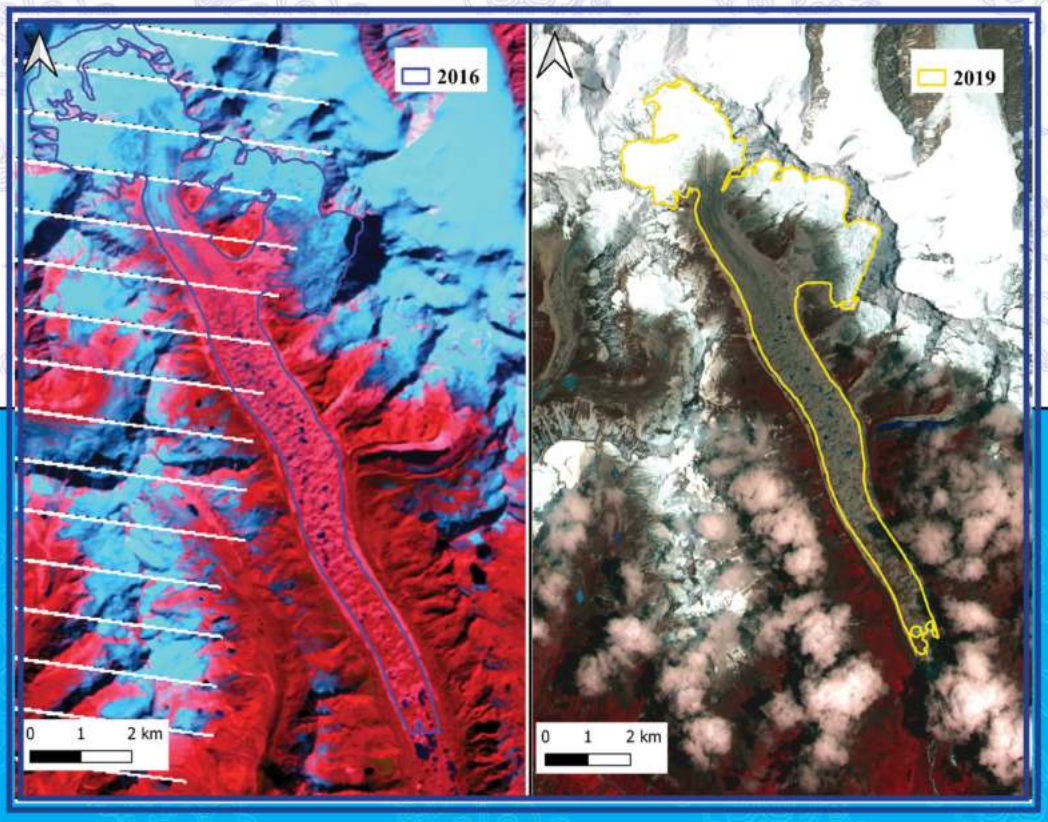
Time Series Monitoring of Glacier in the Head Water of Pho Chhu subbasin (Wachey Glacier)

September-October 2019



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1. Introduction

The glaciers in the High Mountain Asia (HMA) are referred to as the third pole as it has the second largest ice reserves in the form of mountain glaciers after the polar ice caps. Heavily populated regions in Asia depend on melt water from the Himalayas and are known as the water towers of Asia. The variations of these Himalayan glaciers in the recent decades in the phase of global climate change have attracted considerable attention due to their significance with respect to global sea level rise (N. Naito et al., 2012) and being sensitive to global warming (Naito et al., 2001).

Bhutanese mountain glaciers lie in the eastern part of the Himalaya and are known to be summer accumulation type (Ageta Y. and Higuchi K., 1984), meaning, the glaciers in the region gain mass in the form of solid precipitation in summer due to the summer monsoon from the Bay of Bengal. Such types of glaciers are very sensitive to global warming as a certain shift in temperature can lead to precipitation phase change thereby affecting the amount of mass accumulation. Like other glaciers in the Himalayan regions, glaciers in the Bhutan Himalayas have suffered the similar fate of losing mass in the recent decades, which manifested in the formation of supraglacial ponds and proglacial lakes. Among such glaciers, the debris-covered glaciers, which extends much towards lower altitudes, have given rise to formation of many proglacial lakes.

