

Chapter 9

Cloud burst disaster in India, mitigation and their impacts

Desastre por aguacero en India, mitigación y sus efectos

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ABSTRACT

Cloudburst is a natural disaster. Cloudburst is excessive rain accompanied by flashes of lightning. Due to excessive rainfall in one place, there is a lot of loss of life and property due to cloudburst. Cloudburst is a big problem in India. Many people have died because of this. Cloudburst 2017: 7 killed in Dada district, 200 in Kashmir in 2014, 1, 84,000 in Uttarakhand, 10,000 killed in 2013, and 7000 missings. In Ladakh in 2010, 1,000 people died and 400 were injured. Cloudburst has caused damage to humans, animals, roads, the environment, and economics. Cloudburst has an impact on climate change. In this review, the history, impact, loss, M/s, mitigation, etc. of cloudburst in India have been discussed in detail.

KEYWORDS: Cloud burst, cloudbursts in the India, impact, prevention, and mitigation.

RESUMEN

Cloudburst es un desastre natural. El chaparrón es lluvia excesiva acompañada de relámpagos. Debido al exceso de lluvia en un lugar, hay muchas pérdidas de vidas y propiedades debido al aguacero. Cloudburst es un gran problema en la India. Mucha gente ha muerto a causa de esto. Cloudburst 2017: 7 en el distrito de Dada, 200 en Kashmir en 2014, 1, 84,000 en Uttarakhand, 10,000 muertos en 2013 y 7000 desaparecidos. En 2010, 1000 personas murieron y 400 resultaron heridas en Ladakh. Cloudburst ha causado daños a los seres humanos, los animales, las carreteras, el medio ambiente y la economía. Cloudburst tiene un impacto en el cambio climático. En

esta revisión, se han discutido en detalle la historia, los efectos, los daños, la M/s, la mitigación, etc., de los aguaceros en la India.

PALABRAS CLAVE: Aguacero en India, aguacero, impacto, prevención y mitigación.

INTRODUCTION

Cloudburst, a geo-hydrological hazard, refers to a sudden and heavy rainfall that takes place within a short period and a particular space [1]. The intensity of rainfall is often more than 100 mm/h [2]. The disruptive events, cloudbursts occur during the monsoon season in the Himalayas and trigger debris flows, flash floods, landslides, and mass movements. The fragile landscape, the rugged and rugged terrain and the steep slopes accentuate the magnitude of the geohydrological risks. Debris flows, flash floods, landslides and mass movements induced by storms have intensified and become more frequent around the world, especially in mountainous regions, causing widespread destruction of people, land and property [3, to 8]. Debris flows and flash floods caused by Cloudbursts incidences were although not much frequent and intensive yet, during the recent past, their number has increased owing to changes in the climatic conditions. The increasing number of infrastructural facilities on the valley bottom has accelerated damages owing to exposed elements in risk-prone areas [8, to 14]. Instability of terrain and intensive anthropogenic activities accentuate the magnitude of hazards, causing environmental degradation [15]. These disasters are accounting for more than 70% of all economic losses and more than half of the casualties [16]. High variability and climate change have increased the frequency and intensity of rainfall, leading to flashfloods and landslides [17, 11].

WHY DOES IT HAPPEN?

Cloudbursts are caused by the flow of warm air from the ground or under the clouds rushing upward, carrying the falling raindrops with it. Rain does not fall in a constant downpour, causing excessive condensation in the clouds as new droplets form and old droplets are pushed back into them by the updraft. The energy needed for the storm comes from the upward movement of the air. Cloudbursts usually occur at altitudes between 1,000-2,500 meters above sea level [18].

REASONS FOR CLOUD BURSTING

The convective weather situation is the most favorable condition for the agglomeration of clouds, thus leading to heavy weight and sudden intense, concentrated rainfall followed by flash floods. India is surrounded by water bodies from three sides and hence it is more prone to the convective weather situation. This small-scale phenomenon is generally followed by thunderstorms whereby the moisture-laden winds are forcibly raised upwards and the water vapor condenses and a sudden downpour occurs due to the heavy weight of the clouds. Intense vortices created during the triggering weather conditions lead to the generation of strong convection

currents which so forcibly lift the moisture-carrying winds that it takes the form of cumulonimbus clouds. These clouds pour water intensively and the convective uprising air currents of the thunderstorm support a large amount of water in the form of raindrops. The other factors which affect the process of cloud bursting include temperature variations, altitudinal variation, vegetation cover, etc. [19].



