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Lessons learnt from the Deluge of Kedarnath, Uttarakhand, India

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Around 4094 persons went missing in the hydro - metrological disaster that struck Mandakini valley of Higher Himalaya in Rudraprayag district of Uttarakhand, India in June, 2013. The disaster took place in two phases; in the evening hours of 16 June, 2013 breach of landslide dammed lake formed close to Kedarnathon Mandakini river ravaged Rambara and Gaurikund while in the morning hours of 17 June, 2013 breach of the glacial lake, Chorabari Tal, devastated temple township of Kedarnath. Disruption of communication and adverse weather and terrain conditions complicated the situation and people could not be rescued in time. This paper is an attempt to reconstruct the sequence of events as also to highlight the constraints faced on ground. Lessons learnt from this tragedy can help in smooth lining various disaster management related functions for future.

Keywords: Flood, Kedarnath, Uttarakhand, Mandakini, Chorabari Tal, Glacial lake.

1. Introduction

Mandakini valley is located in Higher Himalaya in Rudraprayag district of Uttarakhand and has witnessed as many as four glaciations in the previous 15,000 years and evidences of glaciation in the valley are observed till Rambara[1]. The temple township of Kedarnath is located on glacial outwash deposits at an altitude

Figure 1 View of the temple township of Kedarnath, with camera looking east.

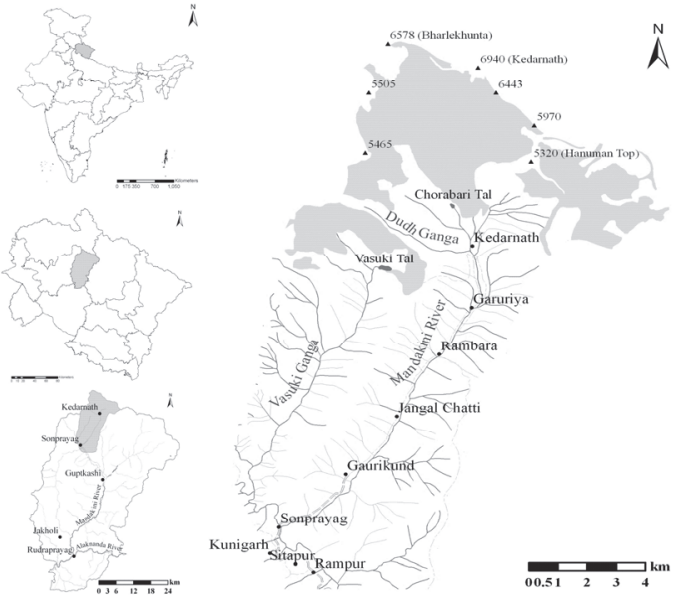

Figure 2 Location map of the area devastated by floods in June, 2013. To the left are maps of India, Uttarakhand and Rudraprayag.

of 3581 meters above sea level (asl). The shrine of Kedarnath is located on raised middle portion of the deposit that is 20 – 25 meters above the level of Mandakini (3562 meters asl). For reaching Kedarnath(Fig. 1) one had to trek upstream along the course of Mandakini from Gaurikund for a distance of 14 kilometers.

Originating from Chorabari glacier Mandakini encircled the glacial deposits around Kedarnath. Construction of embankment to the west of the temple along the left bank of the western channel of Mandakini however diverted most water towards this channel. In the process the eastern channel of Mandakini, also called Saraswati, was abandoned and generally carried little water seeping out of the glacial outwash slope to the north. This gave false sense of security to the inhabitants along the eastern flank of Mandakini who resorted to construction even on hitherto active river channel. Before these two channels meet to the south of Kedarnath the western channel has confluence with Dudh Ganga. Thereafter till Gaurikund, Mandakini maintains a tectonically controlled NNE – SSW course (Fig. 2).

A moraine dammed lake, Chorabari Tal, was present little downstream of the snout of Chorabari glacier. This lake was located in the depression formed in the glacial material to the west of the right lateral moraine and was fed by the seepage of the glacial melt water. The lake did not have a well-defined outlet and its water used to seep out along the moraine slope to the NNW of Kedarnath. Even though the depression was around 200 meters long, 100 meters wide and 15 – 20 meters deep, not more than 2 – 3 meters water used to be there in the lake.

