Monitoring of Landslide and Change Detection using Remote Sensing in Pahang

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***Abstract*—Landslide has become a common disaster in Malaysia, especially in Pahang according to the human activity in economic development. This paper report the monitoring of the landslide and change detection in Pahang by utilize multispectral satellite imagery SPOT 5 and SPOT 6. Erdas Imagine 2014 software was used in the image processing and unsupervised classification has been chosen to analyses the classification accuracy and kappa statistic of the satellite image. Two locations have been selected in study which are Km 16 Panching – Sg. Lembing and Km 52.4 Lebuhraya Kuala Lumpur – Kuantan for which the locations are surround by agriculture and forestry respectively. The results show the method of change detection and factor of landslide can be justified via remote sensing image even within 3 years' time.**

Keywords-component: landslide, remote sensing, change detection, Erdas,

I. INTRODUCTION

Recently, on 11th November 2015, a landslide disaster had struck at one of the main highways in Malaysia, the KM 52.4 Lebuhraya Kuala Lumpur-Karak, leading to a damage in the suburbs, and the road was filled with mud and rubbish. Many users stuck in their travelling because an alternative route through the Bentong-Kuala Lumpur is also disconnected. Nowadays, landslide has become a common problem in Malaysia especially in Pahang and according to recorded there are 14 incident of landslide happened in Pahang from the year 2000 to 2004 [1].

One of the factor of landslide is the changes of weather such as wind, monsoon and temperature. The previous report of Malaysian Meteorological Department in Northeast Monsoon Report Kuala Lumpur Monsoon Activity Centre, November 2014. Kelantan, Terengganu and Pahang recorded a monthly rainfall of more than 1200mm which the highest rainfall was recorded in Kuantan with a total of 1806.0mm [2].

Remote sensing offer a wide range of spatial, spectral and temporal parameters because it uses sensors or detector which are on board of satellite or aircraft. The sensor measures the amount of energy which reflected from or emitted by the earth surface or target in different wavelength intervals [3-4] Techniques used in remote sensing include interpret the aerial photo, satellite image processing and interferometric synthetic aperture radar (InSAR) [5]. 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].

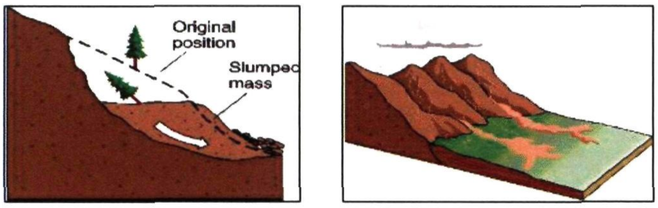
Worldview-2 image has been used to determine the tree species in previous study. This is because the availability in infrared band is sensitive towards the vegetation chemistry and physical composition. Nevertheless the detection and differentiation a bit hard therefore the accuracy a bit low in classification [5]. In another study, the Ikonos-2 satellite image had been used to develop a cartographic index of forest stand and it showed the great potential for the estimation where the coefficient and determination is higher than Landsat image [7].

Change detection with remote sensing image is a process to get information or to detect the changes at same places but on different dates. The information of change detection and extraction is a main point in the decision making. Methods of change detection is usually divided into pixel comparison directly and post – classification comparison. It would provide a convenient ways to access the changes [8-9]. Thus, the accuracy of change detection is often obtained by identifying the value of accuracy assessment of change detection: change error matrix and Kappa coefficient [8]. Therefore the methods also been applied in this study to accomplish the objective which are to investigate and validate the spatial probability factor of landslide and change detection by using remote sensing image with the used of the powerful tools Erdas Imagine 2014 software. Type of the landslide also can be determined in this study.

II. LANDSLIDE TYPE

Basically, the deforestation, rainfall and logging activity brings the calamity of landslide in Pahang. The landslide normally happen in hilly area where there is slope failure. There are many attributes used as criteria for identification and classification of landslide or slope movement. This is including the rate of movement, type of material and nature of movement. There are several types of landslide which are slide, creep, slump, topple, fall, flow and torrent. Comparing to other place, the earthquake induced the formation of landslide and it can be classified in different ways in term of the seismic landslide such as overall sliding, fracture sliding, fall sliding, dump down sliding and fall ejection sliding [10].

