

# Chapter 138

## Monitoring Glacial Parameters in Parts of Zanskar Basin, Jammu and Kashmir

Iram Ali, Aparna Shukla, and Junaid Qadir

**Abstract** Alteration in glacial parameters are pertinent indicators of glacier health and their response to climate change. In the present study, five glaciers of Zanskar basin including Pensli-lungpa, Durung Drung, Kangi, Hogshu and one unnamed glacier have been studied for temporal changes in glacial extent, glacial mass balance via accumulation area ratio (AAR) and ELA. For this purpose various multi-temporal satellite datasets of the study area and ASTER DEM have been used. ELA has been derived by using normalized difference glacier index (NDGI) technique and DEM together. Glacier boundaries have been derived by manual digitization. The mapping of glaciers during the period 1980–2000 & 2000 to 2011 reveals that the glacier cover reduced from 291.98 km<sup>2</sup> to 259.11 km<sup>2</sup>, and 259.11 km<sup>2</sup> to 250.96 km<sup>2</sup> witnessing deglaciation of 11.25% and 3.14% respectively. Moreover, that there has been an increase in SLA of the sub basin from 5126 m a.s.l to 5297 m a.s.l from 1977 to 2000 and 5297 m a.s.l to 5361 m a.s.l from 2000 to 2011. Besides, the minimum and maximum AAR derived mass balance for the study area during the period of study has been 42.61 cm and -13.17 cm, respectively. An increase in the mean ELA in the area is followed by pronounced glacier recession and deglaciation.

**Keywords** Equilibrium line altitude (ELA) • Accumulation area ratio (AAR)

### 138.1 INTRODUCTION

Snow and glaciers are very important components of the Earth's surface. Spatial extent of glaciers and its components are sensitive to climatic conditions and climate change [4]. Glacier length, mass balance and snow melt runoff are some of the glacier parameters that are directly or indirectly related with the climate. Any change in the climate is reflected by the glacier and can be studied by analyzing the glacier parameters. This necessitates active mapping and monitoring of glacier parameters. Deglaciation, retreat, variations in equilibrium line altitudes (ELA),

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I. Ali (✉) • A. Shukla • J. Qadir  
Department of Earth Sciences, University of Kashmir, Srinagar, India  
e-mail: [geoiram@gmail.com](mailto:geoiram@gmail.com)

accumulation area ratio (AAR), glacier thickness and volume are some of the inter-linked and vital glacier parameters with reference to scrutinizing impacts of climate variability on glaciers in a region. Considering the vastness and inaccessible nature of mountain glaciers, and the repetitive observations required, satellite remote sensing technology offers a highly viable tool for monitoring the different glacier parameters in an effective way [1]. More recently [2] analyzed the glacier retreat and morphometric parameters in Doda valley, Zaskar basin in Jammu & Kashmir of the glaciers using multi-temporal satellite data and concluded that the total glacier area loss from 1962 to 2001 is 18.16% and the mass balance for the years 1975 and 1992, is positive but in the year 2001, specific mass balance of all glaciers was negative. The present work is aimed at deriving retreat, deglaciation, variations in the ELA & AAR for five glaciers (Pensli-lungpa, Durung-drung, Kangi, Hogshu and one un-named glaciers) of Zaskar basin using time series LANDSAT MSS, TM, & ETM+ from 1977 to 2013.

## 138.2 STUDY AREA

The study area includes Zaskar valley Ladakh, Jammu & Kashmir in the Great Himalayan Range extending from  $33^{\circ}5'24''$  N  $-77^{\circ}10'12''$  N to  $34^{\circ}5'24''$  N  $-75^{\circ}59'23''$  E. The elevation in the area ranges between 3700–6400 m above MSL. The important glaciers constitute Pensilungpa, Durungdrung, Kangi and Hogshu among which Durungdrung glacier is the largest one.

## 138.3 MATERIAL AND METHODS

In order to carry out the present study, multi-temporal satellite data of years 1977, 1980, 1999, 2000, 2011 and 2013 from LANDSAT MSS, TM, ETM+ and ASTER DEM have been used as primary datasets. For the purpose of deriving snowline, normalized difference glacier index (NDGI) was applied and a threshold value of 0.32 has been found suitable for mapping and differentiating between accumulation and ablation zones. The mapping of the glaciers was carried out by manual digitization from the period 1977 to 2013 which was aided by using various spectral band combinations and false colour composited (FCCs). For the current study accumulation area ratio (AAR) was firstly derived from the below equation  $AAR = S_C / S_G$ . Where  $S_C$  represents surface area of accumulation zone and  $S_G$  the total surface area of the glacier respectively [3] which later on was converted to specific mass balance using equation given below:

$$Y = 243.01 * X - 120.187$$

where  $Y$  is the specific mass balance in water equivalent (cm) and  $X$  is the accumulation area ratio [5].

