Initial results of the spatial distribution of rubber trees in Peninsular Malaysia using remotely sensed data for biomass estimate

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Abstract. The preservation and sustainable management of forest and other land cover ecosystems such as rubber trees will help addressing two major recent issues: climate change and bio-resource energy. The rubber trees are dominantly distributed in the Negeri Sembilan and Kedah on the west coast side of Peninsular Malaysia. This study is aimed to analyse the spatial distribution and biomass of rubber trees in Peninsular Malaysia with special emphasis in Negeri Sembilan State. Geospatial data from remote sensors are used to tackle the time and labour consuming problem due to the large spatial coverage and the need of continuous temporal data. Remote sensing imagery used in this study is a Landsat 5 TM. The image from optical sensor was used to sense the rubber trees and further classified rubber tree by different age.

1. Introduction

For the last two decades the climate change has become one of the most issues that attract attentions from people around the world, especially government and scientists [1]. Sev eral works and researches have been carried out since then in order to address this problem, and some of them have been focused to deal with greenhouse gasses concentration, especially Carbon Dioxide (CO_2) as the suspected agent that related most to the climate change [2-5]. The fossil fuel combustion, deforestation, and industrial activities, may have significantly increase the number of carbon dioxide concentration within the atmosphere [6,7]. Several studies have shown that human-induced activities that using fossil fuels energy are the largest source of carbon emissions in the worldwide [3-5,8]. Realising that circumstance scientists and government as well as decision makers agreed to start developing and using some renewable energy sources as an alternative over fossil fuels, that may have less-contamination effect to the environment.

Biomass energy has become the most developed and successful renewable energy source over the fossil fuels [9-11]. One of the most important biomass in terrestrial ecosystem is rubber wood. Over its lifetime, rubber tree can store about 180 t/ha solar energy in the form of biomass. The economic life of tree is 25-30 years, as it were the rubber become the secure source of energy for relatively long term period [12]. The rubber plantation also can be considered as the essential part towards global warming reduction through its carbon sequestration, with sequestering capability estimates between 235 tonne/ha/30 years and 574 tonne/ha/30 years (Rubber Trees Help Reduce Global Warming, n.d.). Developing rubber should be promising in the near future, because it has become one of the UNFCCC (United Nation Framework Convention on Climate Change) strategy to engage collective gas emissions reduction under the CDM (Clean Development Mechanism) following Kyoto Protocol in 1997 [12].

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Malaysian rubber tree (Hevea Brasiliensis) naturally comes from Amazon Basin of South America and it was brought here by European colonist to establish some plantations. First attempt on rubber seedlings occurred on 1877, with a successful result and expanded on a commercial basis [13]. Rubber seems important for Malaysia as it has been the second main crop with largest share of GDP after oil palm plantation [14]. There have been some efforts to deal with the major issues and challenges in Malaysian rubber plantation, such as increasing rubber production by escalate the acreage of replanting area, developing new rubber clone, and attracting more participants to the industry [15].

The Geographic Information System (GIS) and Remote Sensing (RS) technique may provide spatial information as well as temporal data of a certain place in the world. GIS and remote sensing also often combined with environmental or ecosystem modelling in many application such as forest-degradation analysis, biomass analysis, and terrestrial carbon cycle [16,17]. In particular, remote sensing were specially designed to capture spatiotemporal information on the reflectance properties of landscape and vegetation, while models focus on underlying biogeochemical process [18]. This study will mainly use remote sensing data and techniques to achieve the objectives. The obvious reason are to tackle the time and labour consuming problem due to the large spatial of locus and the need of continuous temporal data. Another cause is to use the excellence of remote sensors that are sensitive to capture earth surface feature especially vegetation characteristics. Various types of vegetation indices such as NDVI (Normalized Difference Vegetation Index), LAI (Leaf Area Index), EVI (Enhanced Vegetation Index), and FBD polarization (Fine Beam Dual) generated from several satellite-based images from LANDSAT, MODIS, and ALOS PALSAR have been used by many researchers to analyse vegetation features like phenology, biomass and forest carbon cycle [19-22,18]. Retrospectively, remote sensing sensors were capable to capture radiative process in plant canopies which further used as input information for biomass modelling, but it often questioned because optical remote sensing tend to provides information on canopy leaf density rather than biomass [23].