Two out of seven types of landslide were identified in this study which are slump type and torrent type as illustrated in Fig. 1 respectively. Slump type is defined as complex movement of materials on a slope including rotational of slump while torrent type is defined as landslide which was triggered by saturation water into soils and slop away debris and rocks [11].



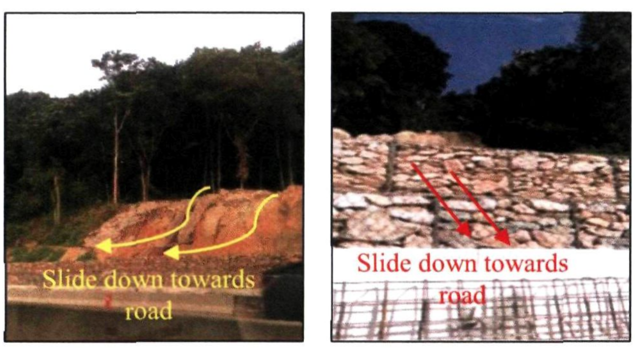
(a) (b)

Fig.1. Type of landslide: (a) Slump type (b) Torrent type

The first area of interest or AOI 1 in this study is Km 16 Panching – Sg. Lembing with coordinate 3°52.339' N, 103°10.103'E, the landslide is classified as slump type. The landslide with the average slope length 5 m and width 3 m had damaged the road and oil palm. Fig. 2 shows the situation after the landslide. The incident occurred on 24th December 2014 according to the heavy rainfall during monsoon season.

(a) (b)

Fig 2 : Site visit Km 16 Panching – Sg. Lembing: (a) View from on road after landslide, 2015 (b) soil or mass under the road rotate and slumped down.



(a) (b)

Fig.3. Site visit KM 52.4 Lebuhraya Kuala Lumpur – Kuantan: (a-b) View from on road after landslide, 2016.

The second area of interest, AOI 2 is at KM 52.4 Lebuhraya Kuala Lumpur – Kuantan with coordinate 3°23.749' N and 101°53.349'E. On 11th November 2015, a landslide calamity has occurred on the main highway where the path is from East Coast to Kuala Lumpur. The area of landslide is surrounded by forestry as shown in Fig. 3. The landslide is classified as Torrent type and it happen on rainy day. The road was covered with mud and the highway immediately become jam-packed by cars along the road for about 4 to 6 hours. More unfortunate, 2 vehicles were reported stuck in the mud. The landslide with the average slope length 15 m and width 8 m had damaged the forestry and the edge of the road.

III. METHODOLOGY

A. Study Area

In this study, two locations have been selected as area of interest which are Km 16 Panching – Sg. Lembing and Km 52.4 Lebuhraya Kuala Lumpur – Kuantan. Both classified as main road for the users to travel for routine activity. The satellite images are given with compliment from Remote Sensing Malaysia Agency (ARSM) after the location has been justified by the advice of Jabatan Kerja Raya (JKR) District of Kuantan on 16th December 2015.

In this study, SPOT 5 and SPOT 6 satellite image with the specification of 3 band and vegetation sensor has been used in classification process. The satellite image for Km 16 Panching – Sg. Lembing in the year 2012 is Landsat TM image captured by SPOT 5 Pansharp PNC with the path/row is 272/342. While for the year 2015, image is captured by satellite SPOT 6 Pansharp All Bands. Then 3-bands simulated with size 699 x 815 proposed to the next level of process.

In the area of Km 52.4 Lebuhraya Kuala Lumpur – Kuantan, the satellite image is for year 2012. Its captured by SPOT 5 Pansharp Supermode All Bands with the path/row is 270/343 whereas for year 2016, image is captured by satellite SPOT 6 Pansharp All Bands. Then 3-bands simulated with size 711 x 692 proposed to the next process in selected software.

