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Investigation of Hydro-metrological Disaster Affected Malpa and Mangti Area, Pithoragarh District, Uttarakhand, India

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Abstract

In the previous some years, the risk of water induced disasters has increased in the hilly terrain like Uttarakhand as a result of deforestation, increasing anthropogenic activities as well as climate change. In Uttarakhand Himalaya cloudburst and extreme precipitation events have been brought down huge amount of debris with large volume of water in the form of debris flow and flash flood. Almost every year several parts of Uttarakhand Himalaya experience hydro-metrological disaster as cloudburst, flash floods and debris flow. Presence of fractured, jointed and sheared rock mass due to vicinity of Main Central Thrust (MCT) zone and highly weathered state of rock played significant role for the slope instability in the area. This year (2017) in Uttarakhand, Malpa and Mangti area, Pithoragarh district and Kotdwar (Pauri district) have been severely damaged by cloudburst and subsequent landslides and flash floods. In August 2017, Kailash-Mansarover Pilgrimage road and pedestrian route were damaged and blocked at several locations and Yatra was suspended till further notice.

Simkhola and Malpa Gad are tributaries of Kali river and meet at right bank of the river, due to heavy localized precipitation or cloudburst Kali river was reportedly flowing at a dangerously high level. Cloudburst is a distinctive phenomenon especially with respect to fragile and unstable Himalayan terrain, although climatic factor as incessant and torrential rainfall is the major triggering factor responsible for this phenomenon but there have always been several other factors which are also responsible for the large scale damage and destruction in a particular location such as geological/structural, geo-morphological as well as anthropogenic factors also enhance scale of damage and destruction. In the present communication an attempt is made to assess the impact of hydro-metrological disaster and identify the causes behind damage and destruction.

Keywords: Hydro-metrological disaster; Malpa; Mangti; Pithoragarh district; Uttarakhand

Introduction

In the recent times incidences of hydro-metrological disaster as glacier lake outburst floods (GLOFs), cloudburst, flash floods, landslides and debris flow are increased many fold and create an alarming situation in front of the public, tourist, pilgrims and government of Uttarakhand. Asi Ganga cloudburst in August, 2012; Ukhimath cloudburst in September, 2012; Kedarnath cloudburst in June 2013 and Bastari cloudburst in July 2016 are some of the examples of recent hydro-metrological disaster in Uttarakhand Himalaya [1-5].

Malpa and Mangti area of Pithoragarh district, Uttarakhand was severely damaged and devastated by debris flow and flash flood incidences due to extreme precipitation event in August 2017. These inflicted heavy loss of human lives, property and infrastructure. As many as 09 human lives were lost and 18 persons went missing in these incidences on early hours (around 0230 hrs) of 14th August 2017 (Table 1).

During field investigation, it has been observed that mostly rivulets have been observed to be overwhelmed by debris flow during these incidences. Due to this main rivers suffer flash flood like situation and slope instability as well as bank erosion have also been common in the catchment area. There is however no denial from any quarter that heavy localised precipitation is a natural phenomenon in the Himalaya and its frequency is observed to have increased in the previous some years. The same is often attributed to climate change. Change in rainfall pattern has been observed in the previous some years. Precipitation related IMD data however depicts no change in average rainfall in Uttarakhand but change in rainfall intensity and duration cannot be ruled out.

Head	Mangti	Malpa	Total
Persons dead	01	08	09
Persons missing	08	10	18
Persons injured	04	01	05
Animals lost	51	00	51
Vehicle lost	02	00	02
Army tent damaged	03	00	03
shops damaged	00	04	04

Table 1: Losses incurred in the Mangti and Malpa area due to the disaster of August 2017 (Data source: State Emergency Operations Centre, Uttarakhand).

