SPATIAL FACTORS AFFECTING THE LANDSLIDE VIA LOGISTIC REGRESSION MODEL IN NANGLAE NAI VILLAGE, CHIANG RAI PROVINCE

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ABSTRACT

Landslide is a natural phenomenon caused by downslope movement of soil and rocks along the hillsides or anthropogenic activities, e.g. deforestation and agricultural practices in steep areas. Landslide risk mapping defined by the application of geographic information system and logistic regression model require the interaction between landslide areas and spatial factors. The study area is located at Nanglae Nai village, Mueang district, Chiang Rai province. The results of this study shown that the landslide areas appeared in 4 areas, including Doi Dang, Tad Hang waterfall, Baan Likai and Pha Lad Roy Wao. Based on the analysis of logistic regression model, it was found that the elevation (449-709 meters) and aspect (North and Northeast) were major spatial factors of landslide risk because they were possessed a high risk for landslides (> 80%) and the accuracy of the model was 71.8%.

Keywords- Landslide, Geographic information system, Logistic regression model, Chiang Rai province

1. INTRODUCTION

Landslide is a natural phenomenon caused by the movement of soil and rocks along the hillsides. This is due to natural disasters such as earthquakes, storms and heavy rain. Landslides, that caused deaths, injuries and missing person, occur throughout the world [1, 2], and economic losses of more than 0.9 billion USD. Therefore, the risk of landslide should be taken into consideration to reduce the damage [3, 4].

Environmental factors that cause landslides, such as rainfall, altitude, slope and aspect, etc., especially, the spatial factors, including slope (20% importance of landslide causal factors) and elevation (16% importance of landslide causal factors) involved with aspect [5]. The risk of landslides is mostly identified by using a logistic regression model and environmental factors for landslide risk prediction [6].

Nanglae Nai village, Mueang district, Chiang Rai province, is selected as study area because it is an important village located along Nanglae Nai stream as well as upstream areas and famous tourist attraction in Nanglae District, such as Nanglae waterfall, Pha Lad Roi Wua and Doi Dang. However, forest areas have been destroyed by unsuitable highland agricultural landuse, such as paddy fields, lychee and pineapple farms [7] resulting in landslide in the area. The aim of this research was to predict landslide risk by using logistic regression model and spatial factors in Nanglae Nai village, Chiang Rai province.

2. OBJECTIVE

1) To predict landslide risk by using logistic regression model and spatial factors in Nanglae Nai village, Chiang Rai province.

3. METHODOLOGY

3.1. Study area

Study area was Nanglae Nai village, Mueang district, Chiang Rai province located from 2210000 to 2220000 degrees north latitude and 580000 to 590000 degrees east longitude (Fig. 1).