Most evidences on ground having been obliterated by flood it is important to look for circumstantial evidences in the narration of the survivors of the deluge so as to reconstruct the sequence of events. As narrated by the survivors of the disaster; i) there were incessant rains in the area between 14 and 17 June, 2013, ii) rainfall on 16 and 17 June, 2013 was particularly heavy, iii) tragedy struck Kedarnath on the night of 16 June, 2013 and in the morning hours of 17 June, 2013, iv) hitherto abandoned eastern channel of Mandakini at Kedarnath became active in the evening hours of 16 June, 2013, v) flooding in Kedarnath was not that devastating on 16 June, 2013 though it washed off the pedestrian bridges over Mandakini connecting Kedarnath to Rambara and turning Kedarnath into an Island, vi) on 16 June, 2013 flood waters washed off Sanatan Dharm Sabha guest house, Shankaracharya Samadhi and a few other structures in the vicinity of the temple together with a few persons, vii) floodwaters of Mandakini did not affect the Kedarnath temple premises on 16 June, 2013, viii) after the flood event, despite heavy rains, most persons in Kedarnath assembled in the temple premises and engaged in prayers, ix) large number of persons however returned to their respective places around 0200 hrs on 17 June, 2013, x) major devastation took place in Kedarnath in the morning hours of 17 June, 2013, xi) Chorabari Tal was intact on 16 June, 2013, xii) Rambara and Gaurikund were devastated in the night of 16 June, 2013, xiii) breach of Chorabari Tal took place around 0700 hrs on 17 June, 2013 and xiv) floodwaters of Mandakini ravaged Rambara, Gaurikund and Sonprayag again in the morning hours of 17 June, 2013.

2. Sequence of Events in the Mandakini Valley

There is no denying the fact that there were heavy rains in the area that led to increased discharge of the streams and rivers. The same is asserted by rainfall and water level data (Table 1).

Devastation in the Mandakini valley took place in two flood events on 16 and 17 June, 2013 and the latter was associated with the breach of Chorabari Tal that had accumulated enough water to force the moraine barrier to give way. The

Table 1 Details of the rainfall at Rudraprayag and Gaurikund and the water level data of Mandakini at Rudraprayag (Source: India Metereological Department, L & T Ltd. and Central Water Commission).

Date	Rainfall (in mm)		Level of Mandakini at Rudraprayag at 08:00 hrs (in meters asl with 626.00 meters asl being the danger level)
	at Rudraprayag	at Gaurikund	
15 June 2013	41.4	250.0	618.12
16 June 2013	105.2	+250	625.00
17 June 2013	100.2	180.0	633.50
18 June 2013	62.1	0.0	626.65
19 June 2013	7.0	0.0	623.00
20 June 2013	0.0	0.0	622.48

former event that washed off Rambara in the late evening of 16 June, 2013 could only happen by the blockade of the course of Mandakini in close proximity of Kedarnath so as to i) flood Kedarnath, ii) force water into the abandoned eastern channel of Mandakini and iii) ensure that enough water is impounded to devastate Rambara and Gaurikund with sudden removal of the barrier.

Hydro - geomorphic setup of the area indicates that Dudh Ganga is the only major stream joining Mandakini between Kedarnath and Rambara that has the potential of bringing down enough debris so as to ensure impoundment of Mandakiniriver. Moreover the confluence of Mandakini and Dudh Ganga is located at a place blockade over which could flood Kedarnath. Blockade at a downstream place would not affect Kedarnath because of high gradient of the river in the area.

It was this blockade of Mandakini on 16 June 2013 that led to impoundment of the channel to the west of Kedarnath. The embankment on the left bank of the channel soon gave way and the abandoned channel of Mandakini to the east of Kedarnath became active. It was this event that resulted in washing off of some people in the late evening of 16 June 2013 from Kedarnath, that thus became water locked. Rising level of the landslide dammed lake forced the barrier to give way and the ensuing floods devastated Rambara and Gaurikund as also pedestrian bridge over Mandakini near Kedarnath. All connectivity with the area was thus snapped.

