Temporal Changes of Mangrove Distribution In Mukim Kuala Selangor Using GIS Approach

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Abstract. Mangrove forests are commonly found along coastal line where they grow in saline soil and brackish water. With the advantage of new technology, mangrove distribution information can be studied by using Geographic Information System (GIS) technique. This study is to analyse the mangrove distribution changes using GIS over Mukim Kuala Selangor, Malaysia of years 2014, 2016 and 2018. Through this study, area selection technique from Landsat-8 OLI/TIRS data was used in image processing. Supervised and unsupervised classification were applied in image processing along with the maximum likelihood classification. The findings of this study show that there were changes occurred essentially on mangrove area at the study area. Therefore, it is hoped that this study can help stakeholders for the management of mangrove distribution as well as the other land cover which is vital to provide ecological balance and essential services for the community.

1. Introduction
Mangrove is a species of trees and shrubs that are salt tolerant and commonly found in tropical climate country along intertidal zones and coastal area [1]. Mangrove gives huge contribution to the environment especially towards the marine life and it also gives protection towards land from the flood, erosion due to harsh tidal currents and sea waves like tsunami [2]. Mangrove grow lavishly in the brackish water and saline soil together with water inundation. They are typically found along the coastal area where plants are able to adapt with saline water [3].
In order to face with increasing of human population that persistently changes the earth, many parties like researchers, planners and land managers are striving to monitor the continuous loss of living organisms and ecosystems [4]. Therefore in Mukim Kuala Selangor, GIS technique was used by the researcher to monitor and manage the mangrove ecosystem as well as the mangrove distribution changes. This study used high resolution satellite imagery to detect latest mangrove area changes from the year of 2014, 2016 and 2018.
Mangrove ecosystems have a remarkable significance in terms of ecological and economical. Hence, there is a vital need for conservation and restoration measures. Therefore, gaining up-to-date data with regard to the range and condition of mangrove ecosystems is fundamental to management and decision-making processes. In Malaysia, there is a need in monitoring mangrove using GIS since the data obtained from this technique in Malaysia is still limited [5]. This paper analyses and discuss the process of using satellite images and the details that can be extracted such as detection of land cover changes and vegetation density.
2. Methodology

2.1 Study area

The precinct of Kuala Selangor is one of the areas in Kuala Selangor District and is located 64 km from the city of Kuala Lumpur. It is located between 3° 10´N to 3° 34´N and between 101° 6´E to 101° 30´E (refer Figure 1). It covers an area of 21.6 km² [6]. Natural resources in Selangor are impending under pressure since the development and growth of Selangor has widen into its surrounding districts. However, Mukim Kuala Selangor still has several patches of mangroves. One of the famous mangrove conservation area in Mukim Kuala Selangor is Kuala Selangor Nature Park (KSNP).

According to [8], Kuala Selangor Nature Park (KSNP) is said to be the first site in Selangor to be designated as a Ramsar site (Convention on Wetlands) as the society analysed the criteria set by Ramsar and found that the park could qualify for the recognition. Hence, there is a need for hard data aimed at the area and its surrounding area in order to strengthen the argument of the analysis. Agriculture especially oil palm plantation is the other major land use in the study area. The river in Mukim Kuala Selangor is Selangor River that supplies water for domestic, agriculture and fishing industries. Most areas in Selangor River especially in its upstream reaches is still in natural state. It also serves for many recreational activities such as river tubing, whitewater rafting, kayaking and one of the famous activities is watching fireflies along the Selangor River. With the benefits it gives, mangrove forests in Kuala Selangor are highly valuable for wildlife conservation and ecotourism.

