Analyzing the effects of land use changes for landslide susceptibility assessment : a case study of LabLae district, Uttradit province ,Thailand

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ABSTRACT: Landslide problem involves several factors, The significant ones include rainfall, slope, and land use. A plan to reduce landslide problem requires studying of landslide inventory on relevant types of land use in Laplae district, Uttaradit province from the past to the present. Such plan can also be applied for land use managing in steep areas and land administration that match conditions of the areas. This area was selected as the case study because it is a highly steep area and encountered two obvious landslides in 2006 and 2011 in nearly the same spot. Remote sensing technology can support this planning with wide-scale spatial data, and it can be used for monitoring land use change after a landslide. This study used multi-temporal satellite images to analyze land use change in a landslide area. The main objective aims to interpret land use from satellite images and examine land use changes induce in recurrence of the landslides that implemented image classification and GIS based analysis techniques.

The results of analysis reveal that the 2006 and 2011 landslides occurred mostly in forest area, which accounted for 176 acre and 16 acre. Regarding the result of land use change during 2006-2011 found that the forest area was changed mostly into fruit orchards about 53 acre, followed by fruit orchard area was changed into forest area about 9 acre. When the landslide inventories cross with the land use change data, it was found that the fruit orchard areas had the greatest rate of landslide recurrence, which accounted for 22% of landslide areas. The final analysis result classified fruit orchard as high susceptibility zone for landslide, so it should be considered other parameters such as slope and aspect for the further analysis.

1. INTRODUCTION

Thailand is affected by flooding every year causing serious damage to people and property. Flood and landslide monitoring are essential to ensure human safety and to efficiently detect early damage areas. Typically, the major factors influencing landslide occurrence include rainfall, slope, and land use. Utilization of remote sensing and Geographic Information System (GIS) for landslide susceptibility assessment could be described using different land use characteristics.

2. STUDY AREA

The study area is situated in Laplae district. It is located in Uttaradit province, the North of Thailand as shown in Figure 1. The total area is around 506.02 square kilometers. The characteristics of this region are flat and very high mountain area. Average height of the mountain is approximately 680 meters above mean sea level. In general, rainy season starts from July to October. The total annual rainfall and the minimum temperature are 1,379.50 millimeters and 14 degrees Celsius, respectively. Orchard and forest are the major land cover type.

Fig.1 Location of the study area at Maepool sub district in Laplae district was presented in red circle.

3. OBJECTIVES

3.1 Land use change analysis using high-resolution satellite data in 2006 and 2011.

3.2 To examine the recurrence of landslide events over different land use types.

4. MATERIALS

4.1 GeoEye-1 pan sharpened image with 50 cm spatial resolution and Landsat-5 TM image with 30 m spatial resolution.
4.2 ArcGIS software was used to analyze land use change.

5. METHODOLOGY

5.1 Satellite data collection

5.2 Ground observation was collected and their Global Positioning System (GPS) coordinates recorded using handheld GPS receiver.

5.3 Geometric Correction was conducted using orthoregistered image and with the use of ground control point (GCP) at least 16 points per image. The second order polynomial equation was adopted for this step. The root mean square errors (RMSE) was not exceed one pixel. The data were resampled to 25 m spatial resolution.

5.4 Satellite images were analyzed based on visual interpretation technique. The image characteristics of shape, size, shadow, tone, texture, pattern, location, and association were used to identify the features on images. Land use types were classified into seven types, including forest, mix orchard, village, crops, rangeland, open land, and water using GIS technique.

5.5 Land use change in 2006 and 2011 were analyzed using the union function. Union function is mathematical model which merged two areas in order to create the new map. (Figure 2)

Fig.2 Union – Overlays two polygon themes

5.6 The ratio of landslide and the recurrence of landslide events over different land use types were analyzed using the overlay function. The principle of intersect is computes a geometric intersection of the input features. Features or portions of features which overlap in all layers and/or feature classes will be written to the output feature class (Figure 3). Three input data were performed using intersect function with the following equation 1.

% recurrence of the landslides = (a ∩ b ∩ c) x 100/a ……. (1)

Where ∩ is Intersect, a is area of traces in 2006, b is area of traces in 2011, and c is land use in 2006

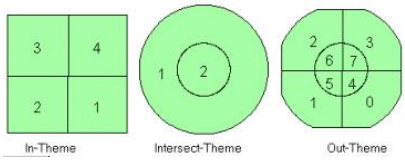

Fig.3 Intersect– Overlays two themes and preserves only features that intersect

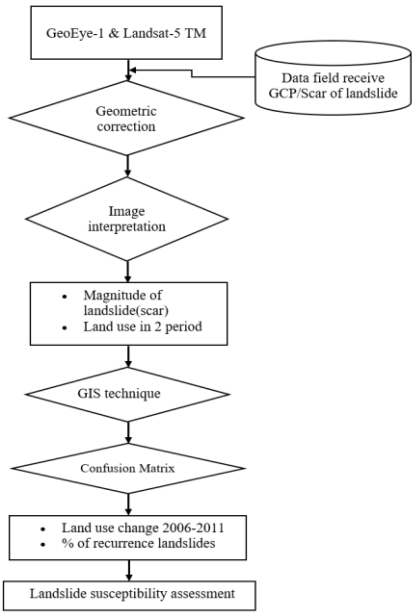

Fig.4 Flowchart of landslide susceptibility assessment

6. RESULTS

6.1 In 2006 and 2011, landslide traces presented in 204 areas (approximately 213 acre) and 171 areas (approximately 540 acre), respectively as shown in Table 1 and 2. The highest landslide susceptibility area was found in forest area, which declined between 2006 and 2011 (approximately 5,304 acre). Mix orchard areas were increased approximately 6,096 acre. Land use change map shown in Figure 5.

