Chapter 6
Mapping of Glacial Lakes and Glacial Lake Outburst Flood in Kinnaur District, Himachal Pradesh Using Remote Sensing and GIS

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ABSTRACT

Glacial lake outburst floods (GLOFs) are increasingly threatening the sustainability and infrastructure of high-mountain regions globally. This study specifically addresses the GLOFs risk in the Kinnaur district of Himachal Pradesh. Using a comprehensive analytical framework, the authors explore factors affecting GLOF initiation, map potential downstream impact zones, and assess societal vulnerability to these climate-induced calamities. For precise analysis, they utilize Landsat images (1989-2018) and Cartosat DEM (30 m) data to map glacial lakes. ArcGIS 10.8 generates geospatial characteristics, while the maximum likelihood classification (MLC) algorithm is

DOI: 10.4018/979-8-3693-1396-1.ch006

employed for land use and land cover (LULC) mapping. Indices like NDSI, NDWI, and NDPI contribute additional insights. Identifying 39 glacial lakes, 10 deemed hazardous due to size (>0.1 km2), the study underscores the specific threat of cross-border GLOFs from China's Upper Satluj River Basin to Eastern Himachal Pradesh. In a prospective deglaciated scenario, it is envisaged that a substantial escalation in glacial lake outburst flood (GLOF) hazard levels will prevail across the majority of administrative units. Given the increasing encroachment of glacial lakes towards precipitous headwalls, the potential for glacial lake outburst flood initiation is significantly amplified. This elevates the risk to surrounding areas, as the displacement of ice and rock can initiate substantial GLOFs. In light of this prognosis, an essential initial action for adaptation in these circumstances involves strengthening resilience and implementing capacity-building measures designed to reduce the risk of GLOFs.

INTRODUCTION

The Indian Himalayan Region (IHR) faces significant and complex challenges in addressing the adverse impacts of climate change. This region, similar to numerous other mountainous areas worldwide, exhibits heightened vulnerability to the consequences of global climate shifts, impacting both its natural environment and man-made environment. The recession of mountain glaciers and the emergence of large glacial lakes stand out as prominent and evolving outcomes of climate change (Bolch et al. 2008). The risks associated with glacial lake outburst floods (GLOFs) are on the rise, evolving in tandem with changes in the stability of the surrounding rock and ice walls (Clague and Evans, 1992; 2000; Mool 2005). With the expansion of residential, tourism, and particularly hydroelectric developments into alpine valleys, coupled with a growing human dependence on limited hydrological resources, there is an urgent need to enhance the integration of strategies for mitigating the risk of glacial lake outburst floods (GLOFs) into climate adaptation planning (Quincey et al. 2007).

Glacial lake outburst floods (GLOFs) represent the sudden discharge of a water reservoir that has developed beneath, on the side of, in front of, within, or on the surface of a glacier. Dams associated with these events can consist of ice, moraine, or bedrock. Given the anticipated warming and ongoing reduction of alpine glaciers (Reynolds 2000; Benn et al. 2000), the focus has shifted from monitoring and evaluating existing GLOF risks to predicting the emergence of potentially dangerous lakes in the future. These lakes are expected to primarily form within depressions on the exposed glacier bed (Frey et al. 2010; Ukita et al. 2011) and will be impeded

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