Hydrological Modeling For Early Warning Systems of Shallow Landslides and Sediment Disasters Using Real Time Satellite-Derived Rainfall

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Floods, surface soil erosions and associated landslides are the most widespread natural disasters and affect more people in the Upper Citarum River basin, Indonesia, which was selected as a study area. Since 1990s, slope movement and landslides occur infrequently during rainy season and caused extensive damage. The type of landslide occurrence mainly is rapid shallow landslides (debris flow). Watershed erosion and high sediment yield are also as a serious problem across the Upper Citarum River basin. Shallow landsliding, as a form of mass movement, is one of the sources of hillslope erosion and catchment sediment yield. One of the possible ways for developing a disaster reduction technology related sediment disasters at the catchment scale is the use early-warning systems of hydrologic conditions and shallow landslides-triggering rainfall-soil moisture.

On shallow landslide occurrence, soil moisture plays an important control; increased soil water content increases the shear stress or decreases the shear strength of the soil mass. Therefore, an accurate estimation of rainfall on slopes and calculation of the dynamic sub-surface water flows are the important factors in prediction of landslide susceptibility. The combined physically-based distributed hydrological model (including soil erosion and sediment transport) and slope stability model has been developed by authors. The hydrological model considers three principal water flux pathways within a catchment: subsurface flow through unsaturated flow (capillary pore), subsurface flow through saturated flow (non-capillary pore), and surface overland flow. The soil water amount calculated with its model (**Figure 1**) is then used for slope stability analysis. Herein, the factors of safety, which represents the ratio of shear strength to shear stress of soil mass, are used to characterize slope stability. Slopes having safety factors smaller than one are considered unstable.

The National Oceanic and Atmospheric Administration (NOAA), USA, provided global precipitation data at very high spatial and temporal resolution. NOAA-QPC Morphing Technique (QMORPH) rainfall estimates are available within 3 hours of real time and available on a grid with a spacing of 8 km. These data are then used in combination with the global coverage data sets of land surface characteristics (e.g., land use, DEM) from hydroSHEDS (http://hydrosheds.cr.usgs.gov/).

In this study, the integrated application of the QMORPH-based satellite precipitation estimation and a hybrid hydrological-geotechnical modeling system is addressed. In addition, the goal is establishing shallow landslides and sediment disasters early warning systems based on real time satellite data.

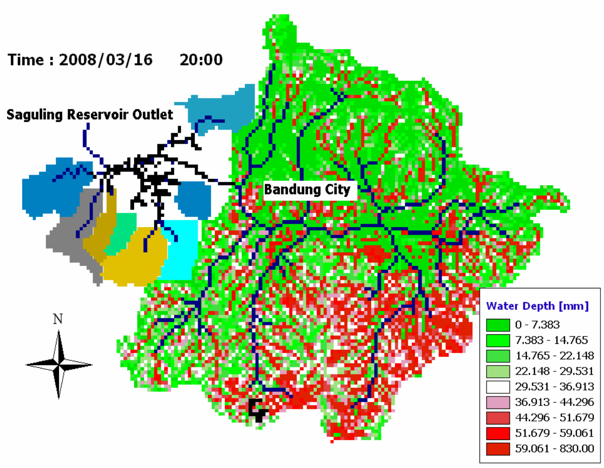

Figure 1 Example display of spatial distribution of saturated soil moisture areas in the Upper Citarum catchment after 12 hours rainfall on 16 March 2008.