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Traditional inputs in disaster management: the case of Amparav, North India

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As suggested by field records, elaborate mitigative planning for the protection of an area around Amparav in North India from the threat of landslide have been in place for nearly a century. The landslide management plan incorporates essentials of both structural and non-structural mitigative measures that reflect a thorough understanding by the landslide managers of the mass wastage processes involved. Implementation of this plan safeguarded this highly fragile zone that is neotectonically active and that has historically been threatened by stream erosion. However, critical lack of awareness of the plan among ordinary villagers led to its being rendered inoperable; culminating in the Amparav tragedy of the 23 September 2004 that took three human lives and destroyed huge amounts of public and private property and infrastructure facilities.

Keywords: Landslide; Himalaya; Mitigation strategy; North India; Nainital; Disaster Management

1. The fragile zone

The evolutionary history of the terrain makes the Himalayas vulnerable to a variety of natural disasters. The mountain belt emerged as a result of the north-northeasterly drift of the Indian Plate, its consequent subduction beneath the Eurasian Plate and its subsequent eventual collision with that Plate. As a result the rocks comprising the terrain have experienced severe metamorphism, deformation and large-scale dislocation (thrusting). The region exhibits traces of a large number of major and minor dislocation planes (faults and thrusts) of regional dimensions (Himalayan Frontal Fault [HFF]; Main Boundary Thrust [MBT]; Main Central Thrust [MCT]; South Tibetan Detachment [STD]; Indus-Tsangpo Suture Zone). Evidence of recent movement (neotectonic adjustments) along these planes have been observed [1–4] and continuing strain build up in the region due to the continuing tectonic movements makes the Himalayan terrain prone to earthquakes and in the past the region has been devastated by a number of seismic events.

The state of Uttaranchal is a Himalayan state located between Nepal and Himachal Pradesh, India; with Tibet lying to its north. The seismic risk in the state is considered to be high. Four

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of the 13 districts of the state (Pithoragarh, Chamoli, Bageshwar and Rudraprayag) fall completely in Zone V of the seismic risk map of India (representing damage risk of ≥ IX on MSK scale) while five other distrcits (Uttarkashi, Tehri Garhwal, Pauri, Almora and Champawat) fall partially in Zone V and partially in Zone IV (damage risk of VIII on MSK scale) and the rest (Dehradun, Haridwar, Nainital and Udham Singh Nagar) fall totally in Zone IV. In the recent past the state has experienced two major earthquakes (1991 Uttarkashi and 1999 Chamoli). The non-occurrence of a major earthquake ($M > 8$ on the Richter scale) in the region for more than previous 200 years enhances seismic risk in the region [5].

The natural weakness of the rocks coupled with high relative relief and concentrated atmospheric precipitation make the region prone to mass wastage processes, particularly in the vicinity of major tectonic discontinuities and shear zones. Landslides and flash floods are therefore a common feature in the region, particularly during the monsoon season.

Landslide, though seemingly small and of stray incidence, causes considerable concern in the region as it claims a heavy cumulative toll of human lives and infrastructure especially during the monsoon season (rainy season in the Indian subcontinent spanning mid-June to mid-September) when prolonged rainfall provides favourable conditions for down slope movement. In the past the state of Uttaranchal has been affected by a number of landslides (table 1). A large number of landslides go unnoticed and do not gain media attention as the losses are small, but the cumulative toll of these events is significant and comparable to any major natural disaster. A total of 78 people died in various minor incidences in the 2004 monsoon season in the state of Uttaranchal and in 2005 the death toll has already reached 40 by the end of July. The cumulative losses in the entire Himalayan terrain from such incidences are likely to surpass the toll of other disasters.

Both the villagers and the administration alike have attempted ways of mitigating the losses and this paper is an effort to evoke efforts undertaken almost a century ago in an area around Amparav in the Nainital district of the state of Uttaranchal. Nainital is a young Himalayan township whose first habitations grew up around the lake (*Tal*; lake in local dialect) in 1842 and by 1880 its population was just 10,054 [6]. Currently, the district headquarters and a famous tourist destination of Kumaun Himalaya, and previously the summer capital of the United Province during the British rule, Nainital was devastated by the landslide of Saturday 16 September 1880, which took 151 lives of which 43 were Europeans and Eurasians [6].

