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Geomorphologic Character & Receding Trend of Kolahoi Glacier in Kashmir Himalaya

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Abstract

Glaciers are a valuable source of fresh water which sustain life and provide water for drinking, irrigation, hydro power generation, etc. Besides, these exert considerable influence on the climate of a region and fluctuate in dimension in response to the climatological changes and therefore, these are regarded as sensitive indicators of the climate of a region. Glaciers are in the process of retreat in almost all the parts of the world due to global warming. The same process of retreat is found in the valley's largest glacier, Kolahoi. Thus, it is of great significance to obtain the accurate information of changes in Kolahoi glacier (34° 07' to 34° 12' N latitude; & 75° 16' to 75° 23' E longitude, Liddar valley, Kashmir Himalayas). The study was carried out using Remote Sensing and GIS techniques and thorough field observations were conducted to identify the geomorphologic features. The area of the glacier receded from 13.57km² in 1963 to 10.69km² in 2005, registering a change of 2.88km²at a rate of 0.068km²per year. The Crevasses developed in the ablation portion of the Kolahoi Glacier and the formation of numerous caves at its snout position act as the important indicators of its recession. The result of this retreat will prove disastrous for the valley in many fields like drinking water, agriculture, horticulture, ground water, hydro power capacity of the state, etc. Therefore, we need to make efforts to save this precious source of water for the present as well as for future generations.

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Key Words: retreat, global warming, Kolahoi glacier, Liddar valley, geomorphology

Introduction

Glaciers are considered as the important renewing sources of fresh water. These play an important role in the hydrological cycle of the earth. A glacier is a naturally moving body of large dimensions formed from the recrystallization under pressure of accumulated snow. Glaciers move very slowly, from tens of meters to thousands of meters per year. Kashmir Himalayas has got the largest concentration of glaciers with 3116 glaciers covering an area of 3200km²; nearly 13% of the states territory [1]. The main glaciers of Kashmir valley are: Kolahoi, Thajwas, Machoi, Nehnar, etc. Different river systems and their tributaries originate from these glaciers. Any change in the temperature or winter precipitation in the form of snowfall influences the flow in the hydrological system of the valley.

Glaciers have receded substantially during the last century in response to the climatic warming; especially in the mountainous regions such as Himalayas. The differences in the global mean temperature between the last glacial maximum and present warm period is about 5°C. However, this slow rate of climate change probably changed in the 20th century due to rapid industrialization. Large emissions of CO_2, other trace gases and aerosols have changed the composition of the atmosphere [2]. This has affected the radiation budget of the earth-atmosphere system. With the acceleration of global warming in the 1980s, it has become more and more important to understand the ability of glaciers to provide water sources and the disasters related to glaciers and climate change [3]. Glaciers in the Kashmir valley are in the process of fast retreat due to increase in temperature, globally. Glaciers are one of the earth's most sensitive indicators of climatic change.

Glacial geomorphology is the study of landform produced by glacial and fluvioglacial processes in the areas of present glaciers as well as in areas covered by the glaciers during the Pleistocene. Much of the spectacular character of the present topography of the northern part of the Liddar Valley has resulted from the glaciations in the remote past. A study of the glacial processes operating currently can throw light on the landforms that were created by similar processes in the past. Therefore, it will be helpful in reconstructing the genesis of the landform features. During the advance movement of glacier; it creates some erosional and depositional features which remain stagnant and act as evidences for the glacial recession. The geomorphologic features of glaciers which act as indicators for its retreat or recession are glacial grooves, cirques, moraines, crevasses, eskers, outwash plains etc. The present study involves the change detection and geomorphic character of the valley's largest glacier, i.e., Kolahoi glacier.

Study Area

The Liddar valley occupies the southern part of the giant Kashmir Himalayan synclinorium and forms part of the middle Himalayas. The Liddar valley lies between the Pir Panjal range in the south and southeast, the north Kashmir range in the main Himalayan range in the northeast and Zaskar range in the northwest. The area gradually rises in elevation from south (1600mts.) to north (5400mts.). The location map of the study area is given in fig. 1.1.

