International Journal of Current Research in Science and Technology
Volume 4, Issue 12 (2018), 1–7.
ISSN: 2394-5745
Available Online: http://ijcrst.in/

International Journal of Current Research in Science and Technology

# Trends of Hydro-Meteorological Disaster in Uttarakhand, India

**Vinay Kumar Pandey**[1,*] **and Ajai Mishra**[1]

1 Consultant Geotechnical Engineer, Mumbai, Maharashtra, India.

2 Professor, Department of Geology, University of Lucknow, Lucknow, Uttar Pradesh, India.

**Abstract:** Hydro–Meteorological Disaster (HMD) referred the meteorological as well as geological disaster those happens due to meteorological disaster such as landslide happened due to rainfall, flash flood, cloud burst etc. Peak of disaster always measured in terms of intensity, time duration of event, social-economical losses and losses of human life. As Uttarakhand is a Himalayan state and having different geological setup and climatic condition. Minor change in climatic condition, affected the weather condition in higher altitude of Himalayan region and HMD may take place. Human population & haphazard infrastructure development is also increasing every year at higher altitude of Uttarakhand. To find out the trend of HMD in Uttarakhand, we have done interpretation of last 50 years available HMD in state of Uttarakhand and also tried to get the hazard prone area. Total 10 major HMD was reported in Uttarakhand from 1969 to year 1998 but after that HMD event drastically increases and total 30 events have been observed only in last 10 years 2009 to July 2018. For better understand the trend of HMD, all district of Uttarakhand have been divided into 3 zones according to altitude of Himalaya and with the help of bar chart between HMD event, location zone and time of HMD event in 10 years' interval. After interpretation concluded the trend of HMD, also find out the badly affected districts of Uttarakhand.

**Keywords:** Hydro-meteorological Disaster, Precipitation, Cloudburst, landslide, flash flood, Greater Himalaya.



## 1. Introduction

Uttarakhand is mountainous, developing state where infrastructure, tourism, industries, agricultural and other activities increasing at rapid rate. A part from increase in modern development, event of natural disaster also increases in last 20 years. The term hydro-meteorological disasters deal with the study of natural hazards that originated by the result of natural phenomena of atmospheric, hydrological or oceanographic or combination of these events such as floods, flash-floods, tropical cyclones, cloud burst, drought and arid conditions and by product of these phenomena such as landslide, ground subsidence etc. Many countries including India have established an operational hydro-meteorological capability to assist with forecasting, warning and informing the public of these developing hazards [1]. Magnitude of disaster have been identified through losses happened due to the vulnerability of the social, ecological & socioeconomically system. The state of Uttarakhand had experienced large number of Hydro-meteorological disaster (HMD) incidences but in last 20 years' intensity & frequency of HMD have been gone up. Major HMD calamities observed & reported in year 1970, 1986, 1991, 1998, 2001, 2002, 2004, 2005, 2008, 2009, 2010, 2012, 2013, 2016 & 2018 in Uttarakhand. These disasters had brought up heavy toll to the state as the losses was estimated in social as well as economical i.e. several thousand millions of rupees and the casualties of several hundreds of people besides large number of cattle heads [2]. In this paper we tried to find out the trend of HMD in the state of Uttarakhand by review of previous studies of different scientists and forums.

* *E-mail: vinay78pandey@gmail.com*

## 1.1. Study Area

Uttarakhand is the north-western state of India that lies between 28.44° to 31.28° N latitude to 77.35° to 81.01° E longitude. It was evolved after the separation of the hilly tract of Uttar Pradesh in November 2000. The total area of this hilly state is 53,483 square km constituting 1.63% of landmass of the India [3]. The state is consisting of 13 districts and 95 development blocks. This state has two divisions; western part is Garhwal and Eastern part is known as Kumaun. The state capital is Dehradun, located in Garhwal division. Uttarakhand is the origin place of several perennial rivers of the Northern Great Plane of India. The entire State is dominated by three river systems that are; The Ganga System, Yamuna-Tons River System and Kali River system.