The present study concerns Amparav, located to the SSE and in close proximity of the lake city of Nainital. The area falls in the Outer Himalayan Zone and can be approached via the Kathgodam–Nainital National Highway (figure 1). The main boundary thrust (MBT), along which the sedimentary rocks of Siwalik Group are thrust over by the meta-sediments of Lesser Himalaya, lies in close proximity to Amparav. The Balia Nala (stream) flows from the northwest to southeast and carries down the discharge of the Nainital lake. The Nala follows the trace of MBT in the vicinity of the area, which is neotectonically active in the region. The trace of the MBT is dextrally displaced by the Kuriya Fault (by around half a kilometre in the region), named after the Kuriya Gad (also stream). This follows the fault trace. The other streams of the region also show striking structural control. The Kuriya Fault shows associated rotational vertical movement that has caused the block to the west (along Nalena Gadhera [seasonal stream] draining through Amparav) to be doubly uplifted [7]. This upliftment makes this block (the study area on which Amparav is located) particularly prone to mass wastage and head ward erosion.

The sedimentary rocks of Siwalik group are exposed in the area around Amparav and these comprise intercalated sandstone, mudstone and shale. The sandstone is reddish brown to fawn in colour, while the shale is mostly chocolate brown. These rocks are disposed at high

Table 1. List of major landslides in Uttaranchal

Year	Event
1816	Pauri Landslide
1842	Joshimath Landslide
1857	Massive landslide blocked the flow of the Mandakini river
1868	Landslide upstream of Chamoli blocked Alaknanda river: Swept through two villages and killed 70 pilgrims
1880	Landslide in Nainital Town: Massive destruction killing 151
1893	Landslide blocked Birahi Ganga and formed an artificial lake near Gohna village in Garhwal Himalaya
1894	Breach of Gohna lake causing Birahi Disaster in Alaknanda valley
1906	Helang Landslide
1945	Patalganga Landslide
1963	Nainital Landslide
1963	Kaliasaur Landslide
1965	Karnaprayag Landslide
1970	Landslides formed an artificial lake in the upper catchment of Alaknanda river: Affected 101 villages, 25 buses of pilgrims were swept away, 55 people and 142 animals perished
	District headquarter of Chamoli district at Chamoli devastated and subsequently shifted to Gopeshwar
1979	Okhimath Landslide: 39 died
1981	Uttarkashi-Kedarghati Landslide
1986	Landslides at Jakholi in Tehri Garhwal and at Devaldhar in Chamoli: 32 killed
1991	Gopeshwar Landslide: 36 killed
1996	Bhimtala Landslide
1998	Massive landslides in Okhimath area formed an artificial lake blocking the course of Madhyamaheshwar river (tributary of Mandakini): 109 killed, 1908 families from 29 villages affected and 820 houses damaged
1998	Malpa Landslide along river Kali on Indo-Nepal border in Pithoragarh district: Wiped out Malpa village killing around 300 people
2001	Phata and Byung Gad Landslides: Around 21 persons killed and several houses damaged
2001	Gohna Landslide: 7 killed
2002	Landslides at Budhakedar: 28 persons killed together with 99 cattle
2002	Khetgaon Landslide: 5 persons killed together with 26 cattle
2002	Bhatwari – Dunda Landslides: 5 killed together with 26 cattle
2003	Didihat Landslide: 4 killed and 10 animals perished
2003	Gadoli Landslide: 4 killed
2003	Uttarkashi Landslide: Landslide at the urban centre devastated massive infrastructure though there were no casualties
2004	Amparav Landslide: 3 killed
2004	Sundardhunga Landslide: 5 killed in the mountains while trecking
2004	Lambagar Landslide: 7 killed together with another 9 missing
2004	Kalindi Parvat Landslide in Uttarkashi: 6 killed
2005	Ramolsari Landslide: This pre-monsoonal landslide caused massive damage to agricultural fields though there were no human casualties
2005	Govindghat Landslide in Chamoli: 11 killed and caused heavy damage to property
2005	Agastyamuni Landslide in Rudraprayag: Landslide along a seasonal stream caused heavy loss of infrastructure at the township killing 4