Figure: 1 Cloudbursts frequently occur in Himachal Pradesh during the monsoon.

Source: <https://www.kurseongmunicipality.org/cloudburst.php>

CONSEQUENCES OF CLOUDBURSTS:

- Flash floods
- Landslides
- Mudflows
- Land caving

Prediction:

- There is no satisfactory technique for anticipating the occurrence of cloud bursts because they develop over a short period of time.
- A very fine radar network is needed to detect the likelihood of a storm and this would be costly.
- Only areas with high rainfall can be identified at short notice. Much of the damage can be prevented by identifying the areas and meteorological situations that favor the occurrence of cloud eruptions [21].

CLOUDBURSTS IN THE INDIA

In the Indian subcontinent, a cloudburst usually occurs when a pregnant monsoon cloud drifts northwards, from the Bay of Bengal or the Arabian Sea across the plains, then onto the Himalayas and bursts, bringing rainfall as high as 75 millimeters per hour [22].

Few disastrous cloudburst accidents are as follows:

September 28, 1908 - A storm caused a flood where the Musi River swelled up to 38-45m. About 15,000 people were killed and about 80,000 homes were destroyed along the banks of this river [22].

1. In July 1970, a storm in the upper basin led to a 15m rise in the Alaknanda River in Uttarakhand. The entire river basin, from Hanumanchatti near the pilgrimage town of Badrinath to Haridwar, was hit. An entire village was swept away [22].
2. On August 15, 1997, 115 people were killed when a cloud burst came bustling, and the trail of death is all that is left behind in Chirgaon in Shimla district, Himachal Pradesh [22].
3. On August 17, 1998, a massive landslide following heavy rain and a cloudburst at Malpa village killed 250 people including 60 Kailash Mansarovar pilgrims in Kali valley of the Kumaon division, Uttarakhand. Among the dead was Odissi dancer Protima Bedi [22].
4. On July 16, 2003, About 40 persons were killed in flash floods caused by a cloudburst at Shilagarh in the Bursa area of Kullu, Himachal Pradesh.
5. On July 6, 2004, At least 17 people were killed and 28 injured when three vehicles were swept into the Alaknanda River by heavy landslides triggered by a cloudburst that left nearly 5,000 pilgrims stranded near Badrinath shrine area in Chamoli district, Uttarakhand [22].
6. On 26 July 2005, - A cloudburst caused approximately 950 millimeters (37 in) of rainfall in Mumbai. Over a span of eight to ten hours; the deluge completely paralysed India's largest city and financial center [22].
7. On August 16, 2007, 52 people were confirmed dead when a severe cloud burst occurred in Bhavi village in Ghanvi, Himachal Pradesh [22].
8. On August 7, 2009, 38 people were killed in a landslide resulting from a cloudburst in the Nachni area near Munsiyari in the Pithoragarh district of Uttarakhand [22].
9. On August 6, 2010, in Leh, a series of cloudbursts left 179 persons dead and over 400 injured in the frontier Leh town of Ladakh region in Jammu and Kashmir [22].
10. On September 15, 2010, a cloudburst in Almora in Uttrakhand drowned away two villages one of them being Balta, leaving a few people alive and the rest entire village dead and drowned. Almora has been declared as a town suffering from the brunt of the cloudburst by authorities of Uttrakhand. Had there been a bit more swaying of clouds, the town of Ranikhet must have drowned also [22].

