Cloudburst, Himalayan Tsunami in Uttarakhand

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Abstract: *In this article, we discuss the cloudburst triggered natural hazards mainly flash floods, rain and landslides in the Uttarakhand Himalaya. It further describes mechanism, implications of natural hazard, illustrates the preventive and mitigation measures. We discuss in this study through collection of old data, case study of cloudburst hit areas, and rapid field visit of the different affected regions. Cloudburst and rain is one of the biggest natural disasters in Uttarakhand state 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. Our this study shows that cloudburst is biggest hazards in the Uttarakhand Himalaya are natural phenomena and unavoidable yet, disasters can be minimized if prevention measures has been taken up appropriately. We have suggested that construction of human areas, institutions and infrastructural facilities along the seasonal streams and the perennial rivers should be avoided to prevent disasters. Further, large scale tree and plantation on the degraded land which will reduce the magnitude of hazards.*

Key Words: *Flash flood, Cloud burst, Himalaya, Avalanches, Landslides, Natural disasters, Floods, India.*

1. INTRODUCTION:

A cloudburst and heavy rain is an extreme amount of precipitation in a short period of time, (***World Meteorological Organization and UNESCO. 2011***. A cloudburst with rain can suddenly dump large amounts of water e.g. 30 mm of precipitation corresponds to 26,000 metric tons/km^2 (1 inch corresponds to 75,300 short tons over one square mile). The mountain habitats share certain similar bio-climatic features and concerns across the world, be it Alps mountain regions of European countries or Andean mountain ranges in the South America (Venezuela, Columbia, Ecuador, Peru, Bolivia, Chile and Argentina) or Hindu Kush Himalayan (HKH) region countries in the South Asia (Afghanistan, Pakistan, India, China, Nepal, Bhutan, Bangladesh and Myanmar). These features and concerns relate primarily to the changing mountain environment due to degradation of resources as a consequence to their excessive use. This has caused reduction in biomass production, marginalisation and low human welfare. Many of these mountain regions are prone to natural hazards–landslides, earthquakes, avalanches, diseases etc. (**Li Tianchi etal., 2001**). Human conflict and wars have also concentrated in many of the poor regions (**Libiszewski and Bachler, 1997)** making life of the mountain people more vulnerable. The minority inhabitants in certain mountain regions suffered not only from the resources exploitation but also from ethnic conflict, violence and wars (**Ives et al., 1997**). But then, there are major differences between the mountain economies of the developed countries of Europe and that of Andean regions and HKH regions in respect of their development trajectories.

Territory-specific approach and exact instruments have been clearly recognized for sustainable development of the Alps mountain region. European Union's macro-regional strategies are pioneering experiments in fostering greater territorial cohesion and European Parliament has adopted a resolution on a macro-regional strategy for the Alps in 2013, with a view to addressing the common challenges such as protection of the environment, investment in competitiveness and innovation, agriculture and forestry, water, energy, environmental and climate issues and transport (epthinktank.eu. , 2013).

2. OBJECTIVES:

- Study the, Archival data from the SGRD, Dehradun show that the series of cloudburst triggered flash floods and landslides have occurred in the Uttarakhand Himalaya from the last centuries.
- Study heavy rain fall and upstream in the north-east region of the Kedar valley.
- Discuss An analysis of rainfall data for the past five years
- Study the brief of damage assessment conducted by the Government administration and Non Government organizations.

