Mapping of government land encroachment in Cameron Highlands using multiple remote sensing datasets

M H M Zin[1], B Ahmad[2,3]
[1] Post-graduate Student, *Department of Remote Sensing, Faculty of Geoinformation and Real Estate*, Universiti Teknologi Malaysia, UTM, 81310 Johor Bahru, Johor, Malaysia
[2] Senior Lecture, *Institute of Geospatial Science & Technology (INSTEG)*, Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia, UTM, 81310 Johor Bahru, Johor, Malaysia

E-mail: baharinahmad@utm.my

Abstract. The cold and refreshing highland weather is one of the factors that give impact to socio-economic growth in Cameron Highlands. This unique weather of the highland surrounded by tropical rain forest can only be found in a few places in Malaysia. It makes this place a famous tourism attraction and also provides a very suitable temperature for agriculture activities. Thus it makes agriculture such as tea plantation, vegetable, fruits and flowers one of the biggest economic activities in Cameron Highlands. However unauthorized agriculture activities are rampant. The government land, mostly forest area have been encroached by farmers, in many cases indiscriminately cutting down trees and hill slopes. This study is meant to detect and assess this encroachment using multiple remote sensing datasets. The datasets were used together with cadastral parcel data where survey lines describe property boundary, pieces of land are subdivided into lots of government and private. The general maximum likelihood classification method was used on remote sensing image to classify the land-cover in the study area. Ground truth data from field observation were used to assess the accuracy of the classification. Cadastral parcel data was overlaid on the classification map in order to detect the encroachment area. The result of this study shows that there is a land cover change of 93.535 ha in the government land of the study area between years 2001 to 2010, nevertheless almost no encroachment took place in the studied forest reserve area. The result of this study will be useful for the authority in monitoring and managing the forest.

1. Introduction

Forests are an important global resource that human populations depend on for wood, air quality, recreation and many other uses. They also serve as habitats for vast of plants and animal species.

Jian (2010) have stated that deforestation is one of the most important components of the global environmental change, and this change has a strong influence on various ecosystem sectors such as carbon cycling, worldwide animal and plant life, and also changes in human life as represented by major changes in land use. Forest encroachments have attracted the attention of both the public and policy makers as a result of the huge damage inflicted upon the environment [1,2]. High demand on good quality agriculture product has led to the conversion of forests for land-use for agriculture and plantations. As a result, farmers turn to illegal way to increase their agricultural products in opening more land for agriculture. This involves felling trees and clearing land on slope. This activity has led to the encroachment of government land.

Remote sensing technology has been used as a tool for mapping of land use and land cover by researchers since it was introduced [3,4,5]. Increasing of deforestation cases all over the world has led to the development of various remote sensing techniques that can be used to monitor and study this

[3] To whom any correspondence should be addressed.

problem [5]. In previous study, forest area has always been classified as one of the land cover classes in land cover map. So we can say that forest area is detectable with remote sensing technique.

[1] To whom any correspondence should be addressed.

The capability of remote sensing data that have multiple scales ranging from as big as a few metres to several kilometres small scale help researcher to study local and also global level of forest management and resource. The multi-temporal data acquisition which allows data to be acquired daily, monthly or annually also give advantage in monitoring at regular basis. Multiple remote sensing data scales also has synoptic sensor coverage also give an information in a place that hard to access, thus help to detect any illegal forest activity in that area. Although remote sensing only provides complimentary information, it is still quite effective tools in assessing and monitoring forest [6].

The unmanaged deforestation can lead to natural disasters that may harm many people. Natural disasters such as landslides that are often associated with Highland often occurred in Cameron Highland and have killed many people. This study was carried out to detect and monitor the encroachment of State land and forest areas in Cameron Highland by analysing and mapping the changes from satellite data.

2. Study Area

The study area is located in Cameroon Highlands, Pahang, Malaysia. It covers from latitude 4°26'57.67" (Brincang town) in the north, down south latitude 4°25'51.01" (Habu) and longgitude 101°21'28.03" in the west to east 101°25'47.06". The study area was selected based on the suspected illegal forest clearing activities for farming and illegal logging. Areas such as Tanah Rata, Brincang and Kampung Taman Sedia, which is situated in the study area where the occurrence of illegal land clearing have been reported in the local newspaper [6]. The study area also covers Mentigi forest reserve which is one of the gazetted ~~as~~ forest reserve in Malaysia. This forest serves as one of the water catchment area for Tanah rata and Habu towns. This study area consists of various types of land use such as forest, urban, tea plantation and vegetable.

