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Pilgrims, progress, and the political economy of disaster preparedness – the example of the 2013 Uttarakhand flood and Kedarnath disaster

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Prevention and mitigation of environmental disasters are affected by many factors, including perceptions and political risks (Dale *et al.*, 1998; Neumayer *et al.*, 2014). Individual perceptions are mostly influenced by memories. In the case of rare extreme events, they are therefore shaped to a large degree by inexperience. Institutional perceptions are often similarly shaped. For example, the threat of an extreme event may be ignored by those charged with disaster prevention if it cannot be predicted (Neumayer *et al.*, 2014). Even in cases where hazards are expected, they may be considered beyond human influence and precautionary action is not taken (Dale *et al.*, 1998). The political risks for governments in what might be perceived as 'over-investment' in mitigation are large without a perceived constant threat or memory of a recent disaster (Neumayer *et al.*, 2014). Further, uncertainty about what is needed to 'disaster-proof' infrastructure often creates disincentives for investment, and private mitigation investment may be reduced by government interventions and/or expectations of post-event compensation via insurance or government aid (Neumayer *et al.*, 2014).

Public financial constraints and private financial opportunities often lead to 'gambling' about the future (Dale *et al.*, 1998). Even following a disaster, the perception that it will not happen again, or at least it will not happen soon enough to be of great concern, pervades. This multi-faceted political economy of disasters is now taking on more urgency as climate is changing and human vulnerability is increasing. In this commentary we use as an example a recent large-scale disaster in India to highlight a need to couple an understanding of the political economy and perception of disasters with a geoscience understanding of environmental hazards, as well as better prediction and warning capabilities, to improve prevention and mitigation of future events.

In 2013 the annual monsoon arrived early by approximately 15 days, in the form of a low-pressure system that developed over the Bay of Bengal, and converged with a high latitude system (Joseph *et al.*, 2013). The collision of these two air masses over the South Himalayan Front (SHF; where the local relief rises from about 2000m to 6500m; Wasson *et al.*, 2008) generated heavy and widespread rainfall over a 3-day period that also melted snow (Dobhal *et al.*, 2013; Dubey *et al.*, 2013). The India Meteorological Department and Wadia Institute of Himalayan Geology meteorological observatory at Chorabari Glacier camp upslope from Kedarnath (Figure 1) reported rainfall in excess of 300 mm over a 24-h period (Dobhal *et al.*, 2013). The analysis of satellite data by Dubey *et al.* (2013) concludes that nearly 600 mm fell over a 36-h period in the immediate vicinity of the Mandakani catchment. Rainfall station data from the India Meteorological Department shows that heavy rain occurred from 14 to 18 June in Uttarakhand with the heaviest of 370 mm on 17 June.