3. STUDY AREA:

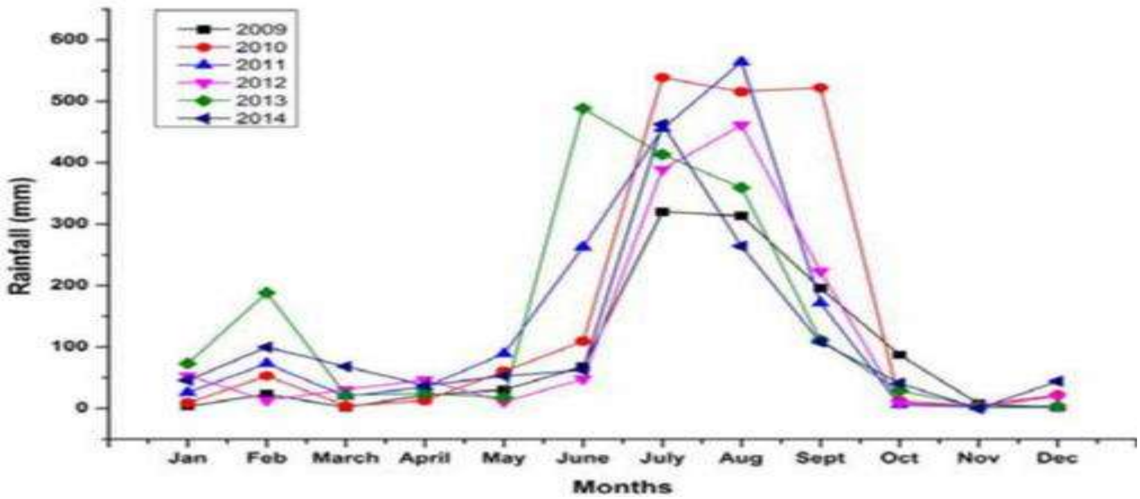
Uttarakhand Himalaya, an integral part of the Himalaya, lies in almost its central part and known as the ‘Indian Central Himalayan Region’. Stretching between 28°43’ N – 31°28’ N and 77° 34’ E – 81°03’E, it has total 53,483 km^2 geographical area of which 93% is mountainous mainland. Out of its mountainous area, 16% area is snow-clad, which is the major source of India’s biggest rivers – the Ganga system (**http://www.q8india.com/blog/2017/08/15/).** It has two distinct geographical entities – The Garhwal Himalaya and the Kumaon Himalaya along with 14 administrative districts. It ranges from 250 m to above 7,000 m altitude with its three dimensional landscapes – the river valleys, mid-altitudes and high Himalaya including alpine meadows and snow-clad regions. It characterises undulating and fragile landscapes, prone to natural (mainly atmospheric) hazards, and receives heavy rain showers during the four months of monsoon season, which is caused to heavy loss of lives and property. Haphazard construction of settlements mainly along the seasonal streams and perennial rivers further accentuate the magnitude of disaster. Beside cloudburst-triggered natural hazards, earthquakes influence the Uttarakhand Himalaya greatly as it falls under IV and V seismic zones.

Cloudbursts-triggered natural hazards are very common features in the Himalaya, which caused heavy damage to entire landscape and human settlements. In this section, we described past incidences of natural hazards, rainfall frequency and intensity, and recent event of cloudbursts. We also discussed mechanism and implications of cloudburst-triggered hazards and preventive and mitigation measures.

4. PAST INCIDENCES:

Archival data from the SGRD, Dehradun show that the series of cloudburst triggered flash floods and landslides have occurred in the Uttarakhand Himalaya from the last centuries, which have resulted in huge losses of lives and property. Among them Pauri (1816), Joshimath (1842), Mandakini River (1857), Chamoli (1868), Nainital (1880), Birhi Ganga(1893), Gohnalake (1894), Helang (1906), Patal Ganga(1945), Nainital(1963), Kaliyasaur(1963), Karnprayag(1965),Upper Alaknanda (1970), Satpuli (1972) Ukhimath(1979), Kedarghati (1991), Jakholi and Devaldhar (1986), Gopeshwar (1991), Gadinigarh (1992), Kewer Gadhera (1993), Bhimtal (1996), Malpa (1998), Okhimath (1998), Fata (2001), Gona (2001), KhetGaon (2002), Budhakedar (2002), Bhatwari (2002), Uttarkashi (2003) , Amparav (2004), Lambagarh (2004), Govindghat (2005), Agastyamuni (2005), Ramolsari (2005) and Kedarnath Valley, Badrinath Valleys, and Pindar Valley (2013) are prominent.

We analyzed average monthly rainfall data (2009-2014) of Uttarakhand state and observed that rainfall occurred largely during four months of summer between June and October with high variability. This is the season when cloudburst is occurred. A decrease in rainfall was also observed during the reported period (Fig. 1) however, intensity of rainfall has increased within a short period of time, which has further accentuated magnitude of cloudburst-triggered natural hazards.



Average monthly rainfall (mm) in Uttarakhand (2009-2014)

HEAVY RAINFALL OCCURRED WITHIN 24 HRS IN UTTARANCHAL

Place	Date and Year	Rainfall in mm
Nainital	22 Sept. 1958	509.3
Tehri	22 Dec. 1957	194.8
Mukhim	19 July 1957	267.2
Narendra Nagar	1 July 1957	267.2
Kirti Nagar	8 Oct. 1956	198.8
Devprayag	9 Oct. 1956	215.9
Dhanauti	17 July 1957	188.0
Ghuttu	10 July 1957	345.7
Almora	29 Sept. 1924	222.5
Champawat	27 Sept. 1879	389.8
Kausani	3 Oct. 1910	200.8

Several localities in Uttarakhand received heavy rain within 24 hours during different years. Table I reveals that Nainital received the highest rainfall in 1958 i.e. 509.3 mm. It is followed by Champawat (389 mm) in 1879.