The Liddar valley begins from the base of two main ice fields, the Kolahoi and the Shisram. From here, its two main upper streams the west Liddar and the east Liddar originate and join near pahalgam. The liddar merges with Jhelum at Gur after traveling a course of about 70kms from Kolahoi to Gur. It has a catchment area of 1134km². It lies between 33° 45' to 34° 15' N latitude and 75° 0' to 75° 30' E longitude. The Liddar valley relives a variegated topography due to the combined action of glaciers and rivers. The glaciated section of the valley contains many erosional and depositional features.

The Liddar valley has distinct climatic characteristics. It has sub-Mediterranean type of climate with nearly 80% of its annual rainfall in winter and spring season.

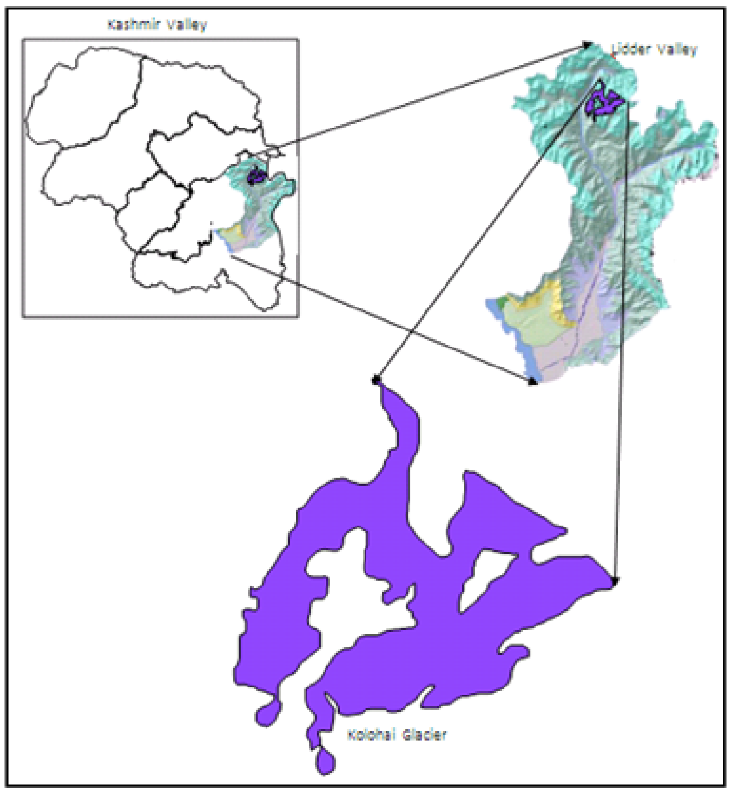


Fig. 1.1: Location map of Study Area

Database & Methodology

In the present study, the database consists of: the Survey of India Topographical map (1963), on 1:50,000 scale, No.: 43 N\8, the geometrically corrected IRS 1C LISSIII (2005) with the resolution of 23.5 meters & the meteorological data of the Liddar valley. An extensive field survey was conducted to identify the glacial geomorphological features of Liddar valley. The research was carried out, utilizing the power of Remote Sensing & GIS in the Erdas Imagine & Arc view 3.2a.

The base map is prepared from SOI Toposheet at 1:50,000 scale. The spatial extent of the glacier is delineated and digitized in the Arcview 3.2a. The map prepared from satellite image is then superimposed on the base map in a GIS environment and the third layer was created by identifying the changed area. The findings are presented in the form of change detection map.

The methodology employed in the present study is given in fig. 1.2.

