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Land use classification and land use change analysis using satellite images in Lojing, Kelantan

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Abstract

Remote sensing is widely used to capture the images of land use/land cover on earth. This paper studies on the land use changes in Lojing, Kelantan in 1989 dan 2006. The land use is then classified, and the classification scheme was adopted from United States Geological Survey (USGS) Land Use/ Land Cover Classification System. Supervised classification method has been used since it was proved by other research to be more accurate compared to unsupervised classification. Accuracy assessment was conducted to calculate the accuracy of the land use map produced so that at the end, a good quality of land use map is produced. The findings of this study is that, there had been an insignificant land use changes between the year 1989 and 2006. The conclusion is, Lojing had been experiencing changes in term of land use due to the increased socioeconomic activities especially agriculture and logging at the highlands of Lojing.

1. INTRODUCTION

For the past centuries until present, humans have been using the earth's land surface for various purposes. Land use is the human use of land and land cover refers to physical and biological cover on the surface of land (Islam et al., 2018). Land use and land cover changes may involve the modification, either direct or indirect, of natural habitats and their impacts on the ecology of the area (Hepcan, 2013; Václavík & Rogan, 2009). For example, conversion of grassland, woodland and forest into cropland and pasture has risen dramatically (Araya & Cabral, 2010; Nor et al., 2017) and this acceleration has spurred renewed concerns about the role of land use change in causing losses in biological diversity, soils and their fertility, air quality and water quality (Nor et al., 2017; Nor et al., 2018; Sodhi et al., 2010).

Land use and land cover change have been recognized as an important driver of environmental change on all spatial and temporal scales. In Peninsular Malaysia, deforestation, land degradation, water pollution and soil erosions are currently at an increasing rate. The unsustainable land use patterns and changes over the time were much related to those issues. Land exploration activities in the highlands areas without mitigation can give more impact on the environment health. Highland regions act as water catchment and serve as the main hydropower generation sources for lowland, provides water resources for agricultural, industrial, and domestic use downstream (Roozitalab et al., 2013). According to Malaysia Islands and Highlands Development Guideline, any forest lands situated 1000 m above the sea level are classified as reserved forest or catchment forest land. Thus, any land clearing is prohibited in this area as it is an environmentally sensitive area (Weng & Mokhtar, 2011).

Lojing Highlands in the State of Kelantan is considered to be one of the strategic locations which can be exploited for economic generation mainly in the fields of agriculture and eco-tourism (Omar & Hamzah, 2010). The land use for heterogeneity purpose in Lojing, Kelantan is getting rapid and most of the lands are developed unsustainably (Hamzah et al., 2010). The highlands, which was pristine as recently as the late 1990s, has lost half of its forest cover, endangering the lives of orang asli settlement and rare species such as Rafflesia flowers. The construction of human settlements and infrastructures, opening of agricultural lands, and the unlimited exploitation of the forests and rivers have been the contributing factors for the transformation process causing serious siltation problems in nearby rivers and threatening the biodiversity conservation in that area (Omar & Hamzah, 2010).

Therefore, the knowledge about land use has become increasingly important. The increasing land use has led to an increasing need for legislatures, government

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agencies and planners to have more up-to-date and accurate data on land use for a sustainable planning and management. Categorizing the heterogeneity of land use is essential for sustainable management of the land because through the categorization, it is possible to detect and avoid the overuse and damage of the landscape beyond sustainable development limits by the use of land use maps (Abkar et al., 2010). Without dense information on land use changes, it is almost impossible to implement a successful sustainability in land planning and management. Understanding landscape patterns, changes and interactions between human activities and natural phenomenon are essential for proper land management and decision improvement (Prakasam, 2010). Remote sensing is a useful technique to develop land use classification mapping and detailed way to improve the selection of areas designed to agricultural, urban and industrial areas of the region (Shooshtari & Gholamalifard, 2015).