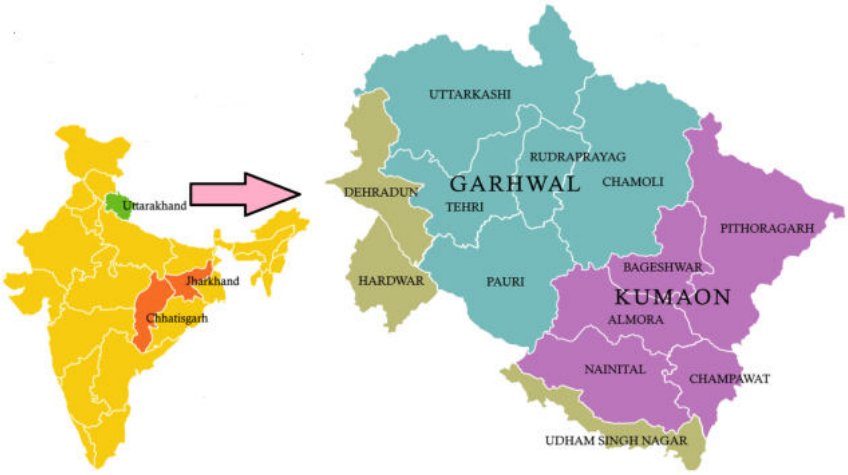


Figure 1: Uttarakhand map (after http://uttarakhand.org/?portfolio=territorial-change-map) [4]

Geologically Uttarakhand belongs to the Western Himalaya, which can be divided into five morphological zones of varying width, each having distinct physiographic features and geological history. The zones from South to North are the Outer (sub Himalaya), the Lower (Lesser Himalaya) the Greater (Higher) Himalaya, the Tethys (Tibetan) Himalaya and the Trans Himalaya. The Outer Himalaya, is delimited by Himalayan Frontal Fault (HFF) in the south and the Main Boundary Thrust (MBT) in the north. The main central thrust (MCT) as the base of Crystalline zone is a zone of intense shearing. The Lesser Himalayan zone is considered to be a tectonic zone sandwiched between MBT and MCT. Greater Himalaya is bounded between MCT and South Tibetan/ Central Himalayan Detachment Fault [5, 6]. The Garhwal-Kumaun Himalaya is seismotectonically an active region of the Himalayan arc. Geographically Uttarakhand is divided into five transverse zones: (a) The Terai: South of the Himalayan Frontal Fault. (b) The Doons: Between the Main Boundary Fault (MBF) and the Shivalik (Outer Himalayan) range. (c) The Middle Himalaya: Between the MBF and the Main Central Thrust (MCT) with ridges as high as about 3000 m. (d) The Inner (or Great) Himalaya: The zone north of the MCT including the permanently snowclad peaks at heights ranging up to just under 8000 m. (e) The Trans Himalaya to the north of the snow clad ridges. The states climate varies tremendously from the sub-tropical humid climate of the Terai region to the tundra-like climate of the Great Himalaya ridges. The variation is even more dramatic along the slopes of the mountain ranges. These variations give rise to tremendous biodiversity, particularly in the forest areas. More than 60 per cent of the people in the mountain districts live in rural areas. The Middle Himalaya region between the MCT and the MBF is the most densely populated Himalayan zone. The Great Himalaya region remains largely remote, sparsely populated and unspoiled [7].

The climatic condition is much different in high altitudinal areas and the lower basins in Uttarakhand. Temperature varies not in different seasons but also with the altitude. Uttarakhand lies on the southern slope of the Himalaya range, and

the climate and vegetation vary greatly with elevation, from glaciers at the highest elevations to subtropical forests at the lower elevations. The highest elevations are covered by ice and bare rock. Below them, between 3,000 and 5,000 metres alpine shrub and meadows. The temperate subalpine conifer forests grow just below the tree line at 3,000 to 2,600 metres elevation, after that transition to the temperate western Himalayan broadleaf forests, which lie in a belt from 2,600 to 1,500 metres elevation. Below 1,500 metres elevation lie the Himalayan subtropical pine forests. The Upper Gangetic Plains moist deciduous forests and the drier Terai-Duar-Savanna and grasslands cover the lowlands along the Uttar Pradesh border in a belt locally known as Bhabhar. These lowland forests have mostly been cleared for agriculture, but a few pockets remain [8]. The State is bestowed with a relatively high average annual rainfall of 1229mm.

