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Impact of Climate Change in Kalabaland Glacier from 2000 to 2013

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***Abstract* - Glaciers are the coolers of the planet earth and the lifeline of many of the world's major rivers. They contain about 75% of the Earth's fresh water and are a source of major rivers. The interaction between glaciers and climate represents a particularly sensitive approach. On the global scale, air temperature is considered to be the most important factor reflecting glacier retreat, but this has not been demonstrated for tropical glaciers. Mass balance studies of glaciers indicate that the contributions of all mountain glaciers to rising sea level during the last century to be 0.2 to 0.4 mm/yr. Global mean temperature has risen by just over 0.6^0 C over the last century with accelerated warming in the last 10-15 years. The major impact will be on the world's water resources. Many climatologists believe that the decline in mountain glaciers is one of the first observable signs of the human induced global warming.**

***Keyword:* Glacier, Glacier retreat, Himalaya, Kalabaland glacier, Satellite images**

I. Introduction

The Himalayan mountain system is home to the world's highest peaks, which includes about 50 peaks which are more than 7500 meters above mean sea level. The Himalaya forms the most important concentration of snow covered region outside the polar region and the Himalayan glaciers are highly sensitive to the on-going warming. Recently, GSI (2009) has updated the detailed glacier inventory of Indian Himalayas and summarized details about glaciers in the districts of Uttrakhand, Himachal Pradesh and Jammu and Kashmir States and compiled the available water resources in form of glaciers (see Sangewar and Shulka in GSI (2009). There are 9575 glaciers spread across the Indian part of the Himalaya (GSI, 2009), some of which form the perennial source of major rivers. Changes in glaciers are one of the clearest indicators of alterations in regional climate, since they are governed by changes in accumulation (from snowfall) and ablation (by melting of ice). The difference between accumulation and ablation or the mass balance is crucial to the health of a glacier. GSI (op cit) has given details about Gangotri, Bandarpunch, Jaundar Bamak, Jhajju Bamak, Tilku, Chipa ,Sara Umga Gangstang, Tingal Goh Panchi nala I , Dokriani, Chaurabari and other glaciers of Himalaya. Raina and Srivastava (2008) in their 'Glacial Atlas of India' have documented various aspects of the Himalayan glaciers covering their origin, classification, landforms, snow cover assessments and basin wise inventory of the glaciers.

II. Study Area

The area is located approximately between latitudes 30° 15′ N and 30° 28′N and longitudes 80° 15′ E and 80° 25′ E. It is a part of the Munsiari subdivision of the Pithoragarh district of eastern U.P. The Shankalpa Divide lies in northwest-southeast direction and extends for about twenty kilometres from Bamba Dhura to beyond Rajrambha and gives rise to a large number of glaciers on either side of it.The main glaciers on the west side of the divide are (1) Kalabaland, (2) Yankchar, (3) Shankalpa, (4) Shivu, and (5) Rajrambha. The eastern side of the divide contains a still larger number of glaciers namely Chiringtashi, Chiring Mabang, Nassa, Damolia, Ghugtan, Jhulang, Nipchukang, Yarkand and Ngalphu glaciers. There are a large number of high peaks on the divide which separate the two sets of glaciers. The most important amongst them are Bamba Dhura (6334m), Chiring We (6559m), Suli Top (6300m), Sui Tilla (6333m), Rimla We (6242m), Lachar We (6291 m), Chaudhara (6510m) and Rajrambha (6527 m).[1]

The largest glacier in the area is the Kalabaland glacier is 15 km in length which originates from the Bamba Dhura-Chiring We section of the divide and flows in a southeasterly direction. The first three glaciers in fact form one single glacier; the Kalabaland and Yankchar join together and form the snout which is named Shankalpa glacier.