Continuous rains caused the level of water in Chorabari Tal to rise. With the recession of the glacier the lake had a weak moraine barrier that could not withstand continuously rising hydrostatic pressure. Stage was thus set for a major disaster in Kedarnath and the barrier gave way around 0700 hrs on 17 June 2013. The volume of water was enormous and it carried with it huge glacial boulders and outwash material that choked the western channel of Mandakini and the flow of

Figure 3 View of the Kedarnath township ravaged by the flood of June, 2013 with camera looking south.

water and debris got diverted towards Kedarnath township that was thus ravaged (Fig. 3). There was absolutely no warning and most people were taken by surprise and had to time to respond. Besides Kedarnath this event caused devastation in Rambara, Gaurikund, Sonprayag and other places.

3. Aftermath of the Deluge

The sequence of events in the Mandakini valley took everyone by surprise and none really got chance of raising alarm of any sort. Attempts were however made to communicate the news of flooding over high frequency police radio set but the seriousness of the incidence could not be assessed from hurriedly communicated incomplete message. All communication with Kedarnath valley was snapped in the late evening of 16 June 2013. Adverse weather and terrain conditions did not provide opportunity of resorting to alternative probes. The outside world as also the local administration therefore remained unaware of the events in Mandakini valley till the afternoon of 17 June, 2013.

Aerial rescue operations could therefore be initiated in the morning of 18 June 2013. Ground search and rescue operations were hampered by washing off of the pedestrian track at many places between Gaurikund and Rambaraand could start on 19 June, 2013. Terrain conditions made it difficult even to airdrop food and water at many locations where people were stranded in large numbers. Challenges faced even in aerial rescue operation can well be understood from the fact that three choppers got crashed during rescue operations in Mandakini valley.

Massive ground and aerial search and rescue operations were however organized jointly by National Disaster Response Force (NDRF), Indo – Tibetan Border Police (ITBP), Indian Air Force (IAF), Indian Army and Civil Administration to evacuate the survivors. Temporary helipads were quickly prepared and activated for evacuating persons stranded between Gaurikund and Rambara. In all around 6,817 persons were evacuated by air and another 18,183 by foot track. Despite best efforts evacuation could only be completed on 23 June, 2013.

4. Lessons Learnt

Lessons learnt while responding to this disaster can help in strengthening the disaster management system that is critical to better management of disasters in future. The same are discussed in the sections below.

4.1. *Information management*

Communications having been disrupted soon after the disaster, there was no information coming to Emergency Operations Centre (EOC) from the disaster

affectedarea. Besides delaying the response this at the same time added to the confusion as different versions were being aired due to the lack of authentic information. EOC at the same time was receiving large number of requests for updated information from officials, media and the next of kin of the persons who had come over to Uttarakhand. To cope up with the increasing load of quarries a number of new telephone connections were hurriedly activated at the EOC. Many telephone numbers were thus circulated through various modes and the same amounted to confusion. Prior arrangement for media briefing and providing information to the next of kin of the persons visiting Uttarakhand were also not in place. This resulted in overcrowding at the EOC that often disrupted routine functioning.

Steady inflow of updated, authentic and reliable information is vital to effective management of any disaster. There thus has to be a mechanism for ensuring inflow of updated information from the disaster affected area. The information received at the EOC from different sources is often voluminous and therefore there has to be adequate information handling capabilities so that the information is quickly analysed and used for decision making for response and resource mobilization.

The communication system should be robust and reliable with at least triple redundancy so as to ensure availability of alternative communication under all circumstances. EOC should at the same time have a single telephone number-with multiple lines andwith capability of being upscaled during major disaster incidences. Dedicated four - digit toll free number of the EOC (1070) can be used for this purpose. The same can be publicized through various modes. Use of one number would be convenient for all concerned.

After any disaster media persons are under immense pressure to report the latest updates and lack of information from authentic source often results in rumors that add to confusion and trauma of the affected population. This at the same time demoralizes the ones engaged in post – disaster operations. Special care therefore needs to be taken for briefing of media at regular intervals by duly authorized person having access to authenticand up to date information and the persons involved in operations should not be overburdened with the responsibility of interacting with media. Media should at the same time be discouraged from venturing into the EOC.