The aim of this study is to provide the empirical information for sustainable planning and management particularly in highland area. The specific objectives of this study are 1) to classify the land use in Lojing by remotely sensed data and 2) to analyze the change detection on land use in Lojing in the two different years (1989 and 2006) (17 years interval).

2. DATA AND METHODS

2.1. Study Area

Lojing, which is located at the footstep of Cameron Highlands, Pahang is one of the new small districts in the state of Kelantan, Malaysia (Fig. 1). It is located between latitude 4˚ 32' to 4˚ 47' and longitude 101˚ 20' to 101˚ 34' E at the south-west of Kelantan and it is about ¼ of the total area of its original district, Gua Musang. Having an area of 181,700 ha (1,817 km2), its height from above sea level is 610 meter to 1,500 meters with an average cool temperature of 18˚C to 25˚C. Lojing is also part of the Titiwangsa range and is easily accessible from the North-South Expressway. Lojing is very least known in the past and it came to know only during the early of 1980's when logging activities had become a daily issue subject among the peoples (Omar & Hamzah, 2010). The name 'Lojing' is believed to be derived from the word 'logging' itself. Lojing area involves three districts which are Betis, Hau and Sigar where the population is 6,686 settlers from the total 69 villages which are located in the 6 main settlements areas (Pos Brooke, Pos Hendrop, Pos Tuel, RPS Balar, RPS Kuala Betis and Pos Blau). The population distribution is indigenous peoples (Temiar tribe), Malays and Chinese, the least in number. Lojing, as stated by Omar and Hamzah (2010) has a very rich species of flora and fauna which can be considered similar to those found in Central and South America. The numerous research works done have discovered many unique species of flora and fauna in the Lojing. The existence of a dense population of Rafflesia kerrii in certain site is extremely rare to be found anywhere else in the world (Maryati & Dalimin, 2010). It has become the icon for nature tourism in Lojing. One of the unique fauna found in Lojing Highlands is the Camponotus gigas, the giant ant which is also the biggest in the world. It inhabits the rotten logs and built nests underground has been documented by Chung and Maryati (1993). Lojing had been actively logged since 1990 and now is rapidly developed for agricultural activities (Hamzah et al., 2010). The conversion of tropical forests in Lojing into a commercial and non-commercial agriculture lands have increased the land use statistic. Statement from Utusan Kelantan on June 17th, uncontrolled land use for agriculture purpose had caused Lojing to become bare and tend to expose to landslides. The large scale of land use too had caused the rivers in Lojing areas to be polluted badly, for example the rivers of Brooke, Belatop and Jelai.

Figure 1: Location of the study area (Lojing in the state of Kelantan, Malaysia)

2.2 Data

2.2.1. Primary and Secondary Data

Data acquisition involved the primary data and secondary data. For the primary data, remotely sensed image of Lojing of the year 1989 (Landsat-5 TM) and 2006 (SPOT-5 J) were acquired from the Agency of Remote Sensing Malaysia (ARSM). The secondary data were acquired to support the satellite imagery and these include topographical map and land cover map (1:10000). Secondary data were used primarily as references to supervised classification process and during ground verification work.

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2.2.2. Global Positioning System (GPS)

GPS provides the mapping community with powerful tools for acquiring accurate and current digital data. The utilization of GPS is for the acquisition of ground location data. A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. The Garmin GPS was used to get the location of selected point sample during ground verification to verify classified image with the ground data.

2.2.3. Digital Camera

A digital camera was used to take photograph of land use/ land cover classes such as forest, built up, agriculture, water body, and barren / cleared land. Sony Steady Shot camera with 10.1 megapixels was used during ground verification where images for each class were taken for reference data in accuracy assessment.

2.3. Methods

Data collection and processing, image processing, data analysis, data interpretation and ground truth research activity were the main components involved in this study. The methodological framework below summarized the processes that were involved in this study (Fig.2).