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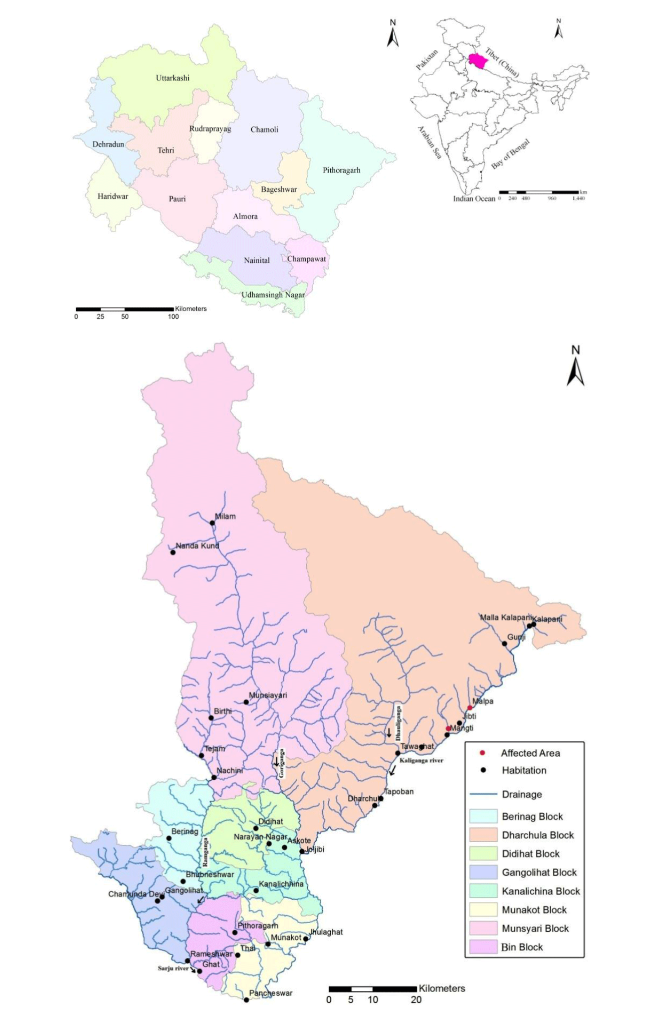

Figure 1: Location map of the study area.

Since the area is tectonically active, heavy localized precipitation and anthropogenic activities play a major role in triggering landslides and flash floods in the area. Previously, Malpa landslide (1998) occurred due to incessant rain brought down quartzite and gneiss of the Pandukeshwar Formation along the fault zone, damming the southeast flowing stream [6].

Materials and methods

Pithoragarh district is the easternmost frontier district of the Uttarakhand and falls in Kumaon division of the state. The geographical area of the district is 7,110 sq. km. At the 2011 census, the total population of the district is 4,85,993. Pithoragarh town is located in Saru valley, is its headquarters. Devastated Malpa and Mangti areas are located right side of Kali river and are worst affected areas during August 2017 flash floods induced disaster. Pithoragarh district has good road connectivity and can be approached from Dehradun, the capital of Uttarakhand, via Haridwar-Kashipur-Haldwani-Almora (NH 72, NH 74 and NH 87). The nearest railhead is at Tanakpur approximately 120 km away from district headquarter. The areas devastated by disasters are located in Dharcula tehsils of Pithoragarh district and fall in the catchment of Kali river (Figure 1). A geological field investigation was carried out after the incidence of flash floods in the study area.

During field investigation, useful information about the debris flow zones along with cloudburst incidences collected from locals. After the field investigation, field information and locations of studied points have been confirmed and analyzed in the laboratory with the help of Geographical Information System (GIS) software. The base maps of the study area were prepared using the Survey of India (SOI) Toposheet No. 62 B/12, B/16 and C/9 on a scale of 1: 50,000.