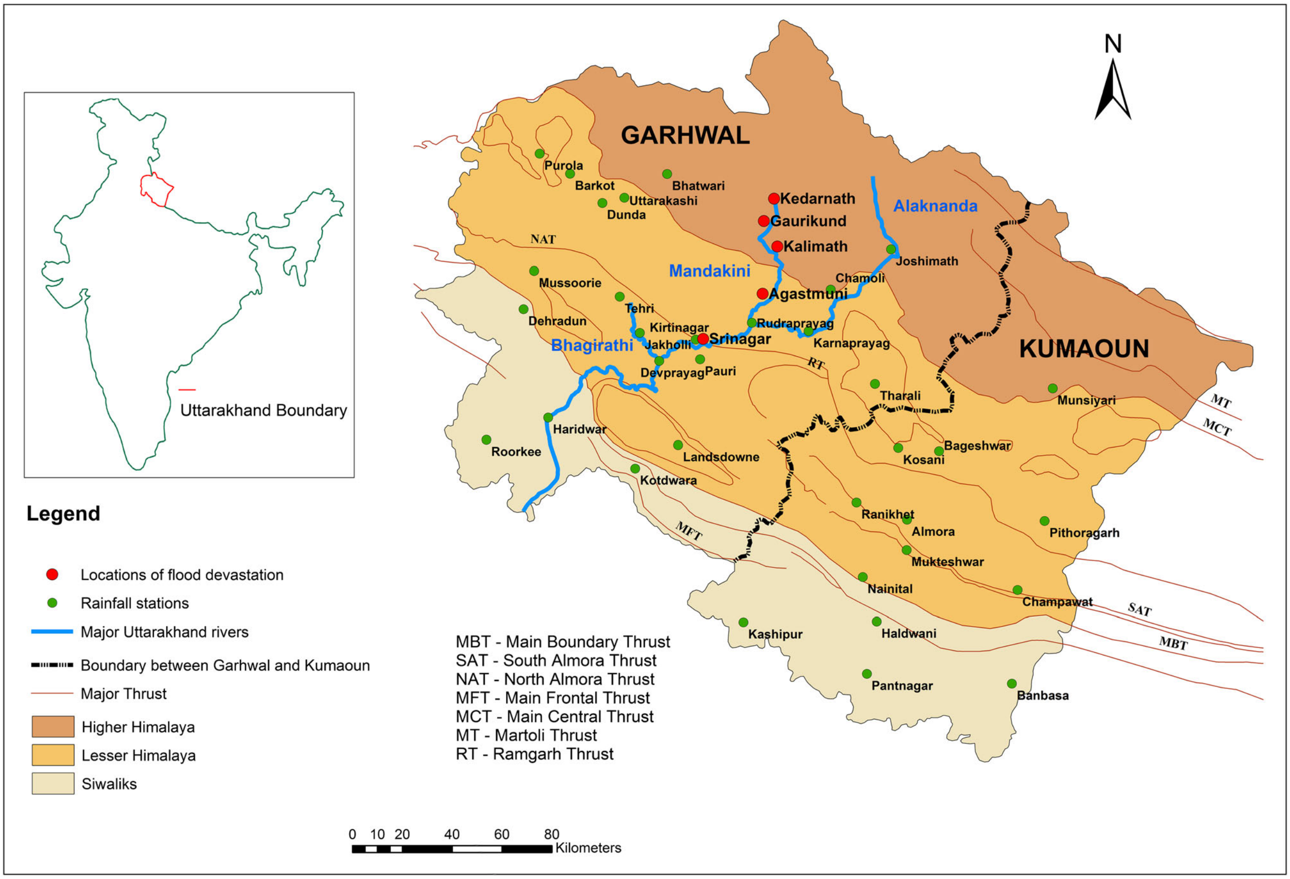

Figure 1. Location of Kedarnath, in the Mandakani catchment, a tributary to the Alaknanda River, in Uttarakhand state, a Himalayan region of northern India. Work in this paper was conducted on the Alaknanda and Mandakani rivers. Also shown is the sparse network of rainfall gauge locations, from which rainfall depths/intensities leading to the 2013 Kedarnath disaster are estimated

The heavy rainfall caused landslides that contributed to deadly debris flows and floods in the Manadakani River catchment. Das (2013) estimated the death toll at 15 000 with a further 11 000 missing, but local people suggest that the number of dead is more likely to exceed 30 000 people (Schneider, 2014). These estimates greatly exceed the official total of fewer than 7000 (NDMMHA, 2013; DMMC, 2013), a number that does not account for hundreds of Nepalese porters who perished while assisting pilgrims on the yearly trek to the holy site at Kedarnath (Figures 1 and 2). Those not killed by the flood waves or landslides perished from exposure or hyperthermia. A joint preliminary assessment of damage costs by The World Bank and the Asian Development Bank is $US700 million (ADB, 2013; WB, 2013). This figure will likely exceed $US3 billion once losses to tourism and rebuilding of transportation networks are included (ADB, 2013).

The principal trigger of the tragedy was very high rainfall in a confined area which produced other hazards including landslides, and generated a very large flood, the return period of which is unknown because of the lack of reliable long-term gauged flow records. However, extreme weather is only part of the story. Coinciding with the rainfall anomaly was the annual pilgrimage to Kedarnath during the peak of the *Chardham Yatra*, a sacred ritual that Hindus ought to undertake during their lifetime (Brockman, 2011). Although the number is uncertain, many tens of thousands of pilgrims were probably on the 17-km trail from the road terminus at Ghorikund at the time. More than 100 000 were evacuated from the entire area affected by the rainfall (Das, 2013).