Normally rain starts in the State in late April and continues up to September. However, the intensity of rainfall increases during the months of June to September. Higher rainfall occurring during first week of July. Rain continues through August until the first week of September. Nowadays, cloud bust during the Monsoon and pre-Monsoon is a regular matter in high altitude area of the Himalayas.

## 2. Discussion

For find out the trend of HMD in Uttarakhand, we collected the previous HMD data, which are documented by various agencies & authors such as *Uttarakhand* State *Disaster Management* Authority, National Institute of Disaster Management, Das PK (2013) [3], Pandey R J(2013) [9], Asthana KL et al (2014) [10], Pandey VK & Mishra A (2015) [2], Sphere India (2016) [11] & Rawat, Bhim Singh (July 2018) [12] and others Summarized list are given below table 1:

| S. No | Date/Year | Location | History of Damage Occurred |
|---|---|---|---|
| 1 | 1867 & 1880 | Nainital | Two major landslides on the Sher-ka-Danda slope in Nainital. The 1880 landslide took place due to rainfall and an earth tremor, destroying buildings, and permanently filled a portion of the Naini lake. |
| 2 | 1893 | Alaknanada | Floods in the Birehi Ganga river near its confluence with the Alaknanda river triggered landslides, causing major blockage of the river with a 10-13 m afflux. A girder bridge was bypassed and another one was destroyed. |
| 3 | 1968 | Rishi-Ganga | The Rishi Ganga river in Garhwal was blocked due to landslide at Reni village. |
| 4 | Jul-70 | Patal Ganga Chamoli | The Patal Ganga (a tributary of the Alaknanda river) got choked and a reservoir was created. The bursting of this choked reservoir resulted in flash floods in the Alaknanda river, triggering many landslides. |
| 5 | 1971 | Kanauldia Gad Uttarkashi | A major landslide on the bank of the Kanauldia gad, a tributary of the Bhagirathi river upstream from Uttarkashi formed a debris cone which impounded water to a height of 30 m. Its breaching caused flash flood downstream. |
| 6 | Aug-78 | Uttarkashi | The Kanauldia Gad, a tributary joining the Bhagirathi river upstream from Uttarkashi in the Uttarakhand formed a debris cone across the main river, impounding breaching used flash floods, creating havoc. A 1.5 km long and 20 m deep lake was left behind as a result of the partial failure of the landslide dam. |
| 7 | 1985 | Kaliasaur Rudraprayag | Kaliasaur is one of the most persistent and regularly occurring landslides areas, located along the Rishikesh-Badrinath road. Landslides in this region results into frequent road blockage and land damage. |
| 8 | Sep-89 | Karanprayag, Chamoli | 3 People died and Two injured |
| 9 | Dec-91 | Uttarkashi | 3 People died |
| 10 | Jul-94 | Chaukhutia, Almora | 4 People died |
| 11 | Aug-97 | Neelkanth, Haridwar | 8 People died |
| 12 | Aug-98 | Okhimath | 69 people were killed due to several landslides near Madhmaheshwar valley. The landslides caused huge devastation in villages. |
| | | Malpa, Kali River, Pithoragarh | More than 210 people were killed. The heap of debris created was about 15 m high. The village was wiped out in the event. |
| 13 | Jul-01 | Meykunda, Rudraprayag | 27 people died |
| 14 | 2002 | Khetgaon, Pithoragarh | 4 People died |
| 15 | Jul-03 | Didihat, Pithoragarh | 4 People died |
| 16 | Sep-03 | Varunavat Parvat, Uttarkashi | Incessant rains triggered massive landslide in the area, causing the burial of numerous buildings, hotels, and government offices located at the foot of the hill slopes. |

