

## Temporal and seasonal variation of supraglacial ponds in Everest region, Nepal.

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Himalayan glaciers are characterized by the presence of debris cover in their ablation zone and are potential for the formation of supraglacial ponds. Supraglacial ponds are storage of meltwater from glacier ice and play a key role in the ablation process in debris-covered glaciers. Knowledge of supraglacial pond development and their temporal and seasonal variation is limited in the Himalayan region. This study provides an assessment of supraglacial ponds at the surface of 29 debris-covered glaciers in Everest region from 1989 to 2017. We used Landsat surface reflectance level-2 science product comprising TM, ETM, and OLI of 30 m resolution from 1989-2017 to study the long-term evolution and Sentinel-2 of 10 m resolution for the year 2016 and 2017 to study short-term variation of supraglacial ponds. Validation of results is done by using WorldView series images of 0.31 m resolution. The result from Landsat image analysis shows a rapid increase in number and area of the supraglacial ponds especially in large glaciers. The mean slope of large glaciers i.e. Ngozumpa, Bhote Kosi, Khumbu, Changri Nup, Imja and Lhotse Shar, and Lhotse Glacier is less than 10 degree is assumed to be favorable condition for the formation of ponds. However, evaluation of glacier velocity, aspect and other controlling factors also needed to understand pond formation, seasonality, and persistence. The area of Spillway Lake and associate lakes at the terminus of Ngozumpa glacier are increased by 21th times in 27 years, indicates the sign of formation of a large glacial lake in near future. Similarly, we found substantial variation in number and area of the ponds in different seasons of the year 2016 and 2017 indicates hydrological activity of ponds in different seasons. From this study, we found that Landsat series and Sentinel-2 images are useful to study the long-term evolution and short-term variation of supraglacial ponds, respectively. However, fine-resolution imagery and field-based measurement are required to minimize the error and better understand of pond formation, their seasonality, persistence, and drainage activities.

Keywords: debris-covered glacier, supraglacial pond, Landsat, Sentinel-2