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Study of Natural Disaster in Manali Valley (Himachal Pradesh), India on 09 July 2023

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सार – जुलाई 2023 में लगातार भारी वर्षा के कारण, विशेष रूप से 7 से 10 जुलाई तक, हिमाचल प्रदेश में आकस्मिक बाढ़, वृष्टि विस्फोट और भूस्खलन हुआ जिस वजह से बुनियादी ढांचे और संपत्ति को भारी नुकसान पहुंचा और लोगों की जान गई। सबसे ज़्यादा प्रभावित जिले कुल्लू, मंडी, सिरमौर, शिमला, सोलन और आस-पास के इलाके थे। हिमाचल प्रदेश में स्थित मनाली उप-खंड समुद्र तल से 1074 से 4017 मीटर की ऊँचाई पर फैला हुआ है। इस क्षेत्र की जलवायु इसके पहाड़ी भूभाग से प्रभावित होती है, जबकि ब्यास घाटी का मौसम राहत, पहलू और ऊँचाई जैसे कारकों से प्रभावित होता है। पीरपंजाल रेंज की घुमावदार ढलानें मॉनसूनी हवाओं के लिए बाधा पैदा करती हैं, जिसके परिणामस्वरूप क्षेत्र में भारी वर्षा होती है और बादल फटते हैं। हिमाचल प्रदेश के शिमला स्थित भारत मौसम विज्ञान विभाग (आईएमडी) की 12 जुलाई, 2023 की रिपोर्ट में राज्य में 7 से 10 जुलाई तक सक्रिय मॉनसून की स्थिति पर प्रकाश डाला गया, जो पश्चिमी विक्षोभ (डब्ल्यूडी) के कारण और भी खराब हो गई। इस संयोजन के कारण तीव्र और अभूतपूर्व वर्षा हुई, जिससे विशेष रूप से पहाड़ी क्षेत्रों में सार्वजनिक और निजी संपत्ति को व्यापक नुकसान पहुंचा। रिपोर्ट में उल्लेख किया गया है कि भारी वर्षा, वृष्टि विस्फोट और भूस्खलन के कारण पहले भी ऐसी ही आपदाएँ हुई हैं, जो संभवतः अवैज्ञानिक निर्माण, जलवायु परिवर्तन और पर्यटन सहित बढ़ती मानवीय गतिविधियों जैसे कारकों के कारण और भी बढ़ गई हैं। रिपोर्ट में भविष्य में ऐसी आपदाओं को कम करने के लिए सटीक पूर्वानुमान और सक्रिय योजना की आवश्यकता पर जोर दिया गया है।

ABSTRACT. Continuous heavy rainfall in July 2023, particularly from the 7th to the 10th, led to devastating flash floods, cloudbursts and landslides in Himachal Pradesh, causing extensive damage to infrastructure and properties and loss of lives. The most severely affected districts were Kullu, Mandi, Sirmaur, Shimla, Solan and nearby areas. The Manali sub-division, located in Himachal Pradesh, spans an altitude range of 1074 to 4017 meters above sea level. The region's climate is shaped by its mountainous terrain, with the Beas Valley's weather influenced by factors like relief, aspect and altitude. The Pir Panjal Range's windward slopes create a barrier to monsoon winds, resulting in heavy rainfall and cloudbursts in the area. The report from the India Meteorological Department (IMD) in Shimla, Himachal Pradesh, on July 12, 2023, highlighted the active monsoon conditions in the state from 7-10 July, exacerbated by a Western Disturbance (WD). This combination led to intense and unprecedented rainfall, causing extensive damage to public and private properties, particularly in hilly regions. The report mentioned that similar disasters have occurred in the past due to heavy rainfall, cloudbursts and landslides, possibly exacerbated by factors like unscientific construction, climate change and increased human activities, including tourism. The report emphasized the need for accurate predictions and proactive planning to mitigate such disasters in the future.

Key words - Western disturbance, Pir Panjal range, Monsoon winds, Flash floods, Cloudburst.