2.2 Sources of imagery

The Landsat-8 OLI/TIRS data (path/row 127/58) which was taken in March 2014, March 2016 and May 2018 respectively was acquired for this study. Satellite images has panchromatic and multi-spectral band sensor but to be specific, there are seven multi-spectral bands for Landsat [5]. Landsat data which has resolution of 30 m for multi-spectral bands contained in path 127, row 58 which have 7 multi-spectral bands (blue, green, red, infrared, two short-wave infrared and thermal) was
downloaded from United State Geological Survey (USGS) [5]. Landsat-8 OLI/TIRS was used due to the quality of satellite data which is medium to high spatial resolution. The satellite data was chosen because of the 3 images have <10% cloud coverage which is almost cloud-free over the study site. Table 1 shows the properties of satellite data used in the study in terms of the name of the satellite, spatial resolution and date of acquisition.

| Satellite                                      | Spatial Resolution | Date of Acquisition |
|------------------------------------------------|--------------------|---------------------|
| Landsat-8 Operational Land Imager (OLI) and   | 30m multispectral  | 24/03/2014          |
| Thermal Infrared Sensor (TIRS)                 | 15m panchromatic    |                     |
|                                                 |                    |                     |
| Landsat-8 Operational Land Imager (OLI) and   | 30m multispectral  | 29/03/2016          |
| Thermal Infrared Sensor (TIRS)                 | 15m panchromatic    |                     |
|                                                 |                    |                     |
| Landsat-8 Operational Land Imager (OLI) and   | 30m multispectral  | 06/05/2018          |
| Thermal Infrared Sensor (TIRS)                 | 15m panchromatic    |                     |

2.3 Image processing

Image processing was started from geometric correction and it is important for georeferenced setting of the satellite image to ensure that the coordinate of the places is at the correct position. The importance can be seen when the data is transferred to different software such as from ArcGIS to ERDAS.

When the geometric correction was done, doing a radiometric correction was the next step. This type of correction is vital as to enhance the satellite image visualisation and for the satellite image to become easier to interpret.

2.4 Area selection

The elements of the visual interpretation have been used in the process of selecting the training area. One of the example is mangrove area has been selected through its habitat located nearer to the water and shows same density pattern.

![Figure 2](image)

**Figure 2.** Selection for different types of area. (a) Mangrove selection. (b) Oil palm plantation selection. (c) Urban and associated areas selection. (d) Water selection.

Additionally, another criteria that was looked for the study is the texture of the mangrove. Mangrove texture is seen to be rougher than texture of the water and the soil. The tone which is also included in the combination of mangrove pattern is different from other elements whereby its tone colour is darker than other types of vegetation and makes it clear to analyse the differences as well as to identify the mangrove area. Apart from mangrove plantation, oil palm plantations were also detected and usually located far from the water bodies such as the river and the sea.
2.5 Image classification

Image classification is important to classify the features on the satellite image. In this study, supervised classification process were conducted where the classification interpret familiar element with the training area or location of the satellite image. Supervised classification requires the pixel to be grouped into classes whereby the interpreter need to do the selection for each of the training area. To do that, hundreds of polygons need to be drawn and the greater the number of polygon drawn, the higher the accuracy of the group classification. However, the pixel group can result to false information due to errors. For example, some of the oil palm plantation classes can be accidentally included in the mangrove area. Other example, the presence of cloud can make the cloud class becomes urban class or other types of class because the pixel value from the cloud has same pixel value with the building in urban area. The value also might be same with other vegetation and caused pixel group belongs to other classes that is not related [9]. Figure 3 shows how the polygon is being drawn in order to classify the image.

![Figure 3](image_url)

**Figure 3.** Drawing polygon to classify image.

In this study, maximum likelihood supervised algorithm has been use as type of classification. Maximum likelihood supervised algorithm is an algorithm that assigned the pixel to a classification that has probability own by some classes and through this process, the probability of the density function is determine by computing the probability of the pixel that belonging to each class [9]. In the meantime, the unclassified pixel during the classification will be assigned to the group based in relative likelihood of the pixel occurring within each class probability density function [9].

This paper has been described extensively on research methodology that are relevant to the study of temporal changes of mangrove forests in Kuala Selangor. Therefore, this research has clarified the area and method used in order to identify the changes on the mangrove distribution. These methods represent description of study area, sources of imagery, image processing, area subset and image classification. The interaction between elements in the aspect forms its basis and paves the way to produce land use or land cover map which shows mangrove distribution changes. Figure 4 shows the flow chart of the study which describe the methodology used during the process of this research.
Figure 4. Flow chart of the study

3. Result and Discussion
Mangroves are usually darker in colour on any combination of spectral bands of multispectral image due to the natural ecosystem of mangroves, which is covered by swamps and sometimes by tidal water. In addition, the chlorophyll content of the mangrove leaves is higher than those of trees and crops which make them appear darker on satellite images as shown in Figure 5.

