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Land Cover Change Detection Analysis for Landslide Monitoring Using SPOT-5 Satellite Images.

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***Abstract*—Landslides have become a common disaster in Malaysia, the incident occurred according to human activity in economic development. Deforestation, urbanization, development of hill slopes and other human land use have given rise to increased risks of landslides. This paper reports the monitoring of the landslide by applying Land Cover (LC) change detection by utilizing two multispectral satellite imagery SPOT 5 for the year 2005 and 2014. ArcMap 10.2.2 software was used in the image processing using Maximum likelihood classification. This study is conducted in Ulu Kelang, Selangor which is located at hilly and sloppy terrain surround by forestry. The results show the method of LC changes and factor of the landslide can be justified via remote sensing image within 10 years' time. The accuracy of image classification was showed an overall accuracy of 95% (2005) and 93% (2014), while kappa coefficient indicates the method of classification and the images used were excellent quality. During this study period, an urban area has shown an increase of 14.143%, while the green area had decreased by 8.432% due to an increase of interest in urbanization development. There were twelve landslides recorded during the years 2006 to 2014, about 91.66% landslide events were affected build up area which were residential area and road. This analysis showed that human influence or activity could be contributing to landslide occurrences. Therefore, the urbanization development is very important to have proper planning to reduce the susceptibility of landslide occurrences in Ulu Kelang, Selangor.**

***Keywords*—Landslide, Remote Sensing, Land Cover, Change Detection, SPOT Satellite Images.**

I. Introduction

Landslides are defined as the movement of a mass of rock, debris or earth downslope influenced by gravity. The often-triggering factors of landslide including intense or prolonged rainfall, earthquakes, rapid snow melting, volcanic activity and variety of anthropogenic activities.

Landslide disaster may affect human life, property and environment [1]. In Malaysia, most of the landslides or slope failure incident occurred due to intense rainfall and urban development over hillside areas [2].

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The most tragic landslide incident was the collapse of the 14-storey Block A of the Highland Tower in Ulu Kelang, Selangor in December 1993 due to the retrogressive failure of the cut slope behind the tower.

Landslide monitoring is the comparison of whatsoever landslide conditions over time. The monitoring landslide activity over an extensive area is important to identify "cause" and "effect" of landslide, detection and prediction of the future landslide; provide alert and alarm signals to ensure the safety of population and infrastructures [3]. Earth Observation-based on satellite remote sensing is useful in landslide monitoring due to its fast response, wide field of view, and relatively low cost [4][5]. Remote sensing offers a wide range of spatial, spectral and temporal parameters because it uses sensors or detector which is on board of satellite or aircraft. Techniques used in remote sensing include interpreting the aerial photo, satellite image processing and interferometric synthetic aperture radar (lnSAR). Later, some improvement has been achieved in remote sensing; light detection ranging (LIDAR) has been used to investigate the landslide. Remote sensing imageries had a capability in acquiring the past and present in mapping landslide occurrence [6][7][8].

Change detection is a technique used in remote sensing to measure surface processes for volumetric change such as map erosion and deposition. Methods of change detection are usually divided into pixel comparison directly and post-classification comparison [9][10][11]. Change detection is useful in many applications related to LC changes, such as shifting cultivation and landscape changes, land degradation and desertification, coastal change and urban development Image pre-processing, deforestation, habitat fragmentation and other cumulative changes.[12][13][14][15]. Some studies have indicated that human-induced land cover change (LCC) contributes significantly to the initiation and reactivation of landslides especially in populated regions, where landslides represent a major risk to infrastructure, human settlements and people [16][17].

In this paper, we propose a method that fuses LC change detection and Maximum likelihood supervised classification based on multispectral satellite imagery SPOT 5 data. We analyze the LC classification, investigate, and validate the spatial probability factor of landslide and LC change detection by using the powerful tools ArcMap 10.2.2 software.

II. METHODOLOGY

A. Study area and Data

Ulu Kelang, Selangor has been selected as study area which is located at coordinate 3° 12' 3.6"N and 101° 46' 1.2"E, is an urbanization area which has very high demands on its land property and housing development, particularly at the hillside area as shown in Figure 1 [18].

