eruptions are generally not necessarily associated with earthquakes[2–5] and that the Lusi eruption was initiated by drilling that was ongoing at a nearby oil-well site, located 150 m away from the eruption site[2–6]. Nonetheless, it is believed that earthquakes are significantly responsible for causing mud volcano eruptions[7], as also suggested by a recent study published in *Nature Geoscience*[8].

This research has used the numerical wave propagation experiments to demonstrate that the Yogyakarta earthquake produced sufficient seismic energy waves, which could have initiated the Lusi eruption. This possibly occurred because of the high impedance and parabolic-shaped, high-velocity layer in the rock surrounding the site of the Lusi eruption, which potentially could have reflected, amplified and focused incoming seismic energy from the Yogyakarta earthquake. These results have thus suggested that Lusi is a natural disaster classified as a tectonic-scale hydrothermal system[8].

The Lusi mud eruption provides a good opportunity to understand and explore a number of processes linked to the occurrence of mud eruptions, for example, deep-rooted volcanic hydrogeology and degasing, role of seismic energy to trigger an eruption, and reassessment of geothermal disasters[8,9].

Thus, with this research and what is known in the past, two hypotheses are broadly suggested for the Lusi eruption: (a) it was prompted by drilling at a gas exploration well, which was demonstrated by observing fluctuations in pressure[2–4] and (b) the *M* 6.3 Yogyakarta earthquake, which occurred ~250 km away from the eruption site, could have initiated the eruption[8]. This is primarily possible because of the fault slip associated with the earthquake, which could have mobilized the mud[8].

However, a number of questions still remain unclear, for example, why the Lusi mud eruption occurred two days after the earthquake and why waves from previous earthquakes did not trigger a similar mud eruption. Thus, it seems possible that both drilling and the earthquake could have initiated the Lusi eruption[9]. Therefore, in future, Lusi and other similar eruptions around the world will serve as key locations for researchers to study and understand mud eruption processes in more detail.

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Peak water and demand side management

Freshwater resources are fundamental for maintaining human health, agricultural production, economic activity and critical ecosystem functions. As populations and economies grow, new constraints on water resources are appearing, raising questions about limits to water availability.

Peak water is the point at which the renewable supply of freshwater is outstripped by the demand. The term 'peak water' has been introduced by Gleick and Palaniappan[1] as a concept to help understand growing constraints on the availability, quality and use of freshwater resources. They presented a detailed assessment and definition of three concepts of 'peak water': peak renewable water, peak nonrenewable water and peak ecological water. These concepts can help hydrologists, water managers, policy makers and the public to understand and manage different water systems more effectively and sustainably[1].

Management measures on the demand side are those which reduce the demand for groundwater and/or facilitate more efficient use of water. The Planning Commission's Expert Committee group on groundwater observed that more than 55% of all irrigation water needs in India is met from groundwater and more than 80% of all rural water supplies is groundwater-dependent. The current rate of global population growth will put a strain on the Earth's natural resources, with another 2.3 billion people likely to be born in the next 40 years[2]. India is the world's largest user of groundwater with an estimated 20 million wells. With the increase in population dependent on agriculture, the land : man ratio has declined from over 0.4 ha/person in 1900 to less than 0.1 ha/person in 2000 (ref. 3). In Punjab, Haryana, Rajasthan and Gujarat there is rapid decline in water levels[4]. Thus, demand side management of groundwater is the need of the hour.

Presently, water-use efficiency in agriculture is very low. To check the rising demand of irrigation, water-use efficiency has to be enhanced. This can be done by land-levelling, field-bunding, drip irrigation, sprinkler irrigation, mulching, etc. Groundwater regulation and control, water pricing and water audit can also help increase water-use efficiency.

The Punjab State Farmers Commission has proposed a new policy to decrease area under paddy by 40% in the next 5–7 years from the current 2.8 m ha to 1.6 m ha. The alternative crops suggested are basmati variety of rice, maize, cotton, sugarcane, sunflower, pulses, soybean and vegetables. Cultivation of paddy in Punjab increased from 3.9 lakh ha in 1970–71 to 28.2 lakh ha in 2011 due to assured pricing that gave farmers good returns. However, contrary to popular belief, the state's canal system irrigates only 27% of the area and the remaining 73% is fed by groundwater from ever-deepening tubewells. Most of the blocks in Punjab come under over-exploited category. It is not certain how much of it is being recharged. The intensity of irrigation is saturated[5]. In Punjab and other states of India before it reaches its peak water, different demand side management measures need to be undertaken to check further decline in water level.

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Streamflow data-sharing policy for the Ganga Basin

Hilly regions of Uttarakhand, Himachal Pradesh and Uttar Pradesh witnessed a spell of widespread torrential rainfall from 15 to 17 June 2013. India Meteorological Department (IMD) had predicted on 14 June that rainfall in Uttarakhand will exceed 100 mm/day in many mountainous areas during 16 and 17 June. This prediction was not followed up and the floods caused a huge loss of life and property. Apparently, no satisfactory early flood warning system was in place for the affected areas and no studies have been completed to set up a flood forecasting model on the catchments in the Upper Ganga Basin.

The meteorological data network in the mountain areas in India is poor. There are very few stations at altitudes greater than 2000 m. Thus we have almost no information about rainfall, snowfall, temperature, incoming and outgoing radiation, wind velocities, etc. in these regions. This is a handicap while calibrating hydrologic models for the catchments in this region and developing improved understanding of the impacts of climate change on the water resources of Himalayan rivers. To fill the data gaps in these difficult-to-access and remote locations, it is necessary to set up a dense network of automatic instruments which can sense and transmit data to a central location.

Ganga Basin is home to nearly 40% of the Indian population and every year one part or the other is under floods. Yet, a search regarding hydrological studies on the Ganga Basin shows only a negligible number of published works. One main reason for rare publications appears to be due to the fact that stream gauge data in the Ganga Basin are maintained as classified information. In fact, the stream gauge data for many other river basins are also classified.

This secrecy does not promote researchers to obtain and analyse the streamflow data. Also, even if a researcher is able to get the data, the primary data (giving numerical values) cannot be part of the paper submitted for publication in technical journals or conference proceedings. This restriction is a hindrance in the peer-review process and critical assessment of interpretations. Therefore, reputed journals would not like to publish such papers which do not permit critical scrutiny. The end result is that, in spite of the immense importance of the Ganga Basin in India, its huge water and power potential and large technical expertise available in the country, hydrology and water resources development matters have not been studied at the desired level of detail. All this is a big disincentive for taking up any hydrological study of Ganga and other river basins in India. The need for declassifying the stream gauge data in the upper reaches of Ganga Basin (say, upstream of Varanasi) cannot be overemphasized to promote research and better understanding of the hydrology of the river basin and improving our preparedness for facing flood-related disasters.

In the context of the recent Kedarnath disaster, the following observation (quoted by Srinivasan, J., *Curr. Sci.*, 2013, **105**, 7–8) on data situation in India is relevant: 'Prof. Dave Petley (Durham University, United Kingdom) has said "The lack of coherent information from government continues to amaze me, especially when compared with the clarity of data that is produced in similar situations in other poor countries, most notably the Philippines" (http://blogs.agu.org/landslideblog/)'.

The country has the scientific expertise to predict the extreme events, but it is not being put to optimum use. Mathematical models to predict floods and landslides are available. Gaps in the knowledge can be filled by commissioning special studies. It will be immensely beneficial for the country if the scientific expertise and hydrological data that are captured by spending large resources and great efforts are put to their best use.

Disclaimer: Views and opinions expressed here are those of the author's and may not necessarily reflect those of the organization to which he belongs.

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