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GUEST EDITORIAL

Impetus to hydrology

‘What happens to rain?’ is the question that hydrologists are interested in. Natural processes that affect the society directly, such as river flow, groundwater storage, floods and droughts are primarily driven by rainfall in most parts of our country. In as much as it deals with such natural processes as streamflow, storage in ponds and lakes, evaporation and evapotranspiration, infiltration to ground, water flow beneath the earth’s surface and water uptake by vegetation, hydrology should in fact be a branch of basic sciences. However, because of a need to evolve implementable solutions to real-life problems and issues related to water – including agricultural water management, industrial and domestic water supply, flood mitigation, hydropower, water pollution and environmental concerns – hydrology has evolved as a traditional branch of civil engineering. The field thus has a potential to be a branch of earth system science – providing an understanding of fundamental processes of water fluxes through the atmosphere, cryosphere, Earth’s surface, vadoze zone and aquifers – as well as engineering science providing implementable solutions to practical problems related to water resources. A leading hydrologist of our times, Sivapalan laments: ‘Hydrology should be an exciting field of study. However, tensions between expectations of hydrology as a natural earth science and as an applied engineering science, are hindering the progress in the field’¹. It is only in recent years, with a frenzied enthusiasm on linking hydrology with climate change impact models, that integration of hydrology with other basic sciences – notably the atmospheric sciences – and recognition of the field as an important component of earth system science are gaining ground.

Hydrologic research in India has seriously lagged behind for a long time because of severe limitations on the availability of useful data to researchers. Similar to most other branches of earth system science, hydrology draws from secondary data collected over a reasonably long period of time. Flood frequencies, for example, are best estimated based on historical peak flows in streams. Research questions in hydrology that have particular relevance to the country today and need significant amount of good-quality data to be addressed meaningfully are related to climate change impacts on Indian

ivers and aquifers; non-stationarity in hydrologic processes, particularly in the extremes of floods and droughts – forced not only by climate change, but also by structural interventions²; effects of rapid land use and demographic change on hydrologic processes; transport of contaminants in streams, rivers and groundwater; real-time flood forecasting with adequate lead times, and understanding of hydrologic processes on watershed and river basin scales, among others. Inaccessibility of good quality and quantity of hydrologic, meteorological, environmental and agricultural data to researchers has not only contributed to a general lack of high quality research contributions from the country, but has also rendered the Indian research community susceptible to repeated criticism on the use of bad quality and unreliable data in research. The government bodies which are custodians of the data have traditionally been reluctant to share them. This reluctance, combined with far too many bureaucratic hurdles in data-sharing, has often led to a great deal of frustration among the researchers. If, for example, the hydrologic community had access to good-quality data – both from satellites and from ground measurements – immediately preceding, during and after events such as the Kedarnath floods in 2013 and the Kashmir floods in 2014 and 2015, a reconstruction of the events through hydrologic (and other) models would have been possible and thus would have provided an understanding of what should be done to prevent losses due to such events in future. There have been many instances where new theories, methodologies and propositions had to be demonstrated by researchers in India with data from other countries^{3,4}, thus in a way denying the benefits of research to our country.

To strengthen research in hydrology and, indeed promote scientific water policy decisions at various spatial scales, it is important to significantly upgrade the data collection, monitoring, communication and storage network in the country, in terms of both technology and density⁵. While a recent initiative by the Government of India through creation of the India-Water Resources Information System (India-WRIS) is an excellent step in making the data openly available, this effort must be taken to a much higher level by recognizing that the data

are needed not only for governance and administrative purpose, but also for enhancing knowledge through high-end research. Archived and real-time data on river flow, soil moisture, evapotranspiration and other variables, integrated with real-time satellite imageries accessible through high-speed networks, exclusively dedicated for research, would stimulate scientists to take up challenging problems. There is also a need for setting up a number of critical zone observatories (CZOs) – measuring atmospheric, hydrologic, bio-geochemical, ecological and other fluxes in the Earth's near-surface zone – in different hydro-climatic regions in the country and networking them together to provide useful data on Earth's near-surface processes. The data and knowledge generated through these should be integrated with those from other CZOs globally, to contribute to the growth of science.

Hydrology education in India is currently limited, in most part, to the traditional civil engineering branch. A typical undergraduate programme in civil engineering consists of one, or, at most, two courses (out of the nearly 40, that a student has to take) related to hydrology. As a result, a student is never in a position to appreciate the significance of the subject. Added to this, the employability of students specializing in hydrology is extremely limited – with mainly the government agencies as potential employers. As a result, students shy away from pursuing higher studies in the area and thus, the number of well-trained hydrologists in the country is small. This is rather ironical, because the country at this stage faces significant and challenging problems related to water resources and well-trained hydrologists are needed in large numbers. Numerous signals point to an impending water crisis in the country: inaccessibility of safe drinking water to sizable sections of population; unsustainable exploitation of groundwater; pollution of large stretches of rivers beyond acceptable levels; contaminated groundwater in several regions of the country due to both natural and anthropogenic sources; transport of water to cities over large distances involving enormous energy; severe water shortages and unplanned urban growth choking natural water bodies and drainage pathways, resulting in frequent and intense flooding in cities. Climate change, in as much as it affects the water availability, water demand, water quality, extremes of floods and droughts, and salinity intrusion in coastal aquifers, will soon likely be an additional and significant stress. These are serious issues that call for an in-depth scientific

understanding involving different fields of expertise. A number of centres of excellence pursuing multidisciplinary research pivoted around hydrology are therefore needed in the country, keeping in view the heterogeneities in geographic features across the country: climate, terrain, demography, land use and land cover. Such centres should bring together, for example, expertise in hydrology, cryosphere, ecology, water chemistry, biological science, earth science, atmospheric science, agricultural science, remote sensing, sustainable development, social and policy sciences, economics, management, and sensor and communication technologies. The centres should train a new generation of hydrologists by departing from the current fragmented and compartmentalized education in hydrology and moving towards providing a holistic and multidisciplinary training. The Indian Institute of Science, Bengaluru has recently established such a centre toward meeting this objective. Several such centres are needed in the country today. The big research questions of immediate relevance that could be addressed by such multidisciplinary centres include those related to feedbacks between climate and land-surface processes including hydrology, slow and fast response of water systems to climate change, coupled forecasting of high-intensity precipitation and fluvial/pluvial floods, medium-range weather forecasts for agricultural water management, water quality and contamination, recycling of waste water and urban water cycles. Resolving these questions would involve developments both in the fundamental understanding of natural processes that promote the growth of science and in innovative technological solutions to immediate and pressing problems related to water faced by the society.

1. Sivapalan, M., *Hydrol. Process.*, 2003, **17**, 3163–3170.
2. Milly, P. C. D. *et al.*, *Science*, 2008, **319**, 573.
3. Basu, B. and Srinivas, V. V., *Water Resour. Res.*, 2014, **50**(4), 3295–3316; doi:10.1002/2012WR012828.
4. Mondal, A. and Mujumdar, P. P., *Adv. Water Resour.*, 2014, **75**, 67–75.
5. Mujumdar, P. P., *Nature*, 2015, **521**, 151–152.

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