India Must Use Science, Technology, Infrastructure To Give Water to Millions

by Ramtanu Maitra

April 10—India is not a water-short nation. Monsoon rains and ice-melt of the Himalayan glaciers during Summer provide its rivers with more than adequate water; and yet, millions of Indians, mostly women, spend the greater part of their daily lives procuring water manually from a distance, to enable their families to survive. This condition is intolerable, and particularly so, since India possesses the scientific and technological capabilities to generate freshwater, as well as the expertise to develop the infrastructure to transfer water from a surplus river basin to water-starved areas. All it needs is focused efforts to prioritize this vital infrastructure, which would provide an essential ingredient to turn India into a hub of manufacturing and agriculture, and pave the way for a healthy and productive future.

India's present-day strength in resolving the uneven distribution of its annual water supply across the country, is evident in its proven excellence in its mastery of space and nuclear technology. Both these sources of knowledge and acquired capabilities need to be exercised to deal with its present and future water requirements. India has developed cadres of scientists and experts in these two areas, who should be channeled now to tackle the water problem.

Topology and Types of Rivers

India receives an average of about 4,000 billion cubic meters of rainfall annually, and India's landmass is close to 3,600 billion square meters. If this water were distributed evenly throughout the country, the landmass would have annually 1 meter's height of water. However, the rainfall distribution is highly uneven. About 30% of India's landmass receives an annual rainfall of no more than 750 mm, while 70% receives less than 1,150 mm. In most parts of the country, the monsoon rainfall, which provides the bulk of water, lasts for 3-4 months, but 75% of that rainwater, after flooding large areas, flows into the sea because of lack of water storage and adequate means for transfer of water.

In addition to the uneven distribution and the brief period of rainfall, India's topology does not allow water from the water-surplus areas to flow into water-short regions.

India's rivers are classified into two categories: Himalayan and Peninsular (**Figure 1**). The Himalayan rivers are in the north. The main rivers are the Indus, Ganga (Ganges), Yamuna, Brahmaputra, and Spiti, in addition to the five rivers of Punjab—Jhelum, Sutlej, Beas, Ravi, and Chenab. The Jhelum, Sutlej, and Indus rivers flow westward into Pakistan.

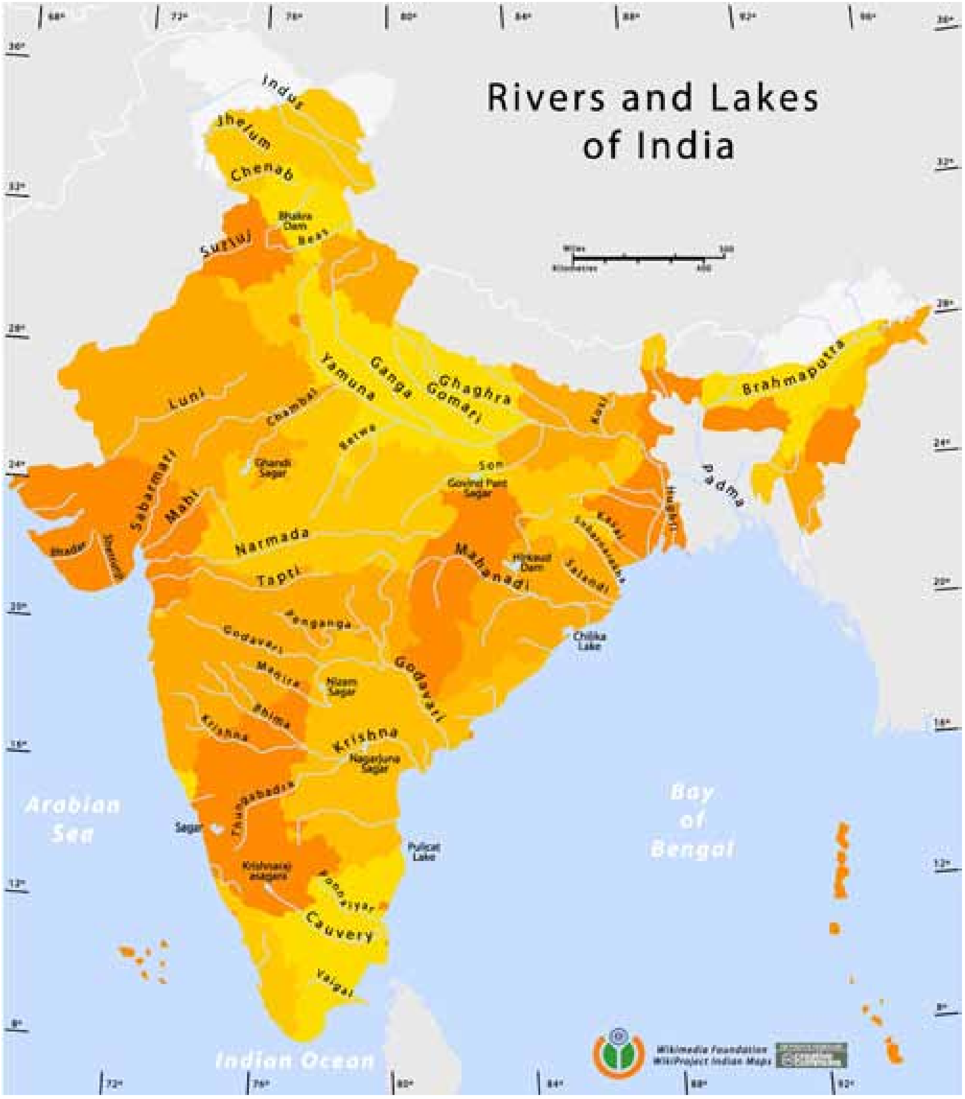
The Peninsular rivers in the southern peninsula of India are the Godavari, Mahanadi, Penner, Krishna, and Cauvery.