11. On June 9, 2011, near Jammu, cloudbursts left 4 persons dead and several injured on the Doda-Batote highway, 135kms from Jammu. Two restaurants and many shops were washed away [22].
12. On 20 July 2011, a cloudburst in upper Manali, 18 km from Manali town in Himachal Pradesh state left 2 dead and 22 missings [24].
13. On September 15, 2011, a cloudburst was reported in the Palam area of the National Capital Territory of Delhi. The Indira Gandhi International Airport's Terminal-3 was flooded with water at arrival due to the immense downpour. Although no one was killed in the hour-long rain, it was enough to enter the record books as the city's highest rainfall since 1959 [25].
14. On September 14, 2012, there was a downpour in Ukhimath in Rudraprayag district, Uttarakhand, killing 39 people [26].
15. On June 15, 2013, a downpour was reported from Kedarnath and Rambara area in the Rudraprayag district, Uttarakhand. So far more than 1,000 people have been killed and the death toll is feared to be as high as 5,000. The debris is still being cleaned up and on 30 June 2013 thousand are still missing. About 84,000 people were stranded for several days. The Indian army and its central command have launched one of the most comprehensive human rescue missions in its history. Spread over 40,000 square kilometers, 45 helicopters were deployed to rescue the stranded. [27, 28] According to a news report, this incident was mistakenly associated with a cloud explosion, but was caused by the disruption of the two Kedarnath glaciers [29, 30].
16. On 30 July 2014, a landslide occurred in the small Indian village of Malin, located in Ambegaon taluka in the Pune district of India. The landslide, which hit the village early in the morning as residents slept, killed at least 20 people. In addition to these deaths, more than 160 people were believed to have been buried in 44 separate houses during the landslide, although more recent estimates put the number at around 70 [23, 30].
17. On July 31, 2014, a cloudburst was reported in Tehri Garhwal district of Uttarakhand. At least 4 people were reported dead [23, 30].
18. On September 6, 2014, there was a cloudburst in the Kashmir valley killing more than 200 people. The Center for Science and Environment (CSE) mentioned heavy and unchecked development aggravated the development in the region. Over 1,84,000 people were rescued after heavy rains have a large part of the State submerged [23, 30].
19. On December 2, 2015, the city of Chennai recorded 494 mm rains eventually causing the 2015 South India floods. The floods saw 400+ casualties around Tamil Nadu [23, 30].
20. On May 8, 2016, Continuous rainfall occurred in Tharali and Karnaprayag in Chamoli district, Uttarakhand resulting in damage, but no casualties [23, 30].

21. On the night of July 5, 2017, a cloudburst was reported in Haridwar, Uttarakhand. Some local stations recorded 102 mm of rain in an hour. Surprisingly no one was killed and no significant damage occurred [23, 30].
22. On July 20, 2017, a cloudburst caused huge damage at Thathri town of Doda district killing LESS THAN 7 people [23, 30].
23. On May 4, 2018, a cloudburst occurred above Belagavi, Karnataka. Weather stations in the area reported 95mm of rain in an hour. No significant casualties or damage had occurred [23, 30].
24. On May 12, 2021, a cloudburst was reported from Tehri, Chamoli districts in Uttarakhand. No significant casualties or damage had occurred [23, 30].
25. On October 20, 2021, a downpour occurred over the town of Pethanaickenpalayam in Salem district, Tamil Nadu. This resulted in 213mm of rain in a single day. Ponds in the area filled up, as did Thennakudipalayam Lake. The Vasishtha Nadi was flooded, filling the Attur Dam with water [23, 30].

Table: 1 Record of cloud burst in India (1908 to 2017)

Year of Occurrence	Affected Area	Rate of Destruction	Source
28 September 1908	Musi River, Hyderabad	15,000 people died and around 80,000 houses were destroyed along the banks of the river.	[23, 30, 31]
July 1970	Alakananda river basin	15,000 died and 80,000 houses were destroyed along the bank of Alaknanda.	[23, 30, 31]
15 August 1997	Chirgaon in Shimla district, Himachal Pradesh	115 people were killed when a cloudburst occurred and a trail of death	[23, 30, 31]
17 August 1998	Malpa, Kali Valley of Kumaun Division	250 died including 60 Kailash Mansarovar pilgrims	[23, 30, 31]
16 July 2003	Shelagh in the Bursa area of Kullu district, Himachal Pradesh.	About 40 people were killed in flash floods caused by a cloudburst	[23, 30, 31]
24 July 2004	Badrinath Shrine, Chamoli District	17 died and 18 were missing	[23, 30, 31]
26 July 2005	Mumbai	A cloudburst caused approximately 950 millimeters (37 in) of rainfall. over a span of eight to ten hours; the deluge completely paralyzed India's largest city and	[23, 30, 31]

