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# Cloudburst and landslides in Uttarakhand : A nature`s fury?

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**सार** – भारत के उत्तराखंड राज्य में बादल का फटना बड़ी प्राकृतिक आपदाओं में से एक है और इससे इस राज्य में लगभग प्रति वर्ष बाढ़ आती है, भूस्खलन होते हैं और बहुत बड़े पैमाने पर जान-माल की हानि होती है। इस शोध पत्र में इस राज्य में 14 जून से 17 जून, 2013 के दौरान बादल फटने और भारी वर्षा होने के कारण आई बाढ़ और भूस्खलन के बारे में उल्लेख किया गया है। उत्तराखंड भूस्खलन के लिए काफी संवेदनशील है और इस राज्य के संपूर्ण भौगोलिक क्षेत्र का लगभग तीन चौथाई भाग प्रबल भूस्खलन जोखिम क्षेत्र के अंतर्गत आता है। यह विनाशलीला रूद्रप्रयाग जिला के रामबाड़ा के निकट बादल फटने से आरंभ हुई और लगातार मूसलाधार वर्षा होने के कारण इस क्षेत्र की लगभग सभी बड़ी नदियां, विशेष रूप से मंदाकिनी और अलकनंदा पानी से लबालब भर गई। इस क्षेत्र के जल भंडारण वाले स्थानों से पानी के बाहर बहने से यह परिघटना और अधिक भयावह बनी। मंदाकिनी नदी के ऊपरी जलग्रहण क्षेत्र का लगभग दसवां भाग बाढ़ और भूस्खलन के कारण बह गया। यह इस राज्य के 80 वर्षों के इतिहास में सबसे दुखदायी आपदा थी जिसने 80,000 लोगों को प्रभावित किया। इस शोध पत्र में मानवीय क्षमताओं के ऊपर प्रकृति की सर्वोच्चता को दर्शाया गया है और बताया गया है कि मानव-प्रकृति संबंधों में संतुलन आवश्यक है, खास तौर पर ऐसे भू-भाग जिसकी मिट्टी कमजोर है और नाजुक स्थिति में है। यह सलाह दी जाती है कि हिमालयी संसाधनों का न्यायोचित ढंग से उपयोग किया जाए और इस भू-भाग में विकास योजना को लागू करने के लिए पर्यावरण हित वाली तकनीक का इस्तेमाल किया जाए।

**ABSTRACT.** Cloudburst is one of the major natural disasters in Uttarakhand state of India and this brings flash floods, landslides and massive destruction of property and lives almost every year in the state. The present paper discusses about flood and landslides which occurred due to cloud burst and heavy downpour in between 14 to 17 June, 2013 in the state. Uttarakhand is very susceptible to landslides and almost three fourth of the total geographical area of the state comes under sever to high landslide risk zone. The catastrophe started with cloud burst near Rambara in Rudraprayag district and due to torrential and continuous rainfall, almost all the major rivers and especially the Mandakini and the Alaknanda swelled up. Overflowing water reservoirs of the region catalysed the severity of the event. About one tenth of the upper catchment area of Mandakini river swept away due to flood and landslide. This was the deadliest hazard in 80 years' history of the state which affected about 80,000 people. The paper reflects the nature`s supremacy over human potentials and advocates the balanced man-nature relationship, especially in such terrains which are most fragile and critically balanced. It suggests the judicious use of Himalayan resources and use of environment friendly techniques in implementing the development plan for the region.

**Key words** – Debris-laden slopes, Torrential rainfall, ISM, Cumulonimbus convection, Orographic forcing, Topography, Anthropogenic intervention .

## 1. Introduction

Uttarakhand state is well known for frequent occurrence of natural disasters like cloudburst. Cloudburst is an extreme form of rainfall, sometimes mixed with hail and thunder, which normally lasts no longer than a few minutes but is capable of creating flood conditions. This leads to flash floods, landslides, house collapse, dislocation of traffic and human casualties on large scale (Sati and Maikhuri, 1992). A Cloud-Burst is a localized weather phenomena representing highly concentrated rainfall over a small area (not exceeding 20-30 km$^2$) lasting for few hours (Sravan Kumar *et al*., 2012).

Meteorologists say the rain from a cloudburst is usually of the shower type with a fall rate equal to or greater than 100 mm (4.94 inches) per hour. During a cloudburst, more than 2 cm of rain may fall in a few minutes (Govind *et al*., 2012).