Destructiveness of the flood was amplified by the occurrence of one or more landslide lake outburst flood (LLOF) and the bursting of a lake on glacial deposits upslope of Kedarnath (pers. obs.). Devastation began when a landslide dammed the Mandakani River below Kedarnath. River water backing up in the temporary lake flooded the temple town. The LLOF created by breaching of the landslide dam sent a large debris flow down the river (Sati and Gahalaut, 2013). Shortly after, floodwaters and sediment from the breached lake on the glacial deposits above Kedarnath collided with debris from other landslides (and fluvial transport processes), creating a second debris flow that slammed

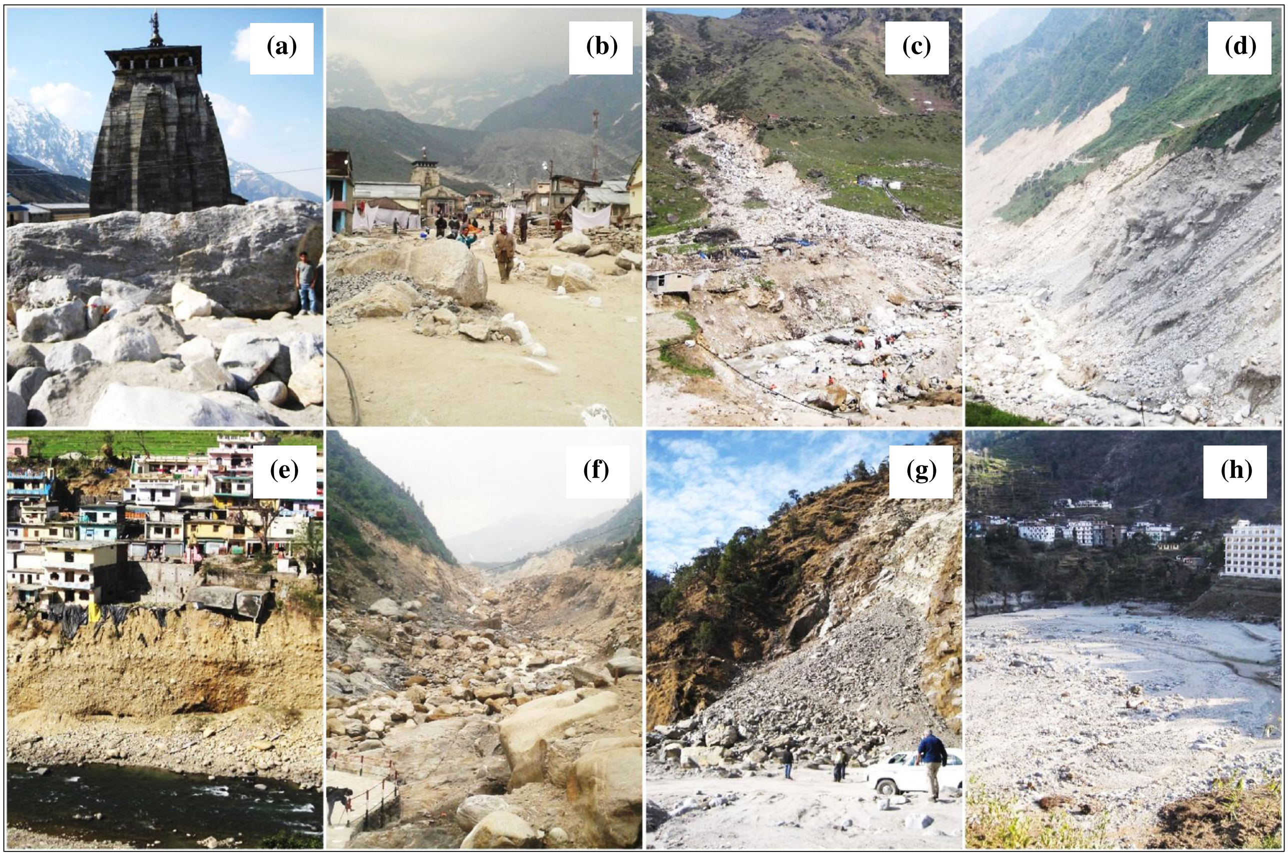

Figure 2. (a) A large boulder was transported, as part of debris flow, halting behind the Kedarnath temple; (b) Kedarnath temple one year after the disaster; (c) a temporary landslide dam few meters south of Kedarnath town was created partly by the debris transported by the Dudh Ganga stream into the Mandakini river (d) continuous large landslides on the slopes along the Mandakini river between Kedarnath and Rambara; (e) toe erosion of the river bank downstream of Kedarnath; (f) boulder deposit from the flood at Rambara, about 7 km downstream of Kedarnath; (g) large rock fall at Gaurikund, 14 km downstream of Kedarnath; (h) valley aggregation at Sitapur (about 20 km downstream of Kedarnath), which raised the riverbed an estimated 50 m

into Kedarnath from the north, devastating the town and killing thousands (Figure 2).

This near-miss appears to have been the closest to destruction that the Kedarnath temple has come since it was built or rebuilt on a former debris flow in the 10th–11th Centuries CE (Bhatt, 1988). At Kali Math, beside a tributary of the Mandakani River, one of the temples constructed in the 10th Century CE (Sankrityanan, 1953) was washed away by erosive floodwater. The damage to this temple provides support for our recent palaeoflood findings that the 2013 event was possibly the largest in a millennium (Wasson *et al*., 2008, 2013).

