

Quarterly Progress Report

Long-Term Monitoring of Gangotri Glacier, Garhwal Himalaya

(January – March 2025)

by

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Background

The Himalayan Mountain Range is home to thousands of glaciers, varying in size and characteristics, covering an area of 37,000 km² and stretching 2,400 km from east to west. According to the glacier inventory conducted by the Geological Survey of India, there are 9,575 glaciers in the Indian Himalayan Region (IHR). Glaciers are widely recognized as key indicators of climate change, and recent observations show a decline in snow accumulation and an increase in ablation across the Himalaya.

Despite the importance of monitoring these glaciers, there are only a limited number of ground-based studies in the region. To address this gap, the Department of Science and Technology (DST) has entrusted the Wadia Institute of Himalayan Geology (WIHG), Dehra Dun, with the task of monitoring Himalayan glaciers. Currently, the Uttarakhand State Disaster Management Authority (USDMA) has sponsored a project titled *"Long-term Monitoring of Gangotri Glacier, Garhwal Himalaya"* which was assigned to WIHG in December 2021, with funding allocated in March 2022.

The approved objectives of the project are the following:

- Mapping and monitoring of the Gangotri group of glaciers.
- Mapping and monitoring of glacial lakes in the Gangotri group of glaciers.
- Monitoring of meteorological (temperature, rainfall and snowfall) and hydrological (water level/discharge and sediment transfer) parameters throughout the year and identification of extreme events.
- Risk assessment of glacial hazards (GLOF, debris flow, flash floods, etc.) using an integrated approach i.e. meteorological, hydrological, seismological and satellite data.
- Dissemination of information to the local administration with regard to any emanating threat from the glacial hazards.

The following outputs were produced from January to March 2025 to meet the objectives of the mentioned project.

The two (02) watch and wards stationed at Bhojwasa to monitor ongoing activities, oversee the instruments, and maintain the base camp. They regularly check the instruments installed in October/November 2023 to ensure they are performing well. Additionally, permission from the Forest Department was obtained in advance for the watch and wards to operate during the winter season of 2024-2025. From January to February 2025, field activities in the Gangotri glacier region were limited due to harsh winter conditions and heavy snowfall.

Significant snowfall occurred from January through mid-March, making access to high-altitude areas such as Bhojwasa extremely challenging. As a result, the project team operated from lower elevations during this period. The Broadband seismic station at Maneri Dam continued to function normally throughout January. At the end of December 2024, the watch and wards team conducted a visit to the base camp and glacier snout region. They confirmed that the Bhagirathi River was flowing in its original course, with no unusual activity observed near the snout.



Figure 1. The base camp of Wadia Institute of Himalayan Geology at Bhojwasa during winter 2025, showing the significant snow cover persisting in the basin.



Figure 3. (A) Snow-covered view of Bhojwasa during March 2025; (B) The hut and base camp, fully covered in snow; (C) The observatory at the base camp, equipped with an Automatic Weather Station and Broadband Seismic Station at Bhojwasa; and (D) the Automatic Weather Station at Chirwasa.

In mid-March 2025, despite persistent snow cover and difficult terrain, the project team successfully reached Bhojwasa. During this visit, they inspected the instruments installed at both Bhojwasa and Chirwasa and confirmed that all systems were functional (**Figure 1**). However, no data were retrieved at that time. The team is scheduled to return in early April 2025 to begin manual data collection and conduct maintenance of the base camp.

Using remote sensing data, the satellite image illustrates the extent of the debris flow event that occurred in July 2017, with the debris spreading downstream from its source near the Meru Glacier. The image also highlights the current condition of the Raktavan Glacier, which, as of 2024, is completely detached from the main trunk of the Gangotri Glacier (**Figure 2**).

In addition, a team assessed the glacier's condition using remote sensing data and found that the water level of the Bhagirathi River is notably very low as winter sets in. Since the 2017 debris event, significant new debris has accumulated around the glacier's snout. This fresh debris has altered the course of the existing channel from Raktavan, which now merges directly with the Bhagirathi near the glacier's snout (**Figure 2**).



Figure 2. Satellite image depicting the debris flow event that occurred in July 2017, showing the downstream spread of debris originating from the Meru Glacier.

During the winter months of January to March 2025, snow cover in the Gangotri region was monitored at multiple intervals to assess seasonal variation and the extent of snow accumulation. The observations reveal notable fluctuations in snow cover throughout the period, influenced by prevailing weather conditions and episodic snowfall events.

In January 2025, snow cover remained relatively high, with values ranging between 54% and 74%. On **10th January**, the snow cover was recorded at 68%, increasing to a peak of 74% by **15th January**. This was followed by a gradual decline to 63% on **25th January** and 54% by the end of the month on **30th January**. The initial increase in coverage likely corresponds to

early January snowfall events, while the subsequent decrease suggests minor melting or settling of snow. February 2025 showed greater variability. Snow cover on **9th February** was recorded at 66%, but it dropped sharply to 49% by **14th February**, indicating a brief period of warmer conditions or reduced precipitation.

However, a significant increase followed in the latter half of the month, with snow cover rising to 74% on **19th February** and reaching 80% by **24th February**. This sharp rise suggests renewed snowfall activity in the region. March 2025 marked the highest snow accumulation during the observation period. Snow cover reached 86% on **21st March**, the peak value for the season.

