THE ANALYSIS OF GLACIAL GEOMORPHOLOGY FOR KHONG KYONG KHANGSU GLACIER, THROUGH GIS & REMOTE SENSING IN NORTH DISTRICT, SIKKIM

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Abstract

Khong Kyong Khangsu, the longest glacier of Change Khangpu glacial basin of Sikkim Himalaya, has been studied for it's geomorphology. The objective of study is to classify the glaciated-geomorphic features into erosion, depositional and fluvial category along-with their origin, development process and other prominent surface changes through integrated manner. Three approaches have been utilized namely: Conventional, Field observation & Modern. Cartosat-1, first Indian stereo-image satellite [three dimensional] in conjunction with IRS- LISS IV [Mss] satellite data have been used as part of GIS & Remote Sensing as Modern approach. The glaciated- erosion features as Cirque, U shaped valley have been depicted in snow accumulation zone through DEM. The glaciated-depositional and glaciated-fluvial features like: Moraine, Terrace and, Channel deposit respectively have been documented with preparation of the glacial geo-morphological map. The retreating pattern of glacier as prominent surface change observed is the testimony for ongoing Global warming cum sea level fluctuation in Bay of Bengal.

Introduction

Sikkim Himalaya has 449 glaciers of varying size in the range of few Km to more than 10 Km in length. These glaciers have their distribution in West District along Nepal border as well as in North district along China border under four glacial basins namely: East Rathong, Talung, Changme Khangpu & Zemu. The snow line of these glacier are at lower altitude than other glaciers belonging to rest of Himalaya on account of it's closeness to tropic of cancer and other related sun azimuth, sun elevation and snow reflectance characteristics.

Most of Sikkim Himalaya glaciers are confined to upper catchment of Tista- an international river as well as life -line of Sikkim. It passes through Sikkim & West Bengal states in India and then to Bangla Desh, where it joins to Brahmputra river before it's merger to bay of Bengal via Sunderban delta [1].

The Himalaya glaciers by large have retreating pattern at present- a state of shrinking for it's snout position towards their respective cirque in backward motion. It is also true for Sikkim glaciers- the indication for ongoing global warming. The glaciers of Sikkim Himalaya have identification code 5 O201 as per UNESCO classification scheme of World glacier Inventory [5].

Area under study

Khong Kyong Khangsu glacier is located in North District of Sikkim, closed to Chumbi valley of China border. It belongs to Changme Khangpu glacial basin- second largest of Sikkim, containing 102 glaciers. [The first one is Zemu having 250 glaciers in West District.] Khon Kyong Khangsu glacier has identification number 5 O 204 0479 with following basic information : [4]

- Length = 9.30 Km
- Area = 22.20 Sq. Km
- Volume = 2.00 Cubic Km
- Orientation = N-S Direction
- Source of stream = Sebonzung chhu

The area under study is approachable through workable road upto Sharvki-Damanchung along the confluence of Sebonzung chhu and Yumthang chhu. Sharvki Damanchung is 10 Km in north of Lachung-a famous tourist spot for Yumthang flower valley/hot spring. The map showing area under study is illustrated through Fig.1.

Methodology

Three approaches, namely: Conventional, Field observation & Modern have been adapted for study of glacial-geomorphology. The most essential feature for visit to a glacier is acclimatization of our body at places of different altitude for suitable time period and has been performed through staying of minimum two to three days at Gangtok, Lachung & Base camp near to the snout of glacier.

Conventional approach includes the collection of auxiliary data, review of relevant literature and collection of Survey of India topo-sheet for the area of study. Khong Kyong Khangsu glacier belongs to topo-sheet number 78 A/9 [Restricted nature] of scale 1: 50,000.

Field observation approach has two stages namely reconnaissance visit and detailed field survey. The reconnaissance visit has been performed during the month of May 2008 for familiarity with terrain and logistic support in the area of study. The field survey including camping near the snout of Khan kyong glacier has been performed during the months of September & October 2009 and 2010, respectively for recognition and documentation of relevant features.

Fig.1 Location map of area under study

Modern approach includes the digital analysis of Remote Sensing data and GIS. The details of used satellite data has been summarized as Table1.

