

Progress Report

Long-Term Monitoring of Gangotri Glacier, Garhwal Himalaya

(July – September 2024)

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 July to September 2024 to meet the objectives of the mentioned project.

- The elevation-wise distribution map of the Bhagirathi basin showing the location of instruments or observatories in the year 2023 was prepared. The first step is data acquisition, including remote sensing imagery, digital elevation models (DEMs), and precise geographical locations of each instrument, typically gathered from GPS coordinates during several field visits. Therefore, data is prepared, and the ASTER DEM is processed to create distinct elevation bands. Each instrument location is overlaid suggesting the categorization of instruments by elevation zones. The result is a visual representation of instrument distribution across different elevation ranges, with color coding or symbols differentiating each zone is given in **Figure 1**. This final elevation-wise distribution map provides a comprehensive view of instrument placements highlighting areas of concentrated observation or potential data gaps.
- In the first week of August, continuous rainfall combined with glacier-related activities may have contributed to a flash flood event in the region. As informed by our watch and ward staff, on 4th August 2024, due to an unusually high discharge and sediment in

the river, our Automatic Water Level Recorder (AWLR) was washed away (**Figure 2**). Despite efforts by the staff to retrieve the instrument, they were unsuccessful due to the high water and sediment in the river.

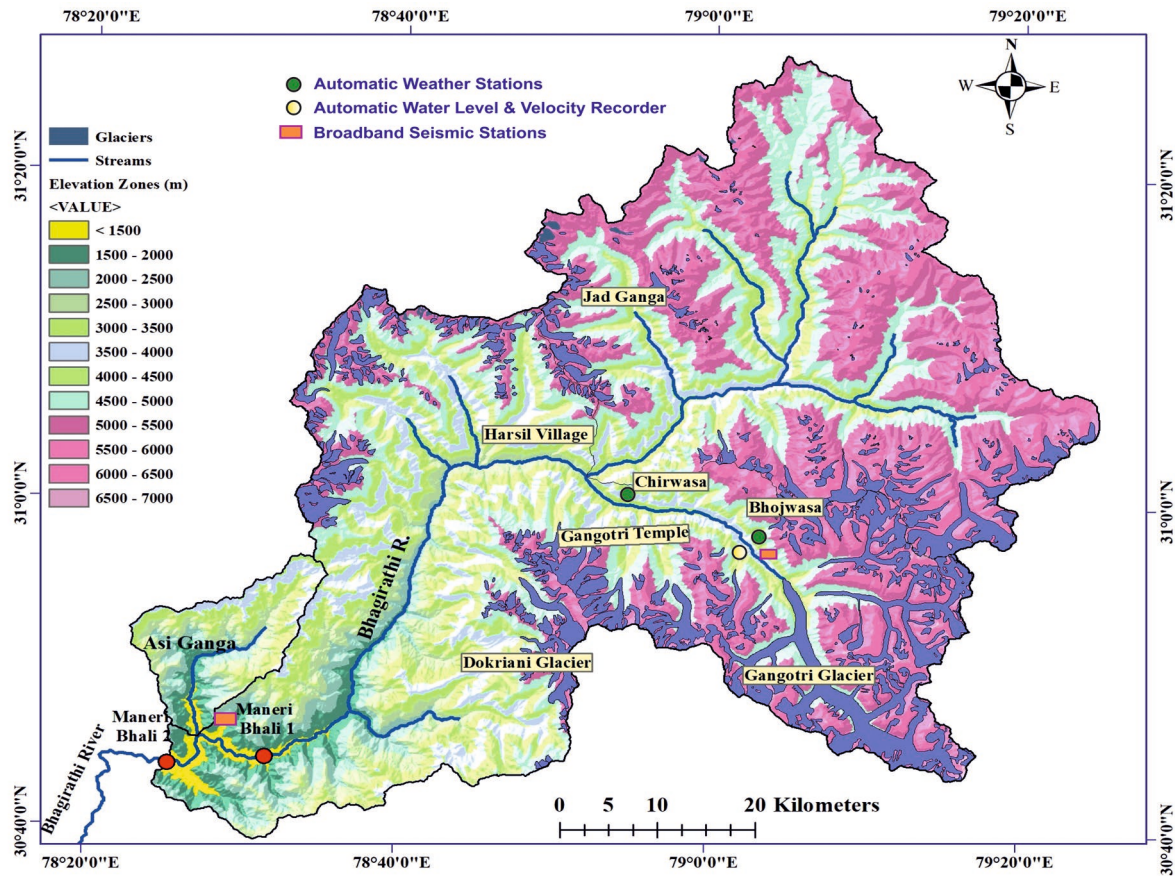


Figure 1: Showing the elevation-wise distribution of the Bhagirathi basin and the location of the Automatic Weather Station, Automatic Weather Station, and Broadband Seismic Stations, installed in November 2023.



