Weight of evidence model applied to landslide susceptibility mapping based on GIS in Bawakaraeng Lompobattang Mountain Indonesia

○ GIS, landslide susceptibility, weight of evidence

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1. Introduction

In Indonesia, landslides are a serious problem that triggers debris flow or flash flood disasters every year during or after heavy rainfalls. Generally, the climate of Sulawesi Island is tropical with special characteristic of two seasons within a year, the northeast monsoon gives rise to rainy season and the southwest monsoon causes the dry season. On March 26 2004, a huge landslide occurred on Mt. Bawakaraeng. On June 20, 2006, flash floods and landslide occurred under the foot of Lompobattang Mountain and the settlements were impacted by substantial loss in the disasters. Due to rainfall increasing of the intensity, the probability of landslide occurrence particularly shallow landslides also increase and they are very sensitive to short-lasting high intensive rainfall (Hasnawir & Kubota, 2012). Consequently, in order to mitigate landslide and to proposed landuse planning management, it is necessary to scientifically evaluate areas susceptibility to landslide. Therefore, this study aims to carry out a landslide susceptibility analysis by applying the weight of evidence model at Bawakaraeng Lompobattang Mountain.

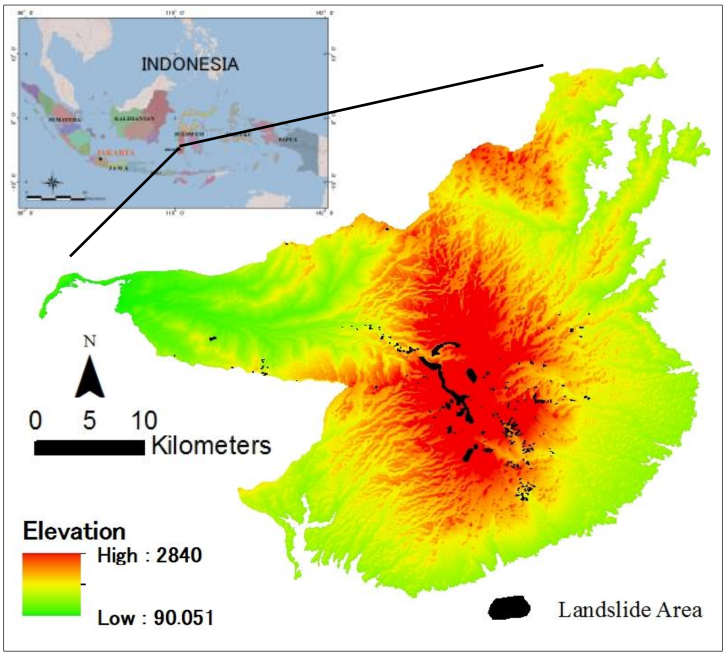

Figure 1. Location map of the study area

2. Material and Method

Topographic data namely, curvature, aspect, slope inclination were derived from ASTER DEM with a spatial resolution of 30 m. Lithology, distance from river and distance from fault, which were collected from the respective governmental institutions. Those data were referred to as landslide causal factors, and they were used as independent variables. Dependent variable was set up by using landslide inventories from google earth image interpretation and they were divided into two portions. First portion, which were used to create the models, are the landslide that occurred from 2004 to 2012. Second portion are landslide that occurred from 2013 to 2014, and they were used as data validation. All parameters and landslide distribution map were digitized and then processed by converting all the raster and vector maps into a raster format with 30 m pixel size in ArcGIS 10. The total numbers of cells of study area are 1,528,838 pixels. The number pixels of landslide data were using to create the models are 6,728 pixels and to validate the models are 1,449 pixels. In this study, the weight of evidence (WoE) modelling was used to produce landslide susceptibility mapping. It uses the Bayesian probability model and applying the WoE shows a simple use and less time consuming (Dahal et al., 2008). Validation is an important part of the model development process. Commonly in landslide susceptibility research, three methods of validation had been described in literatures. First, validation uses same landslide population for modeling, and it is known as success rate. Second, a different landslide population is used for validating without splitting of landslide events or considering recent landslide events. Third, cross validation in which model had generated from partial of the study area then validated in other part of its research area. This study applied the past landslide as data training to construct the model and remaining data were used to validation. Therefore, this study simulates that the future landslide will occur on the landslide susceptibility area, which is predicted using the past landslide.