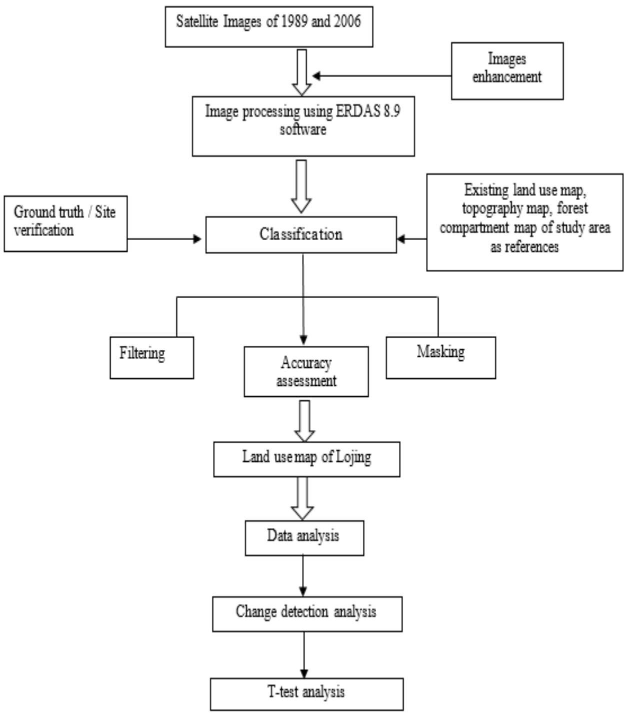

Figure 2: Methodological framework

2.3.1. Image pre-processing

Geometric rectification is critical for producing spatially corrected maps of land use changes through time (Udin & Zahuri, 2017). Geometric correction was done by satellite images belonging to 2006, with the control points obtained by GPS and also from Google Earth. The nearest neighbor resampling method was used to avoid altering the original pixel values of the image data. Geometric correction of the other two images was done by image to image rectification strategy with reference to 2006 image.

2.3.2. Design of categorization scheme

In Lojing, the land uses are increasing for various purposes. There were a numbers of categorization schemes that can readily incorporate land use data obtained by the interpretation of remotely sensed data have been developed for examples U.S Geological Survey Land Use/Land Cover Classification System and Asian Land Cover Classification System (Jensen, 1996). In the US Geological Survey (USGS) Land Use/ Land Cover Classification System, there are six classes of land use/land cover which is urban, agriculture, dense forest, open forest, barren land and water (Table 1). For Lojing, the land uses are dominantly for the built-up area and agricultural land while there is a vast land cover of dense forest and rangeland. In the next table, there is a brief explanation of the land use and land cover classes according to the USGS Level I classification scheme. In this study, USGS land use classification system was referred for the categorization of land use in Lojing. For this study, the land use class for the study area was divided into five theme class as showed in Table 2.

Table 1: Land use/ land cover classes according to the USGS classification system Level I

No.	Classes	Explanation
1.	Urban	Areas covered with asphalt, concrete, typically commercial and industrial buildings with open roofs as well as open transportation facilities, airports, parking lots and multilane interstate/state highways, single/multiple family houses and public rental housing estate.
2.	Agriculture	Characterized by high percentages of grasses, other herbaceous vegetation and crops; including lands that are regularly mowed for hay and/or grazed by livestock, city parks and regularly tilled and planted cropland.
3.	Dense forest	Areas covered by dense forest with relatively darker green colours.
4.	Open forest	Areas relatively sparsely covered by forest vegetation.
5.	Barren land	Cultivated land without crops and barren rock or sand along river/stream beaches.
6.	Water	All areas of open water, generally with greater than 95% cover of water, including streams, rivers, lakes and reservoirs.

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Classification means producing a meaningful material distribution maps through identification of individual pixels or groups of pixels with similar spectral responses to incoming radiation. Those pixels or groups are representing different classes. Computer driven algorithms are used to analyze mathematically the actual values associated with each pixel. These algorithms attempt to cluster similar pixels and groups of pixels into classes.