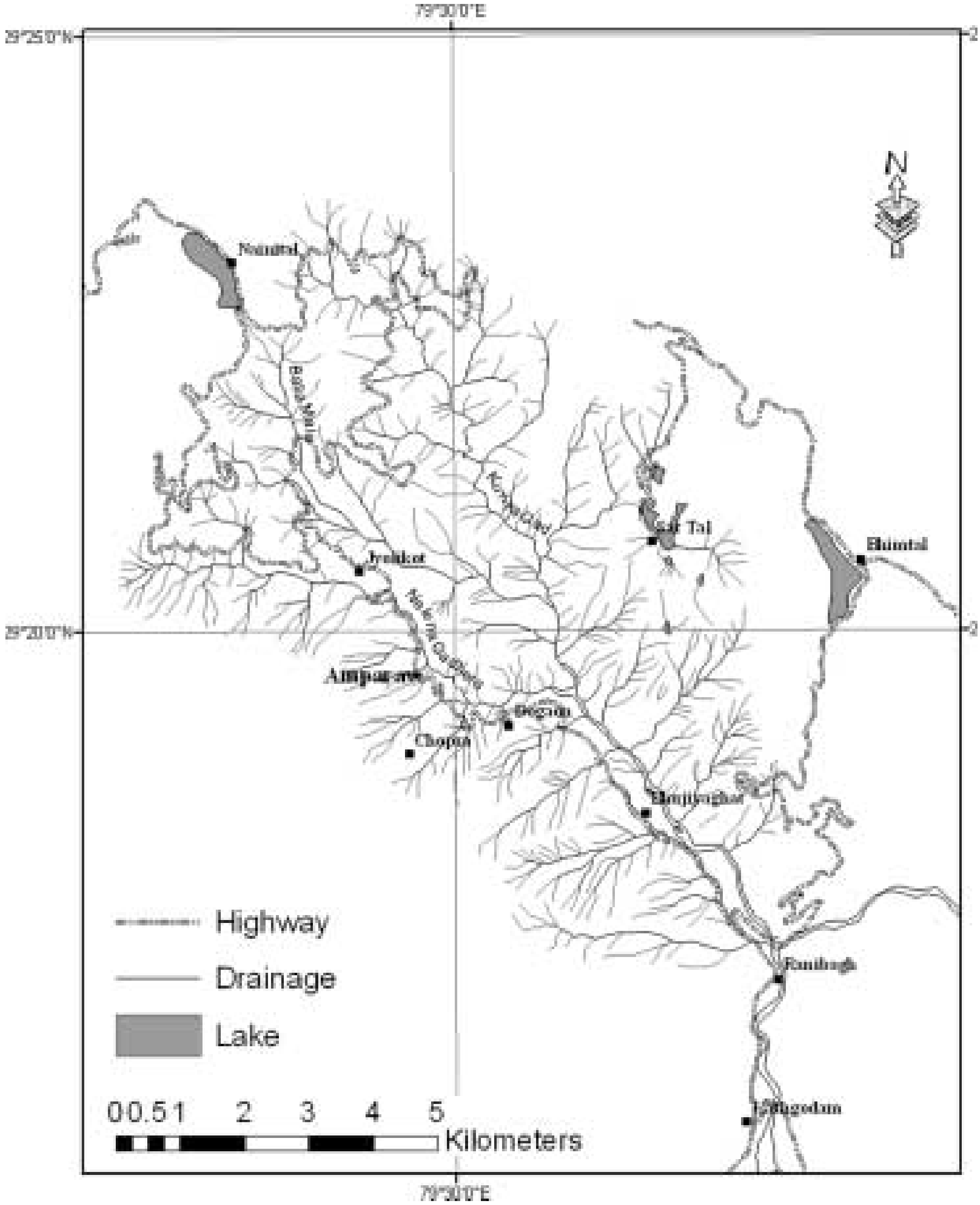

Figure 1. Study area.

angles (45–65°) and generally slope in a north–northeast direction. The sandstone shows evidence of shearing together with two prominent sets of joints. The bedding–slope relationship provides ideal conditions for the down slope movement of clays and mudstone, with the bedding surface of the sandstone acting as the failure surface.

The entire area around Amparav is situated over old landslide material and the old landslide movement has produced a distinct ridge at the toe of the slide that is prominent to the east of Dadar and Matiyali. There exists a pronounced depression to the west of this ridge.

Sheared rock mass in the vicinity of the tectonic discontinuities, the bedding–slope relationship, the presence of old slide material, the presence of vertically uplifted block and low rock mass strength altogether make this area subject to mass wastage. These characteristics would have threatened this habitation some time in the past (about a century ago) and these characteristics that are responsible for triggering the mass movement would have been thoroughly investigated at that time. Although there exists no locally held records pertaining to these studies, these are reflected in the elaborate landslide management plan enacted over a century ago in the region during British rule.