2. Methodology

2.1. Study area
The study area will be located in Negeri Sembilan. As one of the Malaysian territorial state it is located between 101^0 42' to 102^0 42'E and between 2^0 23' to 3^0 18' N, covering about 67 Km^2. This location has been chosen because it has the largest rubber planted area if compared to the other states (Department of Statistic Malaysia, 2012). The location of study area is showed by Figure 1.
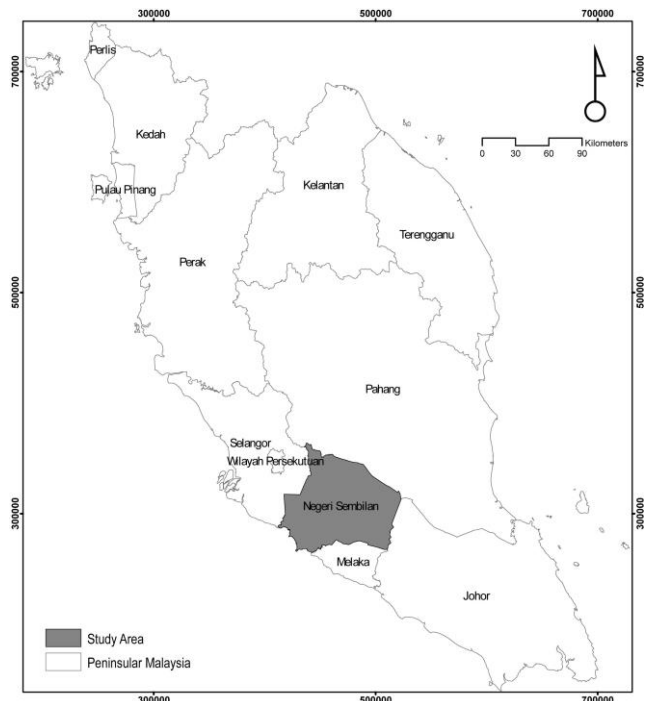

Figure 1. Map of Negeri Sembilan location in Peninsular Malaysia.

2.2. Data
The data used in this study have been carefully chosen since there are few limitations. This study used medium spatial resolution imagery such as Landsat TM because it is the easiest and cheapest obtainable remotely sensed data. The medium level of Landsat TM's temporal resolution also very useful in land-cover change detection. Four scenes of Landsat 5 TM image of 2006 and 2010 have

been acquired from USGS Global Visualization Viewer. The image acquisition date is varied due to the common cloud cover in tropical country. The list of images can be seen in Table 1.

Table 1. List of Landsat TM data.

Scene ID	Acquisition date	Cloud cover (%)
LT51260582006246BKT00	3 September 2006	16
LT51260582010033BKT00	2 February 2010	0
LT51270582006349BKT00	15 December 2006	10
LT51270582010152BKT00	1 June 2010	23

2.3. Image pre-processing

The geometric and atmospheric corrections are first applied during the image pre-processing phase. A topographical map is included in geometric correction. All images were being corrected and registered to UTM 48 N projection. This study also applied Dark Object Subtraction (DOS) technique using ENVI 4.5 in atmospheric correction process. The NDVI is automatically generated after DOS process is finished. NDVI is also useful as an input in this study.

2.4. Identification of rubber planted area

This study uses several techniques to interpret the rubber plantation. Visual interpretation is applied at the first stage. The combination of band 4, 5, 2 from Landsat TM used to distinguish rubber plantation and its different stage of growth [24]. This false colour combination is included in standard supervised classification using Maximum Likelihood classifier to produce land-cover map.

