INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Eastern Himalayas, among the most tectonically active and climate-sensitive mountain systems on Earth, have experienced a rapid proliferation of glacial lakes over the past three decades due to accelerated glacier retreat, shifting precipitation regimes, and unregulated human activity. This transformation has substantially heightened the threat of Glacial Lake Outburst Floods (GLOFs), which can release large volumes of water and debris with severe consequences for downstream communities, infrastructure, and ecosystems.

Despite this rising threat, current GLOF risk assessments remain constrained in scope. They largely focus on glaciological and hydrological parameters, while underrepresenting other critical factors such as seismic activity, proximity to active faults, slope instabilities from landslides, and cascading effects from neighbouring lakes. The dynamic interactions of these drivers are seldom integrated, even though they significantly influence lake stability and outburst potential. In addition, predictive uncertainty is rarely addressed, reducing the credibility of such studies for guiding mitigation and preparedness in data-scarce, rapidly evolving mountain environments. These gaps highlight the urgent need for frameworks that are both comprehensive and probabilistically informed.

In response, this thesis develops a unified, machine learning-based, probabilistically informed framework for GLOF hazard and risk assessment in the Eastern Himalayas. By sequentially integrating geomorphological interpretation, deep learning for feature detection, multi-criteria decision analysis, and Bayesian inference, the framework aims to capture diverse hazard drivers while explicitly quantifying predictive uncertainty. This approach is designed to provide scalable, uncertainty-aware insights that can support early-warning systems, land-use planning, and climate adaptation strategies.