

**Project title:** Landslide Mapping, monitoring and early warning using optical imaging drone and geo-integrated rainfall threshold based models along National Highway corridor of Bhagirathi Valley, Uttarakhand, India

**Abstract:**

The prime objective of the present proposal is to develop a novel geo-integrated landslide early warning system along National Highways encompassing landslide mapping and monitoring techniques using drone (UAV) based optical imaging and geo-integrated rainfall threshold models. In the process, detailed mapping of potential unstable slopes along the major highway (Bhagirathi Valley) of Uttarakhand Himalaya using remote sensing and field mapping tools will be performed. The mapping includes engineering geological and geotechnical characterization of slopes, geometry and factor of safety in present conditions. Different rainfall threshold values will be established by analyzing the past rainfall and occurrence of past failure events for different potentially unstable slopes along the highway. Correlation between rainfall thresholds and geo-engineering properties of potentially unstable slopes with different geometry will be established to develop a spatio-temporal model for landslide prediction along the highway. Additionally, the applicability of an optical-imaging-sensor based drone for the temporal mapping, characterizing and monitoring of identified landslide hazard prone areas (using remote sensing and field based information) in Bhagirathi valley of Uttarakhand Himalaya during monsoon period will be tested for the purpose of early warning to save lives of people in difficult hilly terrain. In the process, multi-temporal acquisition, real-time processing and comparison of drone based optical imaging data sets will be performed to understand the evolution of landslides. The positional change (geographical coordinates along with altitude) of topographical and geomorphological features (in particular fissures, tension cracks, prominent ground objects etc.) could be considered for a multi-temporal analysis with the aim of characterizing the landslide kinematics and evolution. Multi-temporal image correlation and change detection techniques will also improve this approach in terms of defining the surface movement of landslides. Further, digital surface models (DSMs) and digital terrain models (DTMs) can be generated from the high density point clouds and used for multi-temporal analysis. The comparison of DSMs/DTMs can be used for the determination of volumetric changes caused by the evolution of the landslide. This also can be helpful in determining the rate of movement/displacement of the detached mass of the landslide. Finally, the geo-integrated rainfall threshold model will be integrated with optical-imaging-sensor based drone model to develop spatio-temporal landslide early warning along the National Highway corridor of Bhagirathi valley, Uttarakhand.

**Objectives:** 1. Development of geo-integrated rainfall threshold model for different types of landslides.

2. Multi-temporal optical imaging Drone based Landslide Mapping and Monitoring

3. Development of a novel geo-integrated landslide early warning system