B. Method

Basically, in this study all the image proceeded with sampling activity which the steps are geometric correction and radiometric correction. The rectification, also known as geometric correction is the process of projecting the data onto a plane and making it conform to a projection system [4]. At the same time the process involve in this step is the georeferencing where the coordinates of map was assigned to the image data. In this study, all the parameters must follow the standard in Malaysia.

Fig. 3 shows the flowchart of the change detection process by using Erdas imagine 2014 software. They are several steps that involved during the process in this study by using the software which are georeferencing, subset, enhancement, unsupervised classification and recode. After the recode, the image before and after landslide then combined together to highlight the different in change detection.

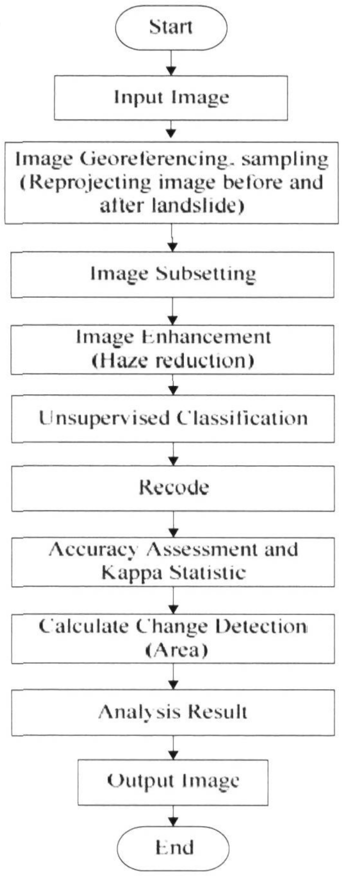


Fig. 3: The flowchart of image processing in Erdas imagine 2014 software.

i. Image Preprocessing
All the parameter can be set up as earlier as the first step to do the georeferencing which the spheroid is set to Modified Everest, the Datum is set to Kertau 1948 and RSO Type is set to Malaysia.

ii. Image Subsetting
In the subset step, eight points were had selected for four corners according to the area of interest. The eight point as referred to the axis of x and y for every corner.

iii. Haze reduction
Haze reduction takes place to reduce the haze and also replace the missing or bad line to normalize a scene to the radiometry of the clearest portion of image [12]. Occasionally, the image of haze reduction is not much different compared to the subset image. This is because the weather and cloud are in very good condition when image is captured by satellite.

iv. Unsupervised Classification
The unsupervised classification approach has the potential and advantage of revealing discriminable classes [13]. It is also preferable compare to supervised classification if the satellite image has an area of the complex terrain. [14].

v. Recode
The results of unsupervised classification were then combine and recoded. Recode is process where the pixel of image is categorized into the main classes [15].

vi. Accuracy Assessment and Kappa Statistic
Accuracy assessment should be an important part of any classification because without any accuracy assessment the image cannot validate how accurate the classification is.

vii. Calculate Change Detection
Two compatible classification are compare to analyses the change image [16]. The equation to assess the accuracy of the change detection has introduced in previous paper [8, 17].

Kappa coefficient:

$$K = \frac{X_{all}\,(X_{00} + X_{11}) - \sum(X_i + X_{+i})}{{X_{all}}^2 - \sum(X_i + X_{+i})} \tag{1}$$

Table 1 shown the change error matrix obtained by comparing the change detection result with the ground truth [8,17,18].

CD result	Ground Truth		
	Unchanged	Changed	Sum
Unchanged	[illegible]	[illegible]	[illegible]
Changed	[illegible]	[illegible]	[illegible]
Sum	[illegible]	[illegible]	X_{all}

X_{00} = number of unchanged pixels which correctly detected
X_{11} = number of change pixels which correctly detected
X_{01} = number of change pixels which incorrectly detected to be changed.
X_{10} = number of change pixels which incorrectly detected to be unchanged.
X_{0+} = number of unchanged pixels in the ground truth
X_{1+} = number of change pixels in the ground truth
X_{all} = $X_{0+} + X_{1+} = X_{+0} + X_{+1}$

viii. Analysis Result
Then proceed by combining the two compatible images together to highlight the different in change detection.