Wachey glacier is one of the biggest debris covered glacier of the Bhutan Himalayas. During the September – October 2019 field survey, reconnaissance survey on Wachey glacier was conducted to see the possibility of formation of glacial lakes, which might pose threats downstream in the form of glacial lake outburst floods (GLOF) in future.

2. Objectives

The reconnaissance survey on Wachey glacier was carried out mainly to see the possibility of formation of bigger supraglacial lakes on Wachey glacier by visually observing glacier morphology and surface topography towards upstream. Even though no big lakes were observed on or in front of the glacier from satellite imageries, several small supraglacial ponds were observed upstream located randomly. GLOFs not only occur from bigger proglacial lakes but do occur from such supraglacial ponds formed on the large debris covered glaciers like that of Tshojo GLOF in 2009.

3. Study site and accessibility

Wachey glacier is located at 28.145°N, 89.997°E in the headwater of Pho Chhu Sub-basin and has a surface area of 28.922 km^2 (BGI 2018). It is one of the biggest and longest glaciers in Bhutan.

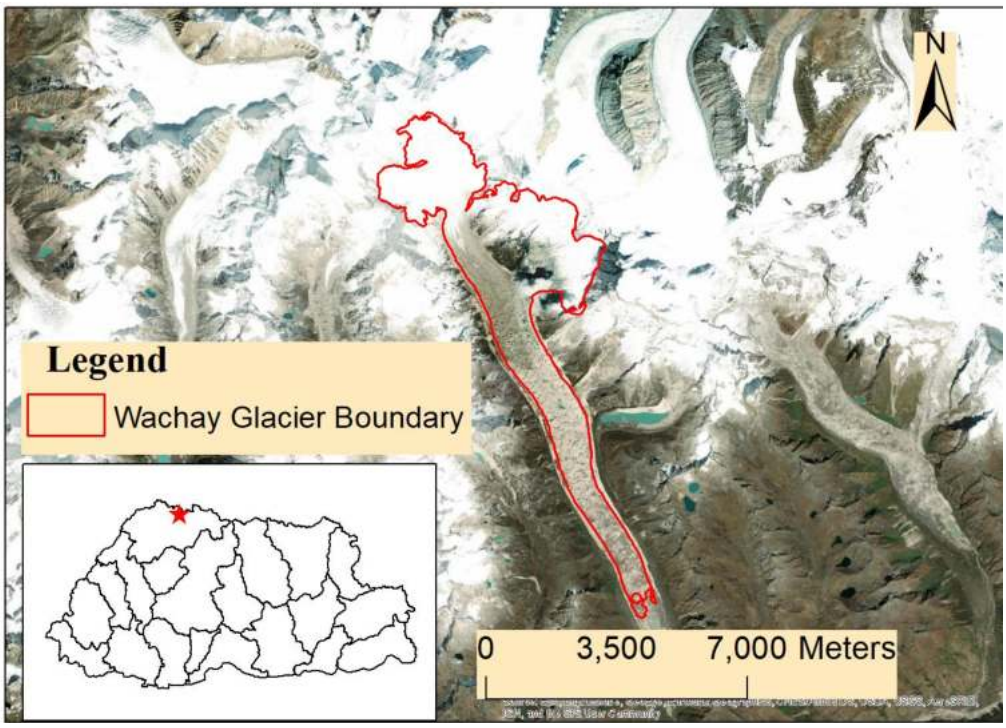

Figure 1 Location map of Wachey Glacier

The elevation ranges from 4376 to 7200 m a.s.l. with a mean slope of 26°. It lies on the upper left of Domchuthang campsite (Snowmen trek route) above Wachey village under Lunana gewog and can be accessed following the famous Snowman trek (Fig. 01).

4. Morphology of glacier and supraglacial lakes

The Wachey glacier identified as "*PPhgr16_273*" is a debris covered glacial lake with a surface area of km sq (BGI, 2018). The glacier is a valley type glacier, which have two main accumulation zones feeding from the mountain locally named as Jejekhangphu Gang and Tongshanjiabu Gang. The glaciers have a mean slope of 19 degree having longitudinal length of 14.39 km (BGI 2018). Table no 01 shows comparison of the glacier frontal variation published by NCHM, GAMDAM and ICIMOD. For 2019 glacier mapping, the latest Sentinel 2 cloud free image of the recent year was deployed using ArcGIS and Qgis platform.

