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GUEST EDITORIAL

Flood management in India

India has a monsoon type climate where more than 75% of the annual rainfall is received in about four monsoon months. However, this is also the period when the country faces floods, mainly due to intense and/or prolonged rainfall events. During monsoon months, the rivers carry about 75–80% of the annual runoff.

A common perception is that despite the various programmes and initiatives to manage floods, incidences of floods are increasing in India. This perception, to some extent, is formed by increasing instances of inundations in urban areas, at times during rainfall events of even mild intensity. This menace is either personally faced by the citizens or is brought to their attention by media. It is noted that the causes behind urban and riverine flooding are different. Urban flooding in India is largely due to unwise infrastructure development, its maintenance, and anthropogenic causes. Riverine floods occur mainly due to natural causes; at times the anthropogenic factors also play a role.

Studies and appraisals by different organizations/ experts have concluded that the citizens, properties and infrastructure in India cannot be provided complete protection against floods. People need to learn to live with floods. Hence, we need to shift attention and efforts from flood control to flood management.

Floods typically occur in India during June to October and many parts of the country begin to face droughts, about five months later. Hence, if a sizeable part of flood water is saved, it would be extremely helpful in meeting the needs during the dry season. Thus, letting the flood water pass to the ocean at the earliest is not a good approach. Flood flows need to be viewed as resource and flood season may be seen as an opportunity to conserve water. With this view, a better flood management approach would be to save most of the flood waters for later use and only pass that quantity which is necessary for environmental reasons or that cannot be conserved and may cause harm.

Various dimensions of flood management in India including the R&D needs are discussed here.

Intense precipitation, often of short-duration, is one of the main causes of floods and these events are likely to become more prevalent in future due to warming climate. Hence, we need better monitoring of such events by employing *in-situ* devices, weather radars and remote sensing technology. River flow data also need to be measured (to the extent feasible) at all major and medium rivers that cause significant damages due to flooding. Both rainfall and flow data are needed at short-time intervals. Measured data need to be sent to a data centre in real-time where these are processed, disseminated to the users and stored in (preferably) on-line shareable databases. Data of other hydro-meteorological variables (such as temperature, radiation, soil moisture) are also needed in modelling and management of floods.

Design flood is computed for hydro-projects by using hydro-meteorological data by either catchment modelling or by flood frequency analysis. The first approach requires computation of the probable maximum precipitation or the standard project storm. Procedure to compute these need to be reviewed and updated since the warmer atmosphere will hold more moisture and generate more intense storms. In the second approach, a basic assumption is that the data series are stationary which means that their statistical properties do not vary with time. However, as a result of climate and land-use-cover changes, this assumption may be violated for some data series. Studies also show that the prevalence of intense rainfall events is increasing, more so in urban areas.

The scientific community has a divided opinion on stationarity assumption. Nevertheless, research is needed in India to determine if the precipitation and flow data at different places have statistically significant signals of non-stationarity and the causative factors. Research is also needed on how to account for non-stationarity, if present in the data and what should be the revised return periods (or risk levels) for the various types of hydro-projects in different zones in India. In Europe, work has commenced on revision of design and construction standards, known as ‘Eurocodes’ and the International Organization for Standardization (ISO) is developing standards on climate change adaptation.

An extreme event whose occurrence depends on multiple statistically dependent events or variables is known as a compound event. Also called as simultaneous or concurrent extremes, such occurrences may amplify adverse impacts of extreme events on society and environment. Recent times have seen increased occurrences of compound extremes. The physical mechanism behind compound extremes is complex and involves a variety of

climatic and hydrologic processes. Efforts are required to capture requisite data on fine spatial and temporal scales and understand the processes that generate compound extremes. Another challenge would to incorporate dependence structure of such events in modelling. Currently, global climate models work on a resolution that does not allow to represent smaller scale features relevant for extreme events. Possible ways to resolve this issue are downscaling or use of fine resolution regional climate models. Since compound events are likely to become more common in a warming climate, research is needed to provide inputs to incorporate these in design and management and in disaster risk reduction.