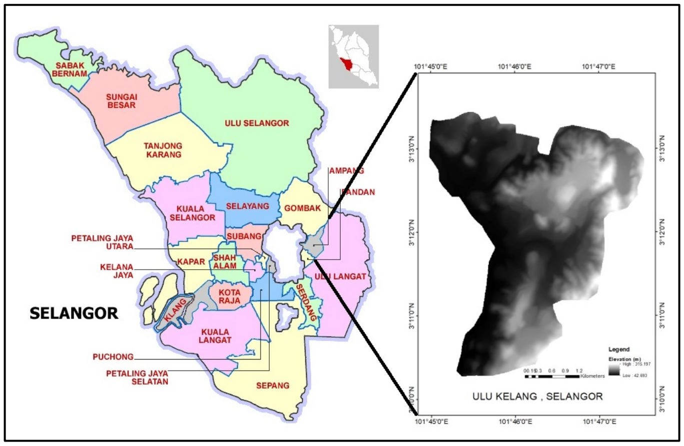

Figure 1: The location of Ulu Kelang, Selangor

This study was conducted based on the landslide occurred between the year 2006 to 2014. The SPOT 5 satellite images with the specification of 3 bands and vegetation sensor with the 5 meter resolution, path (270) and row (343) have been used in the classification process. Two satellite images were selected in the year 2005 and 2014. The satellite images are given with compliment from the Malaysian Space Agency (MYSA).

B. Method

Basically, data/image processing consists of three stages, in which, phase one is data/image collection, phase two is data/image processing, and phase three is result and analysis. In this study, ArcMap 10.2.2 Software was selected to process and analyze the LC map obtain from SPOT satellite images. Figure 2 shows the flowchart of image processing for LC mapping. The image processing for SPOT-5 images was started with georeferencing process which the spheroid is set to Modified Everest, the Datum is set to Kertau 1948 and RSO type is set to Malaysia. In image subsetting stage, SPOT 5 images were subsetting into Ulu Kelang area covers by approximately 15.9 km^2. The processes were followed with haze reduction to enhancement the image quality and replace the missing or bad line to normalize radiometry for the clearest portion of image [19].

The classification of LC was classified using Maximum likelihood supervised classification. In Supervised Classification, the classification process has been controlled by creating, managing, evaluating, and editing signatures using the Signature Editor. Signatures are specific areas to which the names are assigned for supervised classification. Signatures are used to break the different classes like a forest, cultivated, water and the like classes into as many subclasses as per classification requirement. The supervised classification is the most common method in obtaining land use/cover information [12].

The accuracy assessment was applied for validation of the LC classification using Kappa statistical analysis based on 103 random points that were identified and located using a stratified random method in ArcMap 10.2.2 software to represent the different LC classes of the area. The ground truth point’s data and the classification results were compared and statistically analyzed using error matrices. After the LC classification, the SPOT 5 images were combined to highlight the difference in change detection.

The LC change detection analysis has been compared to the landslide events that occurred in year 2006 to 2014. This comparation was conducted to investigate the relationship between LC classification and landslide occurrences at Ulu Kelang Selangor.

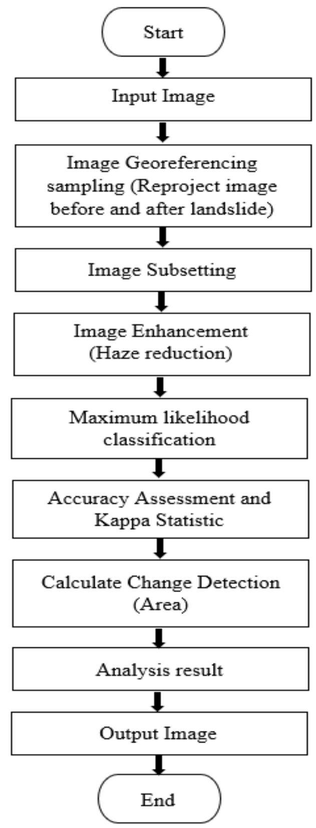

Figure 2: The flowchart of image processing for LC mapping.

