

Progress Report
Long-Term Monitoring of Gangotri Glacier, Garhwal Himalaya
(April- June 2023)

By

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Long-Term Monitoring of Gangotri Glacier, Garhwal Himalaya

Background

The Himalayan Mountain Range contains thousands of glaciers of varying properties, which are spread over 37000 km² and a stretch of 2400 km from East to West. The glacier inventory by the Geological Survey of India indicates there are 9575 glaciers in the Indian Himalayan Region (IHR). It is a well-established fact that changes in the glaciers are a key indicator of climate change; recent observation shows that snow accumulation is reducing while the ablation is increasing in the Himalaya. However, there are only a handful of ground-based studies on Himalayan glaciers. Therefore, the Department of Science and Technology (DST) has given the Wadia Institute of Himalayan Geology (WIHG), Dehradun the mandate to monitor Himalayan Glaciers. Presently, Uttarakhand State Disaster Management Authority (USDMA) has sponsored a project entitled “Long-term monitoring of Gangotri Glacier, Garhwal Himalaya” to WIHG (Letter no. 1765/XVIII-B-1/21-12(5)/2021 dated 21.12.2021) for which the funds were 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.

WIHG has made the following progress in the USDMA project from **April to June 2023-**

1. The two (02) **watch and wards** under the project have been appointed again for the duration of **April 2023 to March 2024**. At present, the watch and wards are stationed at Bhojwasa for the reporting of any unusual activity in the region.
2. Purchase orders of the two (02) **Automatic Weather Stations** have been placed to qualified firms for delivery and will be installed after the monsoon probably in September 2023. The tender for the purchase of two (02) **Broadband Seismometers** has been opened successfully through the GeM portal.
3. The procurement of one (01) **manual meteorological observatory** & one (01) **Automatic Water Level and Velocity Recorder** is under evaluation.
4. In June 2023, a project scientist visited the Gangotri Glacier region for the assessment of debris flow that took place during 2017. Based on the physical observations (**Figure. 1**) and satellite-based (**Figure. 2**) information during the period of **April to June 2023**, it has been indicated that the meltwater stream from Gangotri Glacier is

originating near the left lateral moraine, flowing across the snout of the glacier (Gaumukh) before moving downward.

5. Raktavarn stream from the right side of Gangotri Glacier joins the Bhagirathi River at about 50 m downstream from the front of Gangotri Glacier and further Bhagirathi River flowing uninterruptedly downwards (**Figure 1c**).
6. During the field visit, it is observed that the zone of moraine failure has been widened after the debris flow with respect to 2017 due to the continuous removal of steep unconsolidated ice-cored morainic material (**Figure 1d**). The deposited material is further incessantly eroded by the snowmelt and rainfall.
7. After the field visits it is observed that the average snout recession of Gangotri Glacier is estimated to be ~110 m at the rate of ~18 m/y from **September 2017 to June 2023**.
8. The Bhagirathi River is found flowing uninterrupted during the observation period (**Figure 2**). Remote sensing analysis also indicates that the **Raktavarn stream was joining Bhagirathi below the Gangotri Glacier snout**.
9. Further, snow cover analysis using satellite images indicates that Gangotri glacierized basin witnessed different spells of snowfall indicating an increase in snow cover area from ~80% in April to ~83% in May 2023 (**Figure 3 a, b**). Only the cloud-free image of June 2023 indicates a significant reduction in snow cover area to 69% (**Figure 3c**).