		financial center, leaving over 1,000 dead.	
6 July 2006	Near Badrinath Shrine, Chamoli District	17 people died and 28 injured	[23, 30, 31]
14 August 2007	Bhavi village in Ganvi, Himachal Pradesh.	52 people were confirmed dead	[23, 30, 31]
7 August 2009	Nachni near Pithoragarh District	38 people died	[23, 30, 31]
6 August 2010	Leh town of Ladakh	1,000 people dead and 400 injured	[23, 30, 31]
18 August 2010	Munisyari, Pithoragarh district	30 have died and 50 injured	[23, 30, 31]
19 August 2010	Kapkot village, Bageshwar District	18-20 have died, and more than 30 are missing	[23, 30, 31]
4 October 2010	Pashan, Pune, in Maharashtra	4 dead, many injured	[23, 30, 31]
20 July 2011	Manali town in Himachal Pradesh	2 dead and 22 missings.	[23, 30, 31]
14 September 2012	Rudraprayag, Rudraprayag District	39 people died.	[22, 23]
14-15 June 2013	Kedarnath, Rudraprayag District	10,000 have died and 7000 missing and several injured	[23, 30, 31]
31 July 2014	Tehri Garhwal district of Uttarakhand.	4 people were reported dead.	[23, 30, 31]
6 September 2014	Kashmir valley	Killing more than 200 people. Over 1, 84,000 people were rescued after heavy rains have a large part of the State submerged.	[23, 30, 31]
20 July 2017	That town of Doda district	Killing LESS THAN 7 people.	[23, 30, 31]

IMPACT OF CLOUDBURST-TRIGGERED DEBRIS FLOW AND FASH FOOD

Ecological damage

The environmental impacts of waterspout-triggered debris flows and fast food in four villages in Uttarkashi district were analyzed. The most important variables were the number of forest trees moved, total land degradation, land degradation under existing crops, number of fruit trees moved, land degradation under cropland, number of buildings damaged, the number of damaged bridges, and the volume of rocks. The forest

trees that were dislocated were pines at mid-altitudes and mixed oaks and deodars at higher elevations [32]. A total of 770 forest trees were felled in the four villages, including 500 in the village of Kankrari (the highest). The lowest dislocated trees came from the village of Siror (70). The total degradation of the soil from the areas affected by the storms to the affected areas has been massive; however, we measured the land that was in and around each village. Total land degradation was 52.5 acres with the highest in Kankrari (45 acres) and the lowest in Siror (0.5 acres). Land degradation due to existing crops was 22.6 acres in all four villages, from 0.1 acres in Siror to 20.6 acres in Kankrari. The total number of discontinued fruit trees was 486. Soil degradation under arable land was 22.6 acres. It includes the area of existing crops from both agriculture and horticulture. A total of 19 buildings were damaged while a total of 14 bridges connecting the affected villages were washed away [32].

Economic impact

The economic impact due to the torrential downpour disaster was enormous in terms of affected households, loss of human and animal life, buildings, forests, existing crops including fruits, agricultural land, and bridges (Table 4) . . The value of all these assets has been calculated in Indian Rupees (INR) at the current price. The total number of affected households was 143, of which 100 households belonged to Kankrari village (highest) and three households (lowest) belonged to Siror village. Four people died as a result of the disaster - three women from Mando village and 1 man from Kankrari village [32]. Two cows from the village of Mando died. The total damage caused by the building collapse amounted to INR 1.7 million, with the highest (INR 1.1 million) coming from Kankrari village. A total of INR 0.77 million was lost due to forest loss and the loss for existing crops was INR 3.35 million. The loss due to the relocation of fruit trees was high, amounting to about INR 0.5 million. Much of the arable land was lost worth INR 11.3 million. About 14 million INR were lost due to the collapse of the bridges. Overall, approximately INR 31.62 million was lost due to cloudburst. For each family loss due to the storm, one calamity was recorded as INR 0.22 million [32].

Impact of climate change

Several studies have shown that climate change will increase the frequency and intensity of thunderstorms in many cities around the world. In May 2021, the World Meteorological Organization found that there is about a 40% chance that the global annual average temperature will temporarily be 1.5°C above pre-industrial levels for at least one of the next five years. He added that there is a 90% chance that at least one year between 2021 and 2025 will be the hottest year on record, knocking 2016 out of the top spot. It can be seen that more showers occur in the Himalayan region since the decadal increase in temperature in the Himalayan region is greater than the overall rate of temperature increase [21].

CLOUDBURST'S PREVENTIVE MEASURES ARE:-

- Introduce better flood warning systems.

- Rebuild homes and businesses to withstand flooding.
- Construct buildings above high water mark.
- Fight against climate change.
- Increase in flood protection expenditure.
- Protect wetlands and strategically introduce trees.
- Return rivers to their natural course.
- Introduce water storage areas.
- Improvement of soil conditions.
- Install more flood defenses [33].

