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# Relationship between the probability of landslide and sediment yield in Thailand

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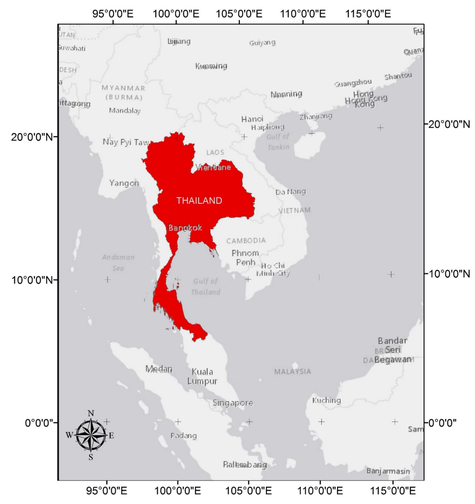
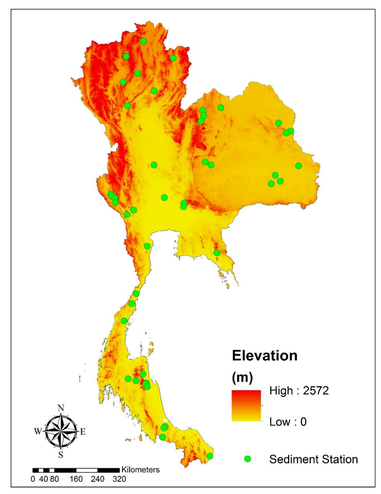
## Introduction

Thailand frequently suffers from loss of lives and properties due to landslide (Syvitski & Miliman, 2007; Rahul, 2012; Vente et al., 2013). Several studies found that rainfall is an important factor of landslide events (Tomoyuki Iida, 2004; Fan et al., 2016). Landslide often occurs in Thailand as a consequence of heavy rainfall especially in the northern and southern regions of Thailand. Landslide debris in mountain area is a major source of sediment yield in downstream areas. However, there are a few studies that analyze the relationship between landslide and sediment yield in Thailand. Therefore, analysis of the relationship between landslide and sediment yield is one of the important challenges for this country. In 2011, Lin & Chen analyzed the relationship between rainfall energy, landslide and sediment yield in Taiwan. They found that high rainfall kinetics energy is one of the causes of sediment yield to river. In Romania, Broeckx et al., 2016 studied about the relationship between landslide susceptibility and sediment yield at a regional scale. They found that landslide is an important predictor of sediment yield in Romania. Furthermore, Chen et al., 2016 stated that landslide is related to sediment yield during typhoon events in Taiwan. They found landslide debris that was flown by heavy rainfall in the typhoon events have a strong effect on the sediment yield in downstream areas of Taiwan. In Thailand, many research studies about landslide hazard map such as Yumuang (2001), which studied about landslide and debris flow in Phetchabun Province by geographic information system (GIS) and remote sensing techniques. In 2007, Soralump S. analyzed landslide hazard map using the engineering soil properties. Furthermore, Ono et al. (2014) assessed rainfall induced shallow landslide in Phetchabun and Krabi province in Thailand by shallow landslide instability prediction model (SLIP). Moreover, Rangsiwanichpong et al., (2015) analyzed the probability of landslide using probability model and compared the results with the real historical events in Thailand. The objective of this research is to analyze the relationship between sediment yields with the probability of landslide hazard in Thailand. We used the log-Pearson type III for analyzing the extreme period of rainfall and sediment data during 1998 to 2014 (16 years). In addition, we used the probability of landslide model for assessing the landslide hazard in Thailand.

## Study Area




location of Thailand




Elevation map of Thailand

Thailand is located at the center of Southeast Asia peninsula. The topography can be divided into 5 major physical regions consists of central valley, highlands of the north, northwestern, northeastern, and southeastern coast, and the peninsula. Roughly 20 percentages of Thailand is covered by mountains and hills, especially in northern and southern regions. Therefore, landslides occur frequently in Thailand due to the influence of monsoon rain. In most cases, landslide would occur in the northern and southern parts of the country which are mountainous.

## Data

### *Rainfall data*

The rainfall data is a one of necessary factor for analyzing landslide hazard map. We used the daily rainfall data from 150 stations over Thailand by Thai Meteorological Department (TMD). We assessed extreme daily rainfall for 5, 10, 30, 50, and 100 year return period by frequency analysis of TMD data.

### *Sediment data*

In this research, we used 45 hydrological stations for observing sediment discharge from the Royal Irrigation Department (RID). These stations were selected overall area of Thailand, especially in landslide area. We used monthly sediment data during 1998 to 2014 (16 years) for the analysis.

