

LAND COVER CHANGES MAPPING IN CAMERON HIGHLANDS USING  
HIGH RESOLUTION SATELLITE AND UNMANNED AERIAL VEHICLE  
IMAGERIES

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## DEDICATION

*I dedicate this master project to my precious family especially...*

*To my beloved mama and abah, Pn. Anita Binti Hj. Sumadi and En. Jumaat Bin Boeran who always support me...thank you for always given me encouragement whenever I need it...*

*Also to my lovely siblings, Nur Fatin Haziqah Jumaat, Muhammad Nur Akmal Jumaat, Muhammad Nur Akif Jumaat and Muhammad Nur Asyraf Jumaat...thanks for all advices to me...*

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## ABSTRACT

Agriculture and tourism are two important economic activities in the hilly area of Cameron Highlands, Pahang, Malaysia. Land opening for agriculture and construction of settlements and hotels to cater for tourism activities are rapidly and continuously ongoing in this area. However, improper planning of these activities has resulted in various environmental issues such as landslide hazards. This research is undertaken to assess the land use and land cover (LULC) changes occurred in the study area for a period of 12 years (2001-2013) using high resolution optical satellite images (IKONOS and QuickBird) and unmanned aerial vehicle (UAV) images from a fixed wing Helang. An object based classification technique was used to classify the satellite images and UAV images into seven LULC classes, namely, forest, agriculture, grass, bare land, urban, water body and areas affected by landslides. The results obtained from the classification technique were verified using land use maps of 2003, 2008 and 2015 that were obtained from the Department of Town and Rural Planning. The overall accuracy and Kappa Coefficient values (values in brackets) of the LULC classification are 86.67% (0.84), 83.89% (0.81), and 93.80% (0.93) for 2001, 2007 and 2013 respectively. Post classification change detection technique was applied in this study to identify LULC changes. Results of the classification show that the forest area decreased consistently from 2001 (196.08ha) to 2007 (180.73ha) and to 2013 (160.09ha). On the other hand, the built-up area, increased during the years from 47.77ha in 2001 to 58.25ha in 2007 and to 63.43ha in 2013. In these periods, a slight increase was noticed in the agriculture and grass lands, however, water bodies did not change much. In general, bare soil areas have only minor changes. Areas affected by landslides are detected in the UAV image and it covered an area of 3.66ha. In conclusion, this study show that the optical satellites and UAV images can be processed to produce accurate classification map, therefore useful for the local authorities to identify land cover changes, furthermore to monitor land encroachment activities and to reduce landslide hazards from occurring and to mitigate its effect.

## ABSTRAK

Pertanian dan pelancongan merupakan dua aktiviti penting di kawasan berbukit Cameron Highlands, Pahang, Malaysia. Pembukaan tanah untuk pertanian dan pembinaan penempatan dan hotel bagi memenuhi keperluan aktiviti pelancongan begitu pesat dan berterusan berlaku di kawasan ini. Walau bagaimanapun, perancangan aktiviti-aktiviti ini yang tidak teratur telah menyebabkan masalah alam sekitar seperti bencana tanah runtuh. Penyelidikan ini dilaksanakan untuk menilai perubahan guna tanah dan liputan tanah (LULC) yang berlaku di kawasan kajian untuk tempoh 12 tahun (2001-2013) menggunakan imej satelit optikal resolusi tinggi (IKONOS dan QuickBird) dan imej pesawat udara tanpa pemandu (UAV) Helang jenis sayap tetap. Kaedah klasifikasi berasaskan objek digunakan untuk mengklasifikasikan imej satelit dan imej UAV ke dalam tujuh kelas LULC, iaitu, hutan, pertanian, padang rumput, tanah kosong, kawasan pembangunan, kawasan badan air dan kawasan yang terjejas akibat tanah runtuh. Hasil yang diperolehi dari kaedah klasifikasi disahkan menggunakan peta gunatanah 2003, 2008 dan 2015 yang diperolehi dari Jabatan Perancangan Bandar dan Desa. Ketepatan keseluruhan dan nilai pekali Kappa (nilai dalam kurungan) bagi klasifikasi LULC adalah 86.67% (0.84), 83.89% (0.81) serta 93.80% (0.93) masing-masing bagi 2001, 2007 dan 2013. Teknik pengesanan perubahan pasca klasifikasi digunakan dalam kajian ini bagi penentuan perubahan LULC. Keputusan klasifikasi menunjukkan kawasan hutan berkurang secara konsisten dari 2001 (196.08ha) hingga 2007 (180.73ha) dan sehingga 2013 (160.09ha). Sebaliknya, kawasan binaan meningkat secara konsisten dalam tempoh tersebut iaitu dari 47.77ha pada 2001 kepada 58.25ha pada 2007 dan kepada 63.43ha pada 2013. Dalam tempoh berkenaan, terdapat sedikit peningkatan dalam guna tanah pertanian dan padang rumput, walau bagaimanapun, kawasan badan air hampir tidak berubah. Secara umum, bagi kawasan tanah kosong terdapat hanya sedikit perubahan. Kawasan yang terjejas akibat tanah runtuh telah dikesan dalam imej UAV meliputi 3.66ha. Sebagai kesimpulan, kajian ini menunjukkan imej satelit optikal dan UAV boleh diproses untuk menghasilkan peta klasifikasi berketepatan tinggi bagi mengkaji perubahan guna liputan tanah, maka ianya berguna kepada pihak berkuasa tempatan untuk mengenal pasti perubahan liputan tanah seterusnya bagi mengawasi aktiviti pencerobohan tanah dan mengurangkan bencana tanah runtuh dari terjadi dan mengurangkan kesannya.