On the other hand NDVI from DOS technique being combined with greenness, brightness and moistness from tasselled cap transformation, and used as inputs for Mahalanobis distance classifier. Mahalanobis distance classifier has been successfully used in several works to improve the rubber trees growth mapping [25]. The results from these two classifiers are being examined in terms of the level of accuracy in the accuracy assessment process. Ground truth information which derived from topographical map used as the reference to measure the accuracy.

3. Results and discussion

3.1. Image classification

The two classification techniques produce almost similar result, but different in terms of their accuracy. Based on the accuracy assessment, Maximum Likelihood classifier produce slightly more accurate result compared to Mahalanobis Distance classifier. The overall accuracy and Kappa coefficient of Maximum Likelihood classifier are higher than Mahalanobis Distance (see Table 2).

Table 2. Accuracy assessment of classification result.

Classifier	Overal accuracy (%)		Kappa coefficient	
	2006	2010	2006	2010
Maximum likelihood	91.1449	84.0653	0.8845	0.7999
Mahalanobis distance	82.8903	76.6756	0.7826	0.7098

There are seven classes which can be identified from the image (see Table 3). The most dominant land-cover type is forest, which covers about 34% land in 2006 and 39% in 2010. It seems that the number of forest is increase, but the change in calculation might be influenced by the cloud cover movement. Rubber has become the second largest cover type in this area, which covers almost 27% of land in 2006 and 16% in 2010.

Table 3. Land-cover classes.

Land-cover type	2006		2010	
	Area	%	Area	%

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Rubber	178832.447	26.809	109110.286	16.357
Forest	231052.406	34.637	260413.835	39.039
Mangrove	3315.467	0.497	20849.92	3.126
Built-up area	32327.270	4.846	21743.215	3.260
Bare land	3784.186	0.567	11221.29	1.682
Water-bodies	1773.945	0.266	5622.598	0.843
Others	215976.663	32.377	238101.231	35.694
Total	667062.384	100	667062.375	100

3.2. Rubber tree distribution

Rubber trees are dominantly planted in centre to east part of Negeri Sembilan (see Figure 2). The result shows almost similar pattern of 2006 and 2010 rubber trees distribution. However the extent of planted area is different. The rubber trees distribution map presented in this paper comprises the small holding areas including the estate plantation areas.
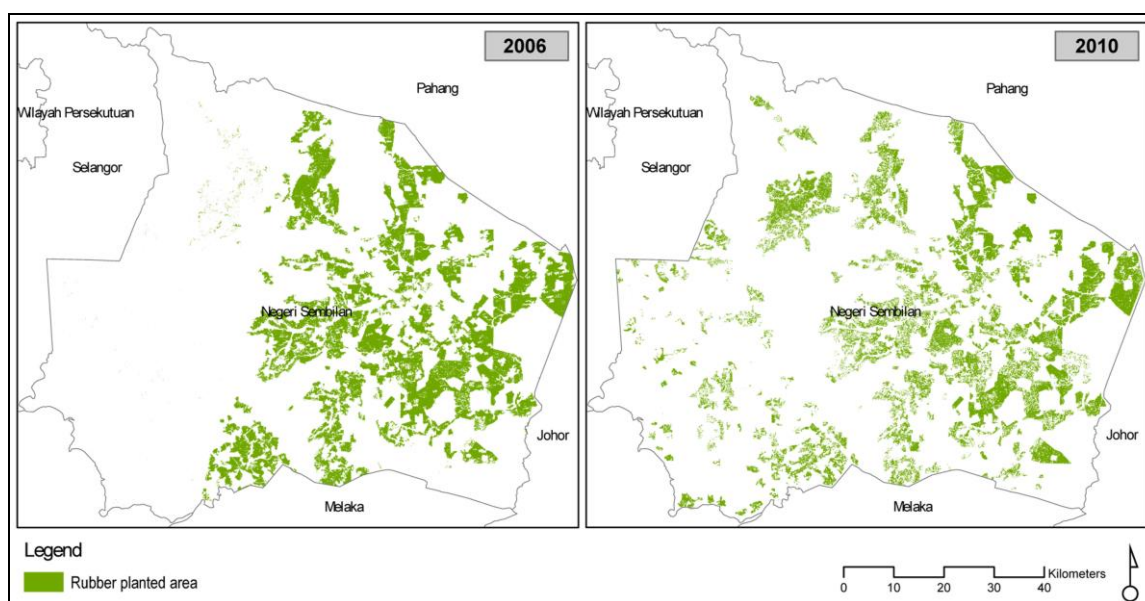

