

## Historical development of Spillway Lake on Ngozumpa Glacier, Nepal

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Continuous loss of glacier mass in the recent period resulted the growth of several moraine-dammed glacial lakes at the terminus of the glaciers in the Himalayan region. It increases the risk of glacier lake outburst floods with the increase in size and volume of lakes. The loss of glacier mass decreases the elevation of the glacier surface and leads to the formation of elevated moraine dam which increase the possibility for developing new glacial lakes. In this study, we document the historical development of the spillway lake on Ngozumpa Glacier, Nepal using a combination of Unmanned Aerial Vehicle (UAV) photos, WorldView imageries (0.5 –2 m), and Landsat imageries. We used Landsat imageries from 1989-2018 to prepare the long-term development of the lakes. High-resolution WorldView images and UAV photos were used for accuracy assessment. We also processed the UAV photos to prepare the Digital Elevation Model to understand the possibility of future development of the lakes. We observed the three small supraglacial ponds (0.03 km<sup>2</sup>) near the terminus of the glacier in 1989 and they have undergone rapid change in their area till 2018 (0.32 km<sup>2</sup>), increased by more than ten times. Several supraglacial ponds are merging together to become a large lake and it will be likely to continue in the future. The further growth of the lake is dependent largely on the subaqueous melting and calving of glacier ice, and on undercutting action of lake water. Subaqueous melting of the glacier ice leads to increase of lake depth and volume of water. However, future development of the lake depends largely on the level of the outlet channel. Presence of glacier ice under the channel may continuously lower its level and drain the water from lake. Geophysical studies are needed to understand the condition of the outlet channel.

Keywords: Glacier, Himalaya, Glacial lake, Glacier lake outburst floods, Nepal, Unmanned Aerial Vehicle (UAV)