term Storage of Information in DNA

IN THIS DIGITAL AGE, THE TECHNOLOGY USED for information storage is undergoing rapid advances. Data currently being stored in magnetic or optical media will probably become unrecoverable within a century or less, through the combined effects of hardware and software obsolescence and decay of the storage medium. New approaches are required that will permit retrieval of information stored for centuries or even millennia.

DNA has three properties that recommend it as a vehicle for long-term information storage. First, DNA has stood the informational "test of time" during the billions of years since life emerged. Nonreplicating DNA molecules are also quite robust. Although DNA stored under nonideal conditions (e.g., in archaeological deposits) is subject to hydrolytic and oxidative damage (*1*), mitochondrial DNA extracted and amplified from 7000-year-old human remains yielded an accurate DNA sequence (*2*). Storage of DNA under more favorable conditions can result in extremely long stability, as evidenced by the reported recovery of viable bacteria from 250-million-year-old salt crystals (*3*). Second, because DNA is our genetic material, methods for both storage and reading of DNA-encoded information should remain central to technological civilizations and undergo continual improvements. Third, use of DNA as a storage medium would permit each segment of information to be stored in an enormous number of identical molecules. This extensive informational redundancy would strongly mitigate effects of any losses due to stochastic decay (*4*).

Data retrieval of information stored in DNA should ideally require minimal prior knowledge beyond a familiarity with molecular biological techniques. In the procedure we have developed, two standard techniques are required for recovery of stored information: polymerase chain reaction (PCR) and DNA sequence analysis. Central to our pro-