Progress Report

Long-Term Monitoring of Gangotri Glacier, Garhwal Himalaya

(April – June 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 April to June 2025 to meet the objectives of the mentioned project.

- Following the project extension from its initial duration, all monitoring activities resumed in the Gangotri Glacier region from April 2025. Significant snowfall during January to mid-March 2025 had restricted access to Gomukh, and the project team visited the snout during late May 2025.
- All necessary permissions to visit the Gangotri Glacier region were obtained from the forest authorities. Since March 2025, the project has been without project staff as both have resigned. The recruitment process was initiated to appoint one Project Scientist and one Project Assistant, of which only one Project Assistant has joined so far. The one position of Project Scientist is still vacant and it will be filled with the eligible candidate.
- Two (02) Watch and Ward were stationed from April 2025 onwards at Bhojwasa to monitor day-to-day activities at the base camp, oversee the instruments, and ensure its safety. They regularly checked the instruments to confirm their proper functioning at Maneri, Chirbasa and Bhojwasa.

- Tenders for the purchase of satellite data and an Automatic Water Level Recorder, as well as for fencing work, have been prepared and will be floated once the third grant is received. The production of a documentary film is planned separately.
- During the several visits conducted between April and June 2025, the project staff confirmed that the Bhagirathi River continued to flow in its original course, with no unusual activity observed near the Gangotri Glacier snout **(Figure 1a)**. The Gomukh region and the base camp at Bhojbasa were found to be free from seasonal snow cover in late April and May **(Figure 1b)**.