Kalabland Gal (Glacier) in Uttar Pradesh, India drains into the Goriganga River, via Ralam Gad. The glaciers flows southeast from the Peak of Chhiring We, joins the Yankchar Glacier and turns sharply southwest. The combined terminus is referred to as Shunkalpa Gal, but here since Kalabaland is the largest contributing glacier, that name is applied to the terminus as well.

A. Data Sources

The multi-spectral satellite data of Landsat ETM+ data for the years 2000 and 2013 have been ETM+ have been procured in the present study.

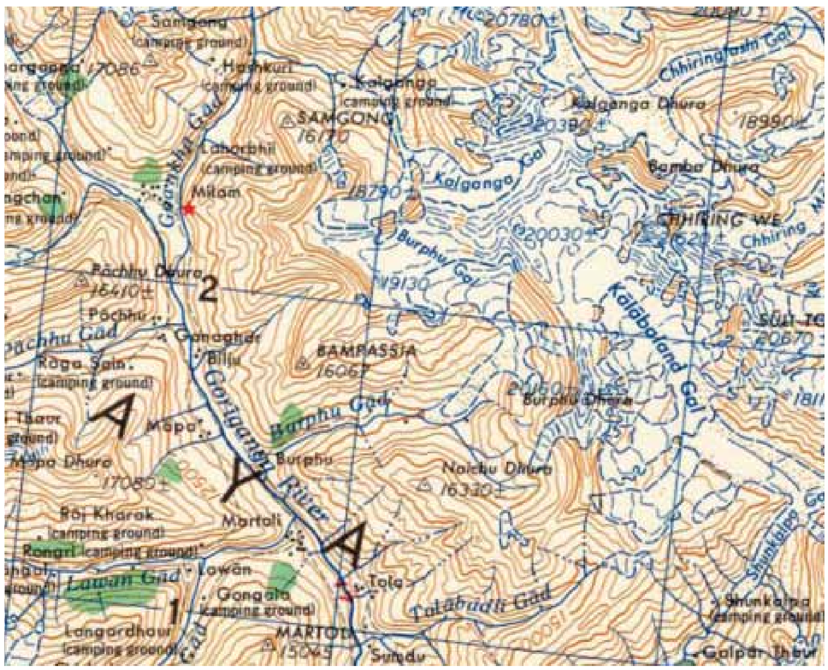

Fig.1 Map of Region

Table I Details of Satellite Data

Satellite Data	Data of acquisition	Spatial resolution
Google Earth	26/10/2000	35
Google Earth	19/11/2012	35
Landsat ETM +	25/05/2000	30
Landsat ETM+	13/11/2013	30

III. Methodology

Phase I: For Google Earth data

Google Earth data of 2000 and 2012 are classified by both supervised and unsupervised classification techniques. After classification process the data is associated with DEM and finally the glacier area of Kalabaland glacier terminus main trunk is calculated by measurement techniques using ENVI 4.7.(fig 3,4 and 5).

Phase II: For Landsat ETM+ data

Landsat ETM + data of Nov 2011 have strips, pre-processing has been done to destripe the Landsat ETM+ data