Image classification is a valuable tool used for a variety of resource-based applications (Li, 2014), for example the forestry companies utilize image classification to assist in the inventory assessment of their allotted forest stands. Another example, the data of image classification can be used to monitor or assess changes in various ecosystems through time due to anthropogenic interferences, natural disasters or global climate changes.

Within the scope of study, the definition of image classification is an extraction of distinct classes or themes from the satellite imagery. An image analyst normally used the two primary methods of image classification which are supervised and unsupervised classification.

Supervised image classification is a method where the small areas, also called training sites on the image which are representative of each land use category are defines. It requires up-front knowledge of the scene area in order to provide the computer with the training classes. The delineation of training sites of a cover or use type is effective and nearly accurate when the knowledge of the real geography of a region and experience with the spectral properties of the cover classes is possessed (Rozenstein & Karnieli, 2011).

The image processing software system is then used to develop a statistical characterization of the reflectance for each information class. This step is called “signature analysis” in the software and it involves developing a characterization of reflectance on each bands. After the statistical characterization are done for every class, the image is then classified by examining the reflectance for each pixel and making a decision about which of the signatures resembles most (Eastman, 2006).

Maximum Likelihood Classification (MLC) and Paralellepiped Classification (PC) are the two algorithms used in supervised classification. The most powerful classifier in common use is that of MLC. Based on statistics (mean; variance/covariance), a (Bayesian) Probability Function is calculated from the inputs for classes established from training sites. Each pixel is then judged as to the class to which it most probably belongs.

A parallelepiped is a geometrical shape whose opposite sides are straight and parallel. This method is quick to run, but not very accurate compared to MLC as the parallelepiped are formed based on their max and min pixel values that may not be representatives of a class. By the end, the resulting classification maps should be checked using ground truth information and field verification surveys. Generally, supervised classifications are more accurate than unsupervised.

2.3.3. Training Data Collection

The training and testing data for the supervised classification and accuracy assessment were collected by using false color composite, an NDVI image, an unsupervised classified image, and fieldwork. The data samples were then split into two subsets, the training data and the test data.

False color composites can help to visualize land use without any enhancement processes (Fonji & Taff, 2014). The false-color images were generated with red=4, green=3, blue=2 bands for Landsat TM, and red=4, green=2, blue=1 for SPOT images.

The vegetation index indicates the amount of green vegetation present, which is useful and important for land use identification because much of the Earth’s land covers are vegetation. NDVI was calculated by the equation: $NDVI = (NIR - RED) / (NIR + RED)$ where NIR refers to the near infrared band response and RED is the red response.

Field investigation was also conducted to collect training data. The field observations provided essential independent reference data for identifying land use types within the Landsat scenes as well as for accuracy assessment.

2.3.4. Image Categorization

The comparative analysis of spectral classifications for the three images produced independently is the obvious method of change detection. The change map of three images will only be generally as accurate as the product of the accuracies of each individual classification. Accuracy of relevant class changes depends on spectral separability of classes involved. For this study, Landsat and SPOT data of the three different years were independently categorized using the supervised classification method of maximum likelihood algorithm. Spectral signature files for all classes were subsequently created and used by maximum likelihood classifier to categorize the continuum of spectral data in the entire image.

2.3.5. Image filtration and masking

The classified images were then further smoothed with a majority filter with a 7x7 kernel to reduce the number of misclassified pixels. It was also to enhance the quality of the maps. Independently classified images were then being compared with each other to determine the changes in the land use.

2.3.6. Land use change analysis

The area of the classes were calculated using the classification of land use. After converting the map into vector, the maps were then being compared. To calculate

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the composition of the land use, the formula shown below has been used.

Percentage % land use,
i= (Wide of land Use)/(Overall land use area)×100

The most commonly used quantitative method of change detection, which is the post-classification comparison change is selected to perform land use change detection in this study. This method requires rectification and classification of each remotely sensed image. Resulting maps are then compared on a pixel-by-pixel basis using a change detection matrix after the classification of image separately.