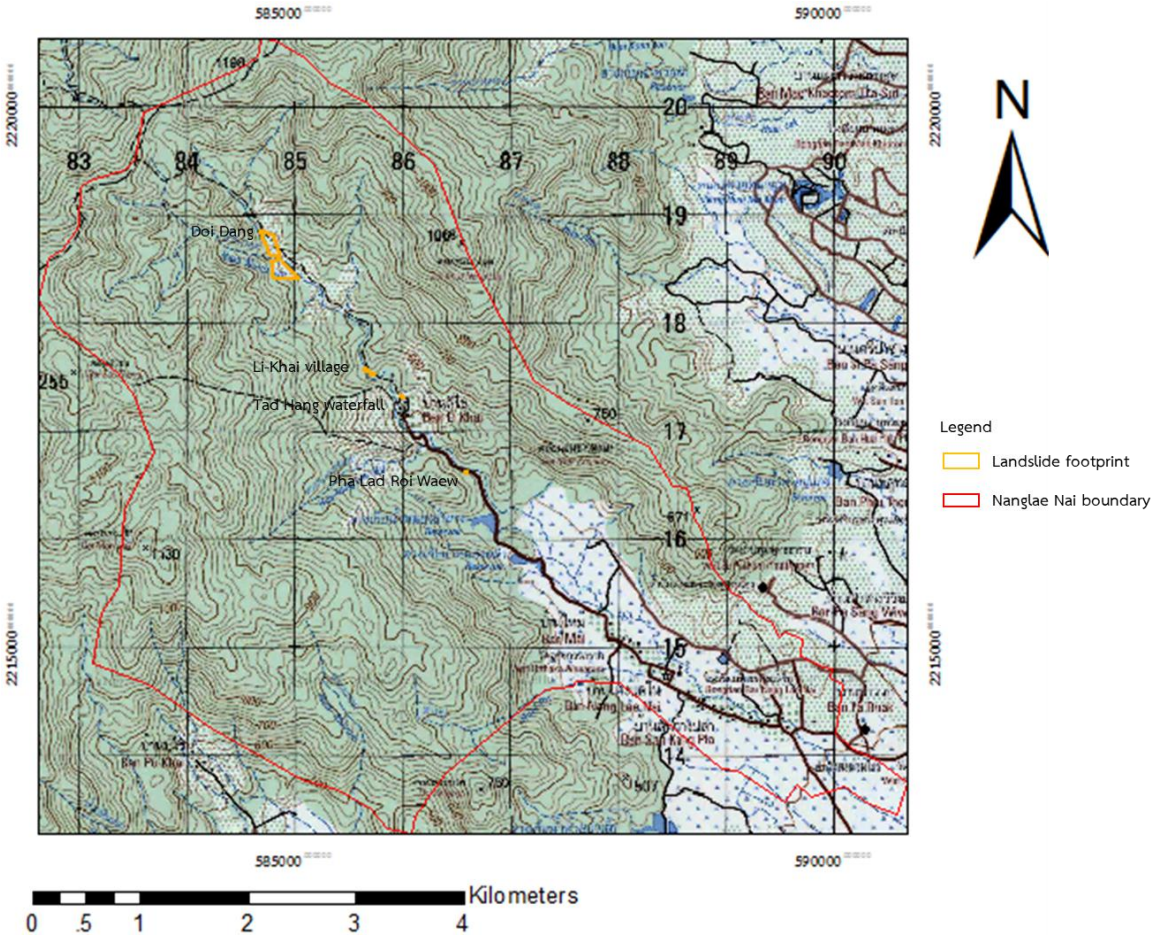

Figure 1 Study area and landslide footprint at Nanglae Nai village.

3.2. Data collection

1) Field survey

In this study, landslide footprint were conducted using walk-through survey along the stream, Li-Khai village to Doi Dang. Landslide footprint areas are also recorded x and y coordinates.

2) Logistic regression model

Landslide footprint areas are imported to determine areas of landslide occurrences. With the use of the statistical program R, points are randomly selected in the study area. Random points were separated into 2 groups. The first group was the points (each point being equal to 1) where landslide occurred. The second group was the points (each point being equal to 0) where landslide never occurred. Spatial factors, including DEM, slope, and aspect were used for the model. After random points establishment, dataset was applied with the use of logistic regression model and the number of dataset were divided into 2 groups. The first group was used for modelling in logistic regression model processing. The second group was used for validation of the model. Spatial factors were selected by stepwise method. As a result the best model was presented the lowest AIC (Akaike's Information Criterion) and the AUC (Area Under the ROC Curve) was used to verify the accuracy of the model.

4. RESULTS

4.1. Landslide footprint in Nanglae Nai village

There were 4 areas of landslide footprints, including Pha Lad Roy Wua, Li-Khai village, Tad Hang and Doi Dang (Fig. 1). Fifty-one points were randomly selected in areas where landslides occurred. As a result the average elevation of the landslides was 668.25 meters above mean sea level and aspect was 114.90 degrees (Southeast direction).

4.2. Landslide risk in Nanglae Nai village

With the use of logistic regression model with stepwise, P-values of DEM and aspect were statistically significant at the 0.10 and 0.05 levels, respectively (Table 1).