| | | | |
|---|---|---|---|
| 17 | 2004 | Ranikhet | One People died |
| 18 | 21 May & 09 June 2004 | Kapkot, Bageshwar | 6 People died |
| 19 | July 2004 | Badrinath, Chamoli | 16 persons killed, 200 odd pilgrims stranded, 800 shopkeepers and 2,300 villagers trapped as cloudburst triggered massive landslides washed away nearly Badrinath road cutting off Badrinath area 200metre of road washout. |
| 20 | 29-30 June 2005 | Govindghat, Chamoli | A cloudburst & landslide occurred in which a huge quantity of debris and rock boulders were brought down along a seasonal nala. Eleven people were killed and property lost. |
| 21 | 21-Jul-05 | Vijaynagar, Rudraprayag | 4 People died |
| 22 | 13-Aug-07 | Didihat, Pithoragarh | 4 People died |
| 23 | Sep-07 | Village Baram/Sialdhar, Dharchula, Pithoragarh | A landslide due to excessive rainfall resulted in 15 fatalities and loss of livestock. |
| 24 | 2007 | Pithoragarh & Chamoli | 23 People died |
| 25 | 2008 | Pithoragarh | One People died |
| | | Amru Band | Total 17 people killed, huge damages to roads and houses. |
| 26 | 2009 | MunsiyariTehsile,Pithoragarh | 43 people died |
| 27 | July to Sept 2010 | Kot, Pauri; Rudrapur, Udham SinghNagar; Dehradun, Nainital, Chamoli, Champawat, Haridwar | 59 people died and 2 missing & 17 injured |
| 28 | 21-Jul-10 | Almora | 36 people died in cloud burst induced flash Flood |
| 29 | 18-Aug-10 | Kapkot,Bageshwar | 18 school children were buried alive and 8 injured due to massive cloudburst |
| 30 | 18-21 Sept 2010 | Ganga-Alaknanda valley, Uttarkashi | 68 people killed in the landslides, which caused extensive damages to the buildings, agricultural lands and roads at several places. |
| 31 | 06-May-11 | Raipur, Dehradun | 3 People died |
| 32 | 15-Aug-11 | Tuneda, Bageshwar | 21 People died & one Injured |
| 33 | August 03, 2012 | Asi Ganga Valley, Uttarkashi | The worst affected areas were Gangotri, Sangam, Chatti and Bhatwari. About 7,389 people from 1,159families in 85 villages were affected. Nearly 28 people were killed in flash floods and landslides. |
| 34 | 13-14 Sept 2012 | Okhimath, Rudraprayag | 68 people killed in the landslides, which caused extensive damages to the buildings, agricultural lands and roads at several places. |
| 35 | 16-17 June, 2013 | Bageshwar, Chamoli, Pithoragarh, Rudraprayag & Uttarkashi | Flash flood induced landslide. 68026 people died, and 4,117 missing. Huge devastation to infrastructures and other properties mainly in 5 districts of Uttarakhand |
| 36 | July 01, 2016 | Pithoragarh and Chamoli Districts | 30 pepole killed in Cloud burst and Several homes in remote villages have been buried by the landslides. |
| 37 | 02-May-18 | Naryanbagar, Chamoli | Several Vehicle damaged. Debris rubble entered in several homes |
| 38 | 01-Jun-18 | Tehri, Pouri, Uttarkashi, Nainital, Pithoragarh | 1 death. Several houses & cattlew sheds damaged. |
| 39 | 02-Jul-18 | Munsiari, Pithoragarh | Sheraghat Hydro Power Project damaged |
| 40 | 11-Jul-18 | Seemadwar, Dehradun | 7 People died. |
| 41 | 16-Jul-18 | Tharali Ghat, Chamoli | Several houses & vehicle damaged |
| 42 | 17-Jul-18 | Yamnotri, Uttarkashi | 3 rope way damages, minor damage of shopes |
| 43 | 19-Jul-18 | Joshimath, Chamoli | 2 People died. 150 m Joshimath Highway washed away. Several farmland & road damaged. |

Table 1: List of Major HMD in Uttarakhand (After 2, 11 & 12)