2. Landslide management plan

Landslide is essentially a down-slope movement of dislodged rock mass under the impact of the earth's gravity. Even with all favourable conditions for landsliding being present, a triggering agent is required to set the earth and stones ('the ball') rolling. Water most of the time acts as the triggering agent; and therefore most landslide management plans pay utmost importance to the management of water. It is clear from the elaborate arrangements that the seasonal streams draining through Amparav and the nearby China Gadhera were causing severe head-ward erosion that was destabilizing the surrounding landmass; and these two seasonal streams were notorious for initiating landslides. Elaborate arrangements were consequently planned and implemented all along the course of these seasonal streams. Listed below are the salient features of the landslide management plan around Amparav:

(1) Elaborate arrangements were made to restrict mass wastage along the seasonal streams identified as causing the problem in the area; particularly that draining through Amparav and the adjoining China Gadhera (figure 2).

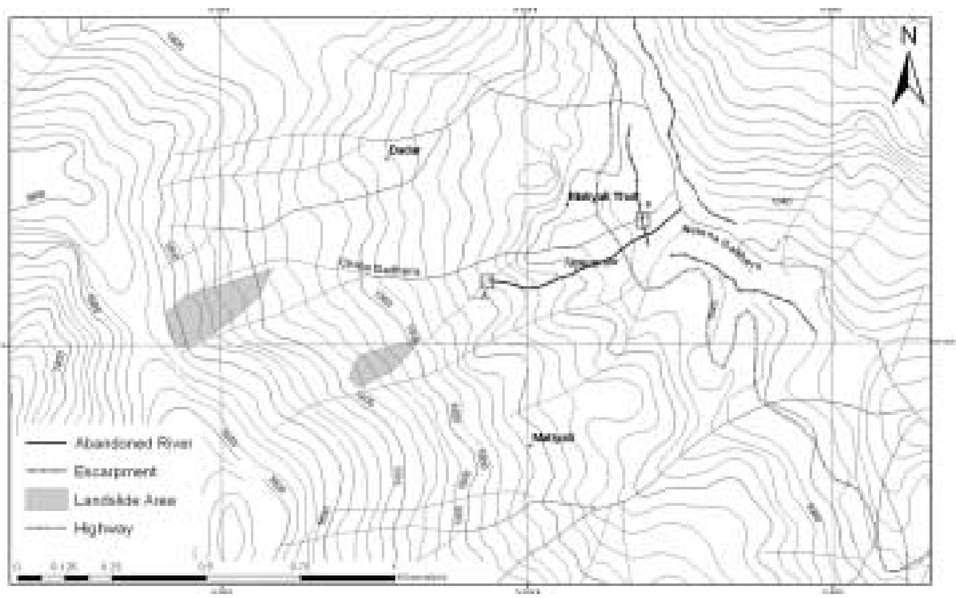

Figure 2. Map of the Amparav area. (A) shows the field location of figures 3 and 5 while (B) shows field location of figure 4. Contours are drawn at 20 m intervals.

Figure 3. Still intact; upstream view of the structure erected for diverting discharge of the seasonal stream flowing through Amparav to China Gadhera (at (A) in Fig. 2). The structure became silted up and the water overran the structure.

(2) The stream draining through Amparav flowed over loose unconsolidated old slide material and would have caused severe mass wastage during the monsoon season. It was therefore diverted to China Gadhera by a massive stone masonry structure (figure 3).
(3) To ensure that the stream bank is not affected by bank erosion in the vicinity of the diversion site, a stone masonry wall was erected along the bank.
(4) Exigencies arising out of exceptionally high precipitation in the catchment seem to be accounted for by the old landslide management plan. The plan ensured that the overflow from the diversion structure along the old course of the diverted stream does not cause problems of mass movement. It was for the safe disposal of the overflow water that provision of cement lined drains (1.5 m wide and 1.5 m deep) was provided at the lower reaches (present road level), together with structures along the abandoned stream course to divert water towards the main catch drain. These drains allowed the excess to discharge safely into the main stream (Nalena Gadhera).
(5) China Gadhera cuts across the sandstone shale sequence and falls into Nalena Gadhera over a cliff. Enhanced discharge along this stream resulting from stream diversion could enhance the rates of head-ward erosion. The old landslide managers seemed to be aware of the probability of enhanced erosion along the course of the China Gadhera and therefore implemented adequate safety measures. The stream course was converted into a number of small rapids by erecting retention walls at regular intervals. The last in the series is more than 150 feet high and forms a spectacular waterfall (figure 4). This

Figure 4. View of the waterfall over the retaining wall erected along the cliff (at (B) in figure 2). This retaining wall is preceded by the concrete lined course of China Gadhera.

massive stone masonry structure that is intact even today rules out the probability of head-ward erosion initiating from this steep drop in gradient. To be doubly sure of success, the entire streambed was lined with concrete. All these structural interventions are still intact and functional.

