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Summary Of The Thesis Entitled,"Application Of Remote Sensing And Gis In Glacial Geomorphic Studies Of Baspa Valley, Himachal Pradesh, India".

A THESIS SUBMITTED TO
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IN
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through the burning of fossil fuels and other human activities, understanding past climate variability as a means to predicting future change becomes ever more important, and represents one of the great challenges for modern science. In above perspective, an attempt has been made here to understand the paleoglacial activity of Baspa valley and following *objectives* were selected for the present study.

1] *To analyze various Remote Sensing and GIS techniques for glacial geomorphic mapping.*

2] *Delineation of lower limit of glaciation.*

3] *Systematic mapping of glacial geomorphic features and understanding its processes.*

4] *Interpretation of geomorphic features (indicators) for understanding past glacial activity.*

In order to achieve aforementioned *objectives* following *methodology* was adopted

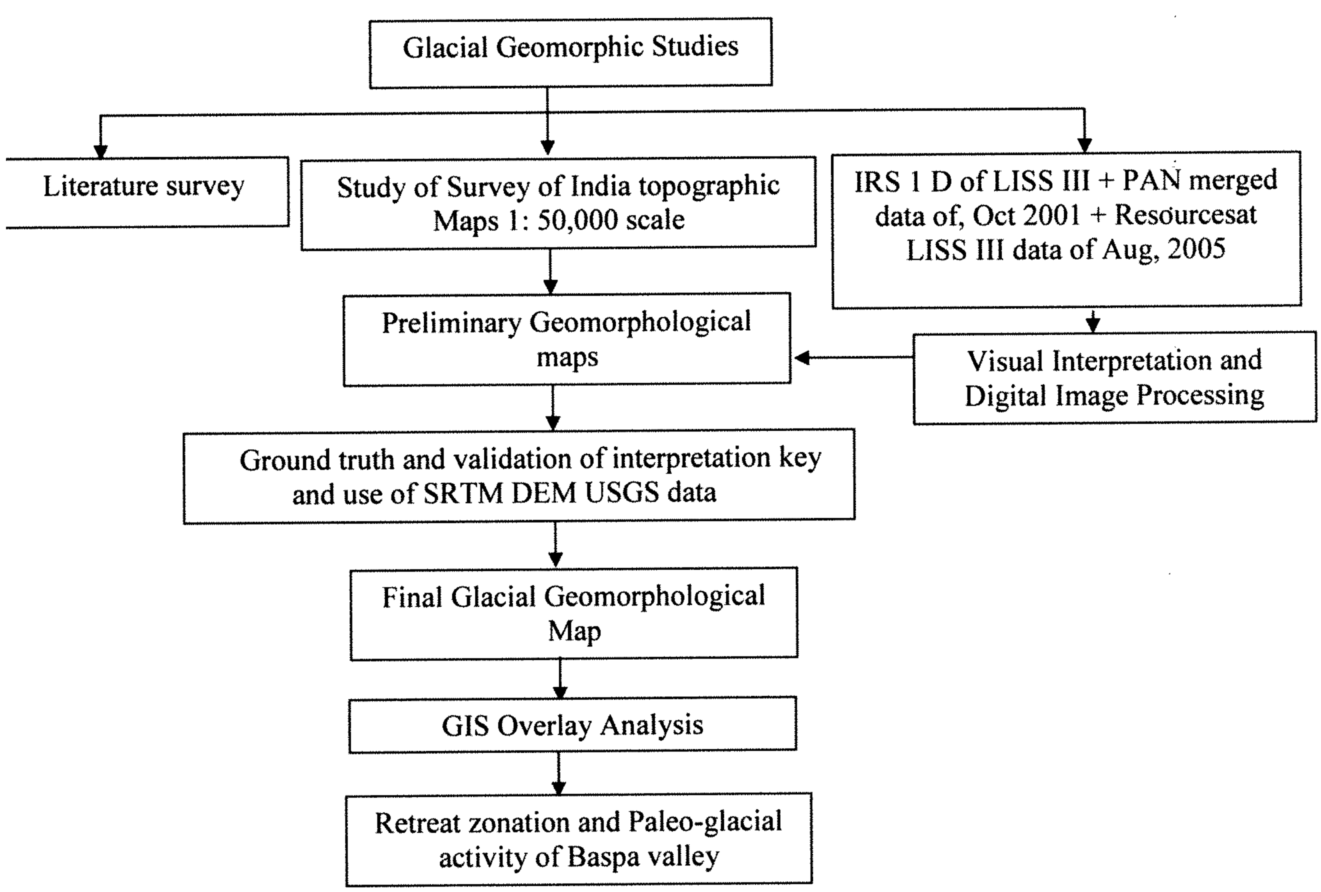

Table 1. Visual interpretation key

Sr. no	Geomorphic Features	Colour	Texture	Shape and Size	Location/Associated Features
1.	Accumulation zone	White	Fine	Circular to semi-circular, small-medium	cirques
2.	Permanent snowfields	White	Fine	Irregular, small	Top of the mountain ridges
3.	Exposed Ablation zone	Grayish white	Fine	U-shape, small-medium	Below accumulation zone,
4.	Moraine covered ablation zone	Brown	Medium	U-shape, small-medium	Below exposed ablation zone
5.	Snout	Black	Fine	Irregular, small	End of ablation zone, emergence of stream from terminus of glacier
6.	Crevasses	Bluish white - black	Fine to Medium	Linear-curvi linear, small	Accumulation zone
7.	Medial moraines	Bluish-White to Brown	Medium	Linear/Small-medium	Middle part of glacier, Ablation zone
8.	Lateral moraines	Brown	Medium-coarse	Linear/ small-large	Margins of glacier/valley walls
9.	Terminal moraine	Brown	Medium	Convex/small - medium	Terminus of glacier, deglaciated valley
10.	Deglaciated valley	Grey/brown	Medium	U shape/medium-large	Below ablation zone
11.	Maximum glacial limit	Grey/brown	Medium	Convex/small - medium	End of deglaciated valley
12.	Lakes	Blue to black	Fine	Circular-Irregular/small	Deglaciated valley valley
13.	Hanging valley	Brown	Small - medium	U shape	Horns and aretes
14.	Debris fans	Gray	Fine-medium	Triangular/small-medium	Foot of the valley

In ERDAS itself using GIS different themes were prepared viz.,

1] Satellite data of LISS III + PAN

2] Satellite data of LISS III, 2005

3] Satellite data of LISS III, 2001

4] Geomorphic features prepared from satellite data

5] DEM and

6] Slope map

An area – area overlay analysis was carried out in order to know the changes and to retreive the information. The Geomorphological maps are prepared in ARC VIEW while 3D view of each glacier is shown by draping satellite data over SRTM DEM to visualize the geomorphic features like cirques, horns and aretes. The results obtained and the information generated after using remote sensing and GIS techniques, is presented in the form of maps and Glacier Geomorphic Inventory.

Based on above Remote Sensing Techniques Glaciers were classified into three major glacial geomorphic zones viz, accumulation zone, ablation zone, and deglaciated valley. These zones comprises of varied type of erosional and depositional geomorphic features as described in the Visual interpretation key above. Certain features which were identifiable only in field include., Striations, frost shattering, and polished rock surfaces of Granitoids and gneisses. Horns, aretes, etc., which also supported the evidence of past-glacial activity.

