Land use and land cover change analysis using satellite images in Gua Musang, Kelantan

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Abstract. The use of multisensor remote sensing to characterise forest structure has significant promise for mapping and understanding forest biological processes, making remote sensing an effective technology in detecting deforestation for forest management and monitoring. The aim of this study is to detect land use and land cover (LULC) changes due to deforestation at Gua Musang, Kelantan using satellite images. The Landsat 8 OLI satellite images were obtained from United State Geological Survey (USGS) for year 2017 to 2019. The supervised classification with maximum likelihood algorithm was applied for image classification to generate land use land cover categories. Then, LULC change detection between 2017, 2018 and 2019 were conducted to analyse the change and pattern. Based on the results, it shows the percentage of each land use changes within three (3) years from 2017 to 2019 for Landsat 8 OLI. Percentage of deforestation due to logging areas for year 2017 to 2019 is 5.95%. Percentage of forest area is 5.57%. For water bodies, the percentages just only cover 0.36% in 3 years. The highest land use change is no changes which is 88.12% happened towards the land from 2017 and 2019. This shows within three years there is no great changes at the area. The overall accuracy for each map is more than 80% which are acceptable. From the analysis, there were no significant changes of LULC during this period due to the increased of timber extraction, agricultural land expansion, urban growth, and poor governance structures.

1. Introduction
Forests play an important role for living beings, as they provide protection for human biodiversity and livelihoods [1]. In addition, forest habitats are well known to have a significant source of biomass. Continued deforestation and habitat depletion would contribute to the reduction of land biomass/carbon stock magnifying climate change's global negative effects [2]. Indeed, anthropogenic influences are endangering forests as a result of rising population growth, which causes plenty of environmental issues such as landslides, avalanches, global warming, water pollution, and plenty of other dangers [3]. Over the last 30 years, the nation of Malaysia has suffered from one of the highest rates of deforestation seen in the world. Commercial farming, mining, and logging are the leading drivers of deforestation in Malaysia [4] had identify, illegal logging has long been a concern in Malaysia, where most of the state has been severely affected by the activity. According to data from the World Wild Fund, Malaysia lost 8.12 million hectares of forest between 2001 and 2019, equivalent to a 28 percent reduction in tree cover. The impact of this issue on the country in terms of climate disruption, global climate change, and biodiversity, as well as the ecosystem, will be irreversible if these rainforests continue to disappear.
According to [5], Deforestation and forest degradation have drastically reduced carbon storage in tropical countries, wherein forests include the world's most carbon-rich ecosystems. Therefore, REDD+ (Reducing Emissions from Deforestation and forest Degradation and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries) was established with the purpose to promote the reduction of emissions from deforestation and forest destruction, the conservation and enhancement of forest carbon stocks and sustainable forest management in developing countries [6]. It is likely, a much more systematic approach would identify how international data reporting and verification framework using historical data, satellite imagery and direct tree estimation can be collected. Furthermore, this program is important to ensure the conservation of forest carbon stocks, sustainable forest management, and enhancement of forest carbon stocks which need to be undertaken by countries and any implementation body [7].

Therefore, in support of REDD++ program, remote sensing provided advanced in monitoring in fulfilling new expectation for consistently precise and reliable data of the forested area. This technology can simplify and facilitate the forest information using multiple sources of spatial data due to it ability in the acquisition of remotely sensed data about an object, area or phenomenon or area under investigation [8]. Remote sensing can provide benefits in quantifying forest structure, mapping aboveground biomass (AGB), monitoring temporal changes, estimating timber volume and planning purposes [9], [10]. Besides, it can overcome the issue in monitoring any forest disturbances or to be specific, logging operations that occurred deep in the forest by using conventional method is found to be difficult, such as transportation being blocked by fallen timber and cannot proceed the journey [11] also for land use land cover classification and mapping is time consuming and high cost to process [12]. Three different years of Landsat 8 OLI (30 x 30m) resolution from 2017 until 2019 were used for the land use land cover (LULC) mapping and also to analyse and detect the deforestation area. LULC change detection is important to assess the information of the forest resources to support sustainable forest management in the conservation area and it very useful in understanding of landscape changes during a period of time [13]. According to [14], (LULC) study has become an essential field study in studying the relationship between humans and their environment since it has the potential to effect ecosystem stability and it support by [15], changes in LULC are one of the most significant aspects of global environmental change. Change detection can be performed to identify the region of change between two images observing the same scene at different times. Furthermore, to increase knowledge in understanding landscape pattern, changes and interaction between human activities and natural phenomenon are essential for proper land management and decision improvement [16].

The aim of this study is to detect the changes of land use and land cover (LULC) due to deforestation and disturbed forest area at Gua Musang, Kelantan. The specific objectives of this study are i) to map LULC from 2017 to 2019 using Landsat 8 OLI data and; ii) to determine the temporal changes of LULC within 3 years due to deforestation.