Table1: Landslide traces in study area (2006 and 2011)

Number traces of landslide		Trace of landslide (Area: acre)	
In 2006	In 2011	In 2006	In 2011
204	171	213	540

Table2: The area of land use in 2006 and 2011

Land use type	YEAR(Area :acre)	
	2006 (acre)	2011 (acre)
Forest	18,052	12,728
Mix orchard	6,778	12,874
village	998	625
crops	338	81
open land	178	22
rangeland	22	-
water	3	39
Total	26,369	26,369

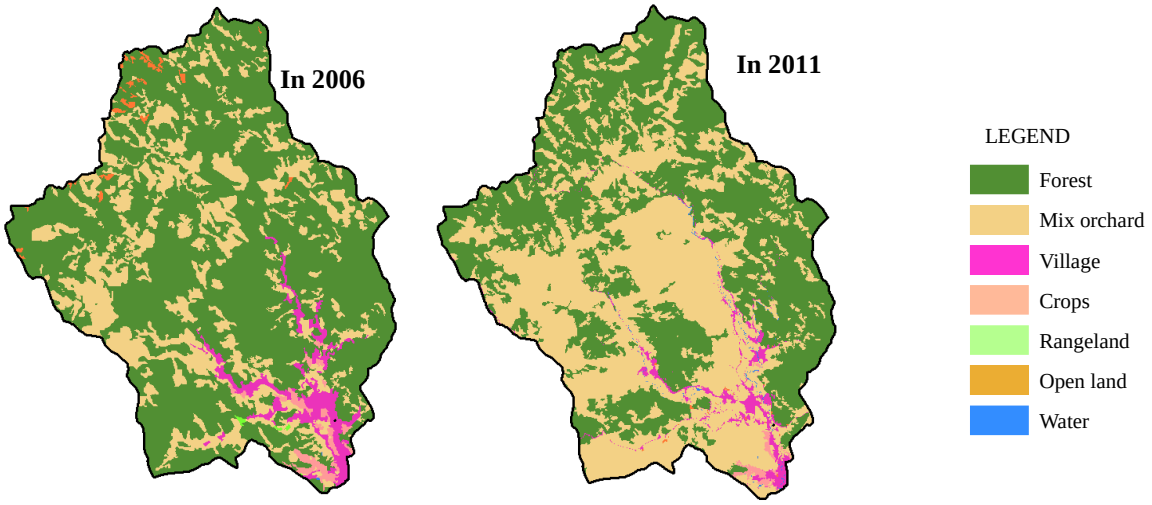

Fig.5 Land use in 2006 (Left) and 2011(Right)

6.2 After landslide event, forest area was changed to mix orchard area (approximately 53 acre). Mix orchard area was planted at the same position approximately 28 acre (Table 3).

Table3: Land use change after landslide events (2006-2011).

Land use type on landslide traces (2006)	(Area :acre) /land use change after landslide events (2011)				
	Forest	Mix orchard	Village	Water	Total
Forest	122	53	0.2	0	175.2
Rangeland	-	0.4	-	-	0.4
Mix orchard	9	28	0	-	37
Total	131	81.4	0.2	0	212.6

6.3 In table 4, the mostly recurrence of landslide events was found in the mix orchard area (22%).
Table 4: The ratio of landslide recurrence.

Land use in 2006	Area: Acre. Landslide in 2006	Area: Acre. Landslide in 2011	% recurrence of the landslides
Forest	175	16	9
Mix Orchard	37	8	22
Total	212	24	31

7. CONCLUSION

The results found that the numbers of landslide traces in 2006 were higher than those in 2011, while the numbers of landslide traces were not related to landslide area. In 2011, landslide areas were found higher than the numbers of landslide traces in 2006 due to severe landslide. Land use change resulted in significant increase in landslide events. For instance, the impacts of converting forest area to other land use type's increased higher landslide due to buried in the soil surface decrease. Forest area was dramatically decreased, while orchard area was increased rapidly in the study area. Orchard area was the highest susceptibility area to landslide recurrence due to lack of groundcover. Groundcover is important for soil surface such as soil water pressure decrease, the adhesion of the roots increases soil strength and preventing mass movement. In this study, the results of land use change significantly related to landslide events. The people living in the hilly area should be concerned with different land use activities. For instance, the landslide recurrence in orchard area have resulted in economic losses. Therefore, Government agencies are the most important organization to provide information and knowledge for people living in hilly area that will improve sustainable living and property.

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