Table 1 Comparison of the ICIMOD, GAMDAM and NCHM glacier surface area

Year	Source	Surface area (km sq)
1980	ICIMOD	34.20
1990	ICIMOD	31.01
2000	ICIMOD	27.72
2010	ICIMOD	26.82
2012	GAMDAM	21.50
2017	BGI	23.96
2019	Manual Delineation using Sentinel 2 MSI image	22.72

Looking at the satellite images and September 2019 field verification, the glacier was found to have clean ice at the upper region with heavy feeding towards the wachey valley. However, the composite of the glacier at the ablation zone is debris covered compounded with morainic surrounding. There are several ice crevasses filled with moraine debris. With rapid changing climate, there is a drastic formation of supraglacial lakes and ponds within a decade, which concludes the overall ice mass, is

retreating at an accelerating rate. The formation of supraglacial ponds within recent time was increasing at the upper regime of the glacier along with the expansion of glacial ponds downstream. Such characteristics reveal that the glaciers at ablation zones are fragmenting causing excessive melt of ice. The table 02 shows that the total supraglacial lake area of the recent year is decreasing with increasing numbers of supraglacial lakes. This may be due to excessive vertical melt.

Table 2 Detection of Supraglacial Lake from 1987 until 2019

#	Year	Numbers of supraglacial lake detected	Total area of supraglacial lake (m^2)
1	1987	75	741879.45
2	2000	39	732375.43
3	2010	60	744121.22
4	2016	55	668129.13
5	2019	228	553488.39

Results and Discussion

Through the various activities carried out in the fieldwork, the following are the finding:

- The glacier was found to have a longitudinal retreat of 2.2 km from 1980 to 2019 with a retreating rate of 56.41 m per year.
- The Supraglacial Lake was found to be forming more in the upper regime and the lake downstream was found to be increasing in size.

