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Susceptibility Based on System Failure: A Case Study of the Congduipu River Basin in Nyalam , Tibet

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Global warming induces the number of glacial lakes and the risk of glacier lake outburst of debris flow (GLODF) increasing in the high-mountain region, especially in Peru and the Himalayan region. GLODF Susceptibility assessment is a critical work that uses the spatial occurrence probability of debris flow to guide risk management and mitigation. Multiple glacial lakes in the basin could trigger GLODFs. The possibilities of multiple glacial lake outburst floods, flood flow paths, the likelihood of transformation into debris flows, and the overlapping relationships of flow paths within the river basin need to be considered in susceptibility assessment, which is a system instability problem characterized by multiple triggering factors and pathways. This paper considered the system failure of GLODF and proposed a new method to analyze it. The method includes seven steps, i.e. setp1-Determine the range of the assessment area or watershed, step2-Screen and classify glacial lakes and gullies, step3- Draw flow path and key node diagram, step4-Label the switches and conductance parameters, step5- Construct the series relationships of flow paths, step6- Evaluate the susceptibility of GLODF and step7- Zone the susceptibility grade. Moreover, the susceptibility indexes of GLODF were proposed in this paper, which considered the main factor affecting glacial lake outbursts and debris flow along the gully. This method was applied to a case that is in the Congduipu River basin in Tibet, China. The river basin is approximately 366 km^2 and has 6 glacial lakes (>0.1 km^2), 11 gullies, and more than 4 GLODF events. The results indicate that among the evaluated glacial lakes, one has a very high probability of outbursts, two have a high probability, and there are three instances each of debris flow disasters with very high and high susceptibility, respectively. The historical disaster records and field investigation results in the Congduipu River basin have verified the evaluation method. This method is applicable to quickly evaluate the susceptibility of GLODF in the river basin with multiple glacial lakes and gullies.