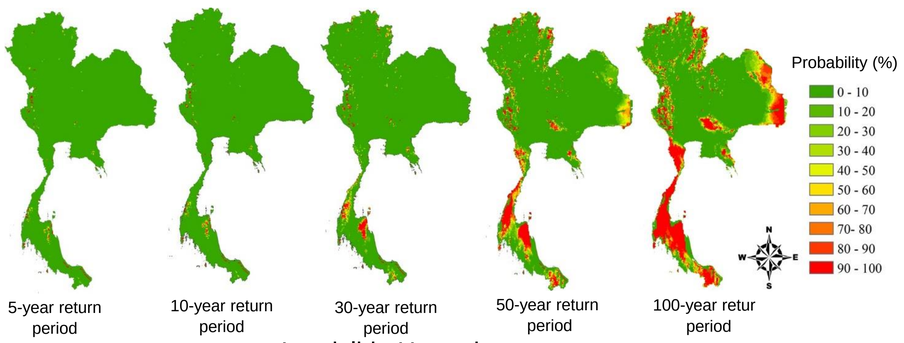
## Results and Discussion

### *Analysis of landslide hazard map and probability trend*

We assessed landslide hazard map in Thailand by multiple logistic regression. The equation for assessing probability of landslide hazard was shown in equation 1. For more detail, refer to Kawague et al., (2010)

$$p = \frac{1}{1+\exp[-(\psi_0+\psi_h \times hyd+\psi_r \times relief)]} \quad (1)$$

Where P is the probability of landslide (%), $\psi_0$ is the interception, $\psi_h$ is the coefficient of hydraulic gradient, $\psi_r$ is the coefficient of relief energy, $hyd$ is the hydraulic gradient (m/m), and $relief$ is the relief energy (m)

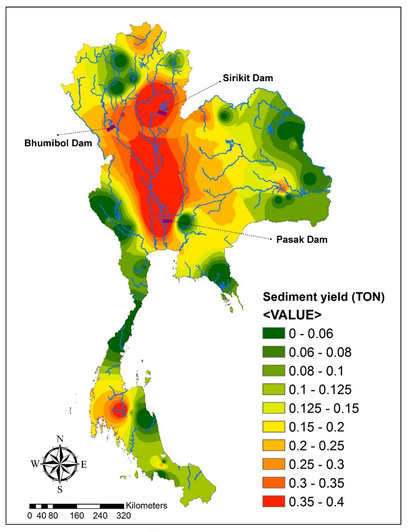


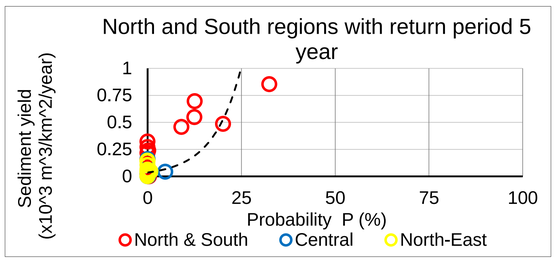

Landslide Hazard map

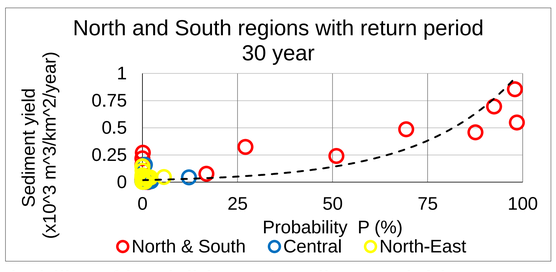
We assessed landslide hazard map of Thailand at 5, 10, 30, 50, and 100 year return periods by probability of landslide model. This study can explains a probability of landslide for each scenarios in term of return periods. The results found that the return period of rainfall mostly effective to landslide in Thailand. Consequently, the results shown that the northern and southern parts of Thailand have a risk of landslide hazard, which landslide in the southern part will occur from heavy rainfall with 10 year return period and the northern part will occur by rainfall with 30 year return period. However, most areas in the southern part are predicted to have higher risk due to higher probability of landslide events