III. RESULTS AND DISCUSSION

A. Land Cover Classification

The SPOT 5 images for LC change detection analysis between 2005 to 2014 were processed part by part. The processed were conducted using ArcMap 10.2.2, which including georeferencing, subset, haze reduction, supervised classification and recode. Then, the analysis of LC mapping in the year 2005 and 2014 was combined to highlight the difference. Five classes have been identified in the Maximum likelihood supervised classifications for LC mapping in Ulu Kelang, Selangor. The LC mapping classification system was adopted from USGS's Anderson Classification System [20]. The classes were divided into Green area (green), water bodies (Blue), Developing area (Yellow) and Build Up area (Red). The description of identified LC classes is shown in Table 1. While the recode images or LC mapping classification for 2005 and 2014 were shown in Figure 3 and Figure 4.

TABLE 1: LAND COVER CLASS AND DESCRIPTION

Code	LC Class	Description
1	Green Area	Forest, Vegetation area and Recreation Park
2	Water Bodies	Lakes, Pool and Waste reclamation plant
3	Developing Area	Construction areas for residential and commercial; and bare soil.
4	Build Up	Residential, commercial, and service; transportation, communication and utilities; industrial and commercial complexes, Institutions and places of worship.

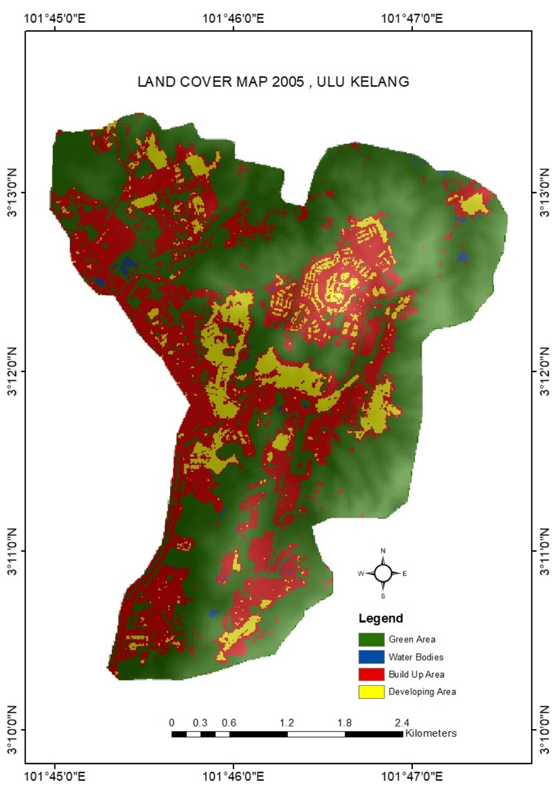

Figure 3. LC map of Ulu Kelang, Selangor in year 2005

B. Accuracy Assessment and Kappa Statistics

In the accuracy assessment, 101 points were selected as references for images in Fig. 3 and Fig. 4. The overall classification accuracy for images in Fig. 3 is 95% in the year 2005 and Fig 4 is 93% in the year 2014. While the assessment based on kappa statistics shows, both images are excellent quality where the value of Kappa Statistics is 0.929 in the year 2005 and 0.898 in the year 2014, as shown in Table 2 and Table 3.