Table 1 Logistic regression model analysis

Variables	Coefficients	Std. Error	Z value	P-Value
(Intercept)	-16.91	9.890×10^{2}	-0.017	0.9864
DEM	-0.0016	8.411×10^{4}	-1.926	0.0541**
Slope	16.31	9.890×10^{2}	0.016	0.9868
Aspect	-0.0051	2.205×10^{-3}	-2.351	0.0187*
Pseudo-R^2 = 7.8 , AIC = 274.51				

*statistically significant at 0.05
**statistically significant at 0.10

The AIC value was 274.51. Pseudo-R^2 was 0.078 resulting in prediction model of 7.8%. Prediction equation is shown in the equations below, Equation 1.

$$Z = -16.91 - 0.0016DEM + 16.31Slope - 0.0051Aspect \quad (1)$$

A map of the risk of landslides in Nanglae Nai village (Fig. 2) is presented probability value from 0 to 0.22. The probability value was 0 (gray area), that there was no chance of landslide occurrence. The probability was 0.22 (green area), that there was high risk for landslide occurrence. An increased slope angle will increase the chance that a landslide will occur. Aspect direction that directly influences landslide occurrence in this area, was north (more than 337.5 to 22.5 degrees) and northeast (more than 22.5 to 67.5 degrees). The accuracy of the predictive model was 71.8% (AUC = 0.7179487).

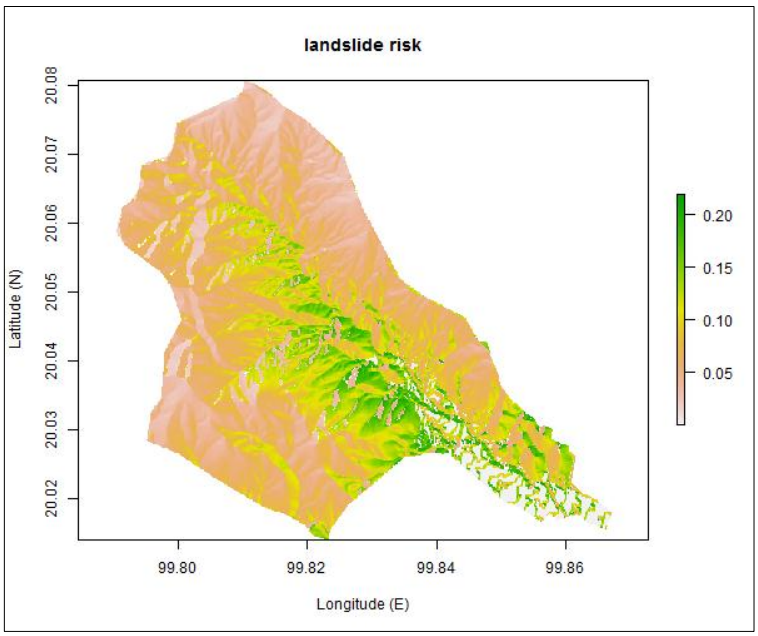

Figure 2 The risk map of landslides in Nanglae Nai village.

5. CONCLUSION AND DISCUSSION

5.1. Discussion

5.1.1. Landslide prediction by logistics regression model

Spatial factors related to landslides in Nanglae Nai were slope of more than 30 degrees, aspect directions, north (more than 337.5 to 22.5 degrees) and northeast (more than 22.5 to 67.5 degrees) and DEM. Although DEM was negative value, DEM and slope in the model were likely to occur landslide in the area [6]. The model was able to predict the risk of landslide in Nanglae Nai village about 7.8% resulting in insufficient spatial factors for prediction. The accuracy of the model was, however, 71.8% that is considered acceptable [5].

5.1.2. Preventing the landslide risk in Nanglae Nai village

People avoid living and farming in high risk zones with slope of more than 30 degrees and aspect directions (north and northeast). If they need for planting or cultivation, they must construct rice terraces for reducing the rate of soil erosion. Forests should be preserved for providing reinforcement and strengthening of soils.

Vetiver grass (*Vetiveria Zizanioides* Nash) should be planted on steep slopes to prevent soil erosion [8, 9].

5.2. Conclusion

There were 4 areas of landslide footprints, including Pha Lad Roy Wua, Li-Khai village, Tad Hang and Doi Dang. Two important spatial factors were DEM and aspect. Aspect, that directly effects landslide occurrence in Nanglae Nai village, was north (more than 337.5 to 22.5 degrees) and northeast (more than 22.5 to 67.5 degrees). The accuracy of the predictive model was 71.8%.

6. RECOMMENDATION

The level of landslide risk should be studied to know the level of landslide risk of the area.

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