To know the trend of HMD in Uttarakhand as given in table 1, all districts have been categorizing in three zones accordance with Himalayan morphological zone (table 2). Zone 1 indicates the Outer Himalayan districts elevation ranges from **600 to 1500 meters, Zone 2 indicates the Lower Himalayan districts, elevation ranges from 3,500 to 4,500 m and Zone 3 comprises elevation more than 4500 m and indicates Greater Himalaya districts**. After that we categorized these data in the 10-year interval groups from year 1969 to 2018. That HMD presented in bar chart (Figure 2). Figure 2 showing the drastically increases the HMD event in Uttarakhand from year 1999 onwards. In year 1969-1978, only 3 HMD event observed and only 1 event had observed in next 10 years 1979-1988, 6 numbers in year 1989-1999 after that

17 numbers in year 1999-2008 and in last 10 years, year 2009-2018 it reaches 30 events.

| Outer Himalayan District Zone 1 | Lower Himalayan District Zone 2 | Greater Himalayan District Zone 3 |
|---|---|---|
| Udham Singh Nagar | Champawat | Pithoragarh |
| Hardwar | Nainital | Chamoli |
| Dehradun | Almora | Rudraprayag |
| | Bageshwar | Uttarkashi |
| | Pauri | |
| | Tehri | |

Table 2: List of Districts as per Himalayan Morphological Zone

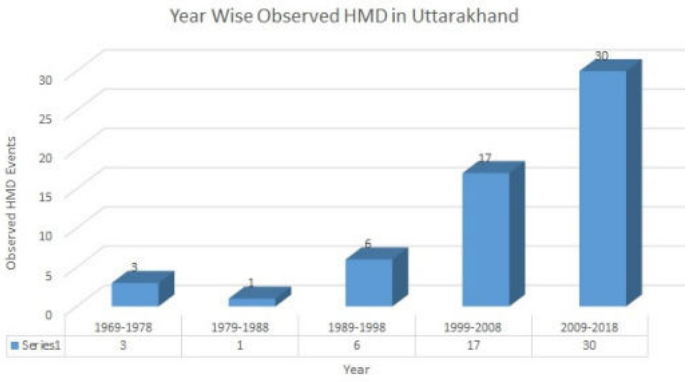


Figure 2: Year wise observed HMD in Uttarakhand

After that understand the zone wise HMD event, we arrange data accordance with Year & zone wise, as shown in figure 3 & 4; indicate that zone 3 are most affected. In year 1989-1998 only 4 HMD event observed which reached 13 & 18 in year 1999-2008 and year 2009-2018 respectively. Zone 2 is second most affected area where only 1 HMD event was observed in year 1989-1998 which increased 4 and 7 in year 1999-2008 and year 2009-2018 respectively. Zone 1 also felt 5 events of HMD in between year 2009 – 2018.