1. Introduction

Continuous rainfall from 05-10 July 2023, with an isolated spell of extremely heavy rainfall from 07-10 July 2023 over hilly regions of Himachal Pradesh, resulted in flash floods, cloudbursts and landslides with widespread damage to infrastructure and property including loss of human lives. The most affected districts were Kullu, Mandi, Sirmaur, Shimla, Solan and adjoining areas. The destruction in the area from Nehru Kund in Manali (2003 m asl) to Aut (67 km from Manali with an altitude of 996 m asl) was unbelievable. The Major portion of National Highway No. Three hundred and five washed away. Public and Govt. vehicles were washed away. The swollen river swept away many old and new houses, hotels, restaurants, shops, bridges, *etc*. The Beas River is said to have risen so high during the recent floods that it reached the Victoria Bridge in Mandi town, which is about 30-40 meters above the riverbed and had not been flooded since 1995. The huge damage to both lives and properties in the region has left trauma in people's minds and the event has remained the country's news headline. It has been more than one year now and the rescue operations and rehabilitation in the regions by local and state authorities have continued for more than six months from the day of the event to restore habitation in that area.

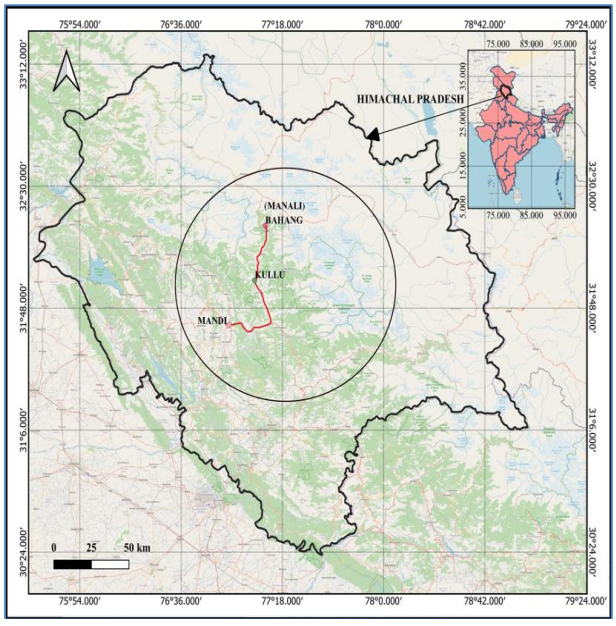

Fig. 1. India map showing the state of Himachal Pradesh and the domain of the disaster. Map not to scale.

2. Study area

India map, including the state of Himachal Pradesh and the domain of the disaster, is shown in Fig. 1. As seen from the figure, Manali subdivision is situated in the transitional zone between lesser and greater Himalayan ranges in the central part of the state of Himachal Pradesh, with an altitude varying from 1074 m to 4017 m above mean sea level. The river Beas originated from Beas Kund, having tributaries like Seri Nallah and Kangni Nallah. Pagal Nallah, Rohtang Nallah, Shanag Nallah and other small tributaries. Being a mountainous region, the climatic pattern of the Beas Valley entirely depends on the relief, aspects and altitudinal variations. It has a direct relation with climatic zonation and prevailing geomorphological processes. The orographic influence due to the windward slopes of the Pir Panjal Range acts as a barrier for the monsoon winds, providing an ideal environment for heavy rainfall and cloudbursts.

TABLE 1

Cumulative precipitation district wise (07 - 11 July 2023)

District	Actual (in mm)	Normal (in mm)
Lahaul & Spiti	124.8	21
Kullu	280.1	30.7
Bilaspur	335.9	44.5
Mandi	245.5	68.2
Shimla	268.9	35.4
Solan	472.6	52

3. Result and discussion

As per the report of Met Centre of India Meteorological Department (IMD) at Shimla, Himachal Pradesh, published on 12 July 2023, active monsoon conditions prevailed in Himachal Pradesh from 07-10 July 2023 with widespread rainfall in most parts of the state during this period (Table 1). In addition to this, a Western Disturbance (WD) affected the Western Himalaya, including Himachal Pradesh from the night of July 08, 2023. Under its influence, rainfall activity intensified and heavy to very heavy rainfall occurred in the hilly regions of Himachal Pradesh. Unprecedented rainfall occurred during these periods, resulting in widespread damage to public and private properties as discussed above. The