3. Data and Method

3.1. Satellite Images

Two multi-spectral remote sensing satellite images acquired in different duration were used in this study. The first is IKONOS data obtained in March, 2001, which has a resolution of 4 meter for multi-spectral band and 1 m for panchromatic band. Multi-spectral band consist of 4 bands that is blue, green, red, and near infra-red. In this study, multi-spectral band and panchromatic band were fused to produce high resolution multi-spectral datasets. Gram-Schmidt spectral sharpening in ENVI 4.5 software was used for this purpose. In remote sensing study, there is one weakness that cannot be overcome, that is cloud cover. Some part of forest area and some other land cover in the image used in this research also have problem with cloud cover. Cloud masking has been done to this image to remove the thick cloud and therefore remove all together information in that part of the image.

The second satellite data used in this study is SPOT5. This data was made available by Malaysia Remote Sensing Agency (MRSA). SPOT 5 have 5 bands which are 1 panchromatic band and 4 multi-spectral bands. Multi-spectral bands for this dataset record information in 10 meter spatial resolution and 5 meter resolution for panchromatic. Both datasets were fused together using Gram-Schmidt spectral sharpening to produce higher resolution multi-spectral SPOT image. Cloud masking is not necessary for the fused datasets since it is cloud free.

Both images were re-projected into MRSO GDM2000 projection to match with the cadastre parcel data. The satellite image was then classified to delineate forest area from other land cover in the study area. Two data of different duration were used to detect changes and the expansion of the encroachment. The whole processing flow for this study is shown in Figure 1.

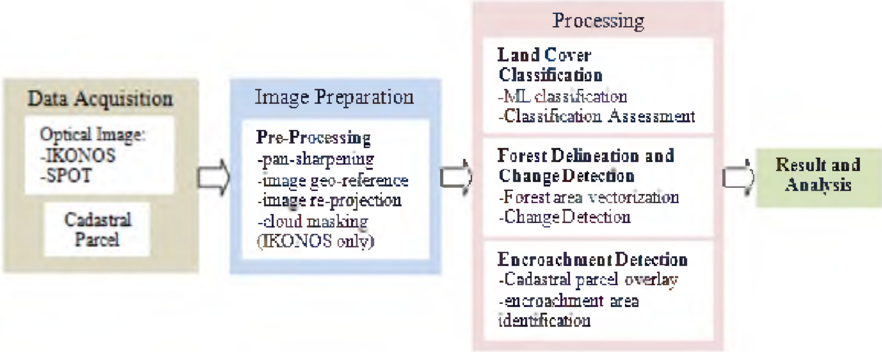

Figure 1. Work Flow.

3.2. Cadastral parcel

A Cadastral is normally a parcel based and up-to-date land information system containing a record of interests in the land (e.g. rights, restriction and responsibilities). Cadastral parcel data for this study area is obtained from Malaysia Survey Department (JUPEM) and it is up to date until 2011. This data contain detailed information about the land owning in the study area. In this study, cadastral parcel data together with satellite image were used to detect encroachment upon the government land.

Cadastral parcel data was overlaid on the classification result to check if any new development or agriculture activity that advances beyond proper limits.

3.3. Forest Area Detection

From previous study, image classification has been used for forest area delineation [7,8,9]. Maximum likelihood classification (MLC) is one of the most widely use supervised classification technique. It is defined by Scott and Symons (1971) as a method for determining a known class distribution as maximum for a given statistic. This probability based decision rule use to assign each pixel by calculating probability of a pixel from training sample and then assigned the pixel to the class which has highest probability [10]. MLC have been used to classify the two satellite images used in this study.

Due to high spatial resolution of IKONOS datasets, we were able to classify 8 classes, which is forest, tea, vegetable, vegetable cover, urban, soil, grass, and water body. For SPOT image, only 6 classes have been classified. This is because of its lower spatial resolution compared to IKONOS. However, this classification process was able to delineate forest area for both images. The result of accuracy assessment using confusion matrix between ground truth and both classified image shows overall accuracy for IKONOS image is 84.97% and kappa coefficient is 0.8823. While overall accuracy for SPOT image is 88.79% and kappa accuracy is 0.845. The results show there is high correlation between the classified image and ground truth information.

3.4. Forest Area Change Detection

Forest areas that are detected from classification process were converted from raster to vector. This conversion is necessary because with vector format it is easier to handle compared to raster format. With data manipulation in vector data format, the change area can be computed easily.

By overlaying the latest data on top of the older one, forest change can be seen clearly (see Figure 2).

