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HIGH-MOUNTAIN HAZARDS IN THE INDIAN HIMALAYA: AN ASSESSMENT OF THE CAUSES AND EFFECTS OF THE CHAMOLI FLOOD IN 2021

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INTRODUCTION

On 7 February 2021, a devastating flood struck the river valleys of the Ronti Gad, Dhauliganga and Rishiganga in India's northwestern State of Uttarakhand. The flood was caused by a bedrock failure on the north flank of Ronti Peak (30.37570° N, 79.37570°E) which generated an ice rock avalanche. More than 200 people lost their lives and severe damage to infrastructure occurred. As a result, the disaster sparked further discussion about the debates of hydropower projects and early warning systems in fragile mountain systems. The purpose of this study was to analyse the causes and effects of the Chamoli flood using basic remote sensing techniques, climate analysis and qualitative assessments. A better understanding of high-mountain hazards in glaciated areas and significant threats posed to vulnerable communities downstream was established.

METHODS

Satellite images from Planet© were assessed to identify the ice rock avalanche detachment location and assess the flood impacts. Further, temperature and precipitation data from NASA GISS and IndiaWRIS were used to analyse any climate variabilities. Using two 2-m resolution DEMs from Shean et al (2021), a DEM of Difference map was created using ArcGIS Pro to evaluate the detachment volume with the following equation: .

$$v = (DEM_{2015} - DEM_{2021}) \times 4$$

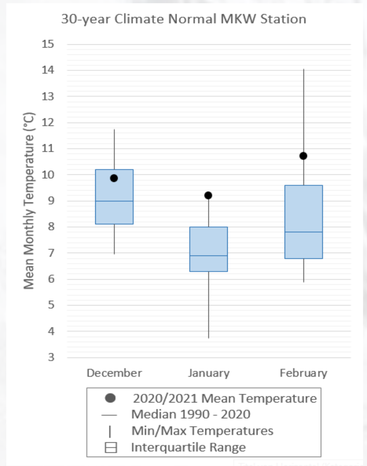

Figure 1. 30-year Climate Normal MSK Station.

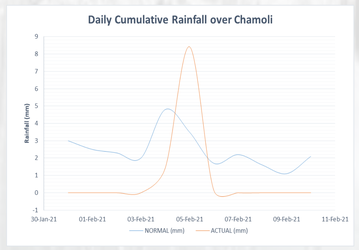

Figure 2. Daily Cumulative Rainfall over Chamoli District (India WRIS, 2021).

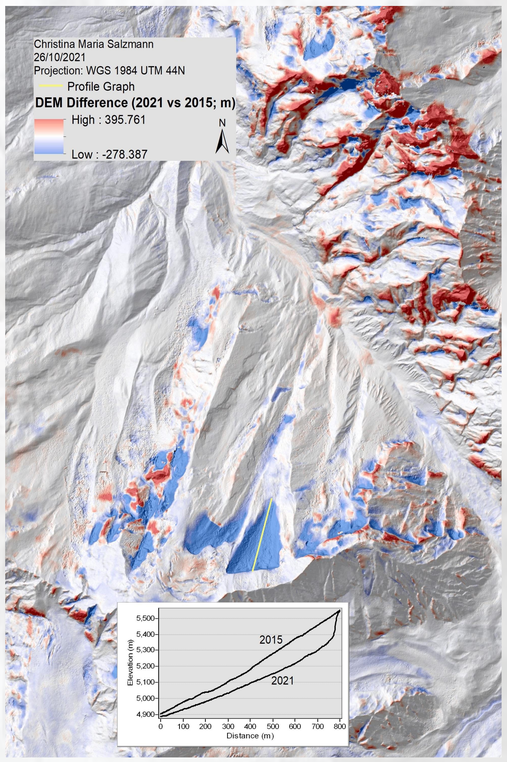

Figure 3. DoD Map (2015 – 2021) Visualizing Surface Changes in Ronti Gad Valley.

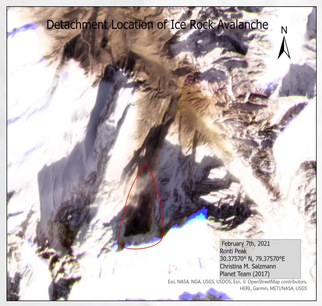

Figure 4. Showing the Ice Rock Avalanche Detachment on 7 February 2021.

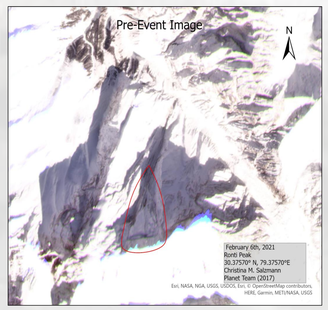

Figure 5. Showing the Hanging Glacier on 6 February before the Detachment.

DISCUSSION

The assessment of satellite images proved the media's misleading initial conclusions of a glacial lake outburst flood (GLOF) wrong and visually indicated the ice rock avalanche on Ronti Peak as the cause of the flood. The DEM differencing (Figure 3) analysis revealed a total ice rock avalanche detachment volume of 26.2 Mm^3, and the profile graph concluded an estimated area of collapse with a length of 610 m, 800 m width and 150 m depth. Temperature analyses have shown that January 2021 was one of the warmest on record (Figure 1). There was no major precipitation event on the day of the disaster, but a few days earlier, a western disturbance brought widespread rain over the district of Chamoli (Figure 2). The warm month of January and the precipitation event prior the disaster could have been potential triggers of the bedrock detachment and ice rock avalanche. However, frictional heating and liquefaction of the snow and ice was generated through the two thousand meter fall and contributed to the majority of the flood water (Shugar et al., 2021).

The disastrous event highlights the need for active strategies and open communications in hydropower developments to ensure public safety and sustainable energy production in the Himalayas. The majority of fatalities occurred in the tunnels and at the construction sites of the Tapovan and Rishiganga Hydropower projects. No early warning systems were in place that could have warned the people. A few extra minutes could have saved lives.

CONCLUSIONS

The bedrock failure on Ronti Peak caused the detachment of the hanging glacier, releasing a cascade of events that led to devastating effects downstream. The frequency and magnitude of natural hazards in the Indian Himalaya will most likely increase in the upcoming decades in response, but not limited to weather patterns, environmental degradation and population growth. With the assistance of appropriate technologies, interdisciplinary work and collaboration, like those in this study, some of the impacts of high-mountain hazards can be mitigated and decreased.

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