S N	Name of satellite Data	Date of Pass	Sensor Characteristics	Spatial Resolution [m]	Remark
1	IRS Resource-sat1 [P6] LISS IV	04 Dec. 2006	Band: B2,B3 & B4 [Mss]	5.8	Altitude= 817 Km
2	Cartosat-1 stereo Image	10 Feb. & 08 Dec. 2007	Band: 0.5 -0.75 Micron	2.5	Altitude= 618 Km Path A =586 Path B=585 Row=269

Table 1: Details of satellite data used for area under study

Satellite data of all available periods in their digital format have been loaded into Lab. computer. The geo-reference image data base has been generated with suitable projection system for creation of image processing environment. Simultaneously, S O I topo-sheet [partly covering the area of study] has been also stored for generation of Ground Control Point [GCP] –as sharp turn road, confluence point of chhu & stream towards Image generation, as part of digital analysis. The second order polynomial model has been generated with R M S error less than half pixel size. All digital data have been registered with superimposition over each other for generation of False Colour Composite [FCC] product. It has been visually interpreted on the basis of photo interpretation keys like- tone, texture, drainage, topography & associated information for documentation of erosion, depositional and fluvial features belonging to glacial geomorphology, as part of Remote Sensing.[3]

GIS [Geographic Information System] is a computer based information system. It captures, integrates, stores, edits/ manipulates and analyses geographic information and displays it in a spatial format. The location of an object [feature] is provided as longitude[x], latitude [y], and elevation/altitude [z] directions respectively. GIS data base is created through generation of digitization of data through topo-sheet, satellite output & field observation in different layers, GIS environment has been used for preparation of Digital Terrain Model [DEM]. The integration of all information provides to form thematic map like glacial geo-morphological map [2].

Result & Discussion

All the geo-morphological features of khan Kyong glacier had developed during Pleistocene period. [about 30,000 years ago from the present] The formation of each geo-morphological feature in either of three zones namely: Glacier, Peri-glacier & High mountain from north to south direction up to the confluence of stream and chhu.[1]. The origin of all geo-morphological features have two mode namely degradation and aggrandization. The degradation process had been active in snow covered portion and characterized by erosion features like- cirque & U shaped valley, belonging to difficult terrain from accessibility point of view. The aggrandization process had been prominent in snow ablation portion and characterized by depositional and fluvial features- like: Moraine & it's variety, multiple terrace and dead ice wastage, channel deposit respectively, belonging to accessible terrain.

Cirque

It is bowl shaped depression occurring at the head of glacier in glacier valley. It belongs to glacier zone in snow accumulation portion. The cirque of Khong Kyong Khangsu glacier has been depicted through DTM of IRS LISS IV, as Fig.2, with field confirmation through visible distance.

U Shaped Valley

It occurs on the wall of valley of glacier, with massive effect of glaciations. It may cut beneath average sea level of the area, subject to it's intensity – due to high erosion power. It has U shape as per field visualization as large view. It is illustrated as Fig. 3 in field near the confluence of Sebonzong and Yumthang chhu.

Fig 2 Cirque of Khong Kyong Khangsu Glacier

Fig. 3 U shaped valley at confluence of chhu

Moraine

It is typical glacio-depositional feature, narrating the past history of glaciations in Peri- glacier zone. It indicates retreating pattern of glacier, leaving unsorted debris along the wall of valley of glacier. Lateral moraine is a variety of moraine as identified in the area. It is parallel ridge of debris deposited along the side of valley and exhibited through visual interpretation of FCC of LISS IV as Fig.4. The corresponding field observation of Fig. 4 has been also illustrated as Fig.5

Terrace

It is composed of fine grained depositional material, formed by action of melt water stream in snow ablation portion. It is almost topographic- flat area like football playing ground. It is associated with either small grass or medicinal shrub at different altitude along the valley of river. Terrace with medicinal shrub, identified in field is illustrated as Fig.6. The other terrace in association with recent talus-as old helipad site with H mark is illustrated as Fig.7.