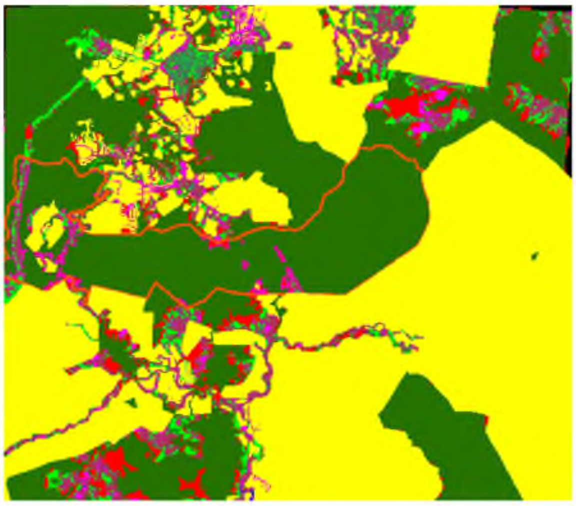

Figure 2. Brown line represents forest reserve boundary, dark green represents forest area, red represents the changes of forest area, yellow represents private lot area and others are classified image.

3.5. Government Land Encroachment Detection
Different dates of remote sensing data can be used to detect the changes of the area, land used or land cover [11,9,12] These changes might happened due to development, legal forest opening, and also illegal forest opening. However, in encroachment detection, cadastral parcel data is needed to show about the legal boundary of any activities. In this study it is assumed that cadastral parcel consist of property lots which is the boundary of piece of land for any parties or individual to do legal activities Any development upon forest lot within the private lot is legal and cannot be considered as act of encroachment. On the other hand, other parts of the cadastral parcel consist of lots or reserve lots such as forest reserve that belong to the government. Any human activity on land belongs to the government is illegal and considered as encroachment.

The land use changes map was overlaid together with cadastral parcel and classified image in order to detect the encroachment (Figure 3). By overlaying these three datasets, any land use that is outside the proper limit can be identified. The legal land use can also be identified from field observation and by identifying the feature shape of it classified image (i.e. golf course, road).

4. Result And Discussion
The manipulation of vector format data has allowed us to detect and compute the changes of forest boundary and the encroachment area easily. For 2001 IKONOS image, we were able to detect about 3532.558 ha of forest area while 3141.195 ha of forest from 2010 SPOT image. From here have detected forest loss in 9 year period is about 391.363 ha for this study area. This forest loss, as mentioned before, is due to human activities that does cut down the forest. But this activity can be legal or illegal. Cadastral parcel was used together with field observation in this study to discover encroachment area. The summary of changes and encroachment were shown in table 1.

Table1. Result summary.

Description	Area (Hectares, ha)
Forest detected from IKONOS 2001	3532.558
Forest detected from SPOT 2010	3141.195
Forest loss	391.363
Encroachment area 2001	296.873
Encroachment area 2010	390.408
Encroachment area expansion	93.535

There are 296.873ha of encroachment area that have been detected from IKONOS data. This shows that encroachments have already happened in 2001and it is continue to expand. From 2010 data, about 390.408ha of encroachment area was detected. This result shows the expansion of 93.535ha between 2001 to 2010 period (Figure 3).

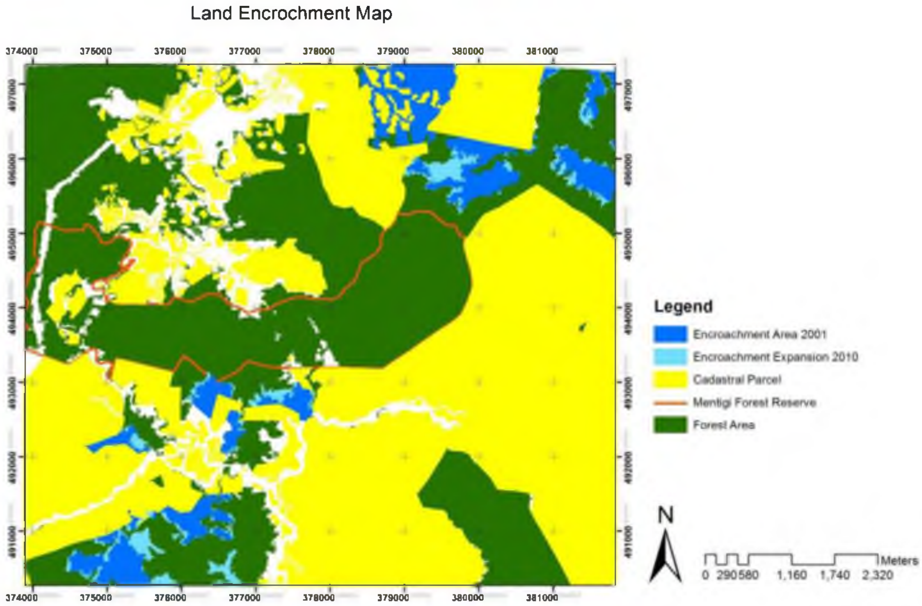

Figure 3. Land Encroachment Map

In this study, we have successfully detect the encroachment which is illegal forest clearing near Brincang and Habu area just like what was stated in local media report [6]. From our analysis on encroachment area using classified image, most of the encroachment area is for agriculture purpose (Figure 4). With reference to figure 3 most of the encroachments that were detected are locate in north east of the image and south-west of the image. This area was classified as agricultural area for vegetables and fruit.