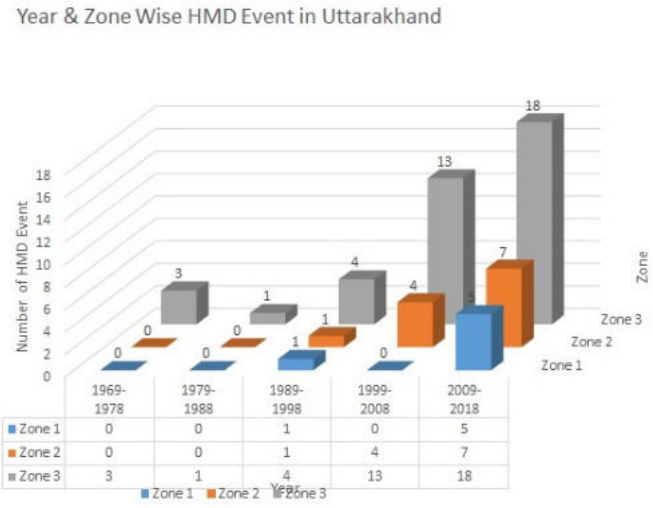


Figure 3: Year & Zone wise observed HMD in Uttarakhand

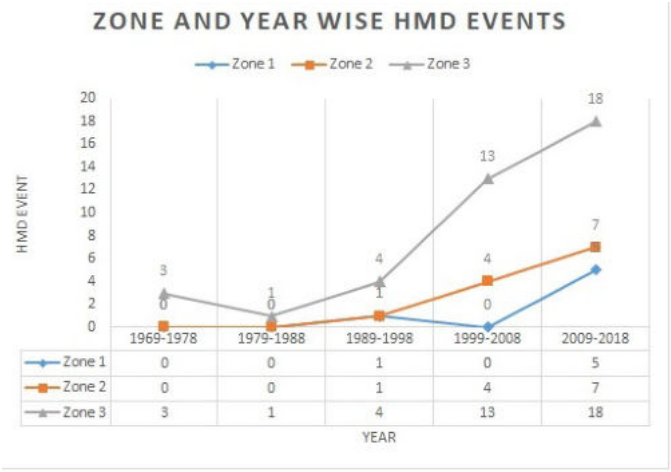


Figure 4: Year & Zone wise observed HMD in Uttarakhand

## 3. Conclusion

Last 20 years' event of HMD have been increased drastically. Most affected districts are Pithoragarh, Chamoli, Rudraprayag, Uttarkashi but other districts i.e. Nainital, Almora, Bageshwar, Tehri, Pauri and Dehradun are also disaster prone. Probable causes of increasing the HMD are variation in climatic condition, atmospheric wind circulation, modern development in higher altitude, increase in tourism in higher Himalayas, unplanned land use development, deforestation and geological condition are also responsible for more socio-ecological casualties. Last two decades' event of HMD shows that frequency & intensity have been increased and prediction indicated that in coming decades we will observe the high intensity & frequency of HMD in greater & lower Himalaya. More economical losses would be happened in lower Himalayan area due to anthropogenic activities, dense population, high infrastructure development, unplanned land use pattern etc. and ecological losses will be happened in greater Himalayan due to high variation in atmospheric condition. Public awareness, implantation of mitigation measures, scientific development and more modern weather monitoring system can reduce the socio-economical losses for better mitigation measures and growth of state.

## References

[1] Disaster Preparedness and Mitigation, http://www.unesco.org/new/en/natural-sciences/special-themes/disaster-preparedness-and-mitigation/natural-hazards/ hydro-meteorological-hazards (Oct 2018).

[2] V. K. Pandey and Ajai Mishra, *Causes and Disaster Risk Reduction Measures for Hydrometerological Disaster in Uttarakhand, India: An Overview*, International Journal of Current Research in Science and Technology, 1(3)(2015), 61-80.

[3] P. K. Das, *The Himalayan Tsunami- Cloudbrust, Flash Flood & Death toll: A Geographical Post-mortem*, Journal of Environmental Science, Toxicology and Food Technology, 7(2)(2013), 33-45.

[4] *Territorial Change Map*, Uttarakhand Solidarity Network, http://uttarakhand.org/?portfolio =territorial-change-map

[5] A. Gansser, *Geology of the Himalayas*, London: Willey Interscience, (1964).

[6] Paul Ajay, *Evaluation and Implications of Seismic Events in Garhwal- Kumaun Region of Himalaya*, Journal Geological Society of India, 76(2010), 414-418.

[7] Chopra Ravi, *Uttarakhand: Development and Ecological Sustainability*, Publisher Oxfam India, (2014).

[8] S. S. Negi, *Uttarakhand: land and people*, New Delhi: MD Pub, (1995).

[9] R. J. Pandey, *Landslide and Risk Assessment in Uttarakhand with Special Reference to Malpa*, International Journal of Innovation Research & Development, 2(3)(2013), 197-205.

[10] K. L. Asthana and H. Asthana, *Geomorphic control of Cloudbrusts and Flash Floods in Himalaya with Special reference to Kedarnath Area of Uttarakhand, India*, International Journal of Advancement in Earth & Enviromental Sciences, 2(1)(2014), 16-24.

[11] *Situation Report: Uttrakhand- Cloud Burst July 02, 2016*, Sphere India Secretariat, New Delhi. https://sphereindiablog.files.wordpress.com/2016/07/sitrep-cloud-burst-in-uk-2nd-july.pdf

[12] Rawat and Bhim Singh, *Uttrakhand Cloudburst Incidents 2018*,https://sandrp.in/2018/07/21/uttrakhand-cloudburst-incidents-2018/, (July 2018)