6. Apart from these structural measures, appropriate land use management practices were enacted in the area for making the landslide management plan successful and avoiding any human miseries due to mishaps in this zone. Even after implementing elaborate stream management plan the area around Amparav, particularly in the vicinity of the abandoned stream course, was not considered safe for human habitation. The village elders were instructed that warning flags were erected in this zone and any habitation and construction was disallowed.
7. As a corollary to the land use management the depression over the ridge at the toe of the old slide was permanently acquired by the administration and the individual landholders were paid compensation. Provision was provided for the draining of water from this depression by providing drains on two sides to rule out stagnation of water to ward off increased threat of landslide due to increased pore water pressure.

The above features show how the British Imperial custodians, in their role as water managers, understood the problem of landslide risk. It must have been very difficult to create the measures of prevention and risk reduction. Nevertheless, they achieved them. The plan is unparalleled. It incorporates the essentials of landslide management. This paper is a tribute to the wonderful work done by the unsung disaster managers of the British Raj. It is hoped that their work will inspire students and researchers.

Disaster in the well managed zone

Disregard for the age old traditional resource management practices and land use dicta is adding to the vulnerability of the masses in the entire Himalayan region [8]. Howsoever elaborate a plan might be, it is bound to fail if the very spirit of it is not respected; and this is what was brought forth by the Amparav tragedy of 23 September, 2004. The disaster plan had been well made and executed and it served its purpose for more than a century; but there was no attempt to create awareness amongst the local inhabitants regarding its utility. With the passage of time the memories of the old disaster and the disaster management plan became blurred and the spirit of the old plan was violated. Post-disaster interrogation of the local inhabitants reveled that an overwhelmingly large proportion of the people had never seriously noted these structures, or had appreciated their utility. The violation of the old landslide management plan is reflected in the following:

(1) Forgetting the old land use restrictions; the local villagers were attracted to inhabit the vulnerable zone along the course of the diverted stream flowing through Amparav because of the commercial opportunities along the road.
(2) Human convenience was preferred to human safety; to ensure smooth pedestrian traffic a concrete bridge with little ground clearance was constructed a little upstream of the stream diversion structure at the head of the diverted stream. Blockade of low set bridges along the course of seasonal streams has often caused major devastation in the region, but this was ignored by the construction of the bridge.
(3) The land falling in the depression at the base of the ridge, earlier vacated to rule out impoundment, was encroached upon and now paddy cultivation requiring water impoundment is practised in this land.

The tragedy that occurred at Amparav on the fateful night (22/3 September, 2004) has to be seen in the light of the above violations. A massive landslide occurred in the upper reaches of the stream amid abnormally high precipitation (211.83 mm: almost one-tenth of the total rainfall in the year 2004 till that date). The failure took place at an altitude of around 4500 feet along the dip slope of the sandstones with the slip surface dipping 45° towards 045°N (in the direction of the surface slope). The slide brought along a large number of dislodged trees in addition to boulders and debris. The concrete bridge upstream of the stream diversion point provided a favourable site for all the material to collect and this material dammed the stream upstream of the axis of the bridge. The bridge could not withstand the increasing hydrostatic pressure and consequently gave way.

It was a mere unfortunate coincidence that the pressure exerted by the debris flow managed to throw the uprooted bridge towards the course of the diverted stream channel that was totally blocked (figure 5). The diversion structure was soon filled with the debris and the gushing water together with boulders and uprooted trees flowed over the structure along the old and abandoned course of the stream.

Seven residential and commercial structures were totally destroyed in the incident. Bad weather conditions fortunately had kept the occupancy rates of these buildings low and the death toll was restricted to three persons. Agricultural land totalling 8.9 ha (14.3% of the total