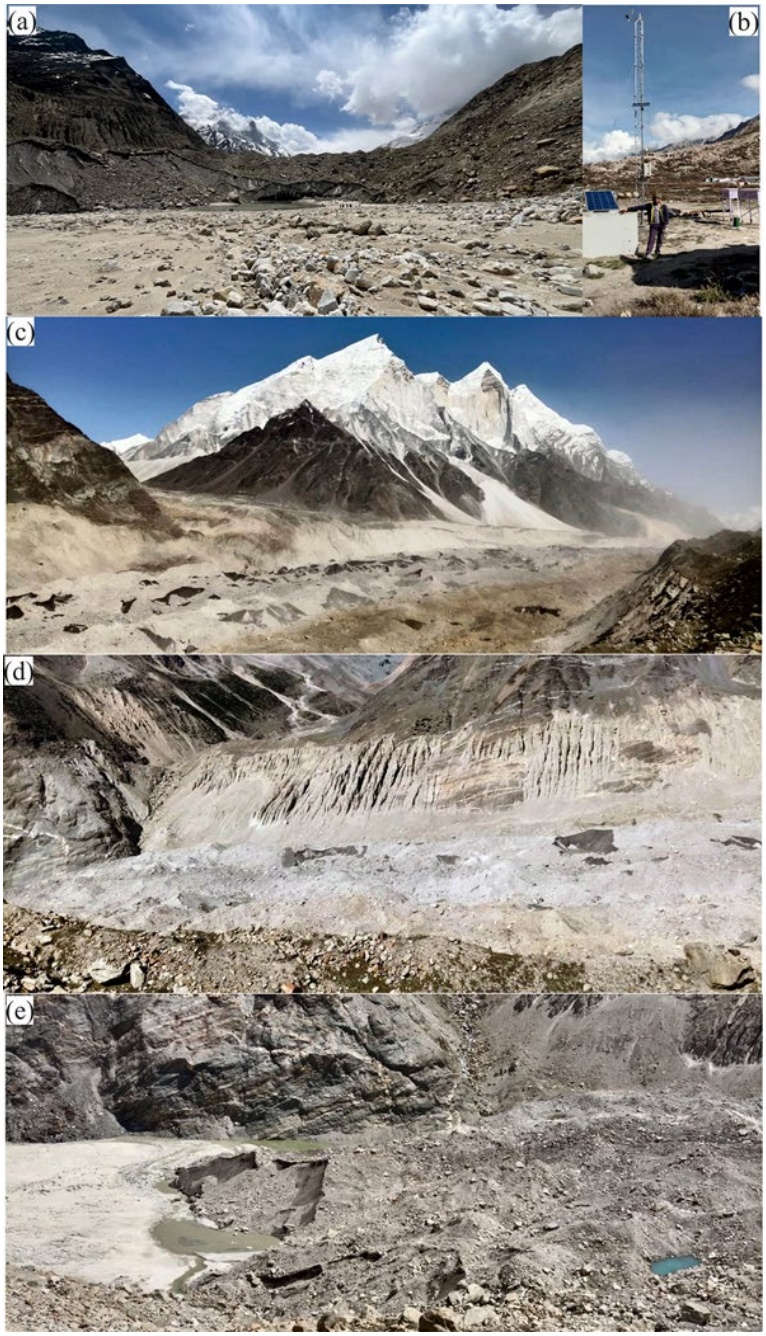

Figure 1. Illustrating: (a) the (Gomukh) snout, (b) the base camp at Bhojwasa with field instruments, (c) thick supraglacial debris cover over the ablation zone, and (d) the meltwater stream emerging from the Raktavan Glacier.

The team also visited the area above Gangotri Glacier region to observe the development of any lakes over the Glacier, known as supraglacial lakes **(Figure 1c)**. It was found that several small lakes have developed due to the melting of the Gangotri Glacier, which itself is extensively surrounded by the thick debris. The formation of these supraglacial lakes reflects the ongoing melting processes on the debris-covered surface of the glacier **(Figure 1d)**.

