We suffer from national laboratories–institutions syndrome, which is reflected in our advising the government to start two national institutes for science education at Pune and Kolkata. If this very amount of Rs 1000 crores have been allocated to ten of the better universities and asked to start undergraduate classes with conditions attached to ensure excellence, I am sure, at least 20 times better graduates would have been produced. Universities do suffer from many problems, many of which could be resolved without any extra financial inputs. I have written a lot about them elsewhere. These should be rectified by discussions and not by neglecting them.

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Water and science in India

Rajamani *et al.*[1] discussed the potential impact of interlinking major rivers on India's monsoons. Their concern is that reductions in freshwater influx caused by river-linking could disturb the near-surface salinity of the Bay of Bengal, leading to perturbation of the monsoonal pattern. Reductions in freshwater discharges to the Bay of Bengal may also arise due to the large number of tanks in watersheds. Reportedly, the number of irrigation tanks currently existing in Tamil Nadu, Karnataka and Andhra Pradesh may total several tens of thousands. Clearly, India's natural resources base comprising rainfall, the landscape, the ecosystems and the environment is being noticeably affected by India's water resources use. Available scientific knowledge unequivocally indicates an imperative for careful water resources management, failing which India may face a national catastrophe in the future. Yet, spurred by short-term economic objectives and political expediency, water resources development in India is uncontrolled. There is no coherent water policy.

India's water crisis is a matter of concern for all citizens. This concern is reflected in many articles on water that one reads in national newspapers. They often express frustration with the inability of the government at various levels to achieve any significant amelioration of the water situation. In the absence of meaningful governmental action, the common desire is that India's water woes be somehow banished through a combination of modern technology and water policies. In this atmosphere, public debate is polarized. At the moment, water debates involve two extremes. One is the concept of transporting very large quantities of water across the length and breadth of the nation by linking major rivers, and the other is the vision of local communities taking control of their water needs through rain harvesting. What is missing in the debate is an inclination, on the part of those who espouse either solution, to frame their strategies within the context of the physical–chemical nature of water, and the complex ways in which water functions in the Earth and its biological systems. The debates invariably explore policy alternatives, with scant attention to scientific issues of water availability. The perception is that technology will somehow find more water through manipulation and control of nature, or that competitive markets will lead to efficient water use.

The ongoing water debate is healthy, and must expand. However, for achieving constructive outcomes, the debates must shift from confrontation to informed discussion. Critical to informed discussion is a basic understanding of the scientific aspects of water that constrain long-term sustainable water use at various levels from a village to the nation as a whole. Based on such understanding, communities must make critical decisions on complex water issues.

How may the stage be set for informed national discourse on water? One possibility is that the nation's scientific leadership dedicates itself to influence the government and educate the public on water and natural resources.

India's strength in science is reflected in its national academies. The Indian National Science Academy, New Delhi, was born in 1935, patterned after the Royal Society of London, with the object of promoting science in India and harnessing scientific knowledge for the cause of humanity and national welfare. Its counterpart in the United States is the National Academy of Sciences. The Indian Academy of Sciences, Bangalore, was formed in 1934, with the goal of promoting progress and upholding the cause of pure and applied sciences. Both the Royal Society and the National Academy of Sciences play influential roles in national and international science policies. Their contributions may arise either in response to solicitations from their respective governments, or in response to initiatives from their own membership.

India's unique problems of water utilization stem from its physiography, geology and climate, and its long history of human habitation. It is essential that India's science academies make a concerted effort to address these problems so as to guide national policy and facilitate public education. They should be pro-active, initiating action even without governmental solicitations.

Assuming that the academies will be so inclined, it is appropriate to outline the underlying scientific issues.

At the heart of water management lies the challenge of adapting social needs and aspirations to the hydrological cycle. Deceptively simple and profoundly complex at the same time, the hydrological cycle involves four components that dynamically interact on widely varying spatial and time scales: atmosphere, surface water, groundwater and biological communities. Individually, each component is characterized by complex geometries,

heterogeneities and difficulties of access to observation. These systems are finite, and are subject to uncertain forcing functions, primarily climate. Additional complexities arise due to poor scientific knowledge about the manner in which organisms and communities respond to changes in their environment. Reports of resource depletion, environmental damage, desertification, global warming, acid rain, and disappearance of species are manifestations of human impacts on highly coupled, difficult-to-characterize Earth systems.

For example, consider the water situation in peninsular India. This region, occupying nearly a third of the country, is mostly occupied by hard rocks. Precipitation is widely variable, from the wet, narrow coastal strip adjoining the Arabian Sea to semi-arid conditions in the rain-shadow to the east. Because of the hard-rock conditions, groundwater availability over much of the region is restricted to within about 100 m of the land surface. Historically, people of peninsular India have relied heavily on tanks and ponds of various sizes for domestic and irrigation purposes. Following independence, dug wells and bore wells have proliferated.

One consequence of the shallowness of the groundwater reservoir is that the resource intimately interacts with atmospheric precipitation. It does not have adequate storage to act as a buffer for droughts lasting for more than a year or two. This problem is exacerbated by overproduction of water, as is happening in many urban areas such as Bangalore, Hyderabad and Chennai. Furthermore, any degradation of water quality due to sanitary wastes, land fills, and industrial effluents can drastically diminish the already limited supplies of freshwater.

The aforesaid problems demand innovative, holistic thinking to develop strategies for meeting societal needs of water within the constraints imposed by the strongly interacting components of a finite Earth. Modern technology cannot somehow solve India's water problems and provide enough water for limitless economic growth. Rather, what is needed is a mindset of adaptive living within the constraints imposed by natural resource systems. This is a formidable task, achievable only through a rational coming together of science and society. In facilitating this coming together, the challenge for India's academies of science include, (1) to see that scientific knowledge actively guides the nation's water and natural resource policies, (2) stimulate education, training, and research on water and natural resources in India's institutions of higher learning through appropriate incentives, (3) guide public education towards water literacy, and (4) express opinions on important issues relating to water and natural resources.

In our technological world, no nation can formulate meaningful water and natural resources policies without adequate scientific input. As India looks ahead to becoming an economic power among the nations of the world, India's science has a major role to play in a wise utilization of its finite water resources. Without a strong participation by the scientists, India's economic prosperity will be seriously in jeopardy.

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