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## LIST OF ABBREVIATIONS

ASTER	-	Advance Spaceborne Thermal Emission and Reflection Radiometer
DCA	-	Department of Civil Aviation
DEM	-	Digital Elevation Model
DN	-	Digital Number
DRLP	-	Draft Regional Local Plan
DSM	-	Digital Surface Model
EOS	-	Earth Observing System
FOV	-	Field of view
GCP	-	Ground Control Point
GDEM	-	Global Digital Elevation Model
GDM 2000	-	Geocentric Datum of Malaysia 2000
GIS	-	Geographic Information System
GPS	-	Global Positioning System
IKONOS	-	No acronym, name of Spanish Earth Observation Satellite
JPBD	-	Department of Town and Rural Planning
JUPEM	-	Department of Survey and Mapping Malaysia
LIDAR	-	Light Detection and Ranging
LULC	-	Land Use Land Cover
NASA	-	Nasional Aeronautics and Space Administration
NRE	-	Natural Resources and Environment
OBIA	-	Object-Based Image Analysis
RGB	-	Red, Green, Blue
RMSE	-	Root Mean Square Error
RSO	-	Rectified Skew Orthomophic
SRTM	-	Shuttle Radar Topography Mission
UAV	-	Unmanned Aerial Vehicle

UTM - Universal Transverse Mercator  
WGS84 - World Geodetic System 1984

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## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Background of Study**

Land use and land cover change is a dynamic physical change that occurs in any area on the earth surface. The use of land can be defined as all human activities which include agriculture, forestry and construction of buildings that change the processes of the surface including geochemistry, hydrology and biodiversity. On the other hand, cover refers to the physical and biological protection on the ground, including water, vegetation, soil, and artificial structures (Ellis, 2010).

Rapid urbanization and development will affect the balance of land use in an area. In the past, the land development process that involves changing the land use from mining sector into logging, logging into agriculture, settlements and agriculture into industrial and lately change of agricultural land into modern agricultural has resulted in a relatively significant impact on the physical environment and on the people during that period. Activities carried out in such areas include agriculture, mining, industrialization and urbanization which generate direct effects of human activities that eventually create important cultural traits such as human settlements, economic activities and relationships.



Meanwhile, a negative land use and land cover area is not earned by humans; rather, such areas include wetlands and forests. The area is described as that which exists in the natural form of non-productive and economic aspects. The actions and attitudes of people directly or indirectly in the development process have led to changes in the environment particularly in terms of the physical landscape of the area.

According to Lambin *et al.*, (2001), some changes in land use are clearly in line with the process of modernization or rather, the process of rapid urbanization through industrialization, agricultural activities, building and construction, transportation, forestry and other agricultural areas such as rubber and oil palm. Goetz *et al.*, (2004) noted that rapid growth of urban areas is associated with increase in economic activity and thus provide many employment opportunities for the population. These factors have encouraged migration from rural to urban areas in order to find work.

In Malaysia, various laws and regulations have been enacted to ensure that development in the highlands is well controlled. The laws are very important and should be implemented by agencies, developers and the public as a guide in selecting, designing and building sites in mountainous terrains, high altitude areas, slopes and hilltops as well as the surrounding area to avoid the occurrence of any mishap. Topographical features should be preserved and blended with elements of the building without compromising stability, balance, harmony and natural uniqueness.