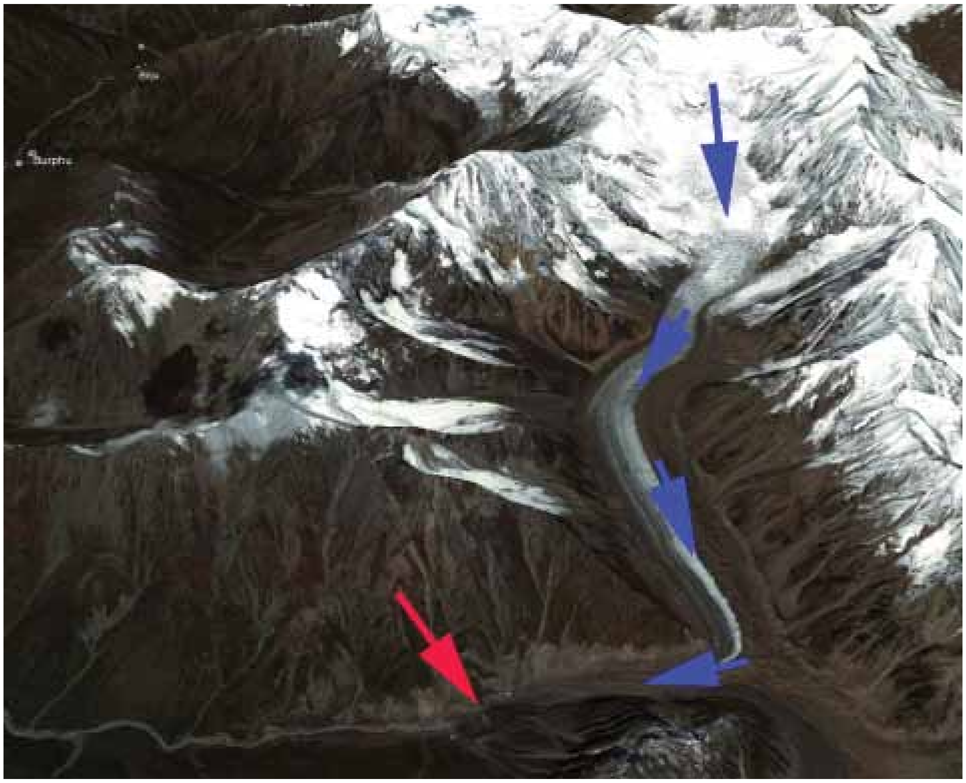

Fig.2 Google Earth Image, blue arrows glacier flow, red arrow terminus.

using ENVI 4.7. The spectral distinction does not exist for all the glacial features in any single band thus identification of all features in single band data. The standard FCC of ETM+ 2, 3 and 4 bands (Blue, Green, and Red) may not be sufficient for snow cover type study because of its spectral saturation in two of these bands. Although the ETM+ bands 1 to 3 are found to be useful to detect dusty surface on glacier their utility is limited in the higher reaches of many glaciers, because of the saturation. However, ETM+ Band 5 and 7, as they do not show detector saturation, are found to be extremely useful for snow mapping [Philip and Ravindran, 1998]. The snow coverage are clearly discriminated from the other features in ETM+ Band 4 irrespective of the amount of saturation. Considering all the above, it is found that despite redundancy in ETM+ bands 5 and 7, a color composite of the bands 4, 5 and 7 (RGB) yields interesting results in discriminating glacial features and the landforms[Philip and Ravindran, 1998]. (Fig. 6 and 7).

IV. Results and Discussions

The Goriganga River is fed by many glaciers and is a target for a number of run of river hydropower projects, some existing such as at Talla Dummar and others projected, such as at Bogudiyar. These projects have only minor dams to divert the water from the river for a short distance before running through turbines and returning to the river. In 2000 both Landsat and Google Earth imagery indicate the terminus location, red arrow. The terminus is heavily debris covered and is evident because of the glacial stream that emerges from beneath the debris covered ice. By 2012 the glacier had retreated 250 m to the yellow arrow. The lowest one kilometer of the glacier has thinned both in width and thickness, is stagnant and will melt away soon. The side by side view from 2000 and 2012 better indicates the change and the thinning of the terminus tongue. The two pink markers are at the 2000 and 2012 terminus respectively, dark pink 2000 and light pink 2012.

