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## Low-cost sensor observations for flash flood and landslide early warning systems in the mountainous area

**Monton Methaprayun**<sup>1</sup>, Apiniti Jotisankasa<sup>2</sup>, Ratchanon Khunwisetkul<sup>1</sup>, Thom Bogaard<sup>3</sup>, and Punpim Puttaraksa Mapiam<sup>1</sup>

<sup>1</sup>Department of Water Resources Engineering, Faculty of Engineering, Kasetsart University, Bangkok, Thailand (monton.me@ku.th, ratchanon.khun@ku.th, punpim.m@ku.th)

<sup>2</sup>Department of Civil Engineering, Faculty of Engineering, Kasetsart University, Bangkok, Thailand (fengatj@ku.ac.th)

<sup>3</sup>Department of Water Management, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands (T.A.Bogaard@tudelft.nl)

Flash floods and landslides are severe natural hazards caused by heavy rainfall, which frequently occur in mountainous areas in most countries worldwide. Hydrometeorological measuring networks are key to tracking heavy storms and quantifying hydrological behaviour. Unfortunately, the monitoring networks in these regions are often scarce due to various challenges such as inaccessibility, limited power and data transmission capabilities, and maintenance requirements. To address these challenges, our research aims to develop and deploy low-cost sensors in the Khao Yai National Park, Lamtakong basin, northeastern Thailand, which are linked to high-resolution radar rainfall observations. This is subsequently used in spatially distributed models that are the basis of an early warning systems that is under development in this hazard-prone mountainous region. These sensors measure various physical parameters, including soil moisture, precipitation, water and air pressure, and transmit real-time data via NB-IoT mobile signals, with backup storage in SD cards. The stations were designed to be simple to maintain, with materials that were readily accessible. All collected data will be transmitted in real-time at high temporal resolutions. First, the rain gauge rainfall data will be merged with weather radar data to compute radar rainfall bias adjustment for preparing high-quality gridded rainfall over the study area. After that, the adjusted radar rainfall product combined with the hydrological measurements will be used as input for spatially distributed physical-based flash floods and landslides modelling. The use of low-cost sensors allows the monitoring network to be more widely deployed, particularly in areas that are difficult to access like the natural park. Furthermore, increasing coverage and denser data collection will lead to more accurate monitoring of the highly heterogeneous rainfall patterns and thus short-term rainfall forecasting. This will lead to a more effective early warning system.