The glaciers within the Baspa valley were later on classified into two groups namely 1] south facing and 2] north facing glaciers. The data generated from glacial geomorphic inventory suggests, retreat of the glaciers since the glacial maxima as demarcated from the satellite data. Careful observation of inventory reflects the role of various factors i.e., size of accumulation and ablation zone, slope of accumulation and ablation zone, nature of rock types, and amount of moraine cover on ablation zone. In addition to all these factors which are closely interrelated to each other, orientation of the glaciers also controls the percentage of retreat. Each of these parameters is considered as separate theme and overlay analysis method of GIS is used to understand the relation amongst them.

Slope - The results indicate that overall the glacier retreat is directly proportional to the slope of ablation.

Mcab/Exab Ratio - The data generated shows a significant relation between the ratio of moraine covered ablation zone (Mcab) to exposed ablation zone (Exab). As this ratio increases the percentage of retreat of the glacier decreases and vi-s-vis. The Mcab/Exab ratio thus develops inverse relationship with percentage of retreat.

Size of Accumulation and Ablation zone - The size of accumulation and ablation zone is comparatively larger for north facing glacier than south facing glaciers. Overall, the percentage of glacier retreat forms inverse relationship with the size of accumulation and ablation zone.

Orientation of Glacier - The facing direction is very important since it provides information about period of solar radiation. The south facing glaciers are exposed to solar radiation for longer time as compared to north facing glaciers. The longer time for solar radiation increases the rate of melting for south facing glacier than the north facing glacier.

For studying the percentage of retreat all the factors has to be taken in toto as they are interdependent. By considering theses factors the percentage of retreat is calculated from the glacial maximum limit demarcated from the satellite data.

Thus, it can be concluded that a visual interpretation technique helps in differentiating the various types of glacial geomorphic features while the image processing techniques can be used as a complementary methods. For the mapping of cirques, horns and aretes SRTM DEM overlapped by Satellite data is proved to be very effective. The digitization of all these maps under the GIS environment helps in generating reliable glacier inventory. GIS overlay analysis is also useful to generate a correlation between the parameters like lithology, slope, size of accumulation and ablation zone, ratio of Mcab/Exab, and orientation of glacier. The glacial geomorphic studies which are carried out for 35 glaciers of Baspa valley suggest, that the south facing glaciers are retreating faster (33.92%) than the north facing glaciers (22.20%). Since 2001, the average snowline in the Baspa valley has gone up by 33 m. In the past the extension of glaciers were at much lower altitude i.e atleast 950 m below the present day extent of the glacier. From this limit the present day south facing glacier shows 4670 m lengthwise retreat while that of north facing show 3880 m of retreat. The retreat is supported by the presence of many empty cirques, hanging valleys, horns and aretes of different shape and size. The enhanced retreating trend reveals that many glaciers in Baspa valley show their individual limbs exposed, which were initially flowing as a single glacier. Present day, Baspa valley reflects increase in the number of glaciers and decrease in the size of glaciers on account of process of *fragmentation.* Terminal and lateral moraines are found to be an important glacial geomorphic indicators and present in almost all the glaciers. The number of sets can be correlated with the stages of deglaciation however dating is required to confirm this fact. Maximum three stages of deglaciation have been delineated by application of Remote Sensing and GIS for Baspa valley.