In India, cloudbursts occur during the monsoon season due to strong convection associated with

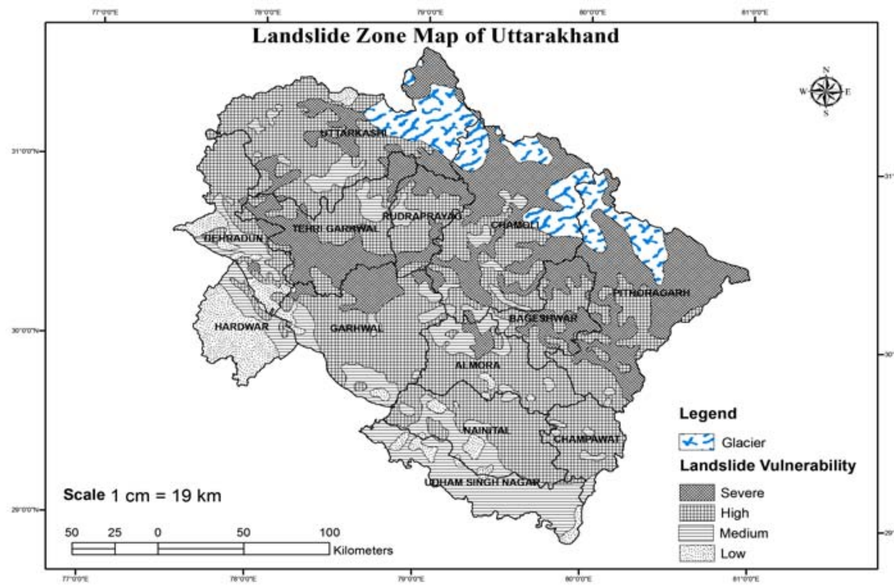


**Fig. 1.** Landslide zone map of Uttarakhand

orographic forcing over the Himalayas, Western Ghats and North-eastern hill states. This convection in the form of cumulonimbus cloud can rise up to 15 km. Hence, thermodynamic and orographic forces act together in the formation. Studies have also shown a relationship between the Himalayan topography and the Indian summer monsoon (ISM) on extreme cloudburst event (Bhaskaran *et al*., 1996 ; Barros *et al*., 2000 ; Kriplani *et al*., 2003 ; Barros and Lang, 2003 ; Barros *et al*., 2006 ; Anders *et al*., 2006 ; Bookhagen and Burbank, 2006 ; Das *et al*., 2006).

Landslides are the geomorphic expression of the slope instability that occurs when the shear stress in a part of the slope exceeds the shear strength and this condition can be achieved : (*i*) by the increase in pore water pressure, which eventually decreases the frictional forces and/or (*ii*) by slope steepening (Crozier, 2004). Landslides are more frequent during monsoon when impervious bedrock creates favourable conditions for creeping of saturated overburden. Such conditions are common on cut slopes along the highways in the Himalaya. Shallow landslide may also be initiated due to under-cutting of ephemeral streams on hill slopes activated due to prolonged or heavy rainfall that also facilitates soil erosion (Barnard *et al*., 2001). Hill slopes in the Himalaya are known for their instability due to ongoing tectonic activity. However, increasing anthropogenic intervention in the recent times appears to be contributing to terrain instability in addition to natural factors, as observed by increasing frequency and magnitude of landslides since 1970 (Sati *et al*., 2011).

## 2. The study area

Uttarakhand is the $27^{th}$ Indian state and the $10^{th}$ in Himalayan region. It lies between 28º 43' and 31º 27' N Latitude and 77º 34' and 81º 02' E Longitude. The total geographical area of the state is 53,483 sq. km., of which approximately 89% is mountainous. Of the total geographical area, about 19 per cent is under permanent snow cover, glaciers and steep slopes. The total population of the state is 10.12 million of which over 6 million people live in the mountainous parts of the state.

Uttarakhand is a disaster prone state. Landslides, forest fires, cloudbursts and flash-floods are seasonal in nature and these strike at a certain period of the year with high frequency. Cloudburst and landslide are the most devastating in the mountains and are unpredictable. So far, in the recent years (1990 onwards) Uttarakhand has experienced a series of landslides/cloud burst such as Malpa (1998), Okhimath (1998), Fata (2001), Gona (2001), Khet Gaon (2002), Budhakedar (2002), Bhatwari (2002), Uttarkashi (2003), Amparav (2004), Lambagar (2004), Govindghat (2005), Agastyamuni(2005), Ramolsari (2005), Asinganga (2012), Kedarnath (2013).