IV. RESULT AND DISCUSSION

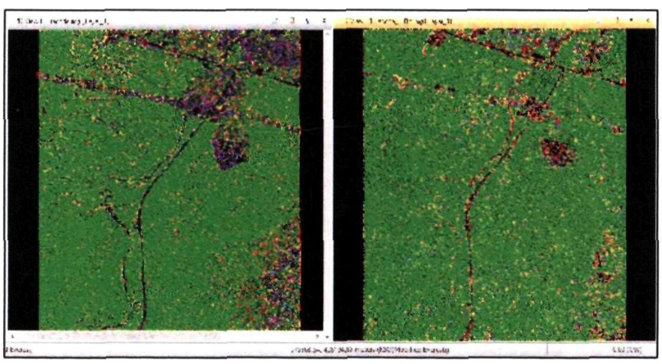
This section will discuss about the type of landslide, the factor of landslide and also the value gained from change detection in area, accuracy assessment and kappa statistic. The result and discussion are based on two locations or area of interest.

A. Recode

The remote sensing images collected from ARSM which are the before and after landslide images are processed part by part. The processed in Erdas imagine 2014, including georeferencing, subset, haze reduction, unsupervised classification and recode. Then, the before and after landslide images are combined to highlight the difference. Seven classes has been chosen at AOI 1 in the unsupervised classification which are agriculture, forestry, ramp, road, urban, green space and free space. Background of the area is agriculture and surrounded by oil palm, recorded as green color. Application of google earth is needed in this study to compare and justify the classes in unsupervised classification. The unsupervised image then been recoded to make analyses easier in change detection. The recode image as shows in Fig.4. Table 2 shows the classes color indicates in the image Fig. 4.

Table 2. The classes color for recode image in Fig. 4.

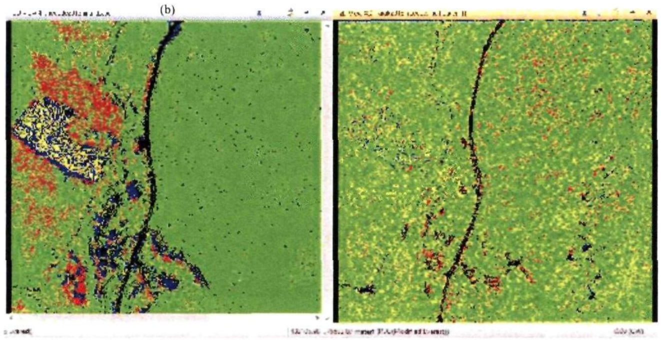
Classes	Colour
Ramp	Yellow
Agriculture	Light green
Open space	Brown
Forestry	Dark green
Green field	Purple
Road	Black
Urban	Red



(a) (b)

Fig.4. Recode Image Km 16 of Panching – Sg. Lembing: (a) Before landslide, 2012, (b) After landslide, 2015.

In AOI 2, six classes have been chosen in the unsupervised classification which are agriculture, forestry, ramp, road, urban, and free space as in Table 3. Compare to the AOI 1 and AOI 2, some differences can be identified. In AOI 2 there is no green field in the study. Background of the area is forestry and just beside the highway is recorded as green color. The application google earth is also used to validate or compare the classes in unsupervised classification images. The recode images for AOI 2 are as shown in Fig. 6 and there are many changes can be displayed. Table 3 indicates color in image Fig. 5 in which classes and color between Table 2 and Table 3 are some different.



(a) (b)

Fig.5. Recode Image KM 52.4 Lebuhraya Kuala Lumpur – Kuantan: (a) Before landslide, 2012, (b) After landslide, 2016

Table 3. The classes color for recode image in Fig. 5.