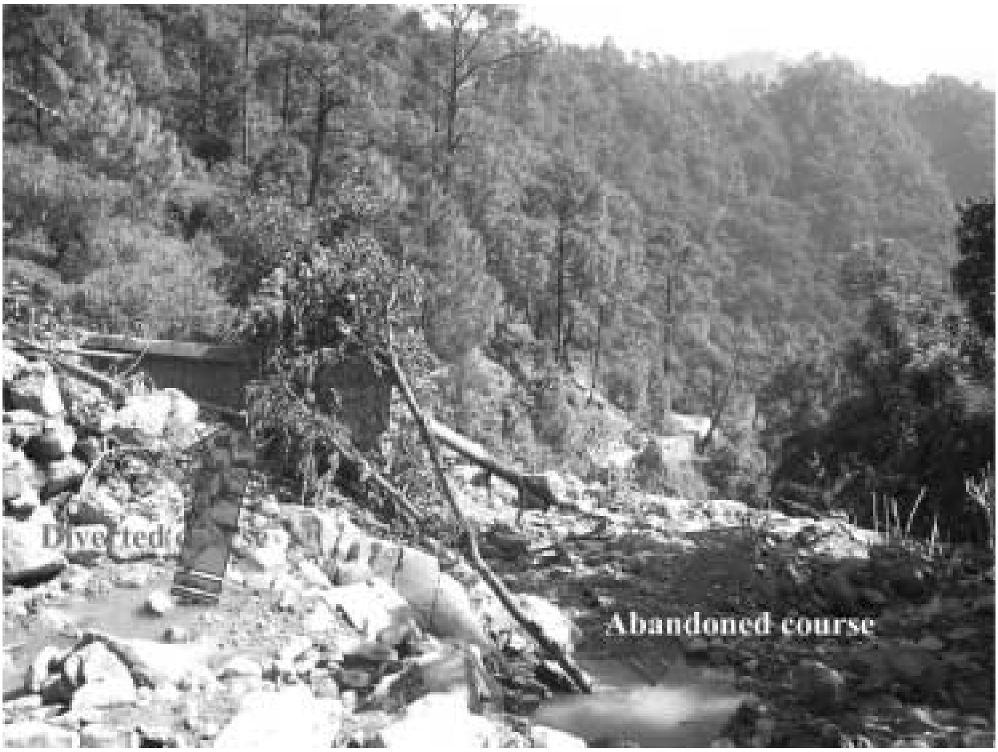

Figure 5. View of the dislodged bridge blocking the course of the diverted stream (at (A) in figure 2).

agricultural land of the village) belonging to 29 different families was lost. Apart from the pedestrian bridge that caused the mishap 300 m of bridle path was also washed off.

After the rains the streams did not discharge significantly the next afternoon and it was hard to believe that so much water could ever accumulate along this small stream.

Conclusion

The foregoing details suggest that the lack of awareness on the part of the local inhabitants regarding their vulnerability to the various hazards to which they are exposed is the prime cause of human and material losses in the incidence. Had the pedestrian bridge been well planned and old land use restrictions remained in place this event would not have resulted in a disaster. The aim of the disaster management community is to minimize human suffering to the extent possible and the following lessons should be learnt from the Amparav tragedy in order to achieve this goal:

(1) Awareness generation and communication of the disaster threat: the Amparav tragedy illustrated the importance of awareness amongst local inhabitants regarding the disaster threat to their community. People need to realize that they are personally in danger. It is human psychology to forget the events of the past. This often is responsible for people engaging in practices that have the potential to trigger fresh disasters. Regular awareness campaigns are necessary.

(2) Planning with a clear view of the potential disasters: Had the site of the pedestrian bridge been carefully selected or its ground clearance been sufficient the Amparav tragedy could have be averted. It must therefore be made the responsibility of the engineering and construction team to ensure that the potential disaster threat in a risk-prone area is evaluated and adequate safety measures are incorporated in the engineering designs.
(3) Political will: It is a common practice for the political leadership to dictate terms to the technical staff responsible for designing and planning the structures. Very often the roads are realigned and structures altered to suit political convenience. It is necessary to make politicians aware of the disaster management essentials, so that they desist from interfering with technical decisions.
(4) Regulations: The administrative authorities are responsible for ensuring that the land use and construction related restrictions advised by the experts and others are adhered to by local inhabitants, through the enforcement of effective regulations. It is the failure on the part of the civil administration that allowed people to settle at a place known to be vulnerable. Even the revenue records show this land – where habitations had cropped up along the course of the abandoned river – as belonging to the State Forest Department.
(5) Documentation: A number of disaster/resource management plans have been implemented in the past in different parts of the region but scientific documentation of these has not been attempted. This results in the loss of a vast knowledge base. There is an urgent and pressing need to undertake detailed documentation of all such measures, to study them, to develop more effective and efficient mitigation practices. This body of knowledge would also be helpful in undertaking restorative measures in disaster affected areas.

These suggestions aim to bring forth appropriate changes in the techno-legal regime as also in the disaster management practices in the region, so as to make this disaster prone terrain a safe place to live.

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