2.3.7. Accuracy assessment

Accuracy assessment is very important in order to know whether the data is exact with the ground truth. In determining the accuracy of classification, the number of reference pixels is important. According to Campbell et al., (2015), it has been shown that more than 250 reference pixels are needed to estimate the mean accuracy of a class to within plus or minus five percent. A stratified random sampling approach was used to assess the accuracy of each of the three land use classifications. In stratified random sampling, the pixels were selected randomly to form the sample. This method was used to select the reference pixels for ground checking.

3. RESULTS AND DISCUSSION

3.1. Image pre-processing

The three satellite images of the year 1989 and 2006 were pre-processed through the geometric correction (Fig. 3). Geometric correction was done to gain an image which is free from distortion and as close as possible to the real Earth surface in order for it to fit into the scale and projection. For a precise analysis, the root mean square (RMS) was ensured to be below 2.00. If the value is more than 2.00, it will affect the precision of the result. As for the ground control points, Google Earth was made reference and 10 points were selected for each image.

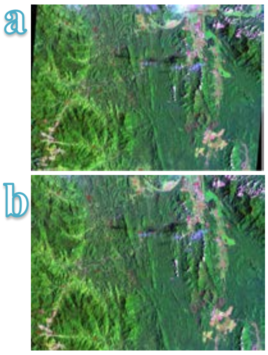

Figure 3: Images of Lojing 2006 a) before and b) after geometric correction

3.1.1. Image subset and mosaic

Imagine subset was done due to the satellite imagery was given in a wide range of area whereas the area of the research was only a small part of it. Thus, only the region of interest was cropped out for the subset process. As for the mosaicking process, it was done to the images of year 2006 (two images) in order to get the area of interest since the data acquired from MACRES for the year 2006 did not meet the area of interest.

3.1.2. Supervised Classification

Area of interest (AOI) was selected accordingly to the ability to recognize the type of land use visually on the satellite images which have a low resolution. There were five classified areas as mentioned in the methodology earlier; they were agriculture area, built up area, water body area, forest area and barren land area. For a better output image, maximum likelihood method was chosen for a supervised classification (Zubair & Ji, 2015) in this research. The output images were interpreted easier when digitizing land use maps in ArcGIS (Daliman et al., 2017).

3.1.3. Land use change analysis

In year 1989, the total area of Lojing is tabulated in Table 3 which is 131 797.2 ha and the land use area for each class are shown in Figure 4. The land use was less during this year but it has a wide land cover of forest area which appears to be 99.09% of total Lojing area. Built up land was only 0.07% while agriculture took up 0.61% of the land use. Water body and barren land was 0.16% and 0.06% respectively. In year 2006, the total area of each land use categories are represented and tabulated in Figure 5 and Table 4 respectively. The land use of Lojing in the year 2006 was mainly comprised of forest area with 97.43%, followed by 1.52% of agriculture area, 0.47% built-up land, 0.41% of barren land and 0.16% water body. The difference in percentage of each class shows that there are slight changes on the land use of Lojing within 17 years (1989 to 2006).

Table 3: Area and percentage of land use in Lojing 1989

Land use class	Area in hectares (ha)	Percentage area (%)
Water body	208.78	0.16%
Built-up land	79.99	0.06%
Agriculture	809.14	0.61%
Forest	130 607.19	99.09%
Barren land	79.99	0.06%
Total	131 797.21	

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Table 4: Area and percentage of land use in Lojing 2006

Land use class	Area in hectares (ha)	Percentage area (%)
Water Body	207.77	0.16%
Built-up land	599.00	0.47%
Agriculture	1925.94	1.52%
Forest	123617.19	97.42%
Barren land	529.68	0.42%
Total	126879.58	