2. Materials and Method
2.1. Study Area

The study had been performed at Gua Musang which is the largest district in Kelantan, Malaysia and it is lies between latitude 4° 52’ 56.28” and longitude 101° 57’ 51.84” (Figure 1). The total area is 7979.787km² with population exceeding 90,000 people. It has a tropical climate, where the rainfall is significant even during the dries month with average annual temperature is 24.7°C and it surrounded by highlands as well as offer pretty nice natural views. Gua Musang was chosen as a study area due to rapid logging activity and also the conversion of tropical forests into a commercial and non-commercial agriculture lands especially at Lojing forest [13] [17]. This activity causes the flow of water on the earth's surface as well as the rise of river water to be faster and the area undergo change due to time. When it rains heavily, the river water level will rise rapidly and cause water to overflow, also the condition of the river changed due to erosion, piles of sand, gravel and silt on the riverbed also increased, thus making the riverbed high and shallow. Finally, it loses the capacity to carry rainwater into the sea
so that it can trigger floods and it shows by the muddy flood which occurred in December 2014 in Gua Musang and Kuala Krai in Kelantan contributed the high impact to the local communities of this state. Based on Global Forest Watch website, from 2001 until 2020 Gua Musang lost 262kha of tree cover, equivalent to a 33% decrease in tree cover, moreover, from 2013 to 2020, 59% of tree cover loss in Gua Musang occurred within natural forest.

![Map of study area, Gua Musang, Kelantan. (Source: Google Earth)](image)

2.2. **Data and Software**

To produce map of land change detection for deforestation there are demands a different year of data in order to compare and monitor the change of landscape for the area. It also involves a several software such as Quantum GIS (QGIS) software is used for images subset and ERDAS imagine software is use for the whole of the project from data processing until the land use map is generate in the end of the project also use for change detection processing.

2.2.1. **Landsat 8 OLI imagery**

Landsat 8 OLI satellite images were acquired for the study area with spatial resolution of 15m panchromatic, 30m multispectral and 30-meter thermal infrared sensor (TIRS). Landsat 8 consist of 11-band combination for spectral characteristic.

| Sensors | Bands | Wavelength (micrometres) | Resolution (meters) |
|---------|-------|--------------------------|---------------------|
| Landsat 8 OLI Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) | Band 1 | 0.43 - 0.45 | 30 |
| | Band 2 | 0.45 - 0.51 | 30 |
| | Band 3 | 0.53 - 0.59 | 30 |
| | Band 4 | 0.64 - 0.67 | 30 |
| | Band 5 | 0.85 - 0.88 | 30 |
| | Band 6 | 0.85 - 0.88 | 30 |
| | Band 7 | 2.11 - 2.29 | 30 |
| | Band 8 | 0.50 - 0.68 | 15 |
2.3. **Methodology**

In this study, data acquisition, image pre-processing, data processing, accuracy assessment, generate map and change detection analysis is the main component.

![Methodology Diagram](Image)

**Figure 2. Methodology of Study**

2.3.1. **Layer stacking**

Each downloaded image was come out with a several layer, due to this, before the image looking forward for processing, layer stacking process was performed using ERDAS imagine software in purpose to combine the multiple layers of the image. In making this process run smoothly, each of the layer or bands should have same spatial resolution.

2.3.2. **Image subset**

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. Then, the image needs to subset in getting the exact and same size where it is focusing at Gua Musang district and the process was doing by using Quantum GIS software. Subset is a process to obtain small portion area from the large portion area. The subset function tool is used for selecting the desire location area according to the given coordinate. This is for easy observation on the satellite image to mark ground control points.

2.3.3. **Image pre-processing**

Georeferencing is a transformation between the image space to the geographical coordinate space. The purpose for this georeferencing is to transform the image coordinates system that can made image distortion due to the certain factor. Geometric correction is performed by start locating points at the raw image and reference image. This mark location point must be at the same location target in order to obtain a good accuracy of RMS error. The tolerance to obtain good accuracy, the mark point of ground control for the RMS error the value must be below than 0.5.

2.3.4. **Supervised classification**

Supervised classification is a method of classification that brings a user to select representative samples for each land cover class in the digital image. In order word select the region feature based from the selection of pixels. Samples of land cover are referring to the training sites. These training sites are used to identify the land cover classes in the entire image. Usually there five algorithms used includes the
Minimum-Distance to the mean classifier, parallelepiped classifier, and gaussian maximum likelihood classifier mahalanobis distance and feature space classifier. For this study, only Maximum Likelihood Classifier used to detect and classify forest cover for this study area, where it has been mentioned by [18] for a better output image, maximum likelihood method was chosen for a supervised classification.

2.3.5 Change detection

One of the methods for change detection using satellite images is to compare the results of classified images. Change detection is a method to identify and analyse how an area has changed between two or more time periods. Change detection is defined as identifying differences of object state at the same location, but in a different time. For this research, there are three Landsat 8 OLI images from 2017 to 2019 to detect deforestation. The advantage of the classified map comparison method is that not only the location but also the nature and type of the changes are determined in the study area. Change detection has been widely used to assess shifting cultivation, deforestation, urban growth, impact of natural disasters like tsunamis, earthquakes, and LULC changes.