Regional tectonics

Geologically the disaster affected area of Malpa and Mangti fall in Central Crystalline domain of Higher Himalaya and falls in the close vicinity of MCT zone (Figure 2) [7]. The exposed rocks in the Kali valley mainly belong to Tethyan sediments, Central Crystalline and Garhwal Group. Higher Himalayan terrain is delimited by the Main Central Thrust (MCT) which separates it from Lesser Himalaya, Vaikrita Thrust and Trans-Himadri Fault (THF) are other major discontinuities present in the area and all are trending NW-SE. Tethyan sediments of Tethys Himalaya and Central Crystalline rocks of Higher Himalaya are separated by Trans-Himadri Fault (THF).

The rock exposure on the right bank of Simkhola Gad near Mangti bridge is observed to comprise of gneiss intercalated with thin bands of biotite schist belonging to the Central Crystallines. The foliation planes were observed to dip towards NE at an angles 65°. The joints were observed to dip at steep angles towards NE and SSW (75°/50° and 60°/190°).

The rock exposures in Malpa area were observed to comprise of massive quartzite intercalated with thin bands of garnet-bearing sericite schist belonging to the Central Crystalline. General trend of the rocks was observed to be NW-SE with steep dips towards NE. The rocks in the area were observed to be traversed by numerous joints that constitute important structural discontinuities affecting the strength of rock mass and stability of slopes. The foliation planes were observed to dip towards NE at an angle 55°. Other two prominent structural weaknesses (joints) were observed to dip towards WNW at very steep angles (80°/310°) and towards SSE at steep angles (55°/170°).

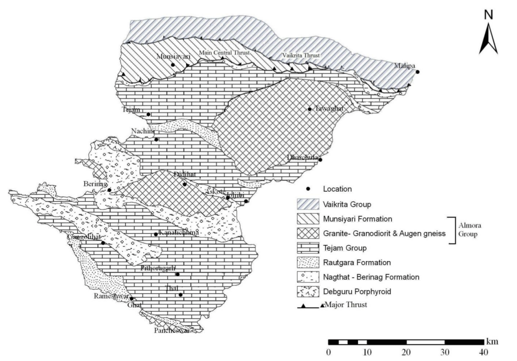

Figure 2: Generalized geological map of the area (After Valdiya, 1980).

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Physiography and climate

The study area is represented by dissected hills, valleys and a typically rugged topography with high relief. The prominent river flowing in the area is Kali river. All the major rivers viz., Sarju, Goriganga and Dhauliganga ultimately meet the Kali river at different places (Figure 1). Kali river also forms the international boundary between India and Nepal. The main land use practice in the study area is terrace farming. Landforms of fluvial, glacio-fluvial and colluvial origin are generally observed in the area. The area is drained by sub-catchment of Simkhola and Malpa Gad these are tributaries of Kali river. Simkhola Gad from the origin flows N-S direction, suddenly takes E-W trend at Mangti bridge and thereafter it follows previous trend. While, Malpa Gad almost follows N-S trend and both the tributaries finally meet with Kali river. The rivulets in the area are generally observed to flow with great force through steep and narrow channels; often resulting in excessive bank erosion and collapse of the banks.

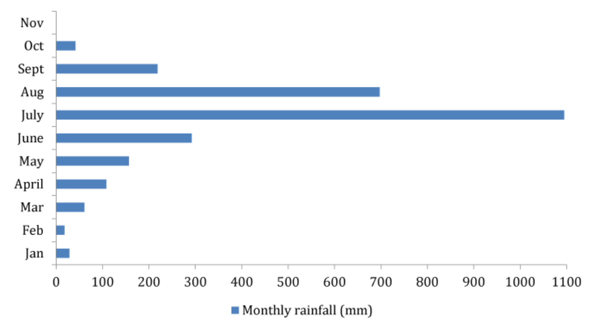

Figure 3: Monthly rainfall data (mm), 2017 of Dharchula Tahsil, Pithoragarh district (Source: DEOC, Pithoragarh).