### *Relationship between landslide and sediment yield*

Thailand has a mean annual rainfall range of 1000-1300mm, especially in the southern part has a rainfall approximately 1450-2700 mm due to the effect of monsoon rainfall. From the results found that the sediment yield was occurred 0.19 million ton/km2 approximately. The results showed that the sediment was occurred in the northern and southern regions because these areas was covered by the mountains and steep slopes. Furthermore, central region had the greater amount of sediment yield per square kilometer, due to the fact that this area is a downstream of many rivers in Thailand consisting of Ping, Wang, Yom, and Nan Rivers (Figure A). The major source of sediment in the central area is the landslide debris in the mountainous areas. Moreover, some river basin in the northern part of Thailand does not have a large dam and reservoir for interception the sediment to downstream area, especially the Yom River basin which the landslide events frequently occurred and caused high damage. Therefore, these are the important reasons to value of sediment in the central regions of Thailand. The results of the return period of sediment by log-pearson type III are presented in figure B, C. As shown, the majority of sediment in Thailand has a significant increasing trend, especially in the area with high probability of landslide hazard (Northern and Southern regions). Therefore, landslide event is the one of major sources of sediment yields in Thailand.




Relationship between probability of landslide and sediment yield

## Conclusions

This study demonstrates that probability of landslide hazard is an important predictor of sediment yield in Thailand and for this reason indicates the large importance that landslide may for sediment yield. The results show that the major sources of sediment yield in the central region was from the landslide in the upstream area in the landslide areas of the northern regions. We found significant relationship between probability of landslide hazard and sediment yield in Thailand. The trend of sediment yield is relate with the probability of landslide hazard, which it will increasing when the probability of landslide hazard increase.

References

1. Broeckx J., Vanmaercke M., Balteanu D., Chendes V., Sima M., Enciu P. & Poesen J. (2016) Linking landslide susceptibility to sediment yield at regional scale: application to Romania. Geomorphology 268(2016): 222-232. Available from: doi:10.1016/j.geomorph.2016.06.012 [Accessed: 10th October 2016]
2. Chen C.W., Chen H. & Oguchi T. (2016) Distributions of landslides, vegetation, and related sediment yields during typhoon events in northwestern Taiwan. Geomorphology 273(2016): 1-13. Available from: doi:10.1016/j.geomorph.2016.08.012 [Accessed: 7th January 2017]
3. Fan L., Lehmann P., McArdell B. & Or D. (2016) Linking rainfall-induced landslides with debris flows runout patterns towards catchment scale hazard assessment. Geomorphology 280 (2017): 1-15. Available from: doi:10.1016/j.geomorph.2016.10.007 [Accessed: 5th January 2017]
4. Iida, T. (2004) Theoretical research on the relationship between return period of rainfall and shallow landslides. Hydrological Processes. 18: 739-756. Available from: doi:10.1002/hyp.1264 [Assessed: 28th December 2016]
5. Kawagoe, S., Kazama, S. & Sarukkalige, P.R. (2010) Probabilistic modelling of rainfall induced landslide hazard assessment. Hydrol. Earth Syst. Sci. 14: 1047-1061. Available from: doi:10.5194/hess-14-1047-2010 [Accessed: 26th August 2016]
6. Lin G.W. & Chen H. (2011) The relationship of rainfall energy with landslides and sediment delivery. Engineering Geology 125(2012): 108-118.
7. Ono, K., Kazama, S. & Ekkawatpanit, C. (2014) Assessment of rainfall-induced shallow landslides in Phetchabun and Krabi provinces, Thailand. Nat Hazards 74(2014): 2089-2107. Available from: doi:10.1007/s11069-014-1292-3 [Accessed: 6th October 2016]
8. Rahul Verma (2012) Landslide hazard in Mizoram: Case study of Laipuitlang landslide, Aizawl. International Journal of science and research. 3(6): 2262-2266.
9. Rangsiwanichpong P. & Kazama S. (2015) Comparison slope failure probability and slope disaster history using probability of landslide model, The 3rd International Symposium on Water Environment Systems. Tohoku University. Japan.
10. Soralump S. (2007) Development of landslide hazard mapping in Thailand. A national training course on landslide risk management. Banguio City. Philippines.
11. Syvitski J.P.M. and Milliman J.D. (2007) Geology, geography, and humans battle for dominance over the delivery of fluvial sediment to the coastal ocean. The Journal of Geology. 115 (1): 1-19.
12. Vente, J., Poesen, J., Arabkhedri, M. & Verstraeten, G. (2007) The sediment delivery problem revisited. Prog. Phys. Geogr. 31: 155–178. Available from: doi:10.1177/0309133307076485 [Accessed: 28th December 2016]
13. Yumuang S. (2006) 2001 debris flow and debris flood in Nam Ko area, Phetchabun province, central Thailand. Envion Geol 51(2016): 545-564. Available from: doi:10.1007/s00254-006-0351-9 [Accessed: 10th October 2016]

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