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Potentially dangerous glacial lakes across the Tibetan Plateau revealed using a large-scale automated assessment approach

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Glacial lake outburst floods (GLOFs) are a major concern throughout the Third Pole Environment, where thousands of glacial lakes have formed, and continue to expand in response to climate warming and glacial retreat. This is particular true in the Himalaya, where several disasters occurring over the past century have caused significant loss of life and damage to infrastructure. This study responds directly to the needs of local authorities to provide guidance on the most dangerous glacial lakes across the TP where local monitoring and other risk reduction strategies can subsequently be targeted. Specifically, the study establishes a first comprehensive prioritisation ranking of lake danger for the TP, considering both the likelihood and possible magnitude of any outburst event (hazard), and the exposure of downstream communities.

A composite inventory of 1291 glacial lakes (>0.1 km2) was derived from recent remote sensing studies, and a fully automated and object assessment scheme was implemented using customised GIS tools. Based on four core determinants of GLOF hazard (lake size, watershed area, topographic potential for ice/rock avalanching, and dam steepness), the assessment identified a concentration of lakes with high to very high hazard levels located along the main Himalayan range, and in southeast TP. A validation exercise revealed that 19 out of 20 lakes that have previously generated GLOFs in the region are classed as having high (5 lakes) to very high (14 lakes) hazard levels under the current assessment scheme. Once human exposure it taken into account, the extent of the GLOF danger across the TP becomes far more constrained. Notably, 16% of all glacial lakes threaten human settlements, with a hotspot of GLOF danger identified in the central Himalayan counties of Jialong, Nyalam, and Dingri, where the potential trans-boundary threat to communities located downstream in Nepal is also recognised. For example, in Nyalam, where 7 out of 10 lakes with the highest levels of potential danger are identified, the Sun-Koshi (Friendship) highway has historically linked China with Nepal, with considerable built infrastructure and large communities located along this important transportation corridor. Cirenmaco, located above the Sun-Koshi highway, emerges as the most dangerous lake, further enhancing confidence in the assessment methodology, given that this lake has been the source already of 3 major GLOF events including the devastating event of July 1981 in which 200 people were killed.

The results presented here provide an important and object scientific basis for decision-making. Importantly the methodology is well suited for replicating across other regions of the Third Pole where objective, large-scale GLOF assessment studies are currently lacking. This would be important, for instance in countries such as India, Bhutan, Pakistan, and Afghanistan, to ensure that nationally and internationally funded GLOF risk reduction strategies are most appropriately targeting those areas where the threat is greatest.