

earch fellows, the relative percentage being nearly 17% each year.

Visiting scientists are non-Indians and this category includes visiting research fellows, visiting professors, visiting assistants/associate research fellows, and visiting experts (Figure 1). The average number of local visiting fellows was 5.25% (range 4–6) during these four years; since most locals with doctoral degrees prefer to get a job either in universities or research institutes after graduation, they seldom prefer postdoctoral fellowships. Thus there is a need for Taiwan to recruit postdoctoral scholars from overseas.

Despite the fact that Indian scholars initially have difficulties with regard to food, living conditions, etc. in Taiwan, the low cost of living, reasonable salary

(USD 1700/month) and excellent opportunities to work in well-equipped research laboratories are major attractions.

Most Indian scholars usually stay for a period of one to three years to gain postdoctoral experience, before returning to India or set out elsewhere in the West to further their research, technological and academic goals. Although there is no diplomatic relation between Taiwan and India (India recognizes the People's Republic of China), visa processing work is being handled without much haste by the Taiwan Business and Culture Office in New Delhi. Fluency in English writing, professionalism, dedication and hard working attitude of Indian scholars are well-appreciated by scientists in Taiwan.

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3. Taiwan 2000: Balancing Economic Growth and Environmental Protection, Academic Sinica, Taipei, 1989.
4. National Science Council, Republic of China Report, 2004.

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Recognition of merit

The editorial 'The Shanghai Rankings'¹ puts all our scientific efforts in proper perspective. A few points would suffice to illustrate the reason for our disappointing ratings and the lack of any university making it to the list. Since the last 10–15 years universities have practically stopped hiring, leading to a vacuum at the base-level for research in universities. Senior scientists being assigned additional academic and administrative responsibilities, have little time for research. In spite of noble efforts to recognize merit at the national level through

the ritualistic NET–Lecturership–GATE, etc. there is no follow-up to give appropriate opportunities to the ones who excel. The editorial noted the casual approach towards research in most universities due to many reasons. I think the time has come to start a cadre of research scientists in universities, institutes and leading laboratories to mobilize talented young scientists to energize the research tempo and thus to encourage creative research. Otherwise, we will continue to be where we are, no matter what efforts we make by offering more and more schol-

arships without any scope for job security.

1. Balaram, P., *Curr. Sci.*, 2004, **86**, 1347–1348.

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Managing water

Gupta and Deshpande¹ have exercised due caution in their first-order assessment of India's water future. Their assessments are based on nationwide hydrological estimates covering 3.1 million km². It is instructive to compare these estimates with those for California, which, in size, diversity of landscape, climate, geology and vegetation, is comparable to India.

India is about 7.6 times the size of California. Compared to India's annual precipitation of 4000 km³, California²

receives 247 km³. India's evaporation amounts to 1789 km³ or 44.7%, and groundwater recharge, 342 km³ or 8.6% of total rainfall. For California, evapotranspiration has been estimated at 65% of total precipitation, and groundwater recharge, 18%. The almost 20% difference between India and California in evaporation loss is intriguing. Does India's evaporation estimate include transpiration? Also intriguing is that groundwater recharge for California is twice that for India.

Errors in these estimates can seriously affect water availability assessments.

Gupta and Deshpande¹ conclude that management of groundwater storage space through rain harvesting and artificial recharge can generate 125 km³ annually, duly recognizing that groundwater recharge on this scale has not been resorted to anywhere in the world. Here, two thoughts are relevant. First, except near the water table, where the water-bearing formation drains water by desaturation,

the ability of a formation to take in or release water from storage is dictated by the ability of the material to deform elastically and change porosity. Such strain-based storage coefficient is usually small in magnitude compared with the storage coefficient of desaturation drainage. Second, as seen from figure 4 in Gupta and Deshpande¹, areas of groundwater surplus lie largely in Maharashtra, Madhya Pradesh, Andhra Pradesh, Orissa and Assam, and their environs. Large parts of these areas are wilderness tracts, occupied by many indigenous tribal people. Their welfare and the need for wilderness protection may preclude large-scale groundwater recharge in these areas. If so, the projected 125 km³ may require downward revision.

Regardless quantities, one clear message is that surface water and groundwater are intimately interlinked. This recognition persuades us to devote attention to the hydrological cycle within which surface water and groundwater are linked. An important development in the earth sciences during the early 1960s was the concept of regional groundwater motion³. At its core, this concept recognizes that water moves vertically down in recharge areas of higher elevations in a watershed, moves vertically up in discharge areas at valley bottoms, and moves laterally in between. This regional flow pattern has profound influence on water chemistry, distribution of soil, and zoning of ecosystems. An implication is that groundwater recharge cannot be arbitrarily carried out everywhere, because induced recharge will have physical, chemical and biological impacts on the total system.

Gupta and Deshpande¹ are enthusiastic in their support of rain-harvest when they state, '...rainwater harvesting and artificial groundwater recharge, where people and communities can directly participate due to the low level of technologies involved'. This statement seems to suggest that the general public can simply be empowered to intercept, store and recharge water, regardless of where they may be located within the hydrological system. The wisdom of this perception

merits reflection from the perspective of regional groundwater motion. Sites for artificial recharge, disposal of wastes, land reclamation, and so on, are to be chosen based on the nature of groundwater flow systems on appropriate spatial and temporal scales. This statement does not negate active public participation in water management. Rather, a water-literate public is essential in other ways for judicious management of available water resources.

Gupta and Deshpande¹ state, 'Therefore, acquiring quantified knowledge about the spatial and temporal distribution of the different components of the local, regional and national hydrological cycle is vital to plan and develop water resources of the country at different scales at the least cost to ecology and environment...'. This statement goes to the heart of India's water resources woes. Climate, landscape, geology and ecosystems subject to physical laws of nature dictate the quantity of water available within the country. The challenge is to adapt our living needs to what is available, tempered by our human and social values. This adaptation entails a coming together of science and society in unprecedented ways. It is becoming abundantly clear that water resources systems cannot be subdued at will by engineering and technology.

Managing water is not just about water anymore. It requires management of interlinked hydrological, nutritional and erosional cycles. Earth scientists and ecologists now recognize that learning to sustain human living from these cycles, without unduly disturbing the balance among them, is a formidable challenge. If India is to be optimistic about its water resources in 2050, the time is now to embark on a major initiative to delineate and characterize hydrogeological basins on various scales, establish permanent monitoring stations, generate water budgets and initiate procedures of rational water management that combine short-term as well as long-term objectives.

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Response:

We thank Narasimhan for his interest in our work. Though presently not in a position to comment on the reasons for the differences in estimates of evaporation and groundwater recharge components between California and India, we recognize the difference. The error in our evapotranspiration estimate cannot be ruled out, as this is the least certain component estimated from the water-balance studies, although this alone may not explain the observed difference.

Figure 4 in our article does take into account the gross hydrogeology of various river basins while estimating achievable artificial groundwater recharge potential of ~125 km³/yr. Achieving this would certainly require detailed investigations of hydrogeology and several innovations in technology together with social, political and legal aspects, as suggested by Narasimhan.

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