Although a slight reduction to 74% was recorded by **31st March**, the overall snow presence remained substantial. This persistent and heavy snow accumulation during March aligns with reported field challenges faced by the project team, particularly in accessing higher-elevation locations such as Bhojwasa.

Overall, the data indicate consistent snow presence with episodic increases, reflecting active winter precipitation patterns. The high snow cover observed in late February and March would have a significant impact on glacier surface energy balance, melt timing, and spring runoff into the Bhagirathi River. These observations underscore the importance of continuous snow monitoring to better understand seasonal dynamics in the upper Himalayan catchments.

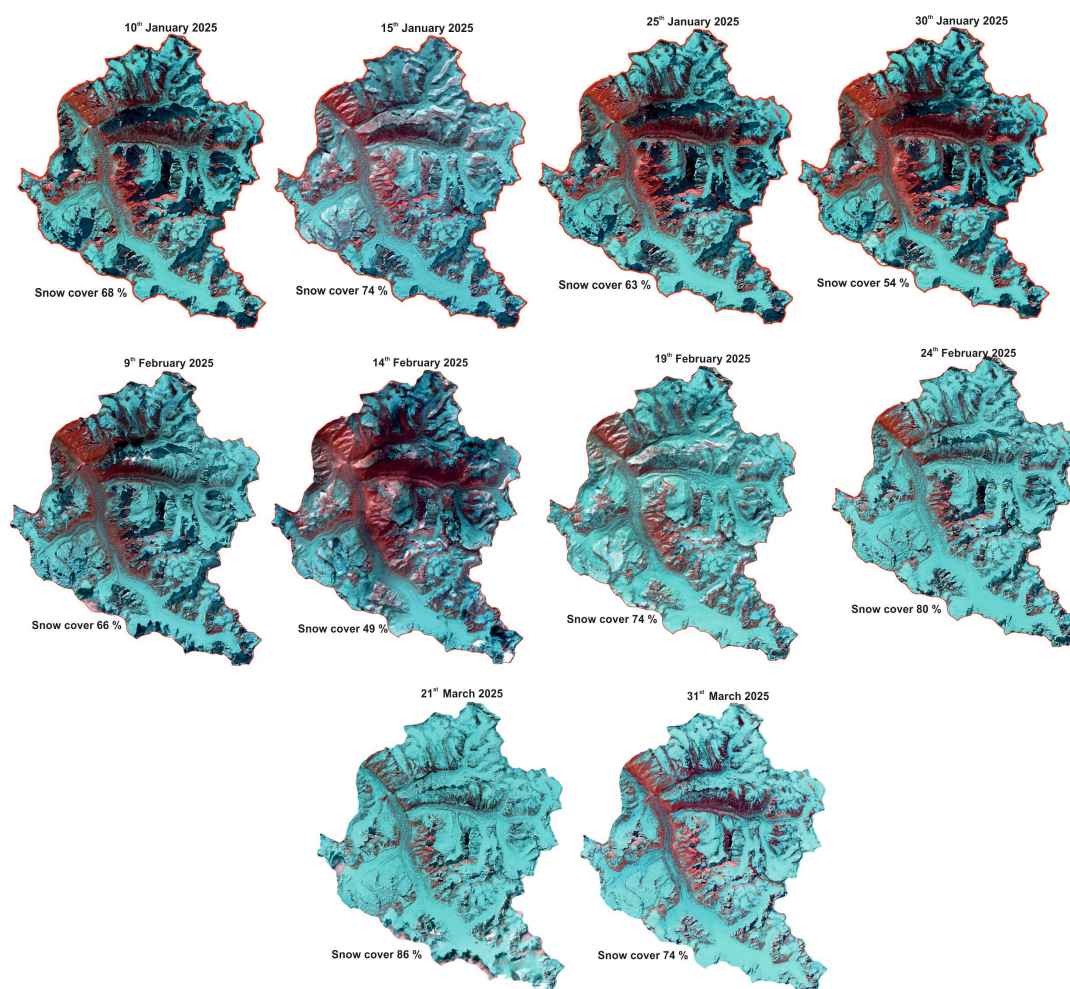


Figure 4: Satellite images showing the distribution of seasonal snow cover-up to Bhojwasa in Gangotri Glacier basin from January to March 2025.

At the end of March 2025, the progress of the project was presented to the Uttarakhand State Disaster Management Authority (USDMA). Following the review, the authority approved a six-month extension along with the release of additional grant funding to support the completion of the remaining project activities. As part of this extension, it was decided that WIHG would purchase and install a new Automatic Water Level Recorder to replace the one lost during a previous flood event.

The installation of this new instrument is essential for establishing V-SAT connectivity, which is required for real-time data acquisition. However, the tender process for V-SAT connectivity is currently on hold until the new Water Level Recorder is in place. Additionally, the procurement of high-resolution satellite data for the project is ongoing. To successfully complete all planned objectives, the project will require an extension of one more field season, particularly to accommodate the installation and integration of the new instrumentation.

All the scientific instruments installed in the region including the Automatic Weather Stations at Bhojwasa and Chirwasa, as well as the Broadband Seismic Stations at Bhojwasa and Maneri Dam, remained fully functional throughout the winter of 2024–2025. Despite the region experiencing significant snowfall during this period, no operational issues were reported. Also, no formation of major glacial lakes was detected near the Gomukh area during the winter season.