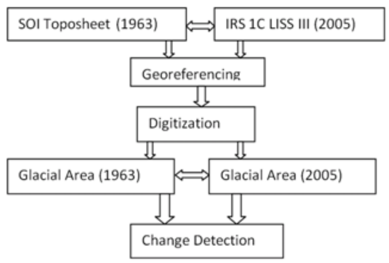


Fig.1.2. Steps of Methodology

Results and Discussion

The results of the present study are divided into three parts. Part –I deals with the various geomorphic features of the Kolahoi glacier which are identified during the field survey. Part –II deals with the change detection in the spatial extent of the Kolahoi glacier from 1963 to 2005. In the last part, discharge from the glacier in two time periods viz; 1992 & 2008 is studied which shows an increase in the glacier melt during the summer season.

(A) Geomorphic Features

Glaciers generally give rise to erosional features in the highland and depositional features on the lowland, although it shows all the three processes, erosion, transportation and deposition throughout its course. Abrasion and plucking are the two main processes responsible for the creation of erosional landforms of the study region. They operate when the glacier moves in the bed rock channels of the east and west Liddar valley in response to gravity and basal sliding.

Glacial Erosional Features

In the glaciated section of the Liddar valley the limited erosional feature like Whalebacks, Roche moutonnee, Glacial valleys and the Cirques were identified. A detailed account of these features is given in the table 1.1.

Table-1.1.: Erosional Features made by Kolahoi glacier.

Erosional feature	Characteristics	Site
(A) Striations, Grooves, & Roche Moutonnee.	Glaciers carry many types of fragments and particles embedded in them. Those particles placed along the base of a glacier may scratch, grind or groove the rock surface during the movement of ice. Such fine cut lines and scratches become exposed when the glacier disappears. These are termed as *striations or striae*, and are considered among the most reliable evidence of glacial erosion of the past ages. The small scale streamlined depressions are called as *glacial grooves* *Roche Moutonnee* is a glacial erosional feature, consisting of asymmetrical mounds of rock of varying size, with a gradual smooth abraded slope on one side and a steeper rougher slope on the other.	1. Glacial striated erratic at ARU. 2. Grooving in limestone at Nagakhoti, East Liddar. 3. Polished Roche moutonnee at Nagakhoti, East Liddar.
(B) Glaciated trough(valleys)	Well developed glacier valleys are called troughs. The glaciated valleys of the study region are asymmetrical and approximately parabolic in form. In their transverse profile, glacial valleys present a typical U-shaped outline, tending more towards a semi-circle. This is attributed to the fact that glaciers, unlike streams cut their sides at an equal or even at a faster rate than their bases.	Glacial trough at Liddarwat
(C)Whaleback	Whalebacks are glacially moulded, hard rock surfaces. Their length is greater than their height. They have smooth rock surfaces on all sides which have been produced by glacial abrasion. Whalebacks in the study region are rounded and elongated hillocks	Northern part of the Liddar Valley.
(D) Cirques	A cirque is a semi-circular steep-sided depression formed through glacial erosion. A cirque is formed at the head of a valley glacier where some snow accumulates and is compacted to form a cirque glacier flowing down slope to feed the valley glacier.	Near Kolahoi Gunj area and Hoskar

Source: Field Observation, 2010

Glacial Depositional Features

Glaciers hardly create any depositional features before they melt. Most of the deposition by glaciers therefore occurs in the zone of melting. The debris deposited directly by glaciers is not sorted or layered. It is heterogeneous in composition and lacks stratification. Such deposits are called moraines or glacial till.

Moraines

Moraines are the most important of the glacial deposits. The three types of moraines –the ground moraine, the lateral moraine and the terminal moraines produce different types of shapes. The major part of the glacial section of the valley is covered with moraines arranged in ridges, which are approximately parallel to the side of the valley. The various types of moraines found in the study region are given in the table-1.2.

Table-1.2: Depositional Features made by Kolahoi Glacier.

