Topic: “Slopeland conservation and sustainable development"

Scorecard-assessment: Making landslide monitoring easy and data collection efficient for watersheds in the Philippines

Decibel Faustino-Eslava[1], Nathaniel Bantayan[2], Lisa Lagdaan[1], Jayson Arizapa[1], Joey Phillip Torres[1], Wilbur Manibo[1], Cheamson Garret Boongaling[3], Carla Dimalanta[4], Donald Luna[1], Loucel Cui[1], Rex Victor Cruz[2], Maria Victoria Espaldon[1], Jenielyn Padrones[2], Cristino L. Tiburan Jr.[2], Noelynna Ramos[4], Betchaida Payot[4], Jillian Aira Ratio[4] and Leo Armada[4]

[1] Earth Systems Research Team (EaRT), School of Environmental Science and Management, University of the Philippines Los Baños, Laguna 4031, Philippines

[2] Institute of Renewable Natural Resources, College of Forestry and Natural Resources, University of the Philippines Los Baños, Laguna 4031, Philippines

[3] College of Human Ecology, University of the Philippines Los Baños, Laguna 4031, Philippines

[4] Rushurgent Working Group (RWG), National Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City 1101 Philippines

Key words: rainfall-induced landslides, mass wasting, I-D threshold, scorecard-assessment

Corresponding Author： Decibel V. Faustino-Eslava
TELEFAX： 63+49 5362251
E-mail： dfeslava@up.edu.ph
Address： School of Environmental Science and Management, University of the Philippines Los Baños, Laguna, Philippines

Abstract

Landslide events are a common phenomenon in many places across the Philippines. Despite its frequent occurrence, the country has yet to come up with a comprehensive database that can serve as a reference material for the understanding of thresholds toward the formulation of early warning systems. This lack of quantitative information has led to the frequent use of empirical thresholds based on researches done abroad. Additionally, the use of remotely sensed images is beginning to play a bigger role in monitoring upland areas for mass wasting occurrences. Despite the availability of

such technologies, there is still a need to validate the information using ground-truth observations. This paper presents the current initiatives being undertaken to eventually come up with a database on rainfall-induced mass wasting events that will eventually be utilized for the formulation of rainfall intensity-duration relationships. In particular, it discusses how non-technical partners are being tapped to help in the monitoring and reporting of mass wasting events. The ultimate goal is for the Philippines to device early warning systems that are based on empirical information and that which will be able to relay relevant and timely warnings at a local community level.

1. Introduction

On the average, 20 typhoons enter the Philippine area of responsibility each year (David et al., 2013). Each event brings with it high amounts of precipitation, especially if the typhoon is able to pull towards the archipelago other wet weather systems such as the southwest or the northeast monsoon. In the recent past however, even in the absence of typhoons, other weather systems, such as the monsoons or the passage of the tail-end of the cold front, have brought unspeakable damages to communities that become affected by floods and landslides triggered by the excessive rainfalls (e.g., Faustino et al., 2013). These continued changes in climate and weather patterns, especially in relation to increases in extreme weather events associated with global climate change (IPCC, 2007), necessitates a better understanding of both the physical controls to the floods and mass wastages, and their triggers.

Landslide inventories play a significant role in landslide hazard assessments. Numerous works have shown that the predictive power of landslide susceptibility analysis relies heavily on the quality and completeness of landslide inventories for any particular region (e.g., Guzzetti et al., 2012). From the works of Caine (1980), Aleotti (2004), Guzzetti et al. (2007; 2008), Cannon et al. (2008), Dahal and Hasegawa (2008), and Coe et al. (2008), rainfall-induced landslide is directly related to rainfall intensity and duration (I–D). At a certain threshold level of I-D, slopes start to fail. In order to define the threshold conditions that must be used in the development of an Early Warning Protocol, a means to monitor real-time or near-real-time landslide triggers must be devised. Rainfall intensity and duration, cumulative event rainfall, and antecedent rainfall are the most commonly investigated variables in this regard. The I-D threshold approximates how much rainfall is required to cause slopes to start failing.

With the frequency of mass movements in the Philippines, one might think that there must already exist a voluminous database on landslides that can be used to generate thresholds for the different regions. At present, however, no such definitive database exists. Published rainfall intensity-duration (I-D) thresholds for triggering landslide events are limited to pyroclastic flow deposits (e.g., Paguican et al., 2009). Other attempts at compiling data on landslides for the generation of I-D thresholds have been hampered by the lack of records on the spatial and temporal details of the events (e.g., Manalo and Daag, 2012). Some of the country's landslide susceptibility maps that have been generated using remotely sensed information and processed by various geospatial techniques have undergone limited field validation.

In the Philippines, the lack of such information has led some workers to utilize empirical thresholds from statistical analyses of the relation between rainfall and landslide occurrences in Taiwan (e.g., Chien-Yuan et al., 2005). However, despite the similar tectonic and climatic conditions of the Philippines with Taiwan, I-D thresholds are site-specific parameters that must be developed with local physical characteristics in mind. A prototype work along this line was carried out for several geothermal production fields in the Philippines (Cruz et al., 2013). However, difficulties with acquiring historical information on rainfall-landslide relationships hindered the formulation an I-D threshold that can be easily validated. Efforts at addressing this gap include the use of remotely sensed images to make up for the lack of on-ground and near real-time observations. The challenge to this, however, is that most upland areas in the Philippines do not have good baselines as to mass movement occurrences. Without a good monitoring system in place, old landslide scars can be remapped as recently mobilized and potentially skew any interpretations for I-D threshold development.