Fig.3 2000 Google Earth

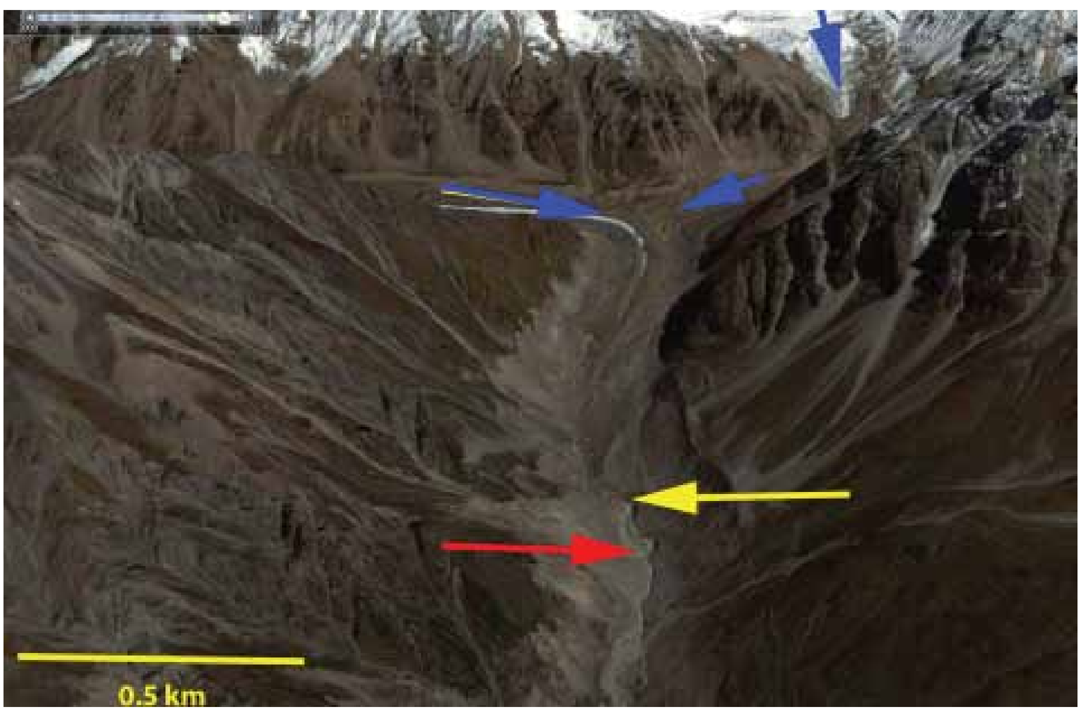

Fig.4 2012 Google Earth

Landsat images from 2000 to 2013 indicate that the terminus retreat is small compared to the full length of the glacier, red arrows. The width and length of blue ice extending southwest at the bend has been reduced from 2000 to 2013 indicating a continued reduction in net flow of ice to the terminus.

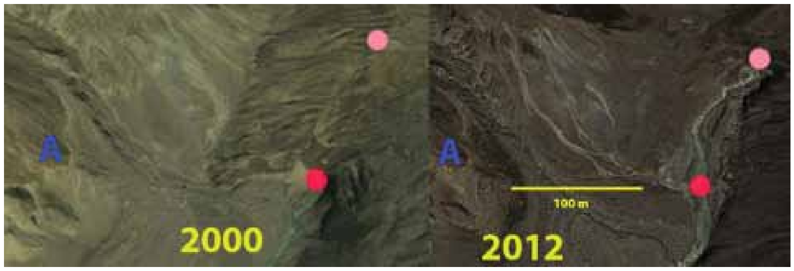

Fig.5 Terminus closeup in Google Earth

Fig.6 2000 Landsat image

Fig.7 2013 Landsat image

V. Conclusions

Loss in main trunk of glacier area was estimated using high and medium resolution of Landsat ETM+ and Google Earth. In this investigation, glacial area loss from 2000 to 2012 was estimated. Kalabaland glacier must have come down about 0.7 km from the current snout position between 2000 and 213.

In the visible bands of Landsat ETM+, the highly reflecting surface of snow and glaciers reach saturation limits and are not useful in discriminating snow types and mapping landforms in these areas. But the TM Bands 4, 5 and 7 in the NIR and SWIR regions are found to be very useful not only in snow mapping but also in identifying various glacial landforms.

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