WHAT REALLY HAPPENED IN UTTARAKHAND ?

The extreme rains of June 16 this year lead to a disaster of unprecedented proportions in the Himalayan state of Uttarakhand. Many theories and explanations for the disaster have surfaced in the aftermath of the floods in the state. Now clearer satellite images of the upstream and downstream areas of the Kedar valley that have emerged are enabling a clearer understanding of the scientific and environmental reasons for the tragedy in the state.

5. A POWERFUL LANDSLIDE:

It is believed that a massive landslide occurred upstream in the north-east region of the Kedar valley. Heavy rainfall occurred at the same time formed a small lake in the north-west of the valley. The debris from the landslide and water from the lake travelled down the slope, channelled into the glacier, and came down to Kedarnath town. The Indian Space Research Organisation (ISRO) is yet to come up with a detailed analysis but agrees with this possiblity.

The theory has been proposed by Dave Petley, professor, Department of Geography at Durham University, United Kingdom, and reported on his blog. According to Petley, high resolution images from ISRO's geographic information system (GIS) platform, Bhuvan, show that the flow of the landslide eroded a large amount of material. He has estimated rough parameters using images of the landslide retrieved from Google Earth.

The difference in height between the crown of the landslide and the channel below was about 500 metres, and the length was about 1,200 metres. Petley puts the scar width at about 75 metres, considered a large landslide. As the downside of the landslide was active and prone to erosions, it created a further accumulation of debris downstream. The amount and flow of debris was so high, that the boulders did not stop at Kedarnath and were carried to Rambara village and beyond.

Heavy rainfall that occurred in the area at the same time formed a small lake in the north-west of the valley. Under normal circumstances, the water would have flowed away. But a block formed by debris led to the accumulation of water. When extreme pressure caused a breach in the boundary of the lake, a large amount of water gushed out, forcing another rock to flow away. This created a new stream, in addition to the two streams that existed already. The amount of water, moraines and debris was high enough to increase the level of the biggest stream in the west, create a new stream in between, and increase water level substantially in the eastern stream.

6. UTTARKASHI CLOUDBURST AND FLASHFLOOD 2012:

On August 3rd and 4th night incidences of cloudbursts occurred in Uttarkashi area. It was around midnight when suddenly people noticed increasing water level with debris in the local rivers. People immediately started shifting from their houses and tried to move to the safer locations. Some people were able to shift with their belongings, but some were not so lucky. Within hours the flow of flash flood washed away hundreds of houses, shops, roads and bridges. The townships Bhatwari and Dunda in Uttarkashi districts are badly hit by this flood disaster. The connectivity between Uttarkashi town and Bhatwari Block is completely destroyed. The bridges collapsed, homes, shops, village path, electricity and water facilities are damaged and hundreds of hectares of agriculture land is destroyed. There is no damage estimation available for livestock population.

7. EARLY RAINS AND GLACIAL MELT:

Uttarakhand received rain early this year. The monsoon reached the state almost two weeks in advance. These early rains coupled with other factors were responsible for the disaster that ensued. Rivers in the region already have heavier flow in June than at other times of the year because of the seasonal melting of glaciers. When water falls on ice, it melts faster; and as it rained on the glaciers of the state, the massive run-off began to swell the rivers.

An analysis of rainfall data for the past five years, available on the website of the India Meteorological Department, points to changes in rainfall trends in India, with a greater number of incidents of excess rain in Uttarakhand in June. The trends in rainfall do not indicate the kind of disastrous rainfall the state received this year, but it does point to the necessity for a robust disaster management programme, which as of now does not exist in the state.

The areas of Uttarakhand affected by the recent floods, particularly Uttarkashi, have experienced excess rains in June for the past several years. Last year, there was a rainfall deficit in the same month across the state. But data for the preceding five years indicates a trend towards excess rainfall in June.

District-wise rainfall trends in Uttarakhand from 2008 to 2012						
	Chamoli		**Rudraprayag**		**Uttarkashi**	
	R/F*	% departure from LPA#	R/F*	% departure from LPA#	R/F*	% departure from LPA#
2008	163.8	59	148.9	-30	298.3	98
2009	32.2	-69	17.8	-92	197.3	31
2010	121.8	18	166.6	-21	189.9	26
2011	170.5	57	369.6	70	363.7	146
2012	41.1	-62	95.4	-56	45.6	-69

In 2011, Uttarkashi received 146 per cent excess rainfall compared to the long period average (LPA). The corresponding figures for 2010, 2009 and 2008 are 26 per cent, 31 per cent and 98 per cent. Chamoli received 57 per cent excess rainfall in June in 2011, 18 per cent in 2010 and 59 per cent in 2008.Rudraprayag also received a deficit rainfall in 2008, 2009, 2010 and 2012, but the year 2011 witnessed excess rainfall of 70 per cent.