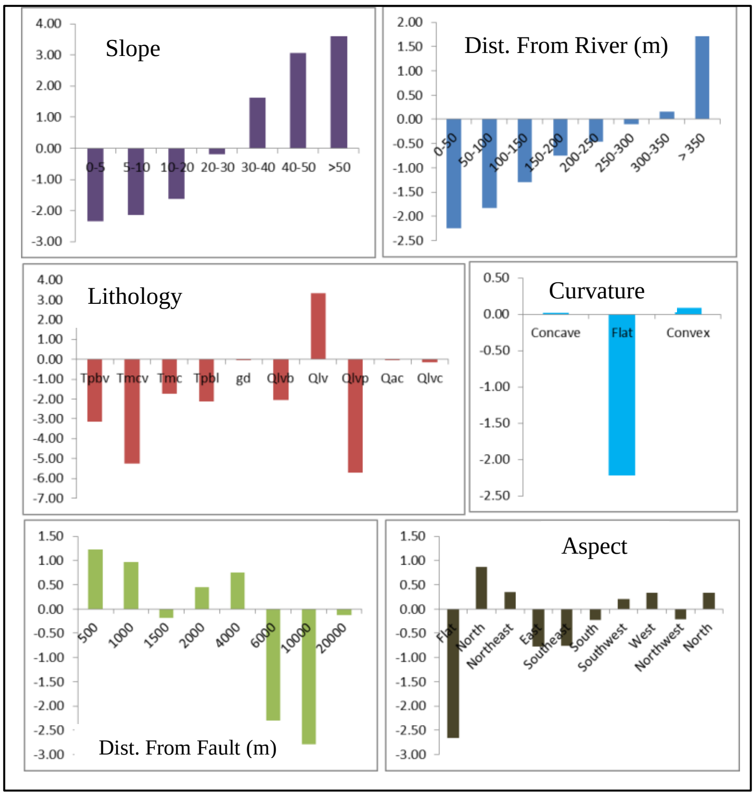

Figure 2. The WoE value for classes of causal factor

3. Results and Discussion

In the study of susceptibility mapping, it is important to assume that the potential landslides can be comparable to the actual frequency of landslide. In other words, the future landslides will occur in the same condition that caused the past landslides. The WoE model calculates the weights and contrast for each landslide causal factors based on the presence or absence of the landslides within the area. The magnitude of the contrast C was determined from the difference, W^+ and W^-. The contrast describes the relationship between causal factors and the landslides. A positive weight (W^+) indicates that the causal factor is present at the landslide location and the value is an indication of the positive correlation between them. A negative (W^-) indicates the absence of the causal factors and shows the level of negative correlation. The resulting total weights, as shown in Fig. 2, directly indicate the importance of each factor. If the total weight is positive, the factor is favorable for the occurrence of landslide and vice versa. Figure 2 describes the degree of the relationship between causal factors with the occurrence of landslide. For example, slope degree classes show that positive value is present above 30^o, this indicates a high probability of landslide occurrence. Similarly, in the case of distance from river, the probability of landslide occurrence is higher in distance above 300 m. The weights are assigned to the classes of each causal factor thematic maps, and summing to produce a landslide susceptibility index (LSI) map. In this study, the LSI map shows the value is -17.982 to 10.827 (Fig.3). If the LSI value is high, this means a higher susceptibility to landslide; a lower values means a lower susceptibility to landslides (Pradhan et al., 2010). The landslide susceptibility map was then produced by reclassifying the LSI map using natural breaks method in ArcGIS 10.0 (Fig.3). The receiver operating characteristic (ROC) and area under ROC curve (AUC) was used as a measure of overall fit and comparison of modeled prediction in the LSI map. The AUC of the model is 0.945 in success rate, which mean more than 94% accuracy and the AUC for validation is 0.879, which mean over 87% the accuracy of prediction (Fig. 4). The curve of the model and validation demonstrates that the susceptibility model is acceptable, and the model could be applied to predict the potential landslide in the future. To support the level of confidence of the models, the degree of validation of data landslide were calculated. Landslide data validation which was considered as the "future" landslide then overlaid on the LSM. The results indicated that the landslide validation were concentrated in the high (H) to very high (VH) class with more than 88% of the study area (Fig.5).