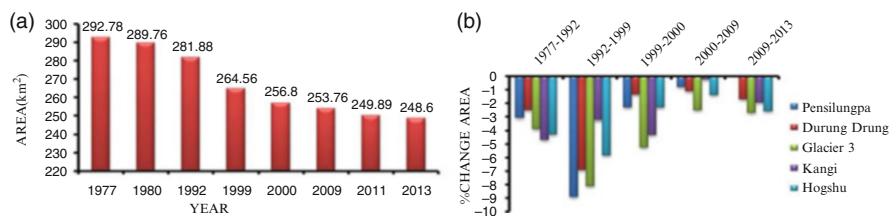
## 138.4 RESULTS AND DISCUSSION

### 138.4.1 Glacier Area Changes

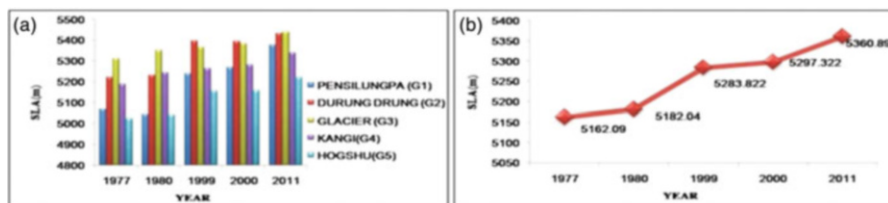
The results reveal that the glacier areas of Pensilungpa (G1), DurungDrung (G2), G3, Kangi (G4) and Hogshu (G5) were reduced from 21.39 km<sup>2</sup>, 82.45 km<sup>2</sup>, 44.72 km<sup>2</sup>, 65.57 km<sup>2</sup> and 78.65 km<sup>2</sup> to 18.28 km<sup>2</sup>, 71.72 km<sup>2</sup>, 35.50 km<sup>2</sup>, 56.59 km<sup>2</sup> and 66.51 km<sup>2</sup>, respectively, from 1977 to 2013 Fig.138.1 (a). This results to a total deglaciation of 14.53%, 13.01%, 20.61%, 13.69% and 15.43% for Pensilungpa, DurungDrung, G3, Kangi and Hogshu for past 36 years (1977 to 2013) Fig. 138.1(b).

### 138.4.2 Variations in Snow Line Altitude (SLA)

An in depth analysis of SLA of five main glaciers in Zaskar basin reveal that there has been an increase in SLA of the sub basin from 5126 m a.s.l to 5297 m a.s.l from 1977 to 2000 and 5297 m a.s.l to 5361 m a.s.l from 2000 to 2011 Fig 138.2 (a). The mean SLA of each glacier is represented in Fig. 138.2(b).



**Fig. 138.1** (a) Variation in the glacier area from 1977-2013. (b) Change in area (%) for individual glaciers from 1977–1992, 1992–1999, 1999–2000, 2000–2009 and 2009–2013



**Fig. 138.2** (a) Variations in snow-line altitudes (SLA) of all glaciers from 1977–2011. (b) Mean snow line altitude (SLA) of each glaciers from 1977–2011

**Table 138.1** Summary statistics of individual mass balance and AAR values of glaciers for year 1999, 2000 and 2011

Glacier name	Mass Balance (cm)	AAR	Mass Balance (cm)	AAR	Mass Balance (cm)	AAR
	1999	1999	2000	2000	2011	2011
Pensilungpa (G1)	17.81	0.56	13.94	0.55	5.9	0.51
Durungdrung (G2)	17.83	0.56	-5.28	0.47	12.6	0.54
Glacier (G3)	17.58	0.56	-9.83	0.45	5.92	0.51
Kangi(G4)	11.62	0.54	-26.84	0.38	-5.19	0.47
Hogshu(G5)	13.58	0.55	-16.89	0.42	4.56	0.51

### 138.4.3 Mass Balance

After analyzing the mass balance of all the glaciers it has been depicted that the mass balance for the years 1977 and 1980 is positive for all the glaciers whereas the mass balance in year 1999 shows moderately positive mass balance Table 138.1.

## 138.5 CONCLUSIONS

The study reveals that NDGI has proved to be the best semi-automatic method for differentiating between snow and ice. Additionally it has been found that the total glacierized area of basin reduced from 292.78 km<sup>2</sup> to 248.74 km<sup>2</sup> from 1977 to 2013. Consequently the mean SLA of the sub-basin has increased from 5126 m a.s.l to 5297 m a.s.l from 1977 to 2000 and 5297 m a.s.l to 5361 m a.s.l from 2000 to 2011. Besides, mass balance for the years 1977 and 1980 is positive for all the glaciers where as the mass balance in year 1999 shows moderately positive mass balance. The results obtained here are in good confirmation with one another. Additionally, the results from the glacier parameters indicate a general degeneration of glaciers in the study area which necessitates their continuous and regular monitoring. This emphasizes the fact that these parameters are important indicators of glacier health.

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