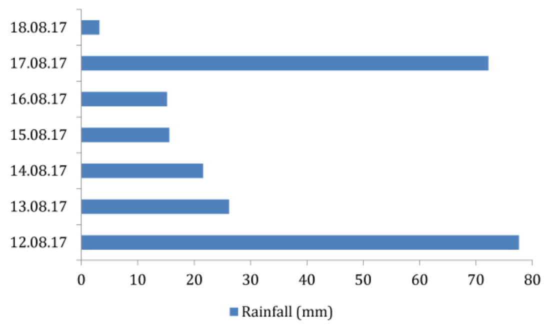

Figure 4: Weekly rainfall data (mm) of Dharchuala Tahsil, August 2017.

The climate of the area is moderate and tropical characterised by hot and dry summer from March to middle of June. Due to southwest monsoon precipitation mainly arises during June to September. A cool winter spanning between December to February, its severity increases in the higher reaches and high peaks of the area are covered by snow in the winter season. The scattered rains and snowfall arise during winter months. The heavy seasonal downpour on the deformed rocks and Quaternary deposits creates a variety of slope failures.

Figure 3 depicts monthly rainfall (mm) in Dharchula Tahsil, Pithoragarh district for the year 2017. Exceptionally high rainfall in July (1094.60 mm) followed by August (697.00 mm) can be observed. However, there was less rainfall (21.60 mm) in Dharchula on 14th August on the same day when devastation took place in Mangti and Malpa area (Figure 4). The distance of Malpa from Dharchula town is about 43 km and variation in rainfall cannot be ruled out in such a distance. However, there was exceptionally high rainfall in July (1094.60 mm), which can be observed in the Figure 3. Devastation might be occurred due to heavy localized precipitation or landslide damming in the upper catchment cannot be ruled out due to heavy discharge in the rivulets during July and August months. Thus, it is the subject of detailed geological and geotechnical investigation in the area.

Whereas, Figure 5 illustrates average monthly rainfall (mm) in Pithoragarh district for last six years. Exceptionally high rainfall in July 2017 followed by July 2016 and continuously increasing trend in rainfall especially in July month can be observed. Last year in 2016, Bastari, Naulra and Didihat areas of Pithoragarh had been devastated due to intensive rainfall event. In the year 2013, unprecedented and unusual rainfall was also experienced not only by the region but also all over the state [8].

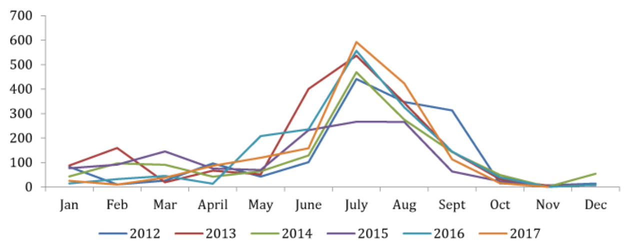

Figure 5: Average monthly rainfall data for last six years of Pithoragarh district (Source: IMD and DEOC, Pithoragarh).

Pithoragarh a disaster prone district

Pithoragarh district of Uttarakhand falls in Lesser and Higher Himalaya, and like any other hilly terrain of the state it is also vulnerable to natural disaster. It has also witnessed series of nature's fury in the past in the form of earthquakes, landslides, cloud burst and flash floods. The 1958 event of M 7.5 and the 1968 earthquake of magnitude 7.0 shook the Bajang-Dharchula belt and rendered its mountain slopes extremely vulnerable6. A major incidence of landslide blocking the river Dhauliganga was occurred in 1956. On 13th to 19th July 1971, cloud burst killed 12 people and buried 35 houses in Dobata village of Pithoragarh district. On 26th July 1996, an incident of cloud burst at Raintoli village in Pithoragarh killed 16 villagers. The most disastrous landslide took place due to unprecedented heavy rains, killing 221 people on 18th August 1998 at Malpa. Dharchula earthquake (M 6.1) of 29th July 1980 and Indo-Nepal earthquake (M 5.5) of 5th January 1997 jolted the region severely and induced several landslides in the area. On 27th July 2001, flash-flood induced by a cloud burst killed 5 people in Khetgaon near Dharchula, Pithoragarh [9]. In Sept. 2007 five persons were killed and nine others were feared

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dead in landslides following heavy rains at Baram village in Pithoragarh district of Uttarakhand [10]. On 8th August, 2009 Lah-Jhekla landslide occurred due to cloudburst, the landslide wiped out two villages namely Jhakhla and Lah, claiming 43 lives [11].