Colour	Classes
Ramp	Blue
Agriculture	Yellow
Open space	Brown
Forestry	Light green
Road	Black
Urban	Red

B. Accuracy Assessment and Kappa Statistics

In the accuracy assessment, 40 point were selected as references for images Fig. 4 and from the overall classification accuracy, the percentage is above than 50%. The quality of the overall kappa statistics for both images are good and very good quality as shown in Table 4.

Table 4. Accuracy assessment and kappa statistics for Km 16 of Panching – Sg. Lembing.

Year	Overall Classification Accuracy	Overall Kappa Statistics	Kappa Quality
2012	82.50%	0.5692	Good
2015	87.50%	0.6234	Very good

Table 5 shows the overall classification accuracy and overall kappa statistics in Fig. 5. 20 point were selected as references and the resulted is above than 50% for the overall classification accuracy. However the quality of the overall kappa statistics for both images are different which are excellent and poor quality in the year 2012 and 2016 respectively. Table 6 shows the reference for Kappa statistic and Kappa quality [8].

Table 5. Accuracy assessment and kappa statistics for KM 52.4 of Lebuhraya Kuala Lumpur – Kuantan

Year	Overall Classification Accuracy	Overall Kappa Statistics	Kappa Quality
2012	95.00%	0.8639	Excellent
2016	88.00%	0.0000	Poor

Table 6: The relationship between the Kappa Quality and Kappa Coefficient.

Kappa coefficient	Kappa Quality
<0	Worst
0 – 0.2	Poor
0.2 – 0.4	Reasonable
0.4 – 0.6	Good
0.6 – 0.8	Very good
0.8 – 1.0	Excellent

C. Change Detection and Factor of Landslide

The change detection from the satellite image gives the information of factor of landslide disaster in more detail. The analysis is based on the increment and decrement of the area before and after the landslide. Table 7 presents the changes in scope of area in unit hectare (ha). The ramp, agriculture, forestry and urban (population) shows the increment within 3 years. While open space, green field and road shows the decrement.

Table 7: The increasing and decreasing of area Km 16 of Panching – Sg. Lembing

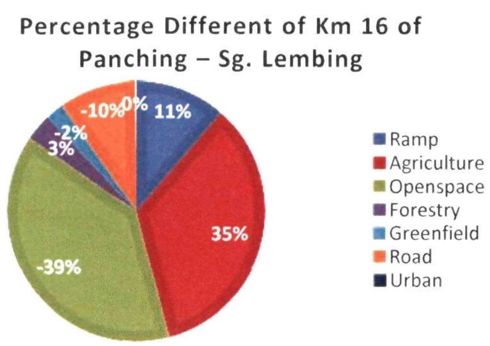
Classes	Change Detection in Area (ha)		
	2012	2015	Increase (-decrease)
Ramp	16.8853	26.887	10.0017
Agriculture	225.926	256.272	30.346
Open space	58.8785	24.9385	-33.94
Forestry	29.0723	32.0099	2.9376
Greenfield	24.0127	21.9989	-2.0138
Road	19.8062	11.3868	-8.4194
Urban	1.01668	1.251	0.23432

Table 7 and Fig. 6 shows the increase of area in 30.346 ha or 35% major changes covered by agriculture (oil palm). In the year 2012, the oil palm was replanted and growth after 3 years. In line with the growth, it causes a decrease in green field which is 2.0138 ha or 2%, which act as catchment area. The lack of catchment area will causes rainfall flow in high density on land surface. According to the report of Malaysian Meteorological Department in Northeast Monsoon Report Kuala Lumpur Monsoon Activity Centre November 2014 states that in December 2014, the East Coast state, Perlis, Kedah, Penang, Perak Utara, South of Selangor and Negeri Sembilan State coastal area have been reported to receive rainfall exceeds 60% of the average level [2].