Figure 2. Rubber trees of Negeri Sembilan in 2006 and 2010.

The greenness index resulted from tasselled cap transformation is showed by Figure 3. The greenness index explained the level/stage of growth and maturity of a certain rubber tree. Based on the comparison map, an assumption can be made that the rubber trees were planted almost in the same period. The soft green colour appeared in whole study area and all of them turned to dark green colour in 2010.
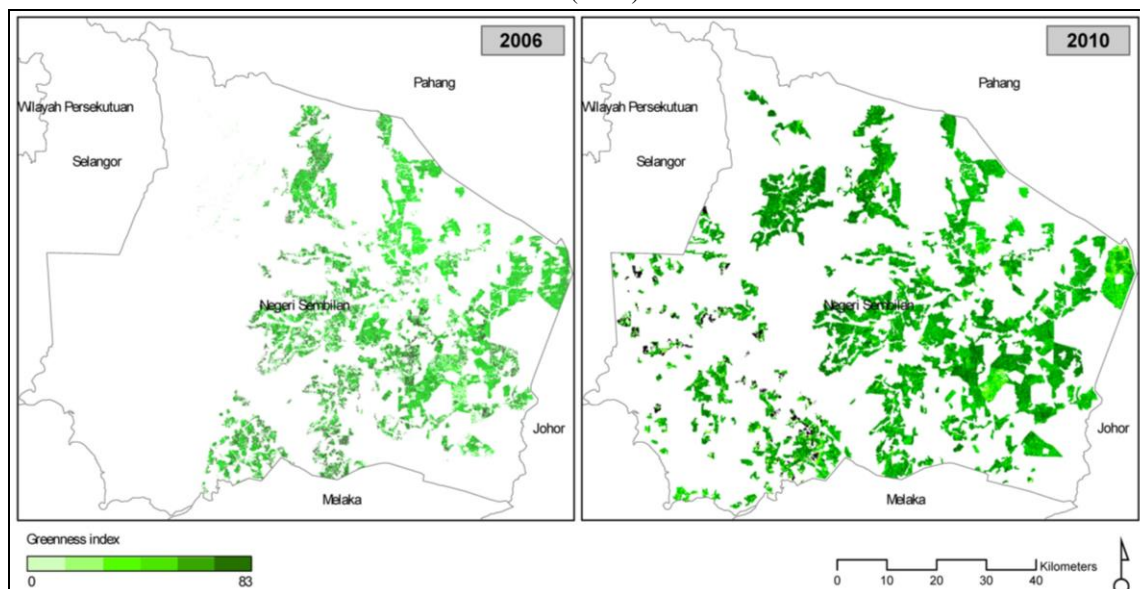
Figure 3. Greenness index of rubber trees of Negeri Sembilan in 2006 and 2010.

4. Summary and conclusions

Landsat 5 TM 30 m was applied to map rubber trees distribution in Negeri Sembilan. The Maximum Likelihood and Mahalanobis Distance classifier have been used and examined to generate land-cover classification. Some conclusions following this study are, first the Maximum Likelihood classifier provides better accuracy compared to Mahalanobis Distance. Second, the rubber trees are dominantly planted in the east part of the study area and the number of planted area is decreasing. Third, these preliminary results of the spatial distribution of rubber trees and greenness index are useful for further exercise in biomass estimate.

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