Recent disaster of June 2013 occurred in the region and catchment areas of major rivers like Ramganga, Goriganga, Dhauliganga and Kali rivers due to torrential rainfall and caused several landslides. This havoc led to the flash flood with huge sediment load causing unusual swelling of the rivers. The most affected villages in Pithoragarh district are around Munsyari and Dharchula, roads were severely damaged [12]. Slope failure incidences took place at many places in the Pithoragarh district on 1st July 2016 amid heavy rainfall. Bastari, Naulra (Kumalgaon) and Didihat were amongst the worst affected regions. Total 160 families of 15 villages with Didihat town are affected in Thal, Munsiyari and Didihat tehsils of Pithoragarh district, 24 persons were killed in this incidence [4].

Figure 6: Inundation along Simkhola Gad after 14th August 2017.

Figure 7: Narrow course of Simkhola Gad near Mangti bridge.

Figure 8: View of Kailash Mansarover Pilgrimage road left bank of Simkhola Gad.

Figure 9: View of damaged right abutment of iron and RCC bridges of Kailash Mansarover Pilgrimage road.

Event-I

In August 2017, first event occurred in the Mangti area, located along the Simkhola Gad. Simkhola Gad with catchment area of 44.97 sq km is the IVth order drainage and meets Kali river at right bank. Mangti village is located at right bank of Kali river near junction of Simkhola Gad and Kali river, about 07.00 km downstream to Malpa. The area is observed to be located on glacio-fluvial material and occupied by outcrops as well as overburden (Figures 6-9). The affected area near Mangti is observed to exhibit gentle to moderate slope and hard compact foliated gneisses are constituted the bedrock. Central Crystalline Group of rocks comprising of gneisses are observed to be exposed right bank of Simkhola Gad, few meter upstream to Mangti bridge. The deposited sediment along the Simkhola Gad, upstream side to Mangti bridge was observed to be comprised of grey, fine grained silty, sandy matrix with rare boulders and fragments of schist and gneiss.

Due to torrential rainfall Simkhola Gad catchment had brought down huge amount of debris with large volume of water. Near Mangti bridge, settlement, road and bridge were severely damaged and destroyed. About 150 meter stretch of Kailash Mansarover Pilgrimage road washed off and blocked. As well as right abutment of Mangti bridge was badly damaged. Toe cutting and direct hitting to the bank by the Simkhola Gad caused the major devastation around Mangti area. Rivulet has however eroded its bank at several places and deposited about 05 to 10 meter thick pile of debris just upstream side to Kailash Mansarover Pilgrimage road (Figures 6 and 7).

Event-II

Second event occurred at Malpa, situated on the right bank of Malpa Gad. Malpa Gad with catchment area of 15.30 sq km is the IIIrd order stream and meets Kali river at right bank. Malpa village is located about 43.00 km upstream to Dharchula, left bank of Malpa Gad whereas before the tragedy of 1998 it was located right bank of Malpa Gad. The area is observed to be located on glacio-fluvial material and occupied by outcrops as well as overburden. The affected area at Malpa is observed to exhibit steep slope and hard compact quartzite intercalated with micaceous schist are constituted the bedrock. Central Crystalline Group of rocks comprising of quartzite are observed to be exposed right bank Kali river at Malpa. The deposited sediments, along Malpa Gad observed to be comprised of angular, sub-rounded rock fragments and rare boulders of quartzite, gneisses as well as sandy, silty matrix.