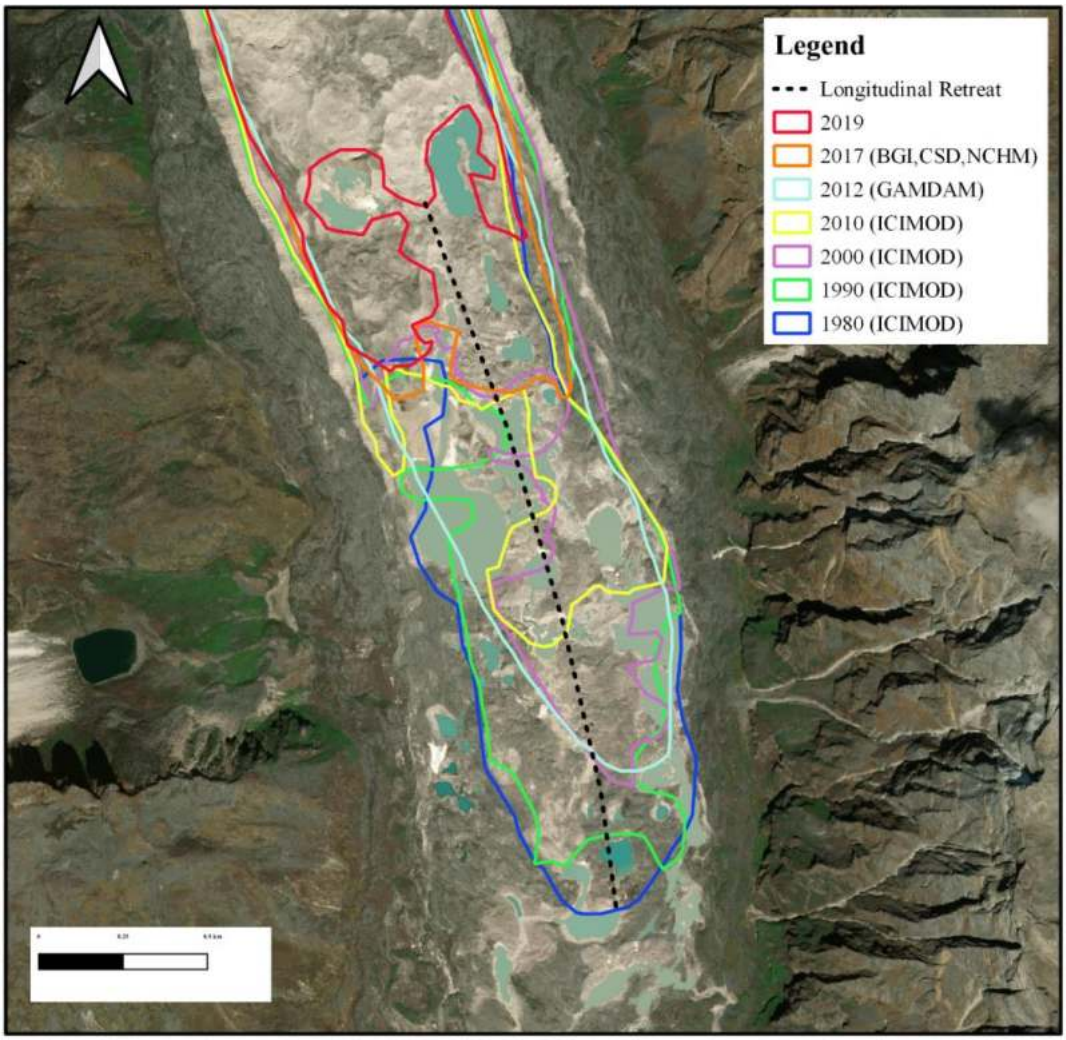

Figure 2. Longitudinal Variation of Wachey glacier from 1980 to 2019

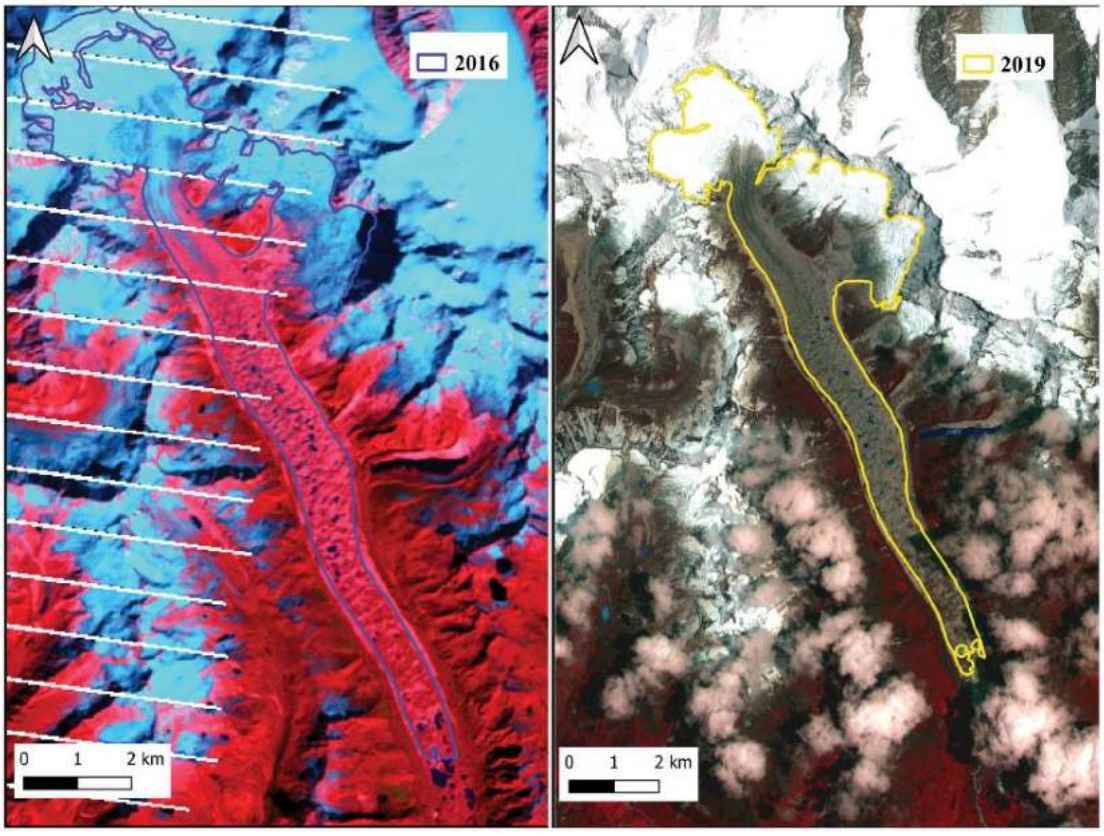

Figure 3. Wachey glacier comparison between 2016 and 2019

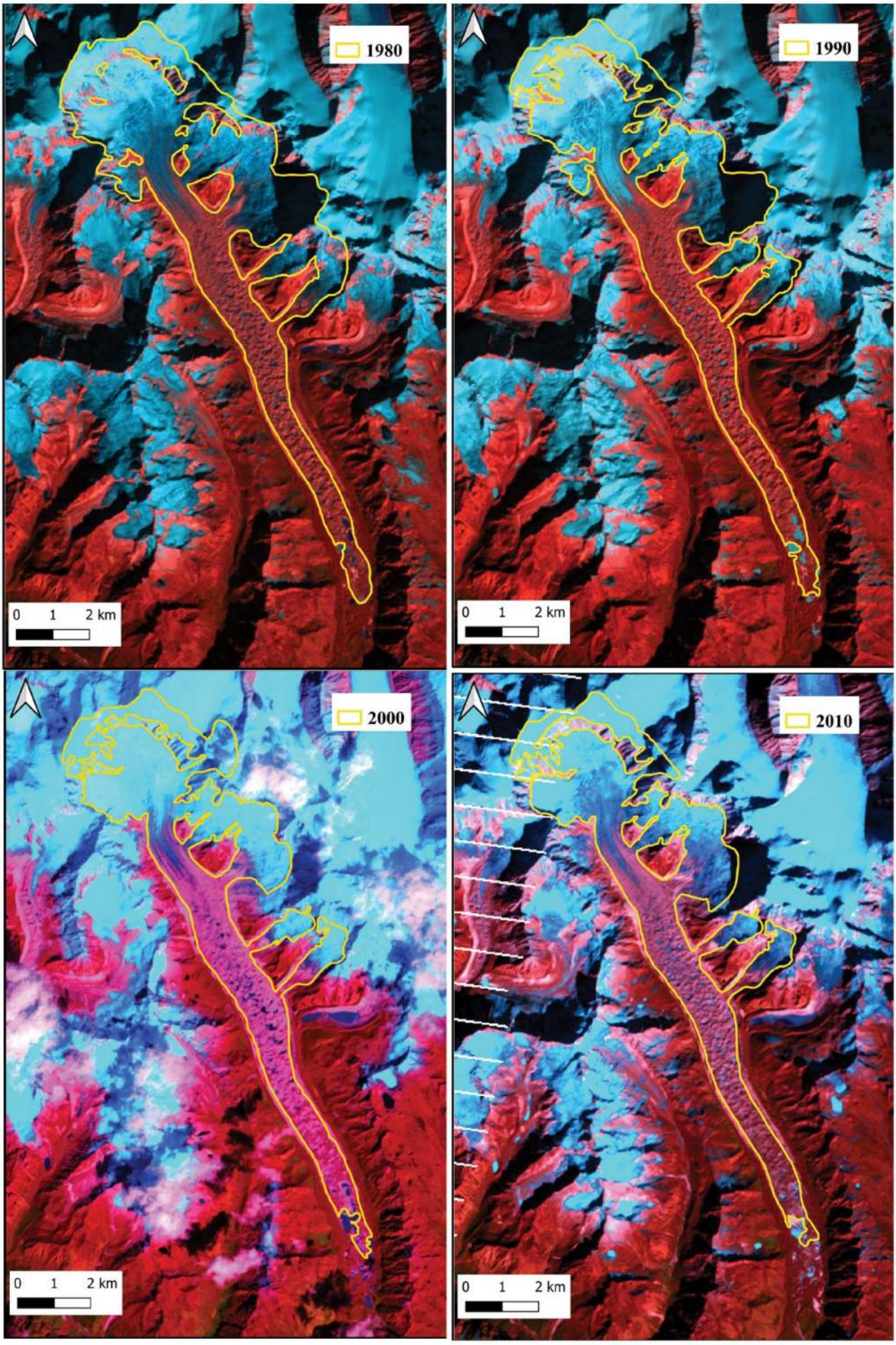

Figure 4. Wachey Glacier comparison between 1980, 1990, 2000 and 2010

6. Conclusion and Recommendation

Based on the field survey along with the remote sensing findings, the team would like to recommend the following for future activities:

- The glacier was found to have a longitudinal retreat of 2.2 km from 1980 to 2019 with a retreating rate of **56.41** m per year. The Supraglacial Lake was found to be forming more in the upper regime and the lake downstream was found to be increasing in size.

- With the glacier still in the stage of retreating, the glacier should be timely monitored to study the supraglacial lake formation and its characteristics influence to the glacial lakes downstream.

7. Reference

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