Figure 2: Location of the Automatic Water Level Recorder during the pre-and post-flood events in Bhojwasa.

- A team from the WIHG visited the Gangotri Glacier in September 2024 to assess and understand the causes of the event. During their visit, the team collected meteorological data from the Automatic Weather Stations (AWS) at Bhojwasa and Chirbasa, as well as seismic data from the broadband seismic stations at Bhojwasa and Maneri Dam (**Figure 1 & 3**).

- Additionally, a team assessed the condition of the glacier's snout. During July and August, the discharge of the Bhagirathi River is notably high. Since the debris event in 2017, significant new debris has accumulated around the glacier's snout, impacting the local hydrology after August 2024. The existing channel from Raktavan, which merges directly with the Bhagirathi near the glacier's snout, has altered its course due to this fresh debris accumulation. This incident has significantly impacted our ongoing data collection and monitoring activities. To restore operations, manual observations have been initiated to monitor the water level at Bhojwasa.
- The two (02) watch and ward staff stationed at Bhojwasa are tasked with monitoring ongoing research activities, overseeing the instruments, and maintaining the base camp. The instruments installed in October/November 2023 have been performing well, with regular checks ensuring their proper functioning. In September 2024, a manual observatory was transported and established to collect various meteorological parameters, including rainfall and temperature data, as shown in **Figure 3**. To safeguard the sensitive instruments at Bhojwasa and Chirbasa from potential damage by tourists and visitors, plans for installing protective fencing are underway. Tenders for the fencing are scheduled to be issued shortly.