Heavy and prolonged rainfall was occurred in Malpa Gad during 14th August, 2017. Due to torrential rainfall Malpa Gad catchment had brought down huge amount of debris with large volume of water. At Malpa, settlement and shops were severely damaged on the left bank of Malpa Gad. About 500 meter stretch of Kailash Mansarover Pilgrimage pedestrian route washed off and blocked due to debris flow together with flash flood. The main settlement was located on gentle to moderate sloping land, right bank of Kali river and left bank of Malpa Gad. Toe cutting and direct hitting to the bank by the Malpa Gad caused the major devastation. Malpa Gad has however eroded steep sloping land and deposited about 10 to 15 meter thick pile of debris right bank of Kali river (Figures 10-13).

Figure 10: Inundation along Malpa Gad after 14th August 2017.

Figure 11: View of Kailash Mansarover pedestrian route, temporary wooden bridge can be observed in the red circle.

Figure 12: Upstream side view of Malpa Gad.

Results and Discussion

First event of debris flow with flash flood took place in Simkhola Gad near Mangti village on 14th August. At the same time SSB persons were halted near Mangti bridge. There were the vehicles parked on the Kailash-Mansarover pilgrimage road and bridge over Simkhola Gad. According to the local people, mid-night debris flow along with flash flood occurred in Simkhola Gad. Debris laden water was observed to have overrun the road, bridge and Army camp. Due to this, a number of SSB vehicles and road were washed off. Because of narrow course of Simkhola Gad near Mangti bridge and encroachment along the left bank of Simkhola Gad damaged and destruction mostly occurred on the left bank. On the right bank of the Simkhola Gad upstream side to Mangti bridge around 05-10 meters thick pile of sediments was deposited.

Figure 13: View of old rock fall zone (1998) of Malpa.

Similar event of debris flow along with flash flood was took place at Malpa. The damaged populated area of Malpa was observed to be located on the Kailash Mansarovar pedestrian route, occupied by outcrops as well as loose/unconsolidated sediments of old landslide debris and rock fall. Thickness of accumulated sediments on the left bank of Malpa Gad is around 10-15 meters and width along the Malpa Gad is around 200 meters.

A number of hotels and shops were damaged and around 08 persons died and 10 persons missing due to huge amount of debris flow in the Malpa Gad (Table 1). Debris flow along with flash flood was to be responsible for the devastation in the area. In the past, during the monsoons of 1998 major rock fall occurred at Malpa right side to Malpa Gad that inflicted heavy losses in Malpa village. More than 200 persons were killed in this incidence and the course of Malpa Gad was blocked [13].

As the area lies in a seismic zone-V, wedge failure due to fractured and jointed rock might had been the cause of the rock fall (1998) as suggested in previous research work [13,14]. Proximity of MCT zone (Vaikrita Thrust), very steep/vertical slope also enhance the vulnerability of the area against the slope failure. Besides, this area lies in higher Himalaya and high peaks are covered by snow in winter season and in summer season they are in direct contact to sun light, therefore frost weathering must also be responsible for the slope failure. After this havoc (1998) people had been living and doing their livelihood work along the left bank of Malpa Gad and this time on 14th August 2017, everything is devastated due to heavy discharge along the Malpa Gad. Similar event was took place in Simkhola Gad near Mangti village due to heavy localized precipitation, heavy discharged occurred along the rivulet and huge amount of debris laden water devastated Kailash-Mansarover Pilgrimage motor road, shops and army camp near Mangti village.

Conclusion

It is noteworthy here, although every year in monsoon season such type of incidences always take place in mountainous terrain of Uttarakhand. But people forget and avoid the instructions and warnings generated time to time by the government, non-government organization (NGO's), print media as well as electronic media. In monsoon season it is dangerous to overlook such instructions and warnings especially regarding landslides and flash flood disaster. Although devastated areas by flash flood are located in the Central Crystalline domain of Higher Himalaya, a highly sensitive domain of MCT zone. Both the streams are perennial, discharge, eroding capacity and velocity of water in the streams in the monsoon season always be high. Therefore, probability of temporary damming of the rivulets in the upstream side during the incidence cannot be ruled out and this is however the concern of detailed geological as well as geotechnical investigation.