Some factor of landslide discovered is the deforestation without control for replanting the agriculture. The long time taken to replant the agriculture leaves the land in open space area and exposed to the agents of erosion. Therefore, the structure of the soil becomes loose and unstable because there is no protection such as turfing crops. Eventually, the landslide can occur.

From table 7, the forestry area increased by 2.94 ha or 3% because the trees are growing and the roots need more water to keep them grow. Nevertheless during October 2014, Southeast Asian countries experienced drier weather condition and this statement can be proved by looking at the boost of open space and ramp at every side along the road in Fig. 4b. Soil dryness inhibits the growth of grass at the roadside. The increase of the ramp in the middle of oil palm shows that there are activities going around it. Small increment in population with 0.23432 ha which is stated as urban in the Table 7 is also a factor of land use in the area. The growth of the oil palm is perpendicular to the population but there is 0% in the pie chart because the difference is too small. Oil palm is an economic area, hence this area becomes a point to generate sources of income. The road area decrease in many ways and landslide is one of the factor. The road slide down as well as soil under the road slump down.

Fig. 6: Percentage Different of Km 16 of Panching – Sg. Lembing

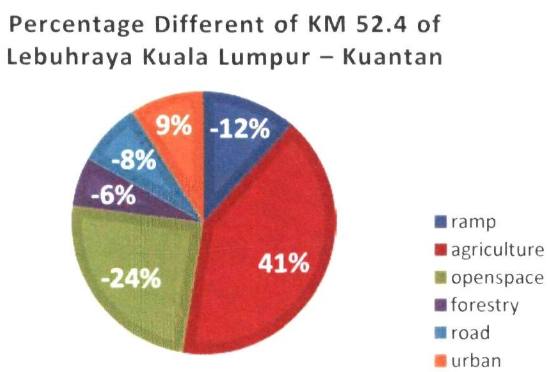


Based on the Table 8, the classes is referred to the AOI 2 which are KM 52.4 Lebuhraya Kuala Lumpur – Kuantan while Fig. 7 show the percentage different. The study area is major with forestry and just beside the highway. The area of ramp state the decrement in 9.6035 ha or -12% but referring to the recode image in Fig 5, the new ramp is developing in the middle of the forestry. From the recode image, there is an information that some activities are going on in the middle of the forestry and it is supposed to be monitored from time to time or need to be managed, therefore any disaster on the hill can be avoided. The development of new ramp in the middle of forestry could be the factor of the decrement of forestry as much as 4.983 ha or 6%.

Table 8. The increasing and decreasing of area KM 52.4 of Lebuhraya Kuala Lumpur – Kuantan

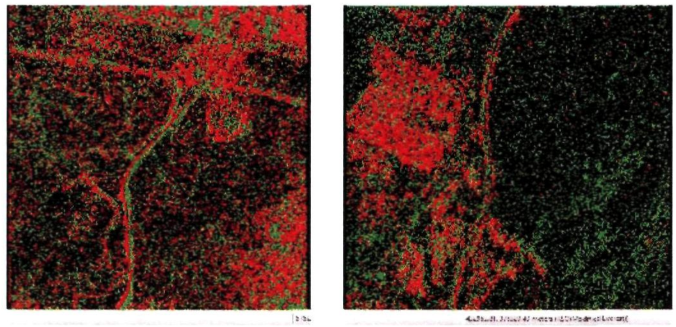
Classes	Change Detection in Area (ha)		
	2012	2016	Increase (decrease)
Ramp	13.0406	3.4371	-9.6035
Agriculture	6.1225	39.7586	33.6361
Open space	29.91	9.74183	-20.16817
Forestry	240.976	235.993	-4.983
Road	13.1131	6.62895	-6.48415
Urban	3.845	11.2979	7.4529

Fig. 7: Percentage Different of KM 52.4 Lebuhraya Kuala Lumpur – Kuantan



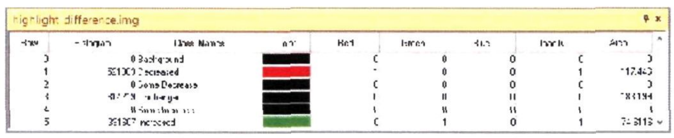
The increase of population or urban in table 8, which are thrice of the value within 4 years shows the area become the point to generate economy. The development in the area which increase in 7.4529 ha or 9% should be managed or stopped immediately because if another landslide occur, many lives could be harmed in future. According to the rises of population, the area of agriculture also increases by as 33.6361 ha or 41%. The agriculture has become the main source of economy for the population. The area of open space and road are decreased by 20.16817 ha or 24% and -6.48415 ha or 8% respectively.