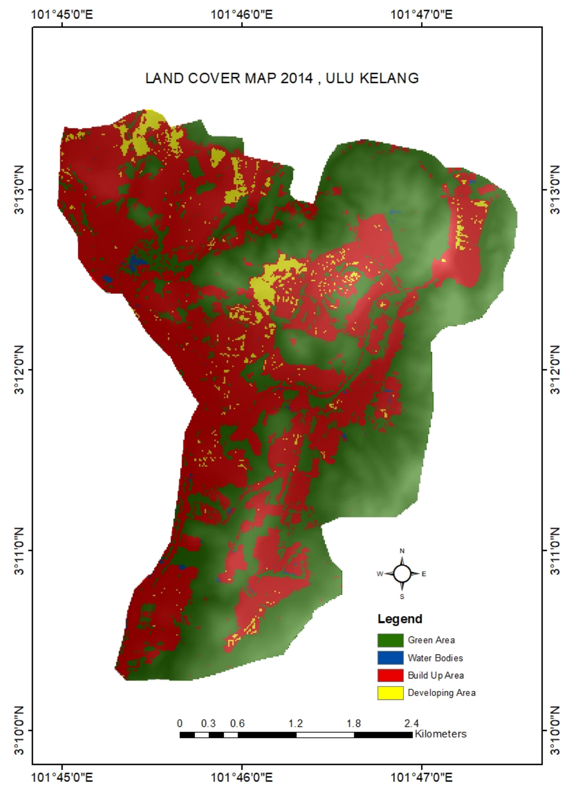

Figure 4. LC map of Ulu Kelang, Selangor in year 2014

TABLE 2: USER AND PROCEDURE ACCURACY ASSESSMENT FOR ULU KELANG, SELANGOR

Year / Land Cover Class	2005 User Accuracy (%)	2005 Procedure Accuracy (%)	2014 User Accuracy (%)	2014 Procedure Accuracy (%)
Green Areas	97	92	97	95
Water Bodies	100	100	100	100
Build Up	96	96	91	93
Developing Areas	91	97	86	86

TABLE 3: ACCURACY ASSESSMENT AND KAPPA STATISTICS FOR ULU KELANG, SELANGOR

Year	Overall Classification Accuracy	Overall Kappa Statistics	Kappa Quality
2005	95%	0.929	Excellent
2014	93%	0.898	Excellent

C. Land Cover Change Detection and Factor of Landslide.

The LC change detection from the SPOT 5 satellite image gives the information about the factor of landslide occurrences in more detail. The analysis is based on the increment and decrement of the area within 10 years from the year 2005 to 2014. Table 4 presents the changes in the scope of area in unit km^2. The most of study area is covered by green area where is located adjacent to the forest reserve of Ampang and Ulu Gombak. The SPOT 5 image of 2005 indicated that; green area, water bodies, developing area and build up an area are about

57.419%, 0.447%, 8.806% and 33.329% respectively. Similarly, in 2014 green area showed high coverage with 48.987% followed by a build-up area with covers of 47.472%.

As shown in Table 4, the major types of LC showed in both years is a green area where is most of the area is forest, followed by a build-up area and developing area. The results showed the build-up area was increased by 14.143% within 10 years from the year 2005 to 2014. This is due to an increase in urban developments in Ulu Kelang area, especially in a hilly area. While the developing area was decreased by 5.573%, where it indicates that most of the developing phase is completed and change to build up area. According to the LC changes from the year 2005 to 2014, green area and water bodies are showed decrement where is the changed are 8.432% and 0.139%. This decrement is caused by the growing of build-up area which is demanding for a residential area.

TABLE 4: THE INCREASING AND DECREASING OF ULU KELANG, SELANGOR

LC Type	LC 2005 Area (km^2)	LC 2005 Percentage (%)	LC 2014 Area (km^2)	LC 2014 Percentage (%)	Change in % from 2005 to 2014
Green Areas	9.168	57.419	7.822	48.987	(-)8.432
Water Bodies	0.071	0.447	0.049	0.308	(-)0.139
Developing Areas	1.406	8.806	0.516	3.233	(-)5.573
Build Up Areas	5.322	33.329	7.58	47.472	14.143

D. Land Cover Change Detection analysis and Landslide Events in year 2006 – 2014.

In 2006 to 2014, a total of twelve landslide events were occured at Ulu Kelang, Selangor. Where two of incidents were recorded as major landslide events occurred in 2006 and 2008. The list of landslide events as shown in Table 5. In this study, only medium to large(major) scale landslides were involved. There were three locations identifies as landslide prone area in Ulu Kelang, Selangor which are Bukit Antarabangsa, Ukay Perdana and Kampung Pasir. All the location is in hillside area at an altitude of 100 to 200 m above sea level.