These two categories of rivers are completely different from each other. The Himalayan rivers rise in high mountains with their sources in glaciers. The ice melt gives them their perennial nature. These rivers flow down from the high Himalayas, a young mountain range, carrying water at a high velocity along with debris from the young mountain, and cutting deep gorges. These rivers have long courses flowing down the mountains, then through level plains and marshy deltaic tracts in the east.

On the other hand, the Peninsular rivers lie in plateaus and low hills that are free from snow. They exhibit a gradual profile, gently flowing through the plateau and narrow coastal plains, depending entirely on seasonal rainfall. As a result, most of these rivers disappear during dry season. Other differences are that the Himalayan rivers are utilized for power generation in hilly areas, and for irrigation, drinking water, and inland navigation in the plains. Their long journey through alluvial plains allows them to build up huge reservoirs of water underground. By contrast, the Peninsular rivers, although suitable for some power generation in their upper reaches, have limited use in irrigation and navigation, confined to the deltaic plains. In addition, the topology of the peninsular region is hard and impermeable, preventing buildup of large underground storage.

India has a long coastline of 7,500-plus km, extending southward from the state of Gujarat in the northwest, to the state of West Bengal in the northeast. Much of the coastline belongs to peninsular India. Coastal areas such as the states of Tamil Nadu, Gujarat, and Andhra Pradesh have a huge problem of water scarcity, due to poor river water availability, low groundwater levels, and high demand. All three states have strong industrial bases and contribute in a large way to the country's economy. Tamil Nadu and Andhra Pradesh have extensive agricultural lands.

FIGURE 1



Applying Science and Technology

The key to resolving India's uneven water distribution, which has caused hundreds of millions to live in perpetual water shortage over decades, lies in using the science and technologies that India has mastered. Back in the 1950s, under the leadership of the late Dr. Homi Bhabha and with adequate support from many accomplished scientists, India started its nuclear power generation program with an eye to resolving the country's future agro-industrial power requirements. Their competent work, undermined for decades by the Western nations for geopolitical reasons, long ago reached the point that it can also resolve peninsular India's water shortages.

In addition to mastering the complete nuclear fuel cycle, India produces its own **pressurized heavy water reactors (PHWRs).** It has installed 16 such indigenous reactors, and many more are in the process of being set up. Most of India's PHWRs are of a relatively small capacity of 200 megawatts (MW). India is in a perfect situation to utilize small PHWRs and their waste heat, to desalinate water all along the vast coastline, providing domestic, commercial, and industrial water to the water-starved citizens. Hundreds of those nuclear desalination plants, providing at least 300-400 million liters per day (MLD), can be set up all along the coastline resembling a necklace, using the waste heat of indigenous PHWRs for desalination, and the power generated by these nuclear power plants to provide power to the community.

However, India grossly lags in developing this essential infrastructural ingredient using its indigenous

FIGURE 2

technology. Although it has dozens of small desalination plants, in the state of Tamil Nadu only two 100 MLD plants have been set up, and another 150 MLD plant has received clearance. All three plants use or will use **reverse osmosis (RO)** as the process to desalinate. A 1.8 MLD capacity desalination plant using the RO process has been set up as part of **Nuclear Desalination Demonstration Project (NDDP)** at Kalpakkam, Tamil Nadu. Another plant, a **Multi-Stage Flash (MSF)** desalination plant, with a capacity of 4.5 MLD, has also been set up at Kalpakkam, to use the steam from the RO plant as its energy input. The hybrid MSF-RO plant produces distilled water for high-end industrial applications, and potable water for drinking and other applications.