2.3.6. Accuracy assessment

Accuracy assessment is a process to compare the classification to geographical data that are assumed to be true, in order to determine the accuracy of the classification process. The assumed true data are derived from ground truth data. Reference pixel is actually a point on the classified image for which actual data are known. For the validation, we looked at two different measures: overall accuracy and kappa coefficient in order to evaluate the final maps. The allowable tolerance for the supervised classification is must be above 80% in order to be accepted as final LULC maps.

3. Results and Discussion

3.1 Land use land cover change detection

Land use land cover changes of Gua Musang from 2017 until 2019 are summarized in Table 2. This table is a result of land change detection of Landsat 8 OLI satellite images. The area shows a difference by year and land use class. Among the four classes, it proven that there no significant changes of land during this period in usage percentage where 88.12% land use in this area is still maintain. However, due to time and circumstances of the area, there are still changes in the landscape had inevitability occur and this condition view by the result from logging activities, forest and water bodies experiencing small change.

Logging activities shows increasing trend to 5.95% and this also make an impact to other features especially forest landscape which rich with flora and fauna to be destroyed. Gua Musang is surrounded by highland which allows the situation to worsen if the trend of increasing deforestation increases rapidly. Reduction of canopy forest areas in land areas height is of great concern. High slope areas unprotected by canopies plants will cause the erosion process to occur faster, this will cause surface runoff to flow faster which will cause the erosion and sedimentation process to be higher and have a negative impact on the river.

Conversion of tropical forests into a commercial and non-commercial agriculture lands is the main factor of deforestation, as a result give an effect towards the water bodies (0.36%). The situation has destroyed many rain catchment areas in the forest in Hulu Kelantan, while the hills have become exposed to hot weather and rain. The water flowing from the highlands carries along the mud to the streams, which enter the main rivers such as Sungai Lebir and Nenggiri up to the Kelantan River causing the water to be polluted.

3.2 Land use land cover classification

Supervised classification method was used to derive land use and land cover map (LULC) because it gives a better and precise information where selection of training sites must be chosen properly to minimize the error. Figure 3 shows the land use and land cover map (LULC) of year 2017, 2018 and 2019 which consist of three classes; forest, water bodies and logging area.
Table 2. Percentage of land use for Landsat 8 OLI from year 2017 to 2019

| Land use class                  | 2017-2019 |
|--------------------------------|-----------|
|                                | Area (ha) | Percentage (%) |
| No changes                     | 83241.97  | 88.12%         |
| Deforestation due to Logging   | 5613.66   | 5.95%          |
| Forest                         | 5264.73   | 5.57%          |
| Water Bodies                   | 341.82    | 0.36%          |
| **Total**                      | **94462.18** | **100%**      |

Figure 3. Map of LULC a) Landsat 8 OLI 2017 (b) Map of LULC Landsat 8 OLI 2018 (c) Map of LULC Landsat 8 OLI 2019
3.3 Accuracy Assessment
Accuracy assessment was conducted during post classification process to determine the level of precision of the maximum likelihood supervised classification using only equalized random sampling. The assessment identifies overall error. From overall accuracy for year 2017, 2018, and 2019 is acceptable which the overall accuracy is more than 80%.

| Satellite Image | Landsat Oli 8 (2017) | Landsat Oli 8 (2018) | Landsat Oli 8 (2019) |
|-----------------|----------------------|----------------------|----------------------|
| Overall accuracy| 93.3                 | 86.7                 | 80                   |
| Kappa statistic | 0.9                  | 0.8                  | 0.7                  |

4. Conclusion
In conclusion, the results gained and thus being analysed and discussed show that the aim and objectives of the study have been achieved. For land use change detection, it has been classified into four classes for each of the year from 2017 until 2019. However, these severe forest reductions and variations between study periods have no evident cause. Timber extraction, agricultural land expansion, urban growth, and poor governance structures are likely to have had a significant impact on the temporal rate and spatial extent of forest loss.

The use of remote sensing technologies to detect deforestation has a positive impact on the management and monitoring of Malaysia's tropical rainforest. In addition, multi-sensor remote sensing to characterise forest structure offers tremendous potential for mapping and understanding forest biological processes. It's challenging to map forest stand and carbon stock distribution at a regional scale using existing approaches based on field observations. In comparison to traditional remote sensing approaches, remote sensing technology has become a better solution for identifying deforestation and forest degradation. Although its dynamic change cannot be directly detected using remotely sensed data, it can be predicted using a model based on data from remote sensing and ground observations.

Human activities are the dominant underlying forces of these changes. The escalation of logging activities had caused disturbances to various parties such as disruption of wildlife habitats, indigenous people, mud floods, water supply disruptions and more. However, it is undeniable that the logging sector is one of the primary industries that have the potential to increase the country's source of income as it will be exported overseas. Thus, satellite technology is able to identify the LULC changes and help to restore the forested area from being directly affected by logging activities leading to deforestation.

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