About 70 per cent of total geographical area of the state is registered under high to severe landslide vulnerability zone (Fig. 1).

## 3. Kedarnath flood : A case

The Himalayan state of Uttarakhand was hit by torrential rain and cloudbursts in certain locations

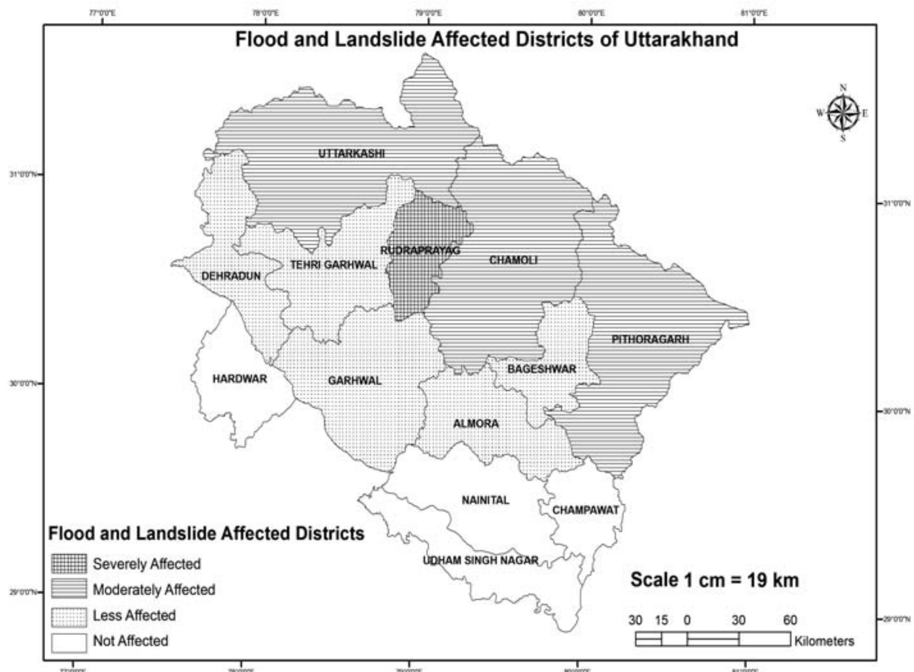


**Fig. 2.** Flood and landslide affected districts of Uttarakhand

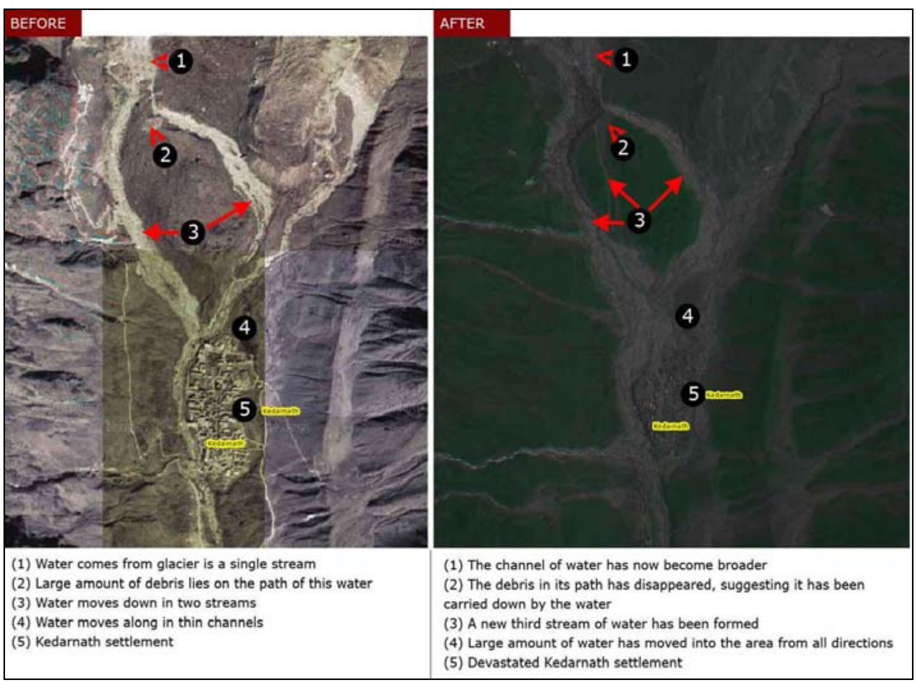


**Fig. 3.** Details of flash floods and landslides (*Source :* NRSC)

between 14 to 17 June, 2013, recording the highest rainfall in 20 years in a three-day period, which triggered landslides and flash floods in multiple locations in the state. The erratic weather conditions attributed to early monsoons in Northern India. The Himalayan Rivers (the Ganga and its major tributaries - the Alaknanda and the Bhagirathi) swelled up as a result and given the steep gradients in the mountains, the waters along with the silt and debris broke all bounds, gathered tremendous momentum and swept down as an inexorable force, causing widespread destruction in the region. The affected areas were particularly remote and environmentally

**TABLE 1**

**District wise rainfall distribution (14-17 June, 2013)**

| District | Actual (mm) | Normal (mm) | Departure (%) |
|---|---|---|---|
| Almora | 208.7 | 26.3 | 694% |
| Bageshwar | 391.2 | 26.3 | 1387% |
| Chamoli | 316.9 | 22.6 | 1302% |
| Champawat | 351 | 33.5 | 948% |
| Dehradun | 565.4 | 36.8 | 1436% |
| Garhwal Pauri | 149.7 | 15.8 | 847% |
| Garhwal Tehri | 327.7 | 22 | 1390% |