Fig. 8 shows the overall of different in changed detection. Only three colors indicate which red, green and black. Based in Fig. 9, red shows the decrease area, green is the increase area and black shows some increase or unchanged area.

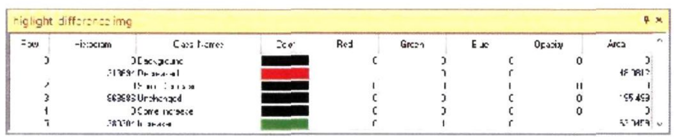


(a) (b)

Fig. 8: Change detection :(a) Km 16 of Panching – Sungai Lembing , (b) KM 52.4of Lebuhraya Kuala Lumpur – Kuantan



(a)



(b)

Fig. 9: Indication of images in Fig. 8 (a-b)

V. CONCLUSION

Based on the processing of the image, the application of Erdas Imagine 2014 software was a very practical way to analyze the change detection and monitor the landslide. It could display a high quality image to create a map and to visualize it. The analysis in the aspects of area was more suitable in the change detection by using the change/unchanged error matrix. The overall classification accuracy for all images were above 50%. The value is 82.50% and 87.50% for the year 2012 and 2015 respectively for Km 16 of Panching – Sungai Lembing while for KM 52.4 of Lebuhraya Kuala Lumpur – Kuantan, the value was 95.00% and 88.00% in the year 2012 and 2016 respectively. However, there was a huge difference between the kappa quality for SPOT 5 and SPOT 6 sensors at KM 52.4 of Lebuhraya Kuala Lumpur – Kuantan. The value obtained in 2016 using SPOT 6 was 0.00 or known as poor quality where as in 2012 it gave the value of 0.8639 known as excellent quality using SPOT 5 sensor. Meanwhile, the Kappa quality for Km 16 of Panching – Sungai Lembing showed a good quality and very good quality for both sensor which SPOT 5 and SPOT 6 sensor where the value obtained were 0.5692 and 0.6234 respectively.

For future research, the DEMs data can be used for more accurate and comprehensive change result especially to analyze the possibility of next landslide regarding the terrain. Further analysis in the texture and soil moisture also may be can implemented. The various causes of deforestation can be included to build a prototype model to stimulate the actual situation which can lead to the landslide.

VI. REFERENCES

[1] Zulkiflee Abd Latif, Siti Nur Afiqah Aman & Biswajeet Pradhan, "Landslide susceptibility assessment using high resolution Lidar-derived parameters and probabilistic frequency ratio model", *Malaysia Journal of Remote Sensing & GIS*, vol. 4, no. 2, pp 72-84, 23-24 March 2015.

[2] Malaysian Meteorological Department, Ministry Of Science, Technology and Innovation, http://www.met.gov.my/documents/10661/48319/LaporanMonsunBaratDayaMei2014?version=1.2

[3] Shefali Aggarwal, "Principles Of Remote Sensing", Satellite Remote Sensing and GIS Applications in Agricultural Meteorology pp. 23-38, http://www.wamis.org/agm/pubs/agm8/Paper-2.pdf.

[4] Norsuzila Ya'acob, Aziean Binti Mohd Azize, Nur Anis Mahmon, Azita Laily Yusof, Nor Farhana Azmi and Norfazira Mustafa, "Temporal Forest Change Detection and Forest Health Assessment using Remote Sensing", International Conferences on Geological, Geographical, Aerospace and Earth Sciences, IOP Conf. Series: Earth and Environmental Science 19, 2013.