Types of Moraines	Characteristics	Location
(A) Lateral moraines	These are thin or thick streaks of rock debris that generally along the sides of a glacier.	Kolahoi Gunj Area.
(B) Ground moraines	These are formed when glacial sediments (Till) are deposited at the floor of glacial valley. The sediments are not sorted because coarse and fine sediments are deposited together.	Glacial till at Kolahoi, Lidderwat
(C) Terminal moraines	These are formed due to deposition of glacial Till across the moving ice sheets at the snouts of glaciers after ablation of ice.	Near Satlangan

Source: Field Observation, 2010

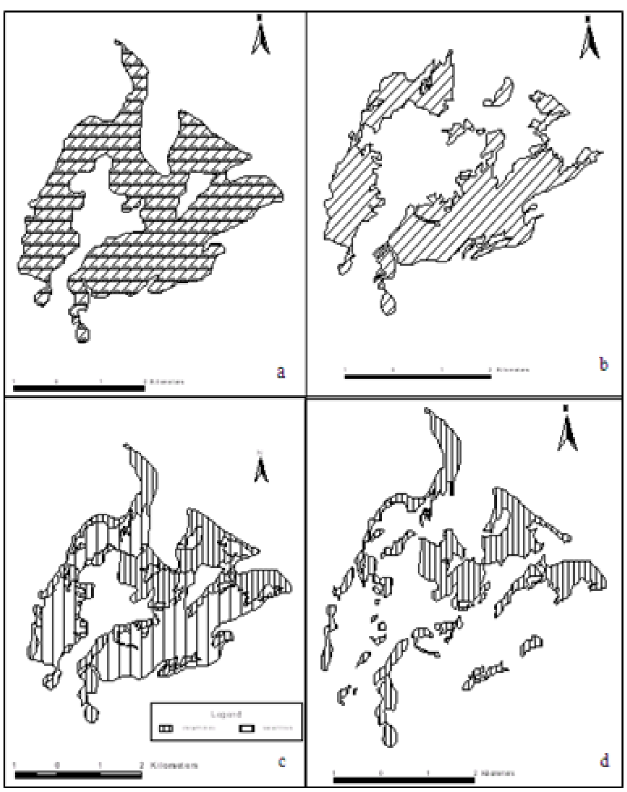
The advance movement of glacier creates some erosional and depositional features which remain stagnant and act as evidences for the glacial recession. The geomorphologic features of glaciers which act as indicators for its retreat or recession are glacial grooves, cirques, moraines, crevasses, eskers, outwash plains etc. The snout of the Kolahoi Glacier has narrowed and moved away from lateral moraines leaving behind end and lateral moraines; the earlier extent of the glacier can be estimated from them. The fresh, lateral moraines on the either side of the glacial trough near Kolahoi Gunj act as strong indicators of the past width and length of the glacier. The crevasses developed in the ablation portion of the Kolahoi glacier testify the fast retreat of the glacier. The main snout of the glacier has developed numerous caves which act as an indicator of fast recession. The distinctive location of end moraines at the three altitudinal sites of the west Liddar valley provides an evidence of three distinctive phases of deposition.

(B) Recession of Kolahoi Glacier

During Pleistocene, Kolahoi glacier was fed by nine other glaciers and its basin covered about 650km². The present snow field feeding this glacier covers only 2.5km², and no other glacier joins it. In Pleistocene it extended for 35km to terminate near 2760m ASL and at present it terminates within 3km from its cirque at 3650m ASL [4].

In the present study change detection was carried from 1963 to 2005 as given in table 1.3 and depicted in fig.1.3. The area of the Kolahoi glacier in the year 1963 was 13.57 km² which receded up to 10.69 km² in the year 2005, a net decrease of about 2.88 km² in 42 years. The rate of change is 0.68 km^2 per year from 1963 to 2005, thereby showing a drastic increase in the rate of retreat in the Kolahoi glacier.

Kolahoi glacier is thus receding at a very fast rate. It may be due to both anthropogenic & natural causes like increase in temperature, deforestation, tourism, increased activity of Gujjars & Bakerwalls, high levels of pollution caused by the emission of greenhouse gases, military vehicular movement, cement plants, etc.