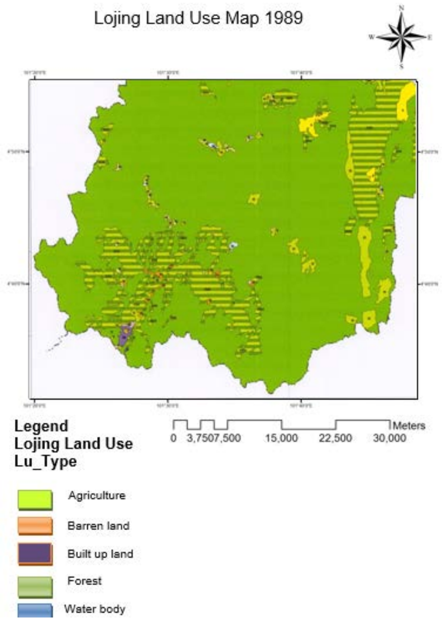

Figure 4: Land use map of Lojing 1989

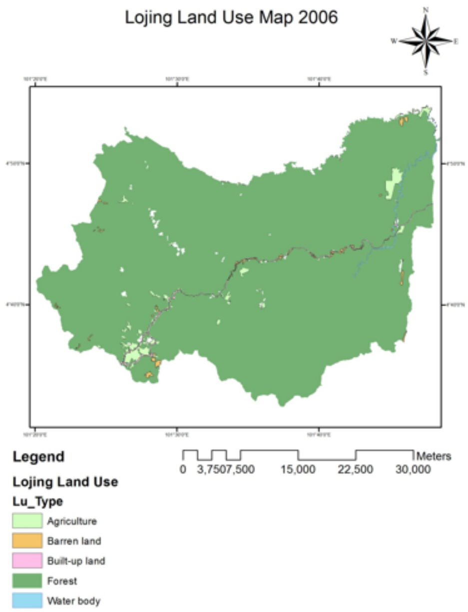

Figure 5: Land use map of Lojing 2006

3.1.4 Land use change statistical analysis

For this part, the land use analysis was done statistically using t-test to test for any significant difference. As for the land use changes or conversion, it was compared according to the changes in area of each class. Referring to Figure 6, the changes or conversion of land use can be easily compared. Percentage values of land use for the both year differs little, leaving no significant changes.

According to past record, Lojing was started to be known through the logging activities which started early 1980's. The forest area covers 99.09% of Lojing in the year 1989 and 17 years later which is in 2006, the forest was left 97.42%. However, looking at the percentage difference (1.67%) of forest cover, the logging activity does not consume much of the total forest area of Lojing.

Built up area was relatively small (0.06%) in the year of 1989 since Lojing was not yet much developed. The land was mostly built up for houses of the indigenous peoples which was a minority population. However, in the year 2006, the built up land increased by 0.91% making it to be 0.47% (Fig. 6). The most probably factor of this is because of the increasing agricultural activities which led to more infrastructures and utilities to exist in Lojing.

The water bodies area was less and it was mainly comprises of the rivers in Lojing. Over the years, the water bodies do not experience any significant changes in amount (maintain by 0.16%) but not the quality. It was feared that more rivers especially, will get more polluted if the logging and agricultural activities keep increasing over the time.

The entrance of multiple companies into Lojing such as Green Agritech Sdn. Bhd., Aspec Floritech Sdn. Bhd. and Mengkebang Resources Sdn. Bhd during early 1980's had introduced a variety of agricultural projects and this has slowly led to growth development of the area. In the year of 1989, agricultural land use was 0.06% and 17 years later (2006), it grew up to 0.47% (Fig. 6). It was believed that over the years, more and more companies had invested in Lojing for agricultural activities since Lojing has highlands which are suitable for many types of crops.

The barren land area was increasing too and this was due to anthropogenic activity which requires the land to be cleared up, for examples, mining activities, cleared land for agriculture and also logging activities. Barren land affects the biodiversity by causing habitat loss to the flora and fauna in that environment (Muqtada et al., 2014) .

Among the five classes of land use, forest has been experiencing a large change in usage percentage while the water body remains in amount. Parallel to the increasing land use of forest, the built up land, agriculture and barren land were increasing too over the time. However, the changes are not yet giving any significant values.