[5] Abd Latif, Z., Zamri, I and Omar, H., (2012b). "Determination of tree species using Worldview-2 data", *8th IEEE Int. Coll Signal Proc Appl.*, Melaka, Malaysia, CSPA 2012.

[6] Rohan Kumar; R. Anbalagan, "Remote sensing and GIS based artificial neural network system for landslide susceptibility mapping", IEEE International Geoscience and Remote Sensing Symposium (IGARSS), IEEE Conference Publication, 2015.

[7] F. N. Essono; L. Coulibaly; H. G. Adegbidi; R. Fournier, "Development Of A Cartographic Index Of Forest Stand Vitality Using An Ikonos Satellite Image ", Geoscience and Remote Sensing Symposium (IGARSS), IEEE International, 2010.

[8] Qiongcheng Xu, Yunchen Pu, Wei Wang, Huamin Zhong, "Multispectral Remote Sensing Image Change Detection Based on Markovian Fusion", Agro-Geoinformatics (Agro-Geoinformatics), 2012 First International Conference on, , Shanghai, 2-4 Aug. 2012.

[9] Xiaoying He, "Change Detection for Map Updating with Classification Posterior Probability of HJ Image and TM Image" Image and Data Fusion (ISIDF), 2011 International Symposium on, Tengchong, Yunnan,.9-11 Aug. 2011.

[10] Jiming Kong, Fayou A, Shujun Tian, Cui Yun & Wenping Wu, "Wenchuan Seismic Landslide Types and Typical Cases Analysis", Environmental Science and Information Application Technology (ESIAT), *2010 International Conference* on (Volume:2), Wuhan,17-18 July 2010.

[11] Lea Tien Tay, Mutasem Sh. Alkhasawneh ; Umi Kalthum Ngah, Habibah Lateh, "Landslide hazard mapping of Penang Island using dominant factors", 2014 IEEE 2nd International Symposium on Telecommunication Technologies (ISTT), Langkawi, Malaysia, 24-26 Nov 2014.

[12] B. Guindon & Y. Zhang, "Robust Haze Reduction: An Integral Processing Component In Satellite – Based Land Cover Mapping", Symposium on Geospatial Theory, Processing And Application, Ottawa, 2002.

[13] M/s Bishen Singh Mahendra Pal Singh, M.V.K. Sivakumar P.S. Roy K. Harmsen S.K. Saha, "Satellite Remote Sensing and GIS Applications in Agricultural Meteorology", World Meteorological Organisation, AGM-8 WMO/TD No. 1182, Switzerland, 2004.

[14] B.Sreenivas & B.Narasimha Chary, "Processing Of Satellite Image Using Digital Image Processing", Geospatial World Forum, Theme Dimensions and Direction of Geospatial Industry, India, 18-21 January 2011,

[15] G. A Olson, A. Cheriyadat, P. Mali & C.G. O'Hara, "Detecting and Managing Change in Spatial Data-Land Use and Infrastructure Change Analysis and Detection", Geoscience and Remote Sensing Symposium, 2004. IGARSS '04. Proceedings. IEEE International (Volume:2), 20-24 Sept. 2004.

[16] B. Faiza, S. S.Yuhaniz, S. Z. Mohd Hashim, A. K. Kalema, "Detecting Floods Using an Object Based Change Detection Approach International Conference on Computer and Communication Engineering (ICCCE 2012), Kuala Lumpur, Malaysia, 3-5 July 2012.

[17] P. A J. van Oort, "Interpreting the change detection error matix", Remote Sensing Environment, 108: 1-8, 2007.

[18] Qiongcheng Xu, Wei Wang; Yunchen Pu ; Huamin Zhong, "Unsupervised Change Detection Based on Iterative Histogram Matching and Bayesian Decision of Thresholding", Computational Sciences and Optimization (CSO), 2012 Fifth International Joint Conference, IEEE, 23-26 June 2012.