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An Integrated System to Support Decision Makers in the Landslide Hazard Early Warning in Halong City - Vietnam

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1. Introduction

Shallow landslides are one of the most dangerous natural hazards causing loss of lives and damages to people. It is well known that subsurface water (generating pore water pressure) is the main factor that triggering shallow landslides. In many countries including Vietnam, extreme weather events induced by climate changes are happening more frequently and with higher intensities. This research is attempting to couple a landslide simulation model (LS RAPID) and a hydrological model (RRI) to exploit the advantages of each model for simulate and predict landslide hazard (location and timing).

2. Study area

The pilot area is a small catchment where a shallow landslide happening in July 2015 after 3 days of heavy rain buried 3 houses and killed 8 people in Cao Thang ward, Halong City, Vietnam. The city is located in the centre of the Quang Ninh province - Vietnam with the complex and diverse topography including mountain, delta, coastal and island. The North and North East are covered by mountain containing 70% city's area. The rainy season starts from May to October. Most of the landslides in Quang Ninh province (and also other provinces in the Northern part of Vietnam) occurred in this period. Landslides are seriously hampering the rapid economic development and urbanization of the city.

3. Methodology

Laboratory tests of soil shear strength were implemented by the ring shear apparatus ICL1 and ICL2 in the undrained condition which provides data to perform analysis of slope stability. From the soil drill (16 locations) and field survey, the relationship between the soil depth and the slope was estimated for generating the soil depth map.

Different scenarios of the excess pore-water pressure ratio (r_u) were applied by LS-RAPID model (Sassa et al., 2010) for 3D simulating the initiation and motion of the rapid shallow landslide to create different hazard maps and also the r_u threshold map.

The hydrological processes are simulated with RRI (Rainfall- Runoff - Inundation) model (Sayama et al., 2012). A piezometer and a water level logger were installed on the top of the occurred shallow landslide to monitor subsurface water levels. An automatic rain gauge was also set up close to the study area (around 1 km). Base on monitored subsurface water data and rainfall data, RRI model was calibrated and then integrated with LS-RAPID scenarios.

For predicting the temporal occurrence of landslides in Halong City, we employ forecasted rainfall data from the Global Forecast System (GFS) - a weather forecast model produced by the National Centers for Environmental Prediction (NCEP) - USA (URL1). IDV software (Unidata, 2016) and Jython script were engaged to automatically access newly updated data from GFS server through OPeNDAP protocol.

RRI model is applied every hour with near real-time and forecasted rainfall to check whether the r_u thresholds are exceeded or not.

4. Discussion and results

Based on soil parameters obtained from the ring-shear apparatus, several scenarios for landslide hazards in the study area were generated and therefore different r_u thresholds were identified for potential landslide hazard areas (Figure 1).

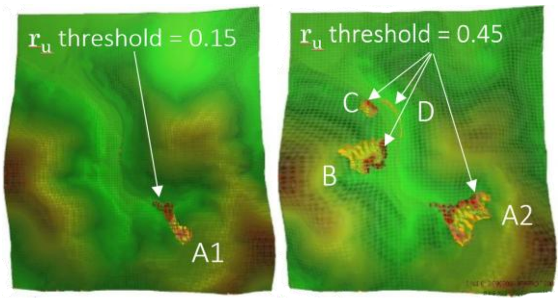

Figure 1: Potential landslide hazard areas and r_u *thresholds*

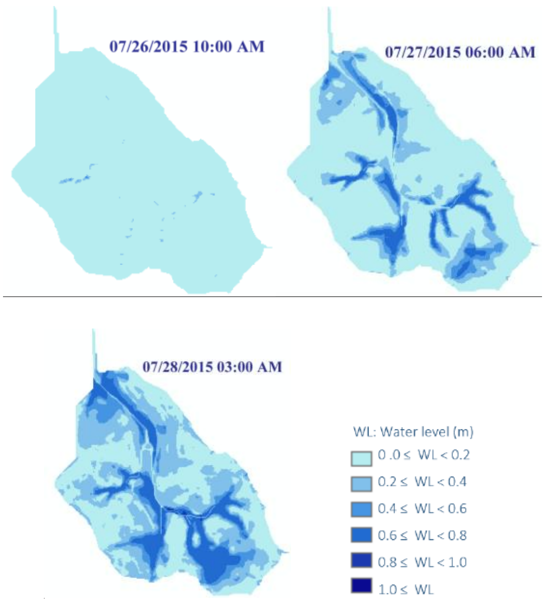

Figure 2: Water levels in different time steps

RRI model simulated the subsurface water depth and the inundation (Figure 2). In the rainy season, the simulation can present quite accurately the subsurface water level (2018 data) and the peak level of inundation (2015 data). However, the simulated inundation depths receded considerably slower than the actual situation in 2015 case.

For 2015 data, the landslide risk maps combing results from LS-RAPID model and RRI model show the risk of landslide in location and time (Figure 3). The hazard area A1 is well simulated comparing to the occurred landslide in July 2015. In locations B and D, where 2 small landslides witnessed, the Risk is quite high (some small parts have the Risk > 1) (Risk = r_u / r_u threshold). These confirmed the proneness to the landslide of predicted areas.

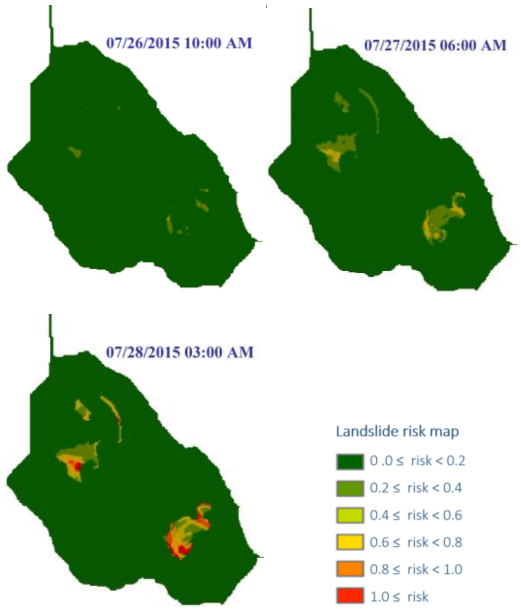

Figure 3: Landslide Risks in different time steps

Although the results from RRI Model and LS-RAPID Model simulations remain several drawbacks, they showed a good agreement and could be very useful for supporting decision makers in rainfall-induced landslide hazard (and flood) early warning and land use planning.

Reference

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