Figs. 2(**a to f**). Depict news outlets and field photographs of the Beas River within the Kullu district, providing a visual representation of the river's conditions and surrounding area.

details of the synoptic conditions that prevailed during the period have been discussed in the Press release Met Department Shimla (2023). The district wise cumulative rainfall from 7 to 11 July 2023 is given in Table 1 (IMD, Shimla 2023).

It is clear from the table that all the districts mentioned experienced unprecedented rainfall much higher from the normal value. The Solan district received highest rainfall of 472.6 mm against the normal value of 52 mm whereas the district Lahaul & Spiti received 124.8 mm rainfall against the normal rainfall of 21 mm during this period (07 - 11 July 2023). The rainfall in Manali was continuing since 05 July 2023. However, under the influence of active monsoon and WD, Bahang (Manali) started experiencing very heavy rainfall from 08 July 2023 night It received 100.6 mm of rainfall within 03 hours during the night hours of 08-09 July 2023. The 24-hr cumulative rainfall at Bahang (Manali) station from 05-11 July 2023 is given below in Table 2 (source DRDO: DGRE Manali). The rainfall brought havoc in and around the area of Manali as witnessed below in Figs. 2 (a - f). As seen from Figs. 2 (a & c), a high amount of water flow lead to landslide, which broke the Manali-Leh highway (source: DD News Himachal & Amar Ujala). Flash floods brought large debris, which piled up on the road, as seen from Figs. 2 (d & e). Figs. 2 (b & f) indicate the human lives affected by the disaster. (Source: Various News media and personnel photography.)

TABLE 2

24-hr cumulative precipitation in Bahang (Manali). The rainfall record is from evening 1730 hrs (IST) to the next day, evening 1730hrs (IST).

Date	Precipitation (mm)
05 - 06 July 2023	15.4
06 - 07 July 2023	10.6
07 - 08 July 2023	12.0
08 - 09 July 2023	133.0
09 - 10 July 2023	129.8
10 - 11 July 2023	38.2

TABLE 3

Past disaster events and affected area around Manali in last 35 years

Date	Events	Region affected	Loss
03-Oct-1988	Massive Flash Flood	Himachal Pradesh.	Huge loss of lives and properties
07-July-1993	Flash flood	Kullu valley	Great loss to the public and govt. properties
4-5 Sep-1995	Massive flash flood	Entire area from Palchan to Mandi	Tremendous loss of lives and properties, including property of DRDO Lab (SASE)
22-Aug-2001	Heavy flood	Pagal Nallah and Seri Nallah near Beas Kund	Hundreds of vehicles were stranded on the Manali - Leh NH at Bahang (3.5 km from Manali town). Huge loss to properties
07-08 August 2003	Cloudburst during the night at 2325 hours at Kagni Nallah (Manali South Portal - 3 avalanche site) near Solang	Makeshift Campus of laborers working on the construction of a road up to the Rohtang Tunnel	About 60 laborers were washed away. Eighteen got injured. Huge loss of machinery of the Boarder Road Organization
17-March-2008	Rock falls at around 1745 hours	Nehru Kund, Manali	Six persons were killed, 08 reported injured, and many were found missing. Damaged numerous vehicles and about 500m stretch of road was washed away.
20-21 July-2011	cloud burst at Pagal Nallah (MSP-07 avalanche site) on the intervening night of 20-21 July	Phindri Nalah near the South Portal of Rohtang Tunnel.	2 people were killed and 22 were injured.
26-July-2017	Cloudburst	Near Dhundi	Two places MSP-03 and MSP-07 has been affected and the connecting road to the Rohatang tunnel has been damaged
23-Sep-2018	Flash Flood	Manali	Swept away the major portion of the road from Bahang to Manali, Petrol pump, shops, houses and Volvo bus-stand
12-13 July-2020	Cloudburst in Kanyal Nalah near Manali town	Kanyal Village near Manali town	Roads were damaged. However, no loss of life was reported
20-Sep-2021	Cloudburst	Dhundi as well as at Burua village near Manali town	Washed away the road between Solang and Dhundi. Several houses, roads, standing crops and orchards were damaged in Majhach and Burua village. However, no loss of life was reported
25-July 2022	cloudburst and flash flood	Seri Nallah near the South Portal of Rohtang Tunnel as well as from other Nallahs	Loss of lives and damage to properties near Solang village