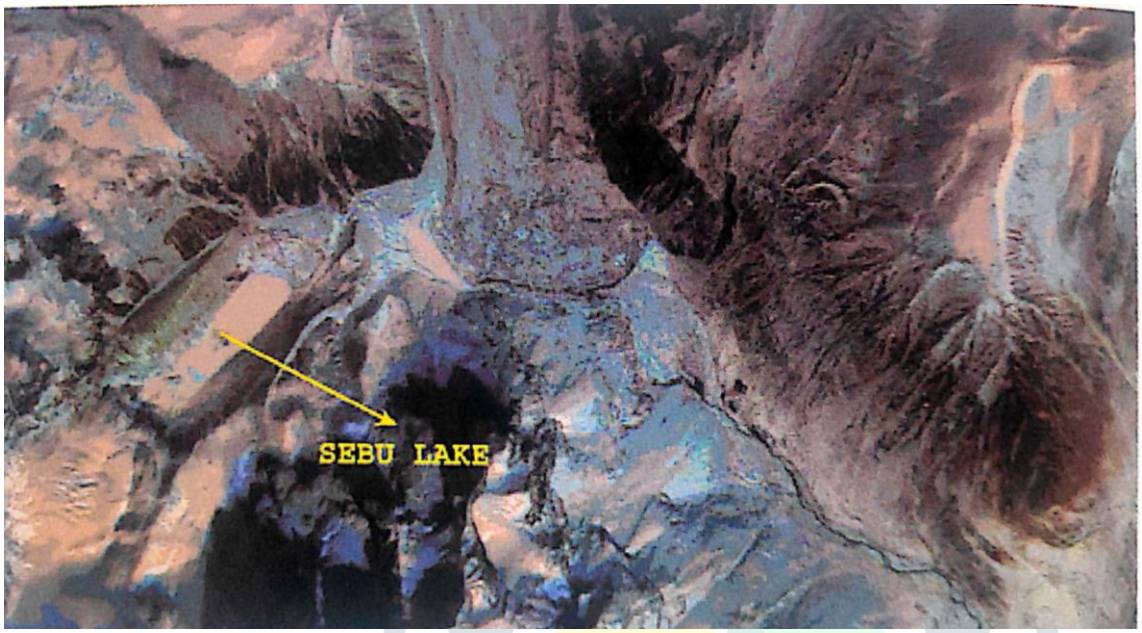

Fig.4 FCC of LISS IV exhibiting Moraine

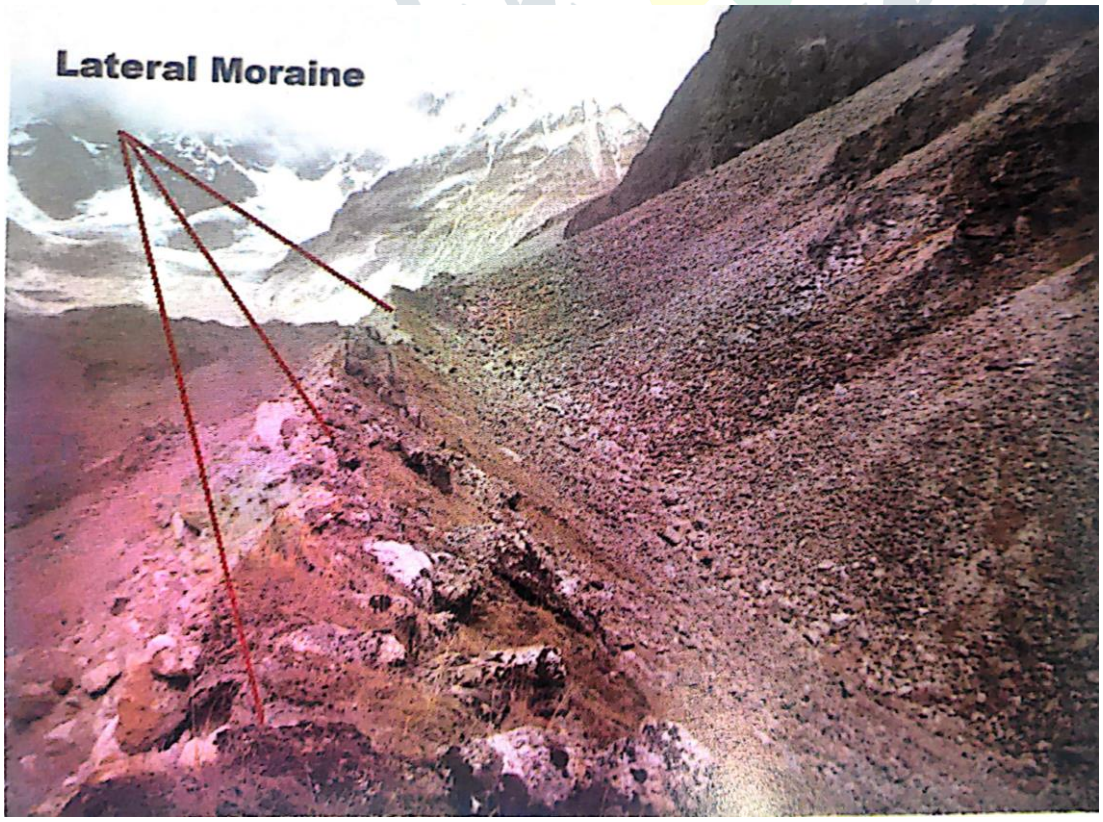

Fig.5 Field photo of Moraine, as per FCC

Fig.6 Terrace with medicinal shrub

Fig.7 Terrace with talus

Channel deposit

It belongs to glacio-fluvial activity. It is composed of variety of sediments in unsorted manner within fast flowing melt water stream. It is associated with braided nature of stream in high mountain portion. It is illustrated through field observation as Fig.8.

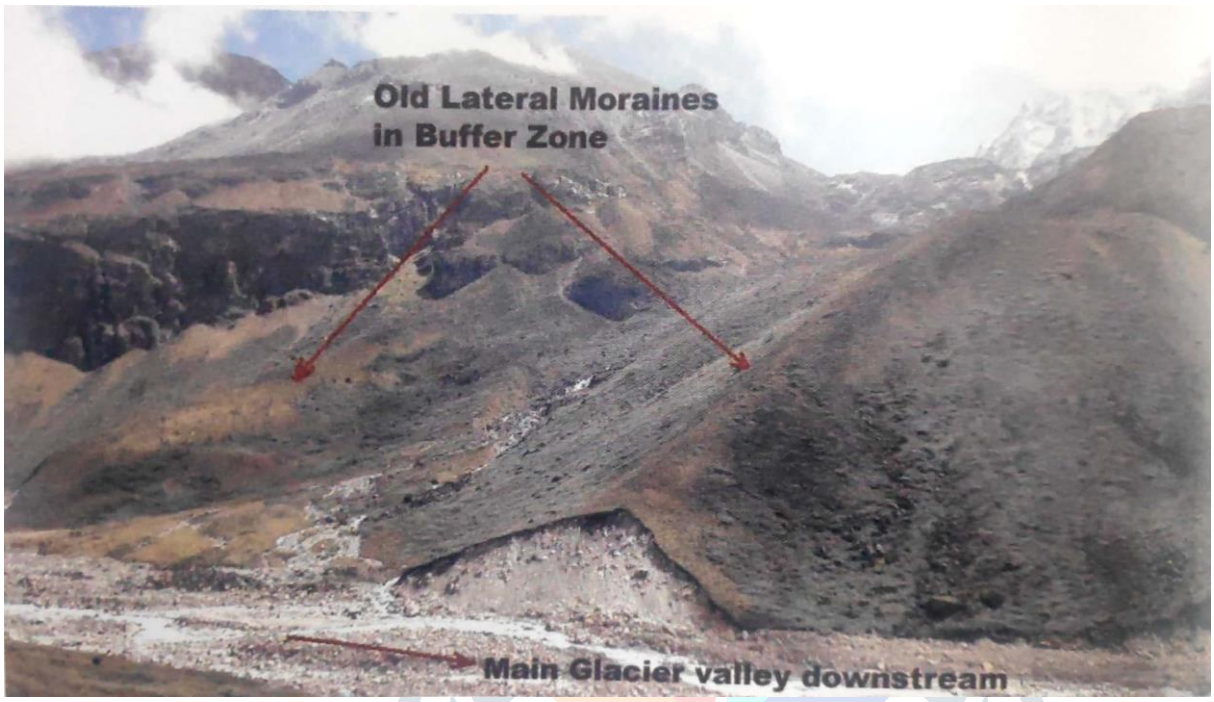

Fig. 8 : Channel deposit

Dead ice wastage

It is dynamic feature for remains of snow as wastage. It occurs in small depression during winter and melts away during successive summer with leaving no impression. It is neither able to map nor documentable, but visible during field observation.

Glacial Geo-morphological map

It deals with the study of glacial landforms as per erosion, deposition & fluvial action, possessing important natural agents. They interplay with dynamic change of landforms in synchronization with regional ecological balance. They have been exhibited as per Fig.9 GEOMORPHOLOGICAL MAP. as prepared through Modern approach on the scale 1: 70,000 [3].