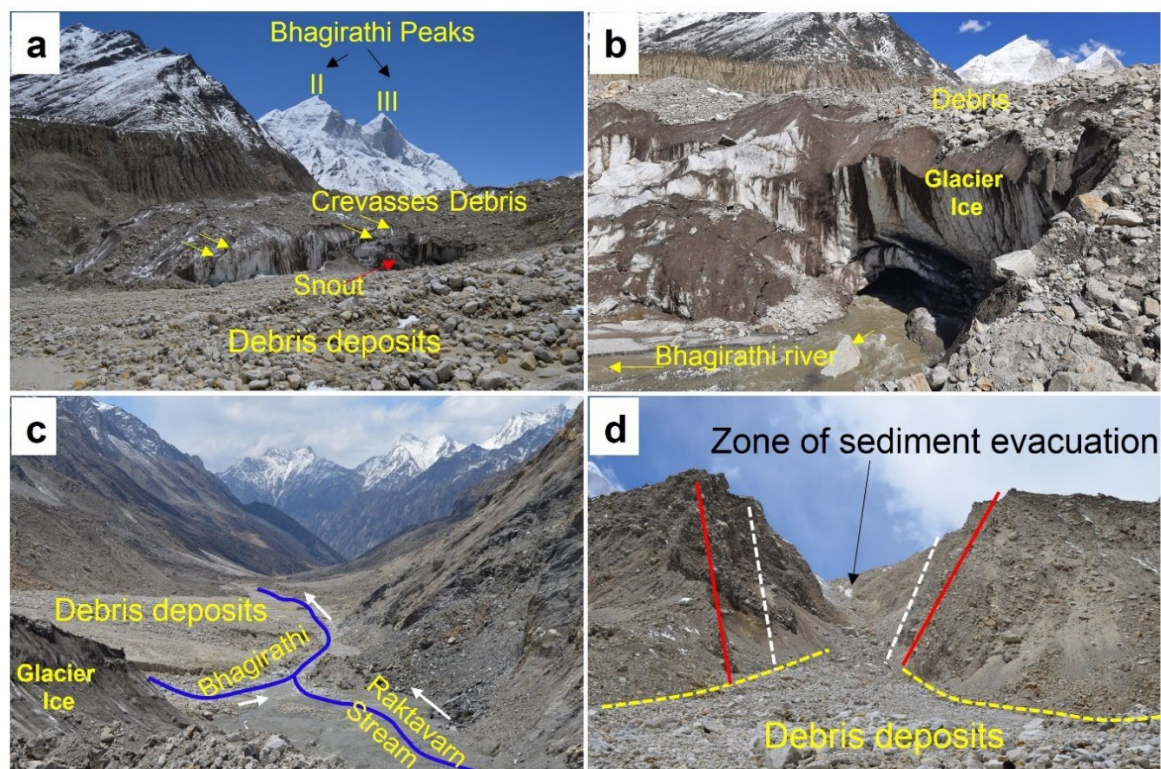


Figure 1. Field photographs showing the frontal part of Gangotri Glacier (a), and a close-up view of its snout (b). (c) an uninterrupted flow of the Bhagirathi River and Raktavarn stream and (d) Zone of sediment supply after 2017 event.

10. *Based on field observations around the snouts of Gangotri and Meru glaciers, there is no emanating threat observed in the region from April to June 2023.*