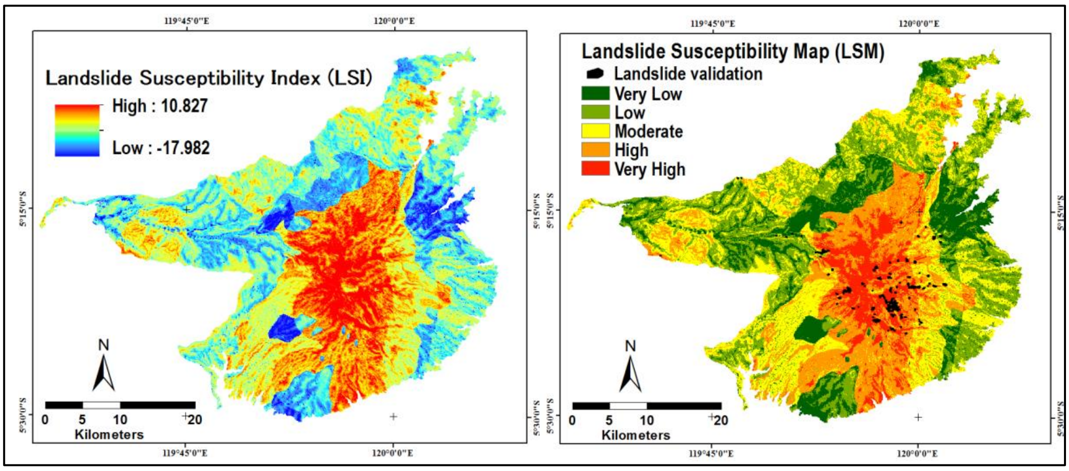

Figure 3. The LSI and the LSM of the study area

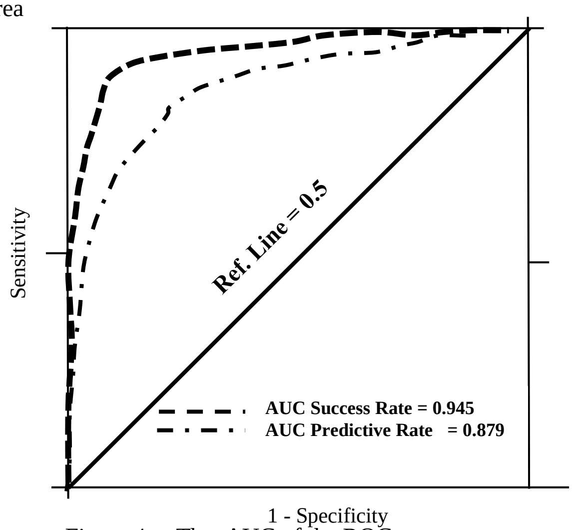

Figure 4. The AUC of the ROC curve

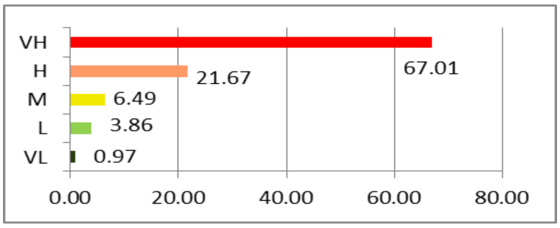

Figure 5. Landslide data validation on the LSM

4. Conclusions

Landslide susceptibility mapping is important while delineating landslide prone areas in mountainous regions. The weight of evidence modelling was applied to produce the landslide susceptibility map because this model is relatively easy to use and modest. Combination of six landslide causal factors i.e slope, curvature, aspect, fault, river and lithology with landslide data inventories show satisfactory result on the AUC of the ROC curve, and the ratio of landslide data validation falls on the landslide susceptibility map. This landslide susceptibility map can be used by planners and the governments as decision makers in development management.

5. Acknowledgements

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