Source: Computed from SOI Toposheets, 1963 & IRS 1C LISS III 2005

Fig. 1.3.(a,b,c & d): Change Detection of Kolahoi Glacier[a:1963;b:2005;c:Change 1963-2005;d:changed area]

(C) Discharge from the Glacier (1992 & 2008)

The Hydrological data of west Liddar of 1992 & 2008 as given in Table 1.4 shows a net increase in the discharge of Liddar river. The variability in the discharge in the years 1992 & 2008 is shown in Fig. 1.4.

Table 1.3: Change Detection of Kolahoi Glacier

Area(Km²) 1963	*Area(Km²) 2005*	*Time Interval*	*Change (km²)*	*Rate of Change (km²/year)*
13.57	10.69	42 years	2.88	0.068

Source: Computed from SOI Toposheets, 1963 & IRS 1C LISS III, 2005

Table-1.6: Discharge at Aru (west Liddar) for the years 1992 & 2008.

{YEAR 1992}		{YEAR 2008}	
Date	Discharge (cusecs)	Date	Discharge (cusecs)
10-01-1992	190	07-01-2008	23
10-02-1992	172	07-02-2008	15
11-03-1992	435	07-03-2008	229
23-04-1992	681	07-04-2008	247
06-05-1992	470	07-05-2008	1393
06-06-1992	810	07-06-2008	1687
06-07-1992	790	07-07-2008	1130
06-08-1992	870	07-08-2008	393
06-09-1992	295	07-09-2008	677
03-10-1992	155	07-10-2008	145

Source:-Department of Irrigation & Flood control, Srinagar

In the months of May, June & July for the year 1992, the discharge was 470, 810, & 790 cusecs respectively. In comparison to this, the discharge from these months for the year 2008 was 1393, 1687 &1130 cusecs respectively. This may be due to the increase in the glacier melt & subsequent runoff and thus indicates the rapid melting of the glacier in the year 2008 in the summer season (May, June & July) in Kashmir.

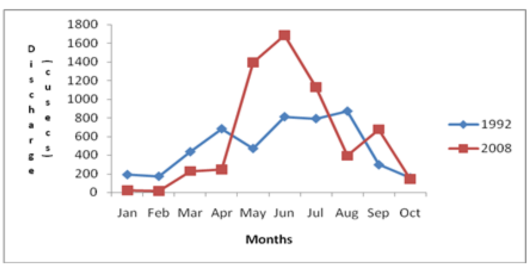


Fig.1.4:Discharge of West liddar River At Aru(For the years 1992 &2008).

Conclusion

Glaciers are in the process of retreat in almost all the parts of the world due to global warming. The same process of retreat is found in the valley's largest glacier, Kolahoi. Its area in the year 1963 was 13.57km² which receded up to 10.69km² in the year 2005, a net decrease of about 2.88 km² in 42 years. This is also evident from the distinctive location of end moraines at the three altitudinal sites of the west Liddar valley which provide an evidence of three distinctive phases of deposition. The Crevasses developed in the ablation portion of the Kolahoi Glacier and the formation of numerous caves at its snout position act as the important indicators of its recession.

The Hydrological data shows a net increase of 2140 cusecs during the summer season (May, June, July) in the discharge of Liddar River. This is due to the increase in the glacier melt & subsequent runoff. The large production of glacial melt water is also testified by the breaking of glacial ice at several places in Kolahoi Glacier

Kolahoi glacier is receding at a very fast rate due to both anthropogenic & natural causes like increase in temperature, deforestation, tourism, increased activity of Gujjars & Bakerwalls, high levels of pollution caused by the emission of greenhouse gases, military vehicular movement, cement plants, etc.

The result of this retreat will prove disastrous for the valley in many fields like drinking water, agriculture, horticulture, ground water, hydro power capacity of the state, etc. Therefore, we need to make efforts to save this precious source of water for the present as well as for future generations.

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