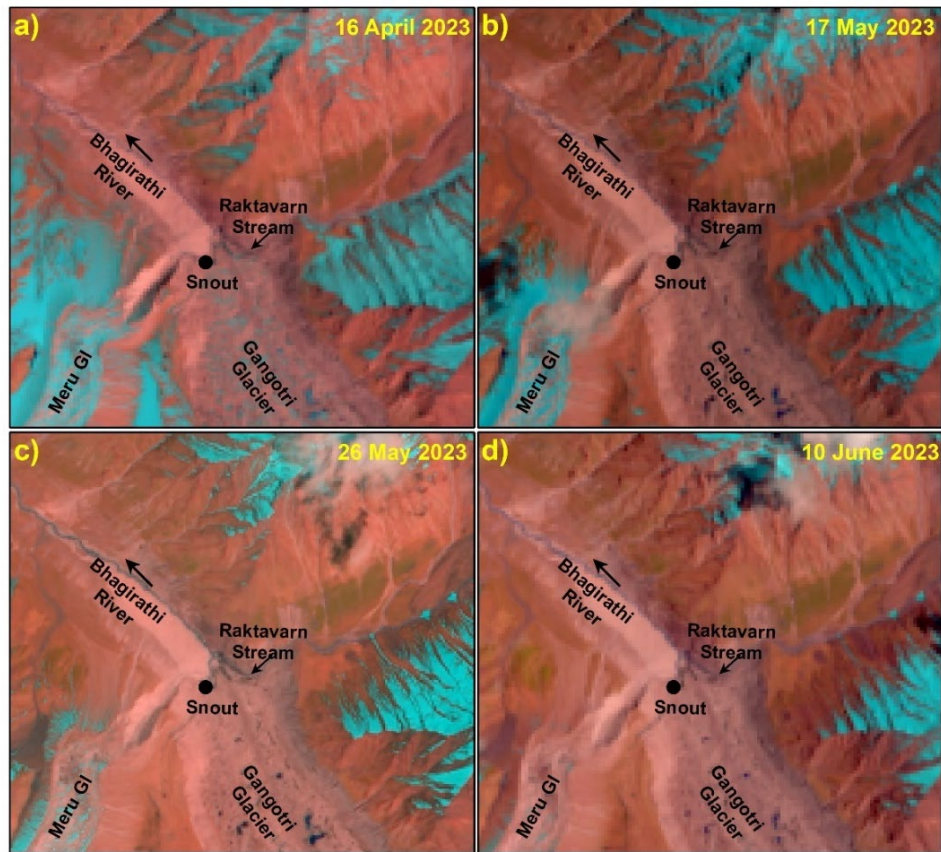


Figure 2. Satellite images indicating the presence of debris, no damming or lake, and uninterrupted natural flow of Bhagirathi River in the frontal region of Gangotri Glacier from April to June, 2023.

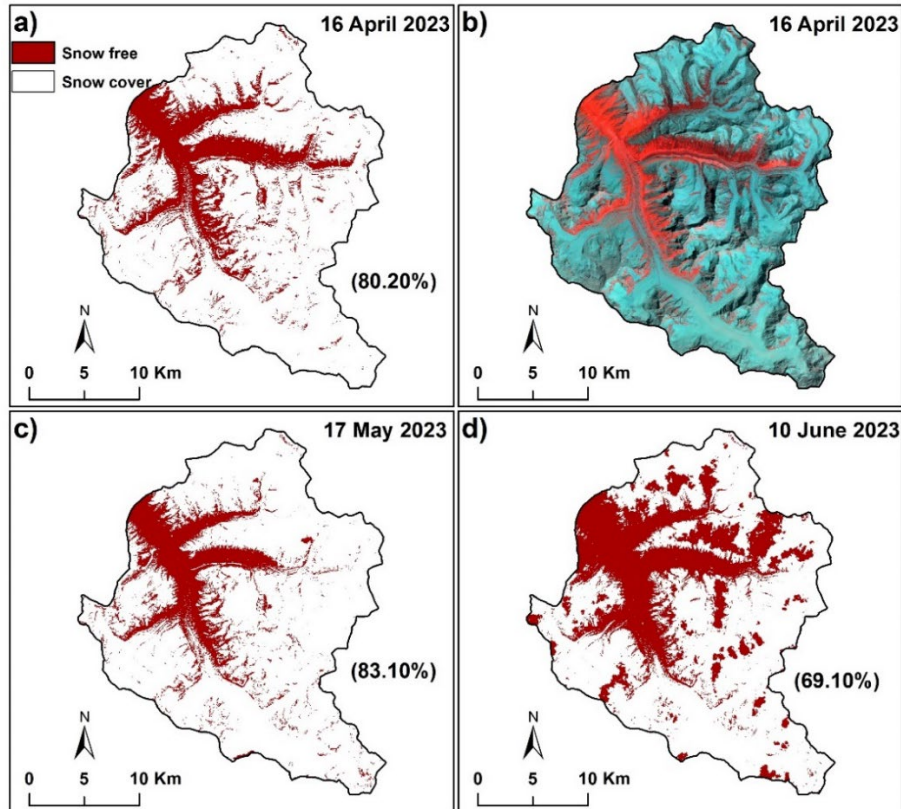


Figure 3. (a, b & d) Snow cover area for April, May, and June months, 2023 in Gangotri Glacier Basin up to Bhojwasa. (b) Landsat 8 satellite image with bands (SWIR-NIR-Red) corresponding to (a).