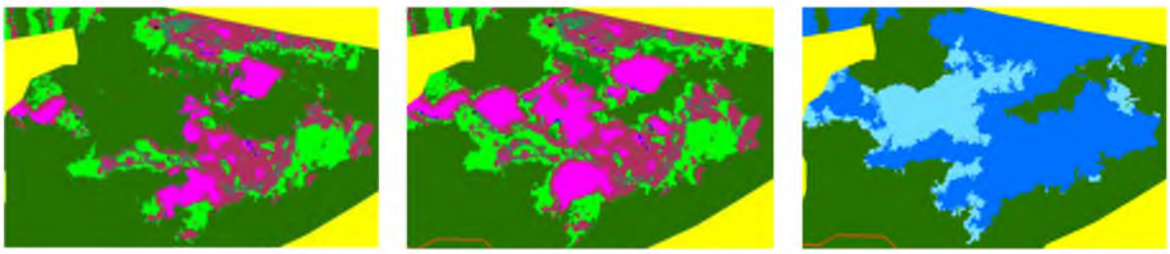

Figure 4. Example of encroachment area by agriculture activity. Image A (2001), B (2010) and C (change detection) are of the same area (north east of the image). Cadastral parcel area of non forest (yellow), forest area (dark green), encroachment area from IKONOS 2001 (dark blue), expansion of encroachment area from SPOT 2010 (light blue), agricultural area (other colour).

5. Conclusion

Successful delineation of forest area using image classification has led to forest change detection. This change detection is used to monitor the expansion of the encroachment area. With the aid of cadastral parcel and field observation, all illegal activities in government land were successfully detected. These illegal activities are assumed as encroachment since it happens outside any private lots of the cadastral parcel. Encroachment expansion was observed from changes of forest area since most of government land in this study area is forest area.

Data analyzing using vector data format has allowed for simple area computation and data manipulation. Trough data manipulation, forest change, encroachment area and expansion were computed (Table 1). Although all the aim of this study have been achieved, the accuracy of all the information extracted in this study is only based on classification accuracy and field observation. The additional information about forest encroachment from government authorities might be helpful for the validation.

However, from this study, the encroachment is successfully assessed by integration of remote sensing and cadastral parcel.

Acknowledgement
Special thanks to Universiti Teknologi Malaysia (UTM) and Institute of Geospatial Science & Technology (INSTEG) Faculty of Geoinformation and Real Estate, UTM Skudai for support of this study. The authors also would like to thank Ministry of Higher Education for providing grant **(Q.J130000.2627.07J14)**. Last but not least, thank also to Malaysia Remote Sensing Agency (MRSA) for providing data for this study.

References

[1] Fearnside P M 2005 Deforestation in Brazilian Amazonia: history, rates, and consequences Conservation Biology **19** 680–688
[2] Janisch J E and Harmon M E 2002 Succession changes in live and dead wood
[3] Tejaswi G 2007 Manual on deforestation, degradation, and fragmentation using remote sensing and gis. strengthening monitoring, assessment and reporting on sustainable forest management In Asia, Forest Deparment, Food and Agriculture Organization of the United Nations.
[4] Mendelsohn R, Kurukulasuriya P and Dinar A 2007 Climate and rural income. *Clim. Chang.* **81** 101–118. (doi:10.1007/s10584-005-9010-5)
[5] Roy D P , Lewis P E, and Justice C O 2002 Burned area mapping using multi-
[6] Sinar Harian 2013 Tindakan tegas terhadap penceroboh, pemusnah hutan Sinar Harian Online
[7] Buchanan G M, Butchart S H M 2008 Using remote sensing to inform conservation status assessment: Estimates of recent deforestation rates on New Britain and the impacts upon endemic birds *Biol. Conserv.* **141** 56-66
[8] Radoux J and P Defourny 2007 A quantitative assessment of boundaries in automated forest stands delineation using very high resolution imagery *Remote Sens. Environ.* **110** 468-475.
[9] Rogan J and D Chen 2004) Remote sensing technology for mapping and monitoring land-cover and land-use change *Progress in Planning* **61** 301-325
[10] Jansen L J M and A Di Gregorio 2003 Land-use data collection using the "land cover classification system": results from a case study in *Kenya Land Use Policy* **20** 131-148
[11] Abd El-Kawy O R, Rød J K 2011 Land use and land cover change detection in the western Nile delta of Egypt using remote sensing data *Applied Geography* **31** 483-494
[12] Schneider A 2012 Monitoring land cover change in urban and peri-urban areas using dense time stacks of Landsat satellite data and a data mining approach *Remote Sens. Environ.* **124** 689-704