wish to achieve and where we wish to reach are constantly expanding.

Increasing globalization led by rapid advances in information and communication technologies is resulting in an economy which depends on knowledge creation, dissemination and use to enhance growth and development. India's agricultural research and education system is the primary organ which coordinates and contributes to enlarging the knowledge base required to improve the efficiency and productivity of the agriculture sector whose growth will continue to be a significant factor for improving livelihoods of the vast majority of the poor and the country's overall growth, development and economy. The system's ability to effectively capitalize on its vast physical network for creating, disseminating and utilizing knowledge is what will enable us to be competitive in the emerging global scene.

Success requires that we act now. What we need is to put in place mechanisms which enable building a shared vision amongst key stakeholders, of ways in which the system must transform itself to cope with a multitude of challenges that we face. This will call for bringing on-board the best of expertise from a range of perspectives to collectively bear upon our understanding and to steer the change. System transformation will come about only through a step-wise progress, constantly analysing and seeking the best way forward. No doubt, the task is daunting, but a beginning must be made.

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Three waters – An evaluation of urban groundwater resource in Delhi

Vikram Soni

In the developing world, population pressures are such that cities have swollen beyond their carrying capacity. As uncontrolled urbanization is riding roughshod over their local natural resource, cities like Beijing and Shanghai in China, as well as Delhi and Chennai in India are now in permanent water crisis. Priceless local water resource is not being conserved in these cities.

For these megacities in the developing world, it is no longer a question of importing an essential resource like water, the water is just not there. In the more stable developed world where there is more wilderness, it may be used to water cities. New York, for example, gets its water from the Catskills forest, which is 150 km away. Delhi does not have such an option.

The sustainable carrying capacity of Delhi is about 8 million – less than half its present population! The study found that a third of the city's water was being imported from the Ganga and the Beas, and further import of water from these heavily agricultured river basins will lead to intense conflict. It was also found that the secondary (non potable) recycling of water was not a realistic option, as the cost per person will be close to half the annual per capita income. This makes it urgently necessary to examine the issue in-depth, especially the preservation of local water resource.

Delhi is defined by two natural features, the River Yamuna and the Ridge – a part of the Aravalli range of hills. Both of these are essential water resources – that is why all the ancient or medieval cities were located either on the Ridge or on the banks of Yamuna. The enduring value of such natural resources and local waterbodies is being lost for short-term gain. Water is a local resource and we must have local solutions for our water problems. Here, we illuminate and set values for three of Delhi's groundwater resources.

The Ridge

Our first water resource, the Ridge, Delhi's oldest natural heritage, is sculpted on quartzite deposits, which have cracks from 2 billion years of natural history. This recharges 80% of the rain falling on it[2]. All rainfed aquifers surrounding the ridge are an incredible resource for pure water and must be preserved by protecting their recharge zones. We have already asked the Prime Minister and the Delhi High Court to intervene, to stop the destruction of the Ridge and preserve it as a water sanctuary and a community groundwater reserve. Protection of the entire Ridge is crucial as studies indicate that the only aquifers in Delhi that have good water are those recharged by the Ridge.

Less than half of the Ridge area in Delhi is notified[3] as reserved forest (78 sq. km). We take a conservative 150 sq. km of ridge area[4] with a yet more conservative recharge potential of 60% (not 80% according to the Central Ground Water Authority report[2]) of rainfall. Delhi's average annual rainfall is 60 cm, which gives us an annual recharge potential of about 60 million cubic m. The importance of the Ridge also lies in the fact that it provides us with the purest quality of water. No other source can provide this, whether man-made or natural. At one-fifth the rate of 1 l mineral water bottles, Rs 2/l, this works out to Rs 11,000 crores a year.

The floodplains

Next we take up the largest and invisible water reserves of this ancient city, which lie in utter neglect and ruin. Most rivers in India have a variable flow which peaks during the monsoon, when the river runs its banks and widens considerably, depositing water and silt on the wide floodplains. The floodplains have a soil constitution of silt and sand that is highly porous – it is this soil type that defines the boundary of the flood plains. If we do a small experiment and fill sand into a pot and then fill it with water, the water occupies more than 60% of the volume. In other words, the floodplains are like a pro-

tected and invisible lake under the sand. Whereas a lake loses water through evaporation, this floodplain concealed lake does not.

A small calculation can help us arrive at the magnitude of this reservoir. Delhi has about a 100 sq. km of floodplain[3] with an average depth of 30–50 m, of which may be two-thirds, is still intact. With a conservative 50% water-holding capacity, this gives us more than 1 billion cubic m of water. This is close to the annual water needs of Delhi! The floodplains get recharged every year when the river floods, but only if the river is allowed to flow and flood. The upstream diversion of the river flow into canals and the building of embankments have been undermining this recharge of late.

It is straightforward to calculate the economic value of this water. At the lower end, the value of a tanker of water in Delhi is Rs 1000 for 10,000 l or 10 cubic m. The recharge value of the floodplain works out to be over 10,000 crores a year.

Any tampering with the river and its floodplains would be an unmitigated disaster. It means the loss of an incredible water resource. But with blissfully unconcerned governments, this is what is happening in Delhi, with huge developments like Delhi Secretariat, Akshardham, etc. already built and with the Global and Commonwealth Games village and metro depots imminent. Building on the floodplains, in a water-starved city, is like cutting the branch you are living on.

The deep underground aquifers

We now come to, literally, our last water resource – the deep underground aquifers, which are the emergency reserves for a city.

Most of shallow groundwater rests in rainfed aquifers that are directly recharged by the rainfall and occur in the first strata of soil directly below the ground. In Delhi, the cut-off depth of rainfed aquifers is about 40 m. Below these, we usually find a layer of impervious soil, either rock or clay. Further down, there are deep underground aquifers that are not seasonally recharged by rain, but are recharged by lateral flow from river or other subterranean water flow. This recharge is slow and an aquifer could take over 50 years to recharge.

Such aquifers should be kept as reserve to be used only in a contingency. They are, however, being used by developers and the city especially in Gurgaon. Once these run out, there will be no recharge the following year! Evacuation then becomes a real possibility.

This evaluation of vital urban water resource is for Delhi. It is imperative to carry this out for all cities of the world. We have estimated the value of what we are destroying as of now. Lest we forget, these permanent values are annual values which will inflate faster than property and the use is entirely non-invasive.

1. Soni, V., *Econ. Polit. Wkly*, 8 November 2003.
2. See, for example, Central Ground Water Authority report (No. 22–24/court/CGWA/2004 dated 12 June 2004), submitted to the Centrally Empowered Committee of the Supreme Court, 2004.
3. Master Plan of Delhi, MPD 2001.
4. Geological Survey of India, Topo maps.

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