Although a flood of this scale is rare, we believe a tragedy of this magnitude will happen again in the near future for five reasons. First, large floods in general are relatively frequent in the Upper Ganga catchment, in which the Alaknanda, Bhagarathi, and Mandakani rivers are major tributaries. There have been two significant ‘flash’ floods in the recent history of the Alaknanda River: 26 August 1894 and 20 July 1970, both caused in part by LLOFs in tributary reaches (Wasson *et al*. 2008; Rana *et al*., 2013). Palaeoflood deposits show that there have been 12 major floods on the Alaknanda in the last 800 years—more than one every century (Wasson *et al*., 2008, 2013). Thus, floods are a recurring—but apparently unrecognized by decision makers—environmental hazard in this area.

Second, throughout the area affected by the heavy rainfall, about 2400 landslides occurred on steep slopes above the river channel (National Remote Sensing Centre, 2013), delivering an enormous and [as yet] unquantified load of coarse sediment into the stream, including huge boulders. The high energy of the ‘sediment-laden’ floodwaters had a cascading effect. As riverbanks were eroded and landslides occurred on foot slopes undercut by the floodwaters, even more hillslope material washed into the river, possibly bulking it up and raising the flood height (cf. Doyle *et al*., 2011). In some locations, the deposition of coarse sediment during the flood elevated the riverbed 30 to 50 m (Figure 2). The river channel now has a greatly reduced capacity to transport high flows and, subsequently, is more prone to flooding vulnerable buildings than before the event.

Added to the 'natural' sediments was debris from the construction of hydroelectric project (HEP) dams that was easily eroded by the floodwaters because of its location within channels. Part of the town of Srinagar was buried by three to four meters of sediment—up to 47% came from HEP debris, known locally as muck (Expert Body, 2014). The HEP dams trapped sediment until it was released as dams broke, and also diverted flows onto hillslopes, generating even more sediment input to the rivers. Without the HEP dams the impact of the flood would have been less in this area.

The third factor relates to the risk of seismic-induced landslides in the region. The Gharwal Himalaya falls in the Central Seismic Gap, for which a large earthquake ($M > 8$) has not occurred for centuries (Mugnier *et al.*, 2013). Such an event, which will occur eventually, or even smaller earthquakes, will likely produce landslides and possibly LLOFs, such as those that contributed to the disaster in 2013.