Hence, in order to supplement the national government's efforts towards landslide monitoring, two concurrent research projects ("Heavy Rain Monitoring and Forecasting in Mountainous Areas and Early Warning for Landslides" of the research program "Improvement of Forecast Capability on Weather, Marine Meteorology and Short Range Climate"; and "Soil Erosion Studies" of the research program "Monitoring and Detection of Ecosystems Changes for Enhancing Resilience and Adaptation in the Philippines", both funded by the Department of Science and Technology) are currently being conducted to include in their targets the monitoring for changes in the environment, particularly on mass wasting occurrences. Some of the end goals for this combined work are the generation of a database on rainfall-induced mass wasting occurrences, and the formulation of rainfall I-D thresholds for the different regions of

the Philippines that can aide in early warning and in proposing better land management options.

2. Materials and Methods

To generate the I-D threshold, historical and recent rainfall-landslide correlations need to be cataloged (e.g., Manalo and Daag, 2012; Saito et al., 2010). A crowd-sourcing platform is also being set up that will allow members of communities to contribute near real-time information on landslide occurrences. From the collated data, best-fit slopes will be computed to generate the I-D formulae for different stages of the early warning protocol. Rainfall monitoring that is both spatially and temporally tied with landslide occurrences data is an important component of this research.

I-D threshold will be measured in millimeter per hour for Rainfall Intensity (I), and hourly for the event's Duration (D). Each event will be separated by 24 hours of non-occurrence of precipitation. The shorter span of time for measuring the rainfall will create a more detailed database that can show a high resolution gradient of the variables in each event. Data will be analyzed using statistical regression to derive coefficients that will be used to predict values for the next hours given a present data. Values and variables will include accumulated rainfall, intensity, and ultimately predict the possible time of slope failure, thus, developing an early warning system for landslides.

In addition to building up data for I-D thresholds, a simplified scorecard-assessment tool that is based on the United Nations' Food and Agriculture Organization's (FAO) Field Methodology and Tools for measuring erosion rates was also devised to capacitate onsite partners in their monitoring work. The scorecard helps determine, in a semi-quantitative manner, the erosion type, state, extent, and severity of mass movements. It sums up the individual grades for each area to provide a total score for a watershed. These documentations and numbers give a relative measure of the present conditions against which future observations can be benched marked.

3. Results and Discussion

The support of regional universities and of local government units has been enlisted towards the establishment of monitoring stations in eight watersheds across the Philippines. These partners are being trained on the use of the scorecard to capacitate even non-technical observers to assess mass wasting occurrences and provide data to technical experts to process. Networks of automated weather stations, agro-meteorological observatories, and other weather observations stations are being tapped to provide the weather parameters against which the mass movement data

can be tied with. It is hoped that with the simplification of the platform for data collection and with the contribution from crowd-sourcing methods, the Philippines can eventually build up a good database for the generation of quantitative information that will lead to a reliable early warning system for landslides.

4. References

Aleotti, P., 2004. A warning system for rainfall-induced shal- low failures. Engineering Geology 73 (3–4): 247–265.

Caine, N., 1980. The rainfall intensity–duration control of shallow landslides and debris flows. Geografiska Annaler. Series A. Physical Geography 62, 23–27.

Cannon, S., Gartner, J., Wilson, R., Bowers, J., Laber, J., 2008. Storm rainfall conditions for floods and debris flows from recently burned areas in southwestern Colorado and southern California. Geomorphology 96, 250–269.

Chien-Yuan, C., Tien-Chien, C., Fan-Chieh, Y., Wen-Hui, Y. & Chun-Chieh, T., 2005. Rainfall duration and debris-flow initiated studies for real-time monitoring. Environmental Geology 47: 715–724.

Coe, J., Kinner, D., Godt, J., 2008. Initiation conditions for debris flows generated by runoff at Chalk Cliffs, central Colorado. Geomorphology 96, 270–297.

Dahal, R., Hasegawa, S., 2008. Representative rainfall thresholds for landslides in the Nepal Himalaya. Geomorphology 100, 429–443.

David, C., Racoma, B., Gonzales, J., and Clutario, M., 2013. A Manifestation of Climate Change? A Look at Typhoon Yolanda in Relation to the Historical Tropical Cyclone Archive. Science Diliman, 25, 2.

Faustino-Eslava, D.V., Dimalanta, C.B., Yumul, G.P.Jr., Servando, N.T. and Cruz, N.A. 2013. Geohazards, tropical cyclones and disaster risk management in the Philippines: Adaptation in a changing climate regime. Journal of Environmental Science and Management 16, 84-97.

Guzzetti, F., Mondini, A., Cardinali, M., Fiorucci, F., Santangelo, M., and Chang, K., 2012. Landslide inventory maps: New tools for an old problem. Earth-Science Reviews, , 112, 42–66.

Guzzetti, F., Peruccacci, S., Rossi, M., Stark, C., 2007. Rainfall thresholds for the initiation of landslides in central and southern Europe. Meteorology and Atmospheric Physics 98, 239–267.

Guzzetti, F., Peruccacci, S., Rossi, M., Stark, C., 2008. The rainfall intensity–duration control of shallow landslides and debris flows: an update. Landslides 5, 3–17.

Hansen, A.: Landslide hazard analysis, in: Slope Instability, edited.

IPCC, 2007. In Climate Change 2007: The Physical Science Basis: Contribution of Working Group 1 to the IPCC Fourth Assessment Report. Technical report, Intergovernmental Panel on Climate Change.

Saito, H., Nakayama, D. and Matsuyama, H., 2010. Relationship between the initiation of a shallow landslide and rainfall intensity—duration thresholds in Japan. Geomorphology 118 (2010) 167–175.