One of the objectives of flood control projects is to keep the water, which can cause harm, away from the people. Rivers tend to temporarily occupy flood plains in high flow seasons. A reason behind increasing instances of riverine flooding is occupation of flood plains of rivers. Damages due to riverine floods can be significantly controlled if flood plain zoning is strictly implemented and no residential buildings, shopping places, offices, and the like are constructed in prohibited areas.

Many rivers and their tributaries have vast flood plains whose width varies from a few hundreds of meters to more than a kilometre. With small interventions, many flood plains can temporarily hold sizeable volumes of flood waters. This will serve at least two purposes: (a) the flood peaks in the downstream areas will be reduced; and (b) through river bank filtration, flood plains will recharge groundwater and help in checking falling water tables.

In the Netherlands, the 'Room for the river' project encompassing four major rivers has been implemented. Main objectives of this project were flood protection, master landscaping and overall improvement of environmental conditions. These objectives were achieved by placing and moving dykes, depoldering, creating new flood channels and increasing the depth of existing ones, reducing the height of the groynes, removing obstacles, and the construction of a 'Green River' which would serve as a flood bypass.

Any infrastructure project including urbanization involving large scale construction should be preceeded by hydrological studies to assess changes in flood risk due to the projects. Counter-measures should be taken at the construction stage itself to mitigate any increase in the flood risks. For instance, if a large natural surface is being converted to paved area, it should be ensured that the modified area provides nearly the same amount of infiltration as the natural landscape. This can be achieved by perforated pavements, tiles, etc. Moreover, natural flow paths of water should not be altered too much by way of boundary walls, etc. as it eventually leads to piling up of water and inundation.

Forecasts have an important and useful role in managing disasters. India has been successful in forecasting cyclones which has resulted in almost zero loss of human lives in recent cyclones since based on the forecasts, vulnerable people are moved to safe locations. Similar success stories need to be replicated for inland floods. Of course, forecasting inland floods in India is much more complex due to topographic and climatic factors, but many countries with similar conditions have been quite successful. In India, we need to consolidate the efforts and provide resources to create a nationwide multidisciplinary flood forecasting setup that uses the best algorithms to issue weather and flow forecasts (with uncertainty) in real-time. This setup should be seamlessly linked with agencies such as National Disaster Response Force (NDRF), State Disaster Response Force (SDRF) which follow up the warnings and trigger disaster relief actions. There is already some progress on these lines, but much ground needs to be covered to install and operationalize a robust flood forecasting and warning system.

For storage reservoirs, operation policies for flood management need to be developed, revised and updated. The twin objectives of flood control regulation should be to keep the flood damages at the lowest possible level and yet end the flood season with a full reservoir. Many projects in China and elsewhere have successfully achieved this goal with the help of a good forecast system and careful regulation. A procedure known as dynamic control of flood limiting water levels is followed in China. Similar operation procedures need to be implemented in India with suitable modifications. Efforts are underway in some countries to upgrade the infrastructure, for example, increase the spillway capacities of dams to safely pass floods of higher magnitudes.

The nexus approach for resource management recognizes and accounts for interlinkages and interdependencies among the associated sectors. Traditional fragmented approach where management decisions for each sector are taken in isolation yields sub-optimal solutions. Nexus approach is well-suited to address disaster management issues.

Creating awareness among the public and educating them about the ways to survive in a flood are of critical importance in moderating the impacts of flood disasters. Women, both as instructors and as participants, should be an integral part of any such training. Like for other disasters, mock drills need to be carried out regularly in the flood-prone areas, so that all concerned are well aware of their roles and responsibilities.

Climate change is going to make flood management more challenging. The country needs to get ready to face the challenges by creating and strengthening infrastructure, institutions and capacity building.

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