| Hardwar | 298.8 | 21.6 | 1283% |
| Nainital | 506.5 | 38.8 | 1205% |
| Pithoragarh | 246.9 | 73 | 238% |
| Rudraprayag | 366.3 | 53.9 | 580% |
| Udham Singh Nagar | 157.7 | 40.2 | 292% |
| Uttarkashi | 375.6 | 25.8 | 1356% |

fragile, with limited transport connectivity. A perusal of Table 1 shows the rainfall statistics of the state during the disaster period. Almost every district received 10 times greater rainfall than normal.

Out of thirteen, nine districts were affected by flood and landslides of which three disricts namely Chamoli, Uttarkashi and Pithoragarh were heavily affected while the Rudraprayag district was the worst affected (Fig. 2).

Due to a cloudburst resulting in heavy rains on 14 June, 2013, in Kedarnath, the epicentre of the devastation, the banks of the lake Chorbaria Tal (Ghandi-Sarovar) situated above Kendarnath town burst causing flash floods and landslides and the town covered with 6 feet of sludge (Fig. 3).

Downstream villages of Rambara, Gaurikund and Sonprayang were washed away. The river Mandakini served as the axis of the catastrophe in the region. The landslide map of the district (Fig. 4) shows the severity of the calamity.

All the major settlements of the district either washed away or completely damaged. According to an estimate, 60 villages of the district were completely destroyed (SIT-REP, 2013).

Chamoli district was another worst hit area where 39 villages were affected. The affected villages were Ghangaria, Pulna, Govindghat, Badrinath, Pandukeshwar, Lambagarh, Narayangarh, Pinola, Phaya and Vinayak