On the aftermath of any disaster next of kin of the affected persons are eager to know about the welfare of their loved ones. Separate arrangements have therefore to be made for responding to such quarries. Special care needs to be taken in cases where there is possibility of linguistic differences between the ones responsible for responding to public quarries and the potential callers.

4.2. *Warning*

Despite claims of advance warning regarding the incidence having been communicated to the government that was communicated was nothing better than a general

forecast predicting heavy rainfall all through the state. Efforts for evacuation of the persons likely to be affected could therefore not be initiated in advance.

Reliable warning, with sufficient lead-time, that is precise in space and time and its effective communication, in a decipherable manner, to the population likely to be affected by the event is the key to saving human lives and mitigating losses. With the present state of scientific knowledge and technological advancement it is possible to generate and disseminate warnings of meteorological events well in advance. Sufficiently dense network of meteorological observatories with real time data transmission facilities is however a perquisite for this, particularly in the Himalayan terrain where weather parameters are highly variable over short distances.

Network of meteorological observatories with real time data transmission capabilities integrated with rainfall - based landslide and flood prediction module can be utilized for generating reliable warnings well in advance. A system capable of immediately communicating these warnings to the grassroots level, in a manner that suggests actions to be initiated by people at large, has to be an integral part of the warning infrastructure. As the region is visited by tourists and pilgrims in large numbers, mobile messaging service with provision of automatic delivery of the warning to all active mobile phones in the area likely to be affected by the said warning could be considered for this. Warning can at the same time be displayed at places where people gather in large numbers and the same can also be aired through FM and other radio networks as also telecasted through television channels. Provisions of the Disaster Management Act, 2005 can be utilized to ensure that these messages are given high priority by all media houses.

4.3. *Relief and rescue*

Though highly specialized and well equipped, the response forces called in for search and rescue on the aftermath of any disaster are often not conversant with the local terrain and weather conditions. They at the same time do not have practical knowledge of the alternative routes, locally available resource and challenges and hardships that are likely to be faced while undertaking rescue. This is often critical, particularly in the mountainous terrain, and thus the responders brought in from outside are often not that effective.

The local people therefore enjoy distinct strategic advantage and in almost all disaster events local people and other survivors are the first responders. It is therefore recommended that local masses be trained in search and rescue and be adequately equipped so that they are better prepared to face the disaster and help their community. The specialized response forces being raised by the states should at the same time have sufficient number of persons having knowledge of local ground realities. This would ensure their effectiveness in the event of any disaster.

4.4. *Governance*

Disaster management being a multi – departmental affair, coordination and unity of command are critical to the success of post – disaster response. SOPs and protocols pertaining to the same have to be therefore to be laid down, circulated and rehearsed well in advance to rule out possibility of lapses after disaster has struck. In accordance with the laid down SOPs senior person commanding authority should take charge of the affairs soon after the disaster darning or impact.

Assessing the number of persons involved in the disaster was a major challenge and there were varying claims from various quarters that added to the confusion. It is therefore required that the pilgrimage, in areas where people have to trek, be regulated and only specified number of persons be allowed beyond a certain point after duly registering their details.

Health check up should be made mandatory for all persons wishing to venture beyond a given altitude. They should at the same time also be briefed on the terrain conditions, weather and associated hazards.

Blockade of motor roads due to landslide and flash flood is common in the hills. It is therefore required that alternative motor roads be planned and developed so as to ensure connectivity during disaster incidences. In view of the terrain conditions helipads are required to be developed in the hills at strategic locations. This would make disaster response prompt and effective.

On the aftermath of the disaster, communication with large number of rescued persons became a problem due to linguistic constrains. It is recommended that the relief camps be adequately be staffed with persons who are conversant with language of the potential victims.

Apart from foreign national the disaster involved people from more than 23 states of India and officials from these states were deputed to take care of the specific requirements of persons from their state. There were however no previous arrangements for the briefing of these officials that required information on geography, terrain, weather conditions, approach and efforts being made for search and rescue. This added to the work of the EOC. Specific arrangements catering to the needs of the officials coming in from different states / nations depending on the potential composition of the routine visitors has this to be incorporated in the concerning SOP.

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