One major problem of the RO, or the **seawater reverse osmosis (SWRO)** process, is that it does not produce power, but consumes it, whereas in a nuclear desalination project, desalination takes place utilizing the waste heat, while the nuclear power plant generates power for all human uses. Moreover, reverse osmosis membranes are subject to fouling or plugging on the membrane surface. This can decrease the permeate production capacity of the membrane or require an increase in operating pressure (and therefore energy) to overcome the fouling effect. As a result, virtually every membrane desalination facility in the world (including SWRO) requires properly pretreated seawater. This involves flocculation/sedimentation to remove suspended material; dissolved air flotation (DAF) to remove potential algal biomass or potential hydrocarbons; granular media filtration (GMF); and/or low-pressure **ultrafiltration (UF)** or microfiltration (MF) to remove suspended particulate matter. The pre-treatment also consumes energy to be supplied from an external source.

Utilizing Space Research

Success in space technology has provided India an opportunity to utilize this hard-earned knowledge to conquer the next frontier, which would provide every Indian with adequate water in the future. Following the successful launching of the Mangalyaan Mars orbital mission (2013) in India's maiden attempt to put a spacecraft in Mars orbit, Prime Minister Narendra Modi described it as an "historic and spectacular" success. He said he was proud that the country dared to reach out into the unknown and achieve the near impossible.

It is now time to use the accumulated knowledge of India's space science research. Scientists have worked for years to identify galactic cosmic rays' positive role in the Earth's low cloud cover. In 1997, Henrik Svensmark and Eigil Friis-Christensen reported a correlation between cosmic rays and cloud cover. They found that the observed variation of 3-4% of the global cloud cover during the recent solar cycle, is strongly correlated with cosmic ray flux. This was hailed by some as the key to the mystery of how the Sun affects climate and produced climatic changes. It was also a confirmation of the longstanding suspicion that cosmic rays were linked to global cloudiness.

Of particular interest is the observation from recent satellite data, that the cosmic ray-cloud correlation is much more intense in low-level clouds than in high-level ones. On the other hand, utilizing human-generated, negatively charged ions to attach to the condensation nuclei in clouds, would enable the water drops to grow and turn into rain.

Physical Infrastructure

One other essential requirement for India is to augment water-short areas of the Peninsular rivers, by transferring surplus water from the Himalayan rivers. It was more than 40 years ago that India's leading water expert, the late Dr. K.L. Rao, proposed interlinking the Ganges with the Cauvery, a 2,650 km-long link. This was to be a huge civil engineering project. But it was never even started. The project had called for bringing in water from the eastern part of India to the South and West.

The Peninsular river interlinking would involve connecting the Mahanadi, Godavari, Krishna, and Cauvery rivers by canals. Water storage dams would be built along the course of these rivers. The objective is to bring in the surplus waters from Mahanadi and Godavari to peninsular India. It is estimated that this part of the interlinking would provide additional irrigation to 13 million hectares and would be able to generate a peak power of 4,000 MW.

The other river basin links would connect rivers flowing north of Mumbai to the rivers flowing south of the Tapi River. Again, reservoirs would be built along the way for water storage. This water was earmarked for the huge Mumbai metropolis as well as for agricultural requirements along the coastal part of the state of Maharashtra.

The third aspect of interlinking would connect the Ken and Chambal rivers to enhance water facilities for the states of Madhya Pradesh and Uttar Pradesh. In addition, the plan called for diversion of west-flowing rivers along the Western Ghats to provide water for irrigational purposes. These west-flowing rivers presently discharge into the Arabian Sea all the freshwater they carry. That leaves the Indian authorities with one more task to make India permanently water-stable.

The interlinking of rivers, which the Modi Administration has promised for India's citizens, calls for creating storage capacities along the way. However, India must also have the objective of storing a significant part of the Monsoon rainwater that now flows into the seas. The storage of water in reservoirs strewn across the land, enhances humidity in a limited area. At night, this humid air descends to improve the land.

For example, the Indira Gandhi Canal (earlier known as the Rajasthan Canal) has brought in water from the Beas River over the last 28 years, with the objective of turning the Thar Desert of western Rajasthan into lush agricultural land. Anyone who has visited that area would have observed how well that objective has been attained.