Although the land use change has not shown any significant values, the trend of land use was generally increasing. If this trend prolong for years and getting rapid, it could cause negative impacts to the environment. Logging activity for example, it affects the biodiversity where the habitat areas are destroyed. Other than that, it will also contribute to the decreasing of biomass sinks for atmospheric trace gases. With the increasing agricultural activities too, it could cause some environmental impacts too such as soil erosion and soil compaction during the conversion process of land for agricultural.

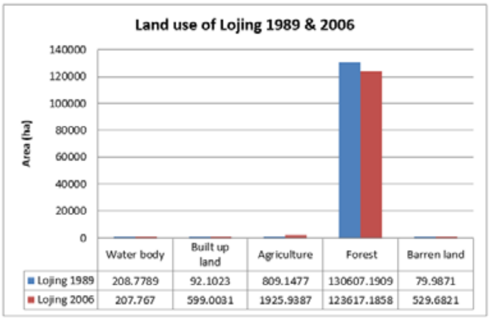

Figure 6: The total area of land use types for 1989 and 2006 in Lojing

3.1.5. T-test analysis

An analysis was done to check whether the mean value of land use in Lojing of the year 1989 and 2006 differs significantly from each other. From the t-test analysis table below, the t-test value gained was 0.98 and the p-value is 0.49 which is more than 0.05 and this means that the result is not significantly different. The observed difference between the sample means (26359.44-25375.91) is not convincing enough to say that the average area of land use of Lojing 1989 and 2006 differs significantly.

3.1.6. Accuracy Assessment

Accuracy assessment was conducted during post classification process to determine the level of precision of the maximum likelihood supervised classification using Confusion Matrix. The assessment identifies overall error.

Table 5: Overall accuracy and Kappa Statistics for the year 1989 and 2006

Satellite Image	Landsat-5 TM (1989)	SPOT-5 (2006)
Overall accuracy (%)	97.52	98.71%
Kappa statistics	0.9204	0.9632

4. CONCLUSION

This study has sought to: for the first objective, the land use in Lojing has been classified into five classes for each of the years which is 1989 and 2006. However, the percentage of change between these three years is not significantly changing. The land use change pattern in Lojing from 1989 to 2006 is still small and the forest composition is still large although result from this study shows a decreasing number from 1989 to 2006. Most of the cleared land in Lojing area is for agricultural purposes. Economical crops such as vegetables of low temperature and flowers and others planted cropland has been seen as growing more and more rapid since the year 2006. From this pattern, it can be said that the main activity here in Lojing is socioeconomic and it started to slowly become an agro-tourism similar to Cameron Highlands. As for the urban areas, there are not many changes that can be seen too since the majority of the population in Lojing area is the Orang Asal and their houses were relocated by the government to group them in a certain area so that they will not live scattered. However, there is an ongoing project on building buildings such as mosque and resort. There are a few limitations in this study such as variability of data from the various sources, time span and data error. To produce a land use map, it requires a much-focused attention on the data and the technical part. Some crucial process while processing the data had to be repeated due to the small error occurred and thus, it consumes times to redo it. Not much data was able to collect since the source is limited. The limitation is not due to the lack of data but due to the unwillingness of certain party to fully give support and help need in this study. Finally, the images gained from satellite were moderately low in resolution and it does affect the accuracy of the image classification. It is highly recommended to get a data or images with a high resolution from agencies and the current and latest data images in order to be able to produce a more accurate and detailed image classification. For a more variable data for the research area, a pre-research on the data available in the research area is needed to avoid from lacking data to support the accuracy of the end result.

Therefore, from this research on categorization and land use changes, relevant and empirical data and information were collected. This research provides the empirical data and information on land use change for the sustainable management and planning. By having a good plan for the land use, the further degradation of environmental quality in Lojing specifically, could be minimized. The data and information gained from this research will be useful for future planning and management of land not only in Lojing but also as a reference for other researches to be conducted on land use changes in Malaysia. The relationship between land use and sustainability is essentially to come with a quantitative measurement to show the implication of land use planning and management.

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