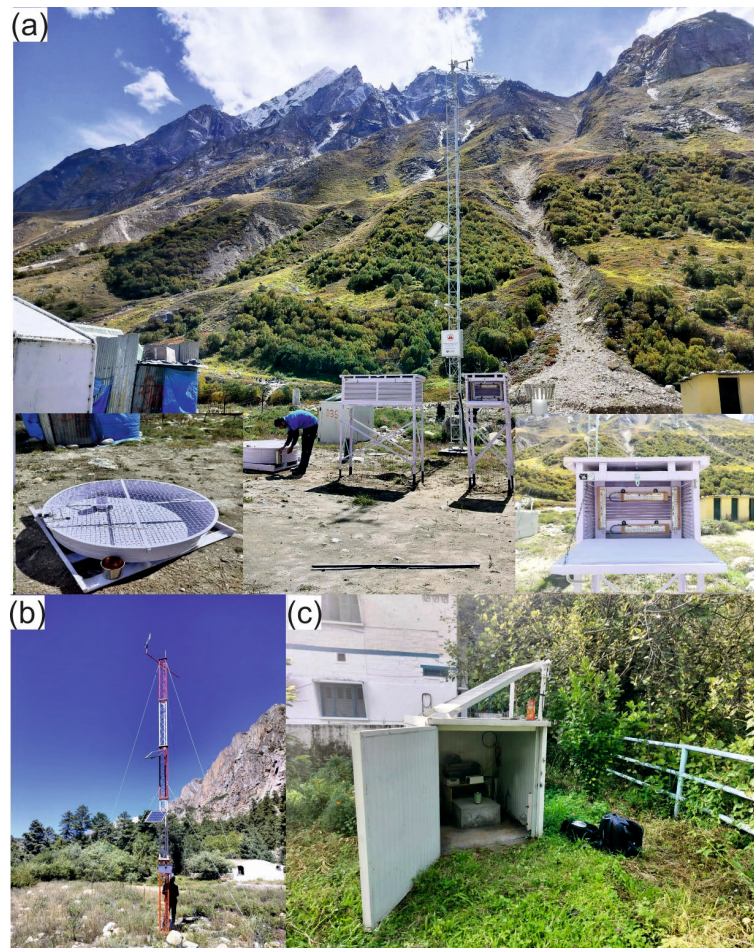


Figure 3: (a) Photograph showing the observatory at the base camp, equipped with an Automatic Weather Station, Broadband Seismic Station, and manual instruments such as maximum-minimum thermometers, an ordinary rain gauge, and a pan evaporimeter installed in September 2024. (b, c) The Automatic Weather Station at Chirbasa and the Broadband Seismic Station at Maneri.

- Furthermore, a formal request for permission to set up temporary fencing at these sites will be submitted to the Uttarakhand State Disaster Management Authority (USDMA) for approval from the district administration having provision for the USDMA to coordinate instructions and support from their end.
- On 30th July, observations showed that the glacier basin was 45% covered with snow up to the base camp. By 27th August, this coverage had increased to 53%, marking an 8% rise in just 32 days. It further increased to 81% by 24th September 2024, indicating an additional 28% rise over the next 24 days (**Figure 4**). This snow cover increase over a short timeframe suggests a snowfall event at higher elevations, likely driven by low temperatures and continuous rainfall during this period.

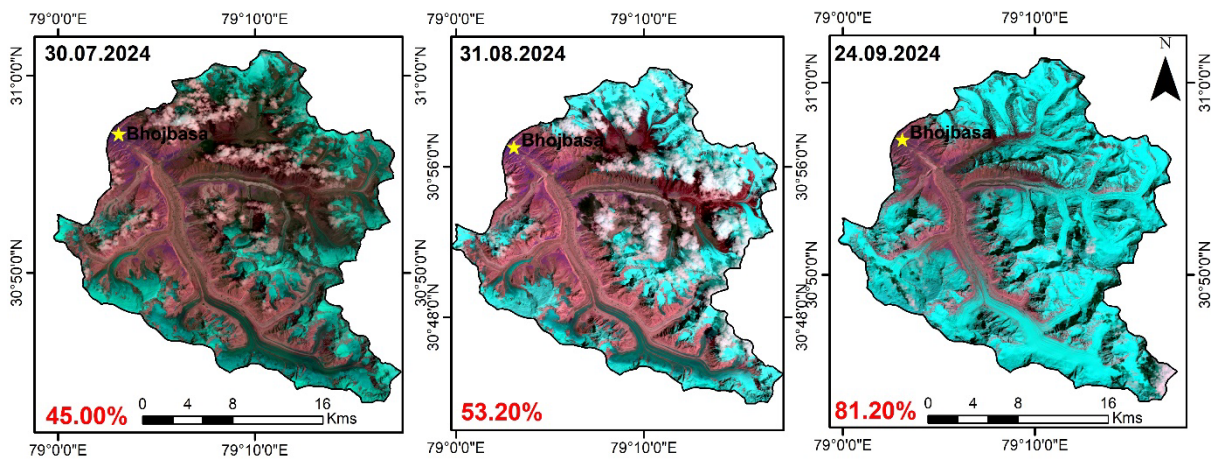


Figure 4: Satellite images showing the distribution of seasonal snow cover-up to Bhojbasa in Gangotri Glacier basin from July to September 2024. Landsat imageries were used to monitor these changes.

- At the end of September 2024, the project's progress was presented to the USDMA, and the authority decided that a proposal for the new Automatic Water Level Recorder could be submitted by WIHG, following the loss of the previous one during the flood (**Figure 2**). As a result, the tender for the VSAT connectivity required for real-time data acquisition is currently on hold. Additionally, the procurement of high-resolution satellite data for the project is in progress.
- Additionally, the project requires an extension of one season to complete its work, as a new Automatic Water Level Recorder will be installed in the region to enable the establishment of VSAT connectivity for the instrument.

Field visits and satellite observations revealed signs of recent debris flow and considerable sediment transfer downstream, but no formation of major glacial lakes near the Gomukh. These events indicate landscape changes that could impact regional stability, posing potential risks to downstream areas.