MECHANISM, IMPLICATION, PREVENTION, AND MITIGATION

The Uttarakhand Himalaya, characterized by its rugged, rugged and steep terrain, is ecologically fragile and vulnerable to landslides and mass movements. Debris flow and flashfloods further accelerate their intensity. Heavy rainfall (termed as cloudburst) during the monsoon season, fragile and unstable landscape, narrow valleys, and high slope gradients are the major causes of natural hazards [34]. The location of human settlements, business avenues, and governmental and nongovernmental institutions along the river valleys and fragile slopes accelerate the magnitude of hazards and convert hazards into disasters. Irrational development activities, over-human pressure on land, deforestation, and climate change are the mechanism of occurring cloudburst-triggered hazards in the Uttarakhand Himalaya, which result in heavy loss of lives and poverty, degradation of landscape – arable land and forestland, and huge damage to infrastructural facilities [34]. Preventive measures are inevitable to avoid and minimize the cloudburst-triggered natural hazards. Hazards can be prevented through the construction of settlements in suitable areas, avoiding their construction along the seasonal Nula and fragile slopes. It needs suitability mapping of the entire mountainous mainland of the state. Imparting training to the rural people for minimizing damage and preparedness are the prominent preventive measures. Further, migration measures are essential. Among the mitigation measures, deployment of trained personnel in the hazard-prone areas, proper rehabilitation of the affected people, proper distribution of medicinal facilities and food, and deployment of NDRF, ITBP, and SDRF are prominent [34].

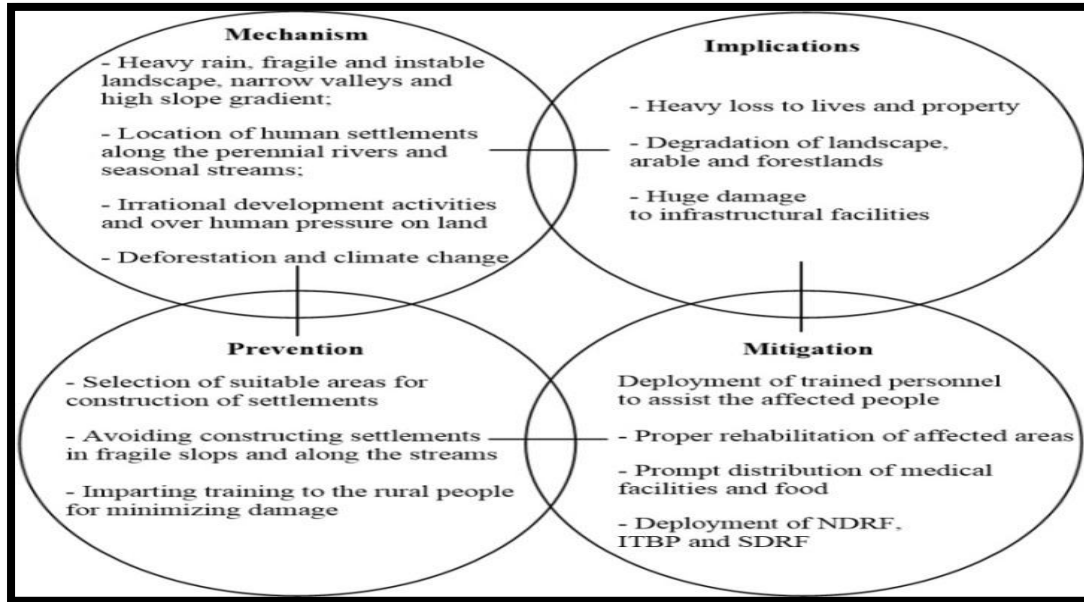


Figure: 2 Mechanism, implications, prevention, and mitigation of cloudburst triggered natural disasters in Uttarakhand

Source: [Sati, V. P. 2018]

CONCLUSION

Cloudburst is a natural disaster. Cloudburst is excessive rain accompanied by flashes of lightning. Due to excessive rainfall in one place, there is a lot of loss of life and property due to cloudburst. Cloudburst is a big problem in India. Cloudburst 2017: 7 killed in Dada district, 200 in Kashmir in 2014, 1, 84,000 in Uttarakhand, 10,000 killed, and 7000 missing in 2013. In Ladakh in 2010, 1,000 people died and 400 were injured. Cloudburst has caused damage to humans, animals, roads, the environment, and economics. To deal with cloudbursts in India, the meteorological department should give warnings in the areas of excessive rainfall. And the government should be ready to deal with this problem.

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