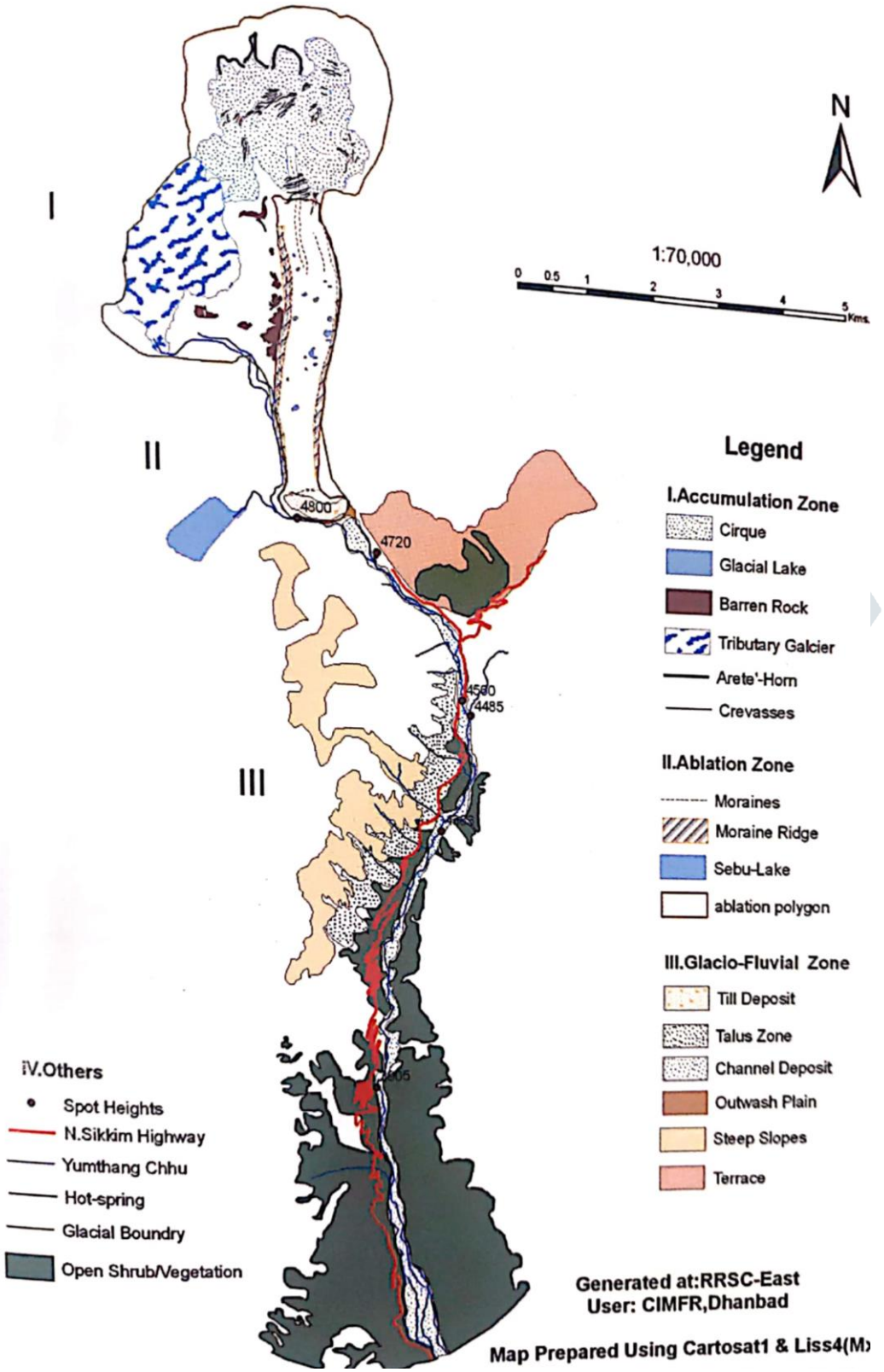

Fig. 9 Geo-morphological map of the area under study

Conclusion

- The geo-morphological mapping of the area under study has been executed through integration of three approaches namely; Conventional, Modern and Field observation with fulfilling the objective.
- Glaciated-erosion features are identical over DTM, which have been not easily approachable in field, on account of difficult terrain.

- Glaciated-depositional features are well recognizable over FCC, in conjunction with Field observation.
- Glaciated-fluvial feature is well documented on geo-morphological map.
- The overall retreating pattern of Khong Kyong Khangsu glacier is well correlated with on- going Global warming and related sea level fluctuation in bay of Bengal.

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