# An estimate of glacier stored ice in the Satluj and Beas Basins of the Himalaya

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The Satluj River originates near Manasarovar Lake and flows through Tibet, before entering India at Shipki La pass. The river flows west-southwest through the states of Himachal Pradesh and Punjab, where Beas river confluences with the Satluj river. Satluj river is fed by the glacier melt, snow melt and rain, and is considered to be the life line of Northern India, providing water for irrigation canals and a number of hydro-electric power projects like Bhakra-Nangal, Nathpa Jhakri, Kol dam and Baspa Hydel Project. The Satluj and Beas basins consist of 2018 and 469 glaciers with a glacierized areas of $1433 \pm 71$ km2 and $499 \pm 25$ km2 respectively. In the future, however, the glaciers in the basin are going be altered due to fluctuations in the climate. Basin scale assessment of the glacier volume in these reservoirs is crucial to assess the future changes in mass loss, melt runoff and hydro-electric potential. Hence in this study, the volume of glaciers in Satluj and Beas basins of the Himalaya are estimated using the automated laminar flow model and scaling equation.

The volume of the glaciers can be derived by using a laminar flow model with glacier surface velocity and slope derived from remote sensing images. Glacier surface velocities are obtained by sub-pixel correlation of consecutive year image scenes and slope is estimated from a digital elevation model at 100 m contour intervals. The thickness is initially obtained over multiple flowlines drawn on the glacier and then interpolated using thin plate spline interpolation over the entire extent of the glacier. The above process has been completely automated by using Python scripting. Currently this model is applicable to glaciers for which uniform velocity fields are available. The thickness distribution of 298 glaciers are estimated by using the model in Satluj and Beas Basins, which cover an area of $588 \pm 29$ km2 and have an estimated volume of $27.5 \pm 5$ km3. However, large area of the basin is occupied by smaller glaciers and due to the presence of cloud cover, velocity field are not available for all glaciers. Hence, the volume of the other glaciers is computed by developing an empirical volume area scaling equation. A power-law relation is derived between the area of the glaciers and volume estimates from the laminar flow model area and volume of the glacier, with scaling exponent $\lambda = 1.2869$. The total amount of glacier stored ice in Satluj and Beas basin is equal to $84 \pm 15$ Gt, obtained from modelled and statistically upscaled estimates of glacier volumes.