Figure 5. Images showing combination of bands 5, 6 and 4 of Landsat-8 OLI/TIRS
In order to understand how a mangrove ecosystem changes, information is needed on what changes occurred, where and when they occurred as well as the rates at which they occurred. Despite ongoing research efforts on ecosystem change patterns, there is a need for research on gaining datasets providing quantitative, spatial land-cover information [10]. The method applied to estimate the mangrove ecosystem changes was by conducting image processing on satellite image maps to detect changes occurred on land cover and land use in 2014, 2016 and 2018. An assessment for accuracy was carried out and the result for the assessment is 80%. This assessment result meets the 80% accuracy standard of the National Park Service (NPS) in the United States that showed the percentage is a good accuracy value for land cover classification [3]. Figure 6 shows the final data that indicates the land use classification and distribution including 4 types of elements which is mangrove forest, oil palm plantation, water bodies, urban and associated areas. The colour used in the final data for each element was referred from the Classification and Land Use Colour Code According to Category 2013 which was published by The Department of Survey and Mapping Malaysia (JUPEM).

![Figure 6](image)

**Figure 6.** Landuse classification in Mukim Kuala Selangor for year 2014, 2016 and 2018

Based on the image analysis, the values of rate of change in land use were found to range from -2.3% to 5.2%. The most affected land use type was mangrove forest and oil palm plantation, which decreased from 5.1 km² in 2014 to 4.4 km² in 2018, and increased from 6.5 km² in 2014 to 8.0 km² in 2018, respectively. The decreasing of mangrove area is due to illegal land clearing mainly for oil palm plantation purpose and it is also a strong reason for the increasing of oil palm plantation area. The other land use types also experienced changes during the 5-year period. Water bodies has no significant changes but increased only from 2.2 km² to 2.3 km² for 2014 to 2016 and decreased from 2.3 km² back to 2.2 km² in 2018. Urban and associated area decreased from 7.7 to 7.5 and from 7.5 to 7.0. The changes is caused by the presence and absence of cloud and some error caused from the image classification process. Table 2 shows the statistical analysis of the land cover changes for the year of 2014, 2016 and 2018 which indicates data of area cover and image percentage according to each class element.
Table 2. Statistical analysis of the land cover changes for the year of 2014, 2016 and 2018

| Class Name             | 2014 Landsat map |          | 2016 Landsat map |          | 2018 Landsat map |          |
|------------------------|------------------|----------|------------------|----------|------------------|----------|
|                        | Area cover (km²) | Image (%)| Area cover (km²) | Image (%)| Area cover (km²) | Image (%)|
| Mangrove forest         | 5.1              | 23.7     | 4.9              | 22.7     | 4.4              | 20.4     |
| Oil palm plantation    | 6.5              | 30.2     | 6.9              | 31.8     | 8.0              | 37.0     |
| Water bodies           | 2.2              | 10.4     | 2.3              | 10.6     | 2.2              | 10.0     |
| Urban and associated areas | 7.7          | 35.7     | 7.5              | 34.8     | 7.0              | 32.6     |

4. Conclusion
This paper gives an overview of the mangrove distribution changes study which has been done by using the GIS approach. Methodology of research which is a basis of strategy to gain final data has been used to monitor the area during the year of 2014, 2016 and 2018. The information about land use has become essential for Malaysia’s plan in order to overcome problems such as uncontrolled development, destruction of important wetlands and loss of wildlife habitats. Based on other previous studies, the GIS has proven to be powerful tools for landuse analysis based on the existing natural resources.

Other than that, the study has determined that the mangrove distribution changes can be analysed by using landsat sources of imagery and area selection technique for image processing. These techniques were popular and commonly used for land use especially for conservation purpose. Kuala Selangor can be further planned for activities related to its unique mangrove forests as the area has high potential value for wildlife conservation and ecotourism.

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