The monsoon winds arrived early in India, and were another factor in the events that led to the Uttarakhand floods. "Monsoon has hit the entire nation early by one month. It is by July 15 that all parts of India receive rains. This year that day came as early as June 15," said Shailesh Nayak, secretary, Ministry of Earth Sciences. He said multiplicity of conditions have together created such a situation. "This year several things synchronised to lead to early monsoons," he said.

In the initial phase, called the onset phase, monsoon hit Andaman and Kerala following the normal time and trend. "However, after that the combination of lower pressure in north-western region and movement of three types of winds led to monsoons hitting other parts of the country way before their normal time," said an official in the Met department. Usually, monsoon sets in by June 1, while this time it arrived in the last week of May. It moved fast towards the north, without taking its characteristic break before hitting one region after the other.

Low pressure over east Rajasthan attracted south-westerly winds from the Arabian Sea, laden with moisture. At the same time, easterly winds from Bay of Bengal came along the foothills of Himalayas. The westerly also crossed Uttar Pradesh and Bihar, creating a trough. The mountains of the north created orographic effect (it occurs when an air mass approaches a mountain range and is rapidly forced upward, causing any moisture to cool and fall as rains).(**Jyotsna Singh Wed, 03 July 2013)**

DAMAGE ASSESSMENT AS OF 8TH AUGUST 2012

The major damage has occurred around Uttarkashi township, which is 210 Km. from state capital Dehradun in Uttarakhand. The national highways from Uttarkashi to Gangotri are completely blocked. The bridge connecting Uttarkashi town and Bhatwari block at Gangori village is collapsed and almost 80 villages are totally cut-off. There is no way to communicate with the people in those areas.

Following is the brief of damage assessment conducted by the Government administration and Non Government organizations:

- 34 persons died and some are missing from the area where team could reach, as mentioned 80 villages are totally cut off and as of now (8 Aug 2012) no information is available from these villages.
- 7 Bridges of vehicle and 6 Bridges of footpath were washed away resulting in no connectivity with Bhatwari area. Electricity supply to these villages is completely erupted and landline and mobile connectivity is also completely down. 60 Kilometers of National highway is damaged at many locations.
- 1700 families are affected from Gangori to Uttarkashi. Most of the families are presently living with their known people and kith and kin. 922 people of approx. 280 families are living in 13 relief camps in Uttarkashi City established by Government in Joshiyara and Gangori.

- No contact has been established (as of date) with seven villages of Sangam chatti area, 3 villages of Gyansu area and 80 villages of Bhatwari Block.
- Around a population of 80000 is affected from this disaster.
- Government has assessed a loss of Rs. 600 crores in the area where they have been able to receive damage information. This will certainly increase as and when the information is available from unreached area.

8. CONCLUSION:

The study revealed that the Uttarakhand Himalaya is highly vulnerable to natural hazards. There is a vital need to policy measures to reduce both risk and disasters. It is essential to avoid settlements' construction along the river valleys to prevent disasters. We should also avoid construction of roads mainly along the fragile slopes and bridges can be constructed. Ropeways are suitable in the fragile landscape of Uttarakhand, which can connect the rural settlements from the main routes so that occurrence of landslides can be minimized.In this way, rain not only enrich in variety of flora, fauna, human communities and cultural diversity but also important as a provider of life, offering water to a huge part of the Indian Himalayan. But in recent past, continuing climate change and anthropogenic activities brings significant changes in the climate and precipitation pattern of the Himalayan area. Construction of hydroelectricity projects should be done in the suitable areas, which are uninhabited and their sizes should be at micro-level. It will take years to roll back the, psychological, social, economic, physical and ecological damage wrought by the terrible floods in Uttarakhand, which killed more than 1,000 people. It is final that cloudbursts a with heavy rainfall, which occurs in upper hilly parts of Uttarakhand. This causes include Government policies and governance failures which aggressive promotion and growth of Indian tourism; unplanned development of roads, hotels, shops, mines and multi-stored housing in ecologically fragile areas; and above all, the planned development of scores of environmentally destructive hydroelectricity dam and bridges. Experts and environmental activists argue indiscriminate development in hilly towns and along rivers has blocked the natural flow of water and exacerbated flood damage.

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