Figs. 2 (d & e). Figs. 2 (b & f) indicate the human lives affected by the disaster. (Source: Various News media and personnel photography.)

The precipitation brought havoc in the region, with swollen Beas entering the habitat areas and washing away everything on its path. A district wise weather warning was issued well in advance by IMD Shimla and Red Alert was issued to several districts on 08 July 2023, including Kullu, Mandi and Shimla. Press releases were issued, and a warning was uploaded to NDMA SACHET platform according to the IMD report of 12 July 2023.

From the digital records available in the Defence Geoinformatics Research Establishment (DGRE), previously known as Snow and Avalanche Study Establishment (SASE), one of the laboratories of the Ministry of Defence, the Government of India. It was found that the region had not witnessed this type of disaster for the first time. Similar types of events have already happened in the past as shown in Table 3. Several extreme weather events such as very heavy rainfall, cloudbursts and associated landslides, have occurred in the state at regular intervals with increased frequency during the past two decades. A few of the past major natural hazards are given below.

The plausible causes for these types of disasters in the area recently and in the past are heavy terrestrial rainfall and cloudbursts. However, scientists and researchers also blame the unscientific construction of private properties, highways, tunnels and hydro projects. Unscientific construction refers to civil constructions such as houses, hotels, resorts and shops being built in an unplanned manner without adhering to the rules and regulations set forth by organizations like the Boarder Road Organisation (BRO), the National Highway Authority of India (NHAI) and the National and State Disaster Management Authority (NDMA - SDMA) which have formulated several Systematic Procedures (SOP) for constructions in mountainous regions. (NDMP Report - 2016, IRC Report - 2018**).** Additionally, the effects of climate change and increased anthropogenic activities, especially heavy traffic during the tourist season in this area, cannot be denied as contributors to such massive destruction (Shah *et al*., 2007; Sangeeta & Singh 2023). Deforestation/decrease in the dense forest area in and around Manali has adversely affected the temperature in the region (Kuniyal *et al*., 2003; Pandit *et. al*., 2014). The annual mean temperature of Himachal Pradesh during 2022 was 1.2 °C warmer than its long-period average for the period 1981-2010 (IMD Pune). The debris/muck after cutting the roads, National Highways and tunnels has narrowed the river's path. The hydropower proliferation has brought rapid land-use changes, adversely affecting local terrestrial ecosystems and communities inhabiting there. The grinding of hills/mountains and the use of big machinery in such a fragile environment have altered the ecological balance. Discussion of policy issues is beyond the scope of this report. However, precise predictions of these types of events in the future will help the authorities mitigate the disaster by planning well in advance

3. Conclusion

The recent disaster of July 09, 2023, in Manali and its nearby area has been reported. The disaster, caused by unprecedented rainfall, resulted in extensive loss of infrastructure, properties and human lives. The widespread rainfall since the last 5 days of the occurrence of the disaster, as well as rainfall two days ahead of the event, caused floods, road damage and blockages for several months in those areas. As per the India Meteorological Department, active monsoon conditions in Himachal Pradesh from 7-10 July 2023 caused widespread rainfall in most parts of the state. A Western Disturbance from the night of July 09, 2023, intensified the rainfall activity from heavy to very heavy, resulting in widespread damage to public and private properties. Proper numerical modelling of the event will help in studying the dynamics associated with this type of event as well as accurate predictions of the event in future. This will lead the authority to plan the proper mitigation methods in future to avoid causalities and the loss of properties associated with this type of event.

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