Although, the rainfall data recorded at Dharchula on 14th August 2017 shows less rainfall (21.60 mm) but on the basis of information gathered from locals and inundation occurred at Malpa and Mangti area, it was an event of heavy localized precipitation or cloudburst. Recent scenario of rainfall i.e., short duration of high intensity rainfall and longer dry spell are future challenges of climate change. Changing pattern of rainfall that makes heavy localized precipitation all the more common in this region is a cause of concern not only for the policy makers and development planners but also for the masses.

Therefore, reliable forecasting of future precipitation influenced by the climate change scenario is an important field of research. It is suggested that all over Uttarakhand where hydro-metrological disaster have been occurred should be monitored regularly and documented properly. As well as combined study based on metrology, hydrology and geology needs to be carried out for the better understanding of these events. So that, in future such havoc can easily be managed and mitigated. Moreover, for better understanding of rainfall pattern, automatic weather stations (AWS) should be installed in such locations and zones where hydro-metrological disasters frequently occur.

As damage and destruction are mostly concentrated along the stream course therefore it is suggested that any type of construction along the stream needs to be banned. Besides, business activities as temporary shops and huts also required to be prohibited. It should be done far away or proper distance from river and stream.

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References

1. Gupta V, Dobhal DP, Vaideswaran SC (2013) August 2012 cloudburst and subsequent flash flood in the Asi Ganga, a tributary of the Bhagirathi river, Garhwal Himalaya, India. Current Science 105: 249-253.
2. Gupta V, Kumar V, Jamir I, Tandon RS (2015) Landslide hazards around Uttarkashi township, Garhwal Himalaya, after the tragic flash flood in June 2013. Natural Hazards 80: 1689-1707.
3. Parkash S (2015) A Study on Flash Floods and Landslides Disaster on 3rd August 2012 along Bhagirathi Valley in Uttarkashi District, Uttarakhand. NIDM, New Delhi.
4. Sajwan KS, Khanduri S, Bhaisora B (2017) Some significant aspect of cloudburst with especial reference to devastating landslides at Bastari, Naulra and Didihat region, Pithoragarh district, Kumaon Himalaya, Uttarakhand. Int J Curr Res 9: 54255-24262.

5. Sati SP, Sundriyal YP, Rana N, Dangwal S (2011) Recent landslides in Uttarakhand: nature's fury or human folly. Curr Sci 100: 1617-1620.

6. Valdiya KS (1998) Catastrophic landslides in Uttaranchal, Central Himalaya. J Geol Soc lndia 52: 483-486.

7. Valdiya KS (1980) Geology of Kumaun Lesser Himalaya. Himalayan Geology, Dehradun, pp: 1-291.

8. Rautela P (2013) Lessons learnt from the Deluge of Kedarnath, Uttarakhand, India. Asian J Environ Disaster Manag 5: 43-51.

9. http://janpakshindia.blogspot.in/2011/06/disasters-in-central-himalay.html

10. http://timesofindia.indiatimes.com/India/Five_killed_in_landslides_in_Uttarakhand/rssarticleshow/2343085.cms

11. Sarkar S, Kanungo DP (2010) Landslide disaster on Berinag–Munsiyari Road, Pithoragarh District, Uttarakhand. Current Science 98: 900-902.

12. Bishwapriya A, Dhakate MV, Gajbhiye PK (2013) An Interim report on preliminary slope stability assessment of recent disaster affected areas of Pithoragarh district, Uttarakhand. Geological Survey of India.

13. Paul SK, Bartarya SK, Rautela P, Mahajan AK (2000) Catastrophic mass movement of 1998 monsoons at Malpa in Kali Valley, Kumaun Himalaya (India). Geomorphology 35: 169-180.

14. Pandey RJ (2013) Landslide and risk assessment in Uttarakhand with especial reference to Malpa. Int J Innovative Res Dev 2: 197-205.