U.S. Water Resources Versus an Announced But Uncertain Climate Change

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IF GREENHOUSE GAS IN THE ATMOSPHERE RAISES THE GLOBAL average temperature as heralded (*1*), a locality might warm during the coming decades as much as the 1°C difference in January between Hartford and Bridgeport, Connecticut, but less than the 6°C difference between Albany and New York City. Although this is not daunting, an accompanying decrease in water resources is. The dismay arises in part because arranging systems for water usually takes decades, as long as for the announced climate change. Vulnerabilities of the present systems in the present climate heighten the dismay. Five warning lamps of vulnerability on the national instrument panel are the ratios of (i) consumption and (ii) storage to supply, and the (iii) variability of runoff, (iv) dependence on hydroelectricity, and (v) overdrawing of ground water. In today's climate and in all the 21 American water-resource regions, at least one warning is flashing, and in the Great Basin, Missouri, and California regions four or five are flashing (*2, 3*). Hence, the emphasis on water when climate change is examined (*4*).

Because water resources are the bottom line after evaporation is subtracted from precipitation, a change in climate levers a bigger one in water resources. "Elasticity" is the ratio of percentage change in runoff to that in a climate element (*5*). The elasticity of runoff in several streams from Hudson Bay, Canada, to Lake Okeechobee, Florida (*6*), was found to be 3 for difference in precipitation and 32 for absolute temperature. Compared to these elasticities, those for runoff from snow in the Colorado River drainage were higher for temperature and lower for precipitation (*7*). An international appraisal concluded that a 1° to 2°C warming coupled with 10% less precipitation could reduce runoff 40 to 70% (*8*), an elasticity of 4 to 7. The computed elasticities for annual runoff and precipitation rise from 2 near the Atlantic coast to 4 in western Texas and Kansas (*5*). In addition, because snow would store less water if it melted sooner (*9*), warm spring weather would amplify the impact of climate on water supply in the West.

Even though we know in general the leverage of climate upon future water resources, the lack of the needed predictions of climate at hand or even near frustrates us in planning for climate change. We need regional or even local, not global, predictions. At minimum, we need predictions for each of the 21 water-resource regions of the United States.

Although the division of the United States into about 21 boxes in general circulation models (GCMs) might lull us, computations dispel any illusion. Three GCMs were used to compute the scenarios underlying the governmental appraisal of the impact of climate change on the United States (*4*). Predictions of the summer climate in the Great Plains for scenarios with doubled greenhouse gases ranged from 0.8 mm/day drier than today to 0.2 mm/day wetter (*10*). A brave but widely accepted view is that 10 to 50 years will pass before a consensus is reached about predictions of regional precipitation and runoff (*11*). So, despite the sensitivity of water resources to climate, the inability to predict climate in a basin makes a recommendation to factor in climate change when planning water systems facile rather than helpful.

On the other hand, several things would help. Coping with present variability prepares for climate change. Both conservation of some of the 80% consumption by irrigation and markets for efficient allocation would help (*12*). Diversification is another practical precaution. Collection of water over a region by connections and over times by storage in reservoirs and in the ground would decrease sensitivity to climate change. Because water yields can be increased by operating existing facilities jointly rather than independently, overcoming obstacles to joint operation would also help (*13*).

Because we shall not soon know whether runoff will change decades hence, we must know whether it is changing now. Before the facile recommendation for more gauges, however, comes the question, "Water data—who needs it?" (*14*). If we envision the designer of a water system that will endure a century, the question becomes, "Given the cost of building now for a predicted climate versus retrofitting later and given the normal interest rate, how profitable is more precise knowledge of the present, variable runoff?" The challenge for hydrologists is to learn the most efficient method of monitoring and then bolster recommendations for more data with credible estimates of the return on the more precise knowledge.

A testimonial to the importance of an accurate forecast for a single season is: "Angry farmers in eastern Washington [said] badly bungled water forecasts . . . [caused] them to spend millions of dollars on unneeded drought relief measures" (*15*). So, amidst the challenges of forecasting climate for the next century, meteorologists should meet the more modest challenge of dependable forecasts for the next season.

The final challenge is for a range of scientists to go beyond the passivity of computing the impacts of changed water resources. It is to pull from their fundamental investigations of the plants and soil of watersheds, of the management of runoff and of its consumption—especially the large one of irrigation—adaptations that will now temper the impact of variable weather and then after a few decades will help our affairs and Nature to meet the challenge of any climate change.

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REFERENCES AND NOTES

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12. D. F. Peterson and A. A. Keller in (*3*), pp. 269–306; K. D. Frederick and A. V. Kneese, in (*3*), pp. 395–419.
13. D. P. Sheer, *National Water Summary 1985* (U.S. Geological Survey, Washington, DC, 1985), pp. 101–112.
14. Present data provide some evidence of increasing flows following especially low ones from 1940 to 1983: N. C. Matalas, in (*3*), pp. 139–149. My question was anticipated and discussed by J. E. Schefter and D. W. Moody [*Water Res. Bull.* **17**, 978 (1981)].
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