

Satellite sensing of Luggye glacier mass balance since 2001 and variations of Luggye glacial lake over the past four decades, Bhutan Himalayas

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Abstract

Luggye glacial lake is one of the most rapidly expanding moraine dammed glacial lakes in Bhutan Himalayas. Despite a previous catastrophic record of outburst it is prone to burst again looking at the enormous volume of water it contains and significant rate of expansion. This study reveals the factors controlling the accelerated expansion of Luggye glacial lake and changes of Luggye glacier using multi-temporal Landsat satellite images (1972-2015), ASTER digital elevation models (DEMs) and meteorological data (2006-2014). The surface area of lake has increased by 1.18 ± 0.19 km² (229.07%) and expanded at the mean rate of 0.03 ± 0.005 km² a⁻¹. The surface area of Luggye glacier has diminished by -1.17 ± 0.64 km² (-21.52%) and the south facing glacier has suffered major loss in an area. The terminus of Luggye glacier has retreated at the average length of -43.93 ± 2.21 m a⁻¹ between 1972 and 2016. A strong negative correlation ($r = -0.83$) exists between areal increase of Luggye lake and clean glacier surface area loss and is highly statistically significant ($p < 0.005$). The study also reveals significant mass loss (2.17 ± 1.98 m w.e.a⁻¹) and downwasting rate (2.81 ± 1.97 m a⁻¹) of Luggye glacier between 2001 and 2015. Thus, the substantial mass loss of glacier due to increase in the annual mean, maximum and minimum temperatures accompanied by slower accumulation as a result of reduced precipitations could have resulted in accelerated expansion of Luggye glacial lake in the last few decades.

Keywords: glacier mass balance, glacial lake, ASTER, Landsat, Bhutan Himalayas

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