Another issue is illegal exploration of forests, especially in the permanent forest reserve due to the greed of people ignoring the rules and provisions of the existing law. This issue is often a major topic in the media. The number of complaints regarding illegal logging and encroachment of forests usually involving the activity of harvesting, clearing of land for agricultural purposes, ownership of forest products without permission and status of wooded area. The Government takes a serious view on the issue of illegal production of forest products such as sandalwood, which is not only detrimental to the government but also threatening to the extinction of the species composition of forest biodiversity.

Geographic Information System (GIS) has widely been used in monitoring changes in land use and land use planning. GIS in land use analysis does not only show the capabilities of GIS as a tool in the management of the database, but also exposes its suitability for use in the evaluation and selection of the strategic plans for land use planning of the area (Narimah and Tarmiji, 2005). In GIS, there are two types of data formats that can be used in analyzing data; they include vector and raster data (Chang, 2008). GIS can also be used to manage land use information as the data is composed of vector and raster data formats, example are lot parcel, utilities, satellite data and photogrammetry data.

Remote sensing technology is widely used in the identification of changes in land use for a given period of time. According to Herold *et al.*,(2006), advancements in remote sensing technology enable the scientists to identify sustainable land processes and land cover changes at their areas. However, one of the main challenges of this technology is to ensure that the change is not the result of short-term changes in land cover (Lunetta *et al.*, 2006; Lambin *et a.l.*, 2003).

Satellites have been demonstrated as efficient tools for continuous acquisition of earth's surface data. Due to that, the recent increase in the quality and availability of satellite images has allowed performing image analysis on a larger scale than in the past. For example, high spatial resolution satellites such as WorldView with 0.46m resolution, IKONOS with 1m resolution and Quickbird with 0.65m resolution provide 1 meter and less than 1 meter pixel resolution in the acquired imagery.

Unmanned Aerial Vehicle (UAV) is a small unmanned aircraft that can be programmed to run input-cost airlines that have been incorporated into the navigation processor on board. This small plane can communicate using radio and Global Positioning System (GPS) with ground control system. Lin (2008) stated that among the reasons for developing UAV technology are that it can be used to perform aerial photography at low elevations and can also be used during cloudy days or rainy seasons. This is because during the monsoon seasons, clouds are the main cause of disruptions in the collection of

satellite images. Therefore, this technology is the most effective to be used in Malaysia being a country that has much cloud cover.

Many developments have been carried out in Cameron Highlands due to high demand as it is a famous tourist destination. Due to high demand for infrastructural developments and agricultural production, the green area on the slopes including forest areas have turned into construction and agricultural areas. Examples of the developments undertaken are chalet, stalls and housing. Due to geographical factors, constructions still need to be carried out on slopes because there is limited availability of flat lands. Therefore, development is carried out in high-risk areas and more importantly, development continues even though it is exceeding the capabilities of the highlands.

Although many physical changes reflect the developments and bring economic benefits, they also have negative impacts such as environmental hazards and disasters. As a result, Cameron Highlands is not only exposed to soil erosion, but also to landslides and mud floods. In fact, it caused the river in the area to get shallow as a result of accommodating deposits eroded from land. The situation worsens when heavy rain occurs. More frustrating, cold weather in the area is no longer as fresh as it used to be.

## **1.2 Problem Statement**

Development has always been associated with the exploration of natural resources. Natural resources are the basic needs of development that can be used by humans for a long time if the use of these sources is controlled. Large-scale forest clearing was carried out in the name of development for a variety of purposes. Undoubtedly, it has many negative effects on the environment. More troubling, uncontrolled logging activities can create disturbance to ecosystems and reduce biodiversity. If interference is occurring in one component of ecosystems, natural processes such as the water cycle, photosynthesis,

and other parts of the natural cycle will be interrupted and will threaten the stability of the physical environment.

Cameron Highlands is a highland area that is rich in flora and fauna and popular for its cold weather. Tourism is the main economic activity in Cameron Highlands because of its beautiful view and the presence of a lot of strawberry farms and tea plantation such as the BOH plantation. Cameron Highlands has undergone phenomenal changes as a result of development. Uncontrolled developments in Cameron Highlands not only have impacts on the environment but they also affect tourism activities. Thus, if the unplanned developments continued, the forest areas will be significantly reduced.

Local media have reported the occurrence of illegal land clearing in Blue Valley; Menson Valley, Brinchang, Tanah Rata and Kampung Taman Sedia. This activities has caused the disaster such as mudslides and landslides. For example, mudslides has struck Kampung Raja, Ringlet town and Bertam Valley