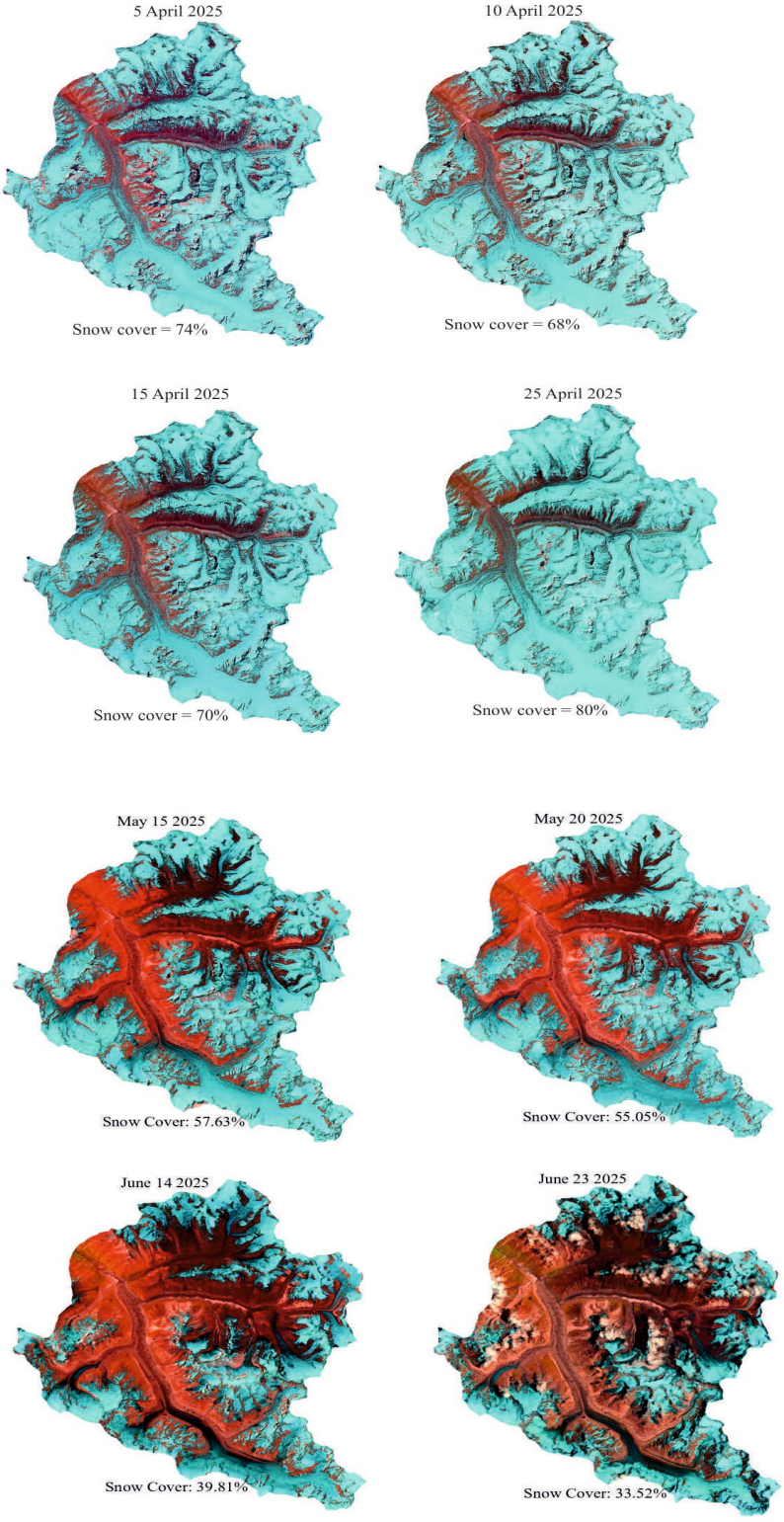

Figure 2. Snow-covered distribution in the Gangotri Glacier basin at the onset of the summer season, derived up to Bhojwasa, where the Automatic Water Level Recorder (AWLR) is installed.

As observed earlier, the meltwater stream from the Raktavarn Glacier was flowing freely and merging with the main Bhagirathi stream, contributing directly to the river system, as it was connected with the main trunk of the Gangotri Glacier when the project was formulated. In an earlier visit in December 2024, the team had also confirmed normal river flow and the absence of abnormal activity near the snout **(Figure 1d)**.

- The broadband seismic station at Maneri Dam functioned normally throughout June 2025, while the field instruments at Bhojbasa and Chirbasa were also found to be working well. The integrated module for real-time data transfer from Maneri through the broadband seismic station was tendered, procured, and delivered to WIHG. This module will be installed during the next field visit as the project staff have now rejoined and will be deployed shortly.
- To confirm the extent of snow in the basin, field observations were complemented by satellite-based analysis. The analysis of Sentinel-2 satellite data over the Gangotri Glacier during April 2025 onwards reveals significant variability in snow cover, influenced by both seasonal patterns and regional meteorological conditions typical of the central Himalayan basin. In the Gangotri glacier basin, the snow cover during April 2025 showed notable fluctuations. On 5 April, the basin recorded about 74% snow cover, which decreased to 68% by 10 April, reflecting the onset of seasonal melting with rising temperatures. Interestingly, a slight increase was observed on 15 April (70%), followed by a more significant rise to 80% on 25 April. This unusual increase in late April can be attributed to fresh snowfall events at higher elevations, which temporarily replenished the snowpack despite ongoing ablation processes. From May onwards, a consistent reduction in snow cover was observed, driven by higher pre-monsoon temperatures and enhanced melting. On 15 May, the snow cover reduced sharply to 58% and further declined to 55% by 20 May. This downward trend continued into June, with snow cover decreasing to 40% on 14 June and reaching just 33% by 23 June **(Figure 2)**.
- Overall, the pattern indicates that while late-season snowfall events in April briefly increased snow cover, the dominant process through May and June was ablation, leading to rapid depletion of the seasonal snowpack. This progressive melting is likely to have contributed significantly to river discharge in the Bhagirathi Basin during the pre-monsoon period.

All the scientific instruments installed in the region, including the Automatic Weather Stations at Bhojwasa and Chirbasa, as well as the Broadband Seismic Stations at Bhojwasa and Maneri Dam, have remained fully functional to date, with no operational issues reported. Field visits conducted between April and June 2025, supplemented by satellite imagery, revealed no fresh evidence of debris flow activity in the vicinity of the Gomukh region. Furthermore, no major glacial lake formation was detected near Gomukh at the onset of the summer season, although a few small supraglacial lakes were observed over the ablation zone of the Gangotri Glacier.