Fourth, the enormity of the 2013 event reflects increasing vulnerability. The number of pilgrims annually visiting Kedarnath was less than 90 000 in 1987, growing to 575 000 in 2012 (Whitmore, 2010; ShriBadrinath ShriKedarnath Temple Committee, 2014). The increase in pilgrims is in part the product of increasing mobility of the growing middle class of India, as well as a lucrative religious tourism trade that has evolved largely without regard for safety (Panjabi, 2009; Singh, 2009). Only a handful of pilgrims undertook the trek to Kedarnath a few decades ago. As the road infrastructure has improved, so have access and interest. The main route leading to the walking trail at Ghorikund is lined with rest houses, many poorly constructed, or situated in locations vulnerable to landslides and floods. Tour packages now provide 'door-to-door' service, making the trip feasible to a sector of society that was previously unable to endure the harsh conditions and long journey. Members of the poorer sections of society are also increasingly making the long journey on foot (Whitmore, 2010).

Fifth and last, part of the reason for events such as the 2013 Kedarnath disaster is the apparent acceptance of the underlying hazards as unlikely events, rather than probable events when viewed over a time scale of centuries. Even in the aftermath of horrifying recent disasters, a short-term perspective often prevails. In other locations, resorts spring up on beaches following tsunamis, houses and factories are reestablished in low-lying areas following floods, and cities are rebuilt following devastating storms (Ziegler *et al.*, 2009, 2012a,2012b). A classic local example is a school building near Agasthmuni, which was flooded in 2013 (Figure 3). Rather than shifting the building to a safer location, it has been renovated and repaired on site: local officials assume that events of the magnitude of the Kedarnath disaster occur only about once in a century.

Granted, some rebuilding in at-risk areas is unavoidable because of socio-economic and cultural factors and the lack of other available land, but in other circumstances it is irresponsible and often driven by a short-term profit motive. In Uttarakhand, the state government is looking again towards tourism as a major driver of the economy (Prashant, 2014). On the road to Kedarnath, guesthouses are being restored in preparation for future pilgrimages. Many will be built in vulnerable locations—many more vulnerable than before because the aggraded river channel now has a reduced capacity to convey large flows.

Many recommended changes that will reduce vulnerability have already been made in the case of Uttarakhand (e.g. Kala, 2014). Among others, responsible planning should recognize the inherent dangers of traveling to regions where hazards easily become disasters. Responsible tourism must be promoted. Tour operators should be trained professionals, and tourist establishments should be built to established codes, noting the difficulty of establishing an appropriate code (Neumayer *et al.*, 2014; Singh, 2004). Access should be restricted at dangerous times of the year, recognizing that this may involve considerable political risk. At the minimum, pilgrims should be briefed on the conditions and required to carry sufficient clothing and appropriate 'equipment' to cope with extreme conditions. Last, while warnings of heavy rainfall were provided by the India Meteorological Department and the forecasts achieved reasonable skill, it appears that the communication of the forecasts and warnings was less than desirable. Better forecasting of extreme weather events will be difficult to achieve in this complex terrain, but communication can be improved. Furthermore, monitoring of dangerous phenomena such as glacial and landslide lakes, along with an effective warning system, is all needed to improve disaster prevention. All of these measures need to be embedded in a functioning disaster risk management scheme, something that was completely missing in Uttarakhand before the event in 2013 (Menon, 2013).

While these post-event recommendations come easily, it is much more difficult to understand why and how the current vulnerability has developed and how change can be effected in the current political economy. Whatever is accomplished in the aftermath of this disaster, a change in perception is needed. We need to recognize that while the disaster was unprecedented, the underlying hazards leading to it are not and will happen again. The current perceptions that such events are unlikely coupled with the continued vulnerability related to tourism is again priming the system for another tragedy. Flood risk management should take precedence over crisis management.

Figure 3. Following the floods of 2013 the school house at Agastmuni was restored in place, on the banks of the Mandakani River. The river now flows only a few metres below the school. Prior to the flood, the school was situated several metres above the river. Thus, the risk of flooding at the school is now much higher than before the flood

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