Based on LC change detection analysis, an increasing of build-up area with decreasing the green area contribute to landslide occurrences in Ulu Kelang, Selangor. From analysis, the increment of 14.143% build up areas from 5.322 km^2 into 7.58km^2 shows that expanded of urban area, especially a residential area. This factor directly affects the degradation of green areas which are forest and vegetation areas. Based on landslide analysis in 2006 to 2014, about 91.66% landslide events were affected build up area (residential area and road). Where the initial landslide was occurred at green areas, then affected to nearby build up areas. There was one landslide incident has occurred at developing area and affected to nearby build up areas. All the landslide events occur in hillside areas. However no initial landslide recorded at build up area.

TABLE 5: LIST OF LANDSLIDE EVENTS IN ULU KELANG, SELAGOR IN 2006 – 2014.

No	Location	Date	Scale of Landslide
1	Kampung Pasir, Ulu Kelang	31 May 2006	Major
2	Condominium Wangsa Height, Bukit Antarabangsa	23 April 2008	Medium
3	Taman Bukit Mewah, Bukit Antarabangsa	6 Dis 2008	Major
4	Wangsa Height, Bukit Antarabangsa	19 Sept 2009	Medium
5	Jalan Wangsa 7, Bukit Antarabangsa	19 Sept 2009	Medium
6	Ukay Club Villa, Taman Kelab Ukay	9 April 2010	Medium
7	Jalan Wangsa 1, Bukit Antarabangsa	1 August 2010	Medium
8	Jalan Ukay Perdana 1/8, Ukay Perdana	21 May 2011	Medium
9	Taman Bukit Jaya, Bukit Antarabangsa	21 June 2011	Medium
10	Ukay Perdana	Feb 2011	Medium
11	Jalan UP 4, Ukay Perdana.	May 2012	Medium
12	Jalan UP1/5, Ukay Perdana	27 Oct 2014	Medium

By referred to Figure 5, there were eleven incidents of landslide events were affected residential area and road which were the landslide is initially started from nearby green area. This incident shows that build up area in hillside was influence the instability soil structure in surrounding area. This indicate that build up area was strongly affected by landslides especially in hillside areas. Although most of initial landslides occur from nearby green area.

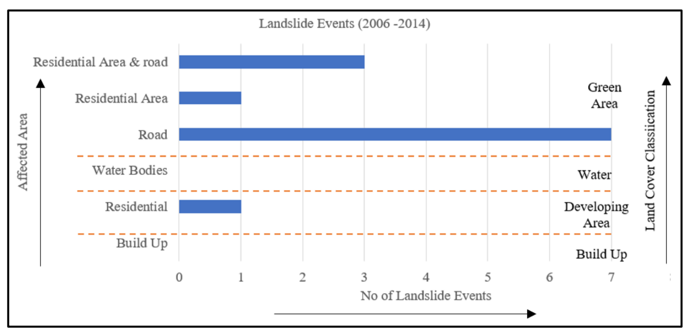

Figure 5: Landslide Events recorded in Ulu Kelang, Selangor in 2006 to 2014.

The discussion shows that LC change detection is important in monitoring and prediction landslide occurrences by investigate the LC changes with landslide activity. LC change detection can be considered as an analysis to determine susceptibility index of landslide events in LC context. There were similar studies have shown the LC changes was influence the landslide susceptibility [21][16][22]. Thus, all development should be well planned and organized based on the aspects that led to the occurrence of landslides.

IV. CONCLUSIONS

Based on the processing of the satellite image, the application of ArcMap 10.2.2 software was a very practical way to analyze the LC change detection and monitor the landslide. In this study, SPOT 5 images were used to obtain LC maps for the year 2005 and 2014. The LC classification using Maximum likelihood supervised classification. It could display a high-quality image to create a map and to visualize it. The overall classification accuracy for images is 95% and 93% in the year 2005 and 2014, respectively. The Kappa quality is showed a very good quality where the values were 0.929 and 0.898 for both SPOT-5 images. According to the result of classification, the green areas were decreasing about 8.432% from year 2004 to 2014, where degraded from 9.168 km^2 into 7.822 km^2. While Build up area increased by 14.143% due to human activities. From the LC change detection and landslide events analysis, the result obtained that most of landslide incidents have affected the build up area was starting from nearby green area due to instability soil structure in surrounding area especially in hillside area. The increment of build-up areas and decrement of green area were showed that LC is an important contributing factor in the occurrence of landslides.

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