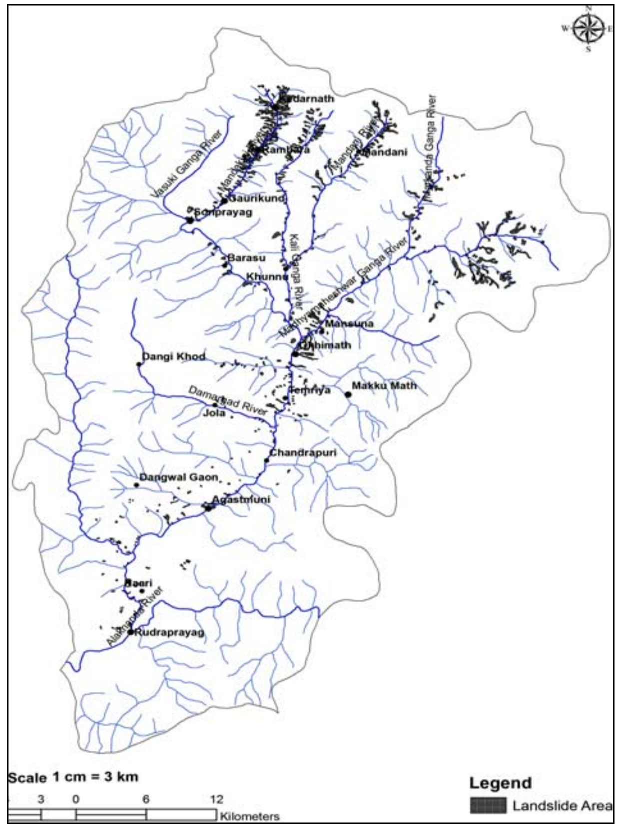


**Fig. 4.** Landslide affected areas of Rudraprayag district

Chatti. Several villages, such as those in Urgam valley, *viz*., Devgram, Bansa, Barginda, Geera, Talla Barginda, Bharki, Beetha, Pilkhi, Aroshi, Salnna, Thenna and Lyari, as well as Karchhi and Karchhoo villages in Niti valley, were completely cut off due to damaged roads and the Govindghat town of the district washed away.

In Uttarkashi the stretch between Uttarkashi to Gangotri damaged completely. The worst affected villages were; Matli, Tiloth, Didsari, Jadau, Bhatwari, Sukhi, Jhala, Gangori, Ujeli, Josiyara, Maneri, Sayanj, Kamakhani, Lagadi, Mandla, Gyansu, Bhatwari, Mukhwa, Beersari, Bishenpur and Dharali. Ankoli, Darsara, Agora, Dhandatla, Gajoli, Naugaon and Feku were some villages that lost their connectivity completely.

In pithoragarh district total of 10 villages were affected. The worst affected villages in this district lie in Dharchula block. The most affected villages were Munsyari and Dharchula. The Table 3 presents a brief account of the damage.

The state is known for small hydroelectric projects. Due to the landslide and flood, 70 hydroelectric plants were damaged and the water stored in small reservoirs for electricity generation amplified the severity of destruction.

**TABLE 2**

**Damage and loss in the flash flood and landslide**

| Affected district | No. of villages affected | No.of persons missing | No. of causalities | No. of houses damages/washed away | No. of animals died |
|---|---|---|---|---|---|
| Rudraprayag | 60 | 6000 | The causality due to the disaster was 1056 as report by Govt. | 700 | Approximately 9500 animals killed |
| Chamoli | 39 | 2500 | | 130 | |
| Uttarkashi | 68 | 3000 | | 160 | |
| Tehri Garhwal | 20 | - | | 90 | |
| Pithoragarh | 10 | 100 | | 25 | |
| Bageshwar | 8 | - | | 15 | |
| Almora | 8 | - | | 10 | |
| Deheradun | - | - | | 1 | |
| Pauri | 5 | - | | - | |
| | 218 | 11600 | | 1131 | |

*Source :* SIT-REP, Sphere, India (SPHERE India situation report)

## 4. Conclusion and suggestion

This flood was the heaviest and deadliest in 80 years for the state of Uttarakhand. The rainfall received in three days in the region was more than the entirety of the normal total rainfall Uttarakhand receives in a monsoon season. A combination of factors such as degraded forest cover, change of moderate debris-laden slopes into near vertical slopes during road widening and building construction without adequate and appropriate engineering measures have made the slopes vulnerable to the onslaught of torrential rainfall in the region. In the urban clusters obstruction of natural drainage is responsible for slope destabilization and diversion of the debris-laden waters into the habitation areas. The unscientific urban development speaks volumes about the poor governance and lack of urban development policy and approximately two-thirds of the landslides in the region were accelerated by anthropogenic intervention, mostly by the removal of slope toes at road cuts.

Development is a basic need of every region but while tampering with the Himalayan slopes, one needs to be extra careful as the slopes which have evolved by exogenic and endogenic processes are precariously balanced. It would be unjust to say that our planners and policy makers are not aware of the sensitivity of the Himalayan region, but it seems that the awareness is masked by the pressure of utilizing the Himalayan resources for growth and providing easy and fast accessibility by developing road networks. Rapid and unplanned urbanisation is playing a key role in destabilising the Himalayan equilibrium. There is an urgent need to discourage the settlement establishment on steep mountainous regions. A proper assessment and monitoring plan of urban growth in areas situated in high and vulnerable landslislide zones should form part of the strategy to manage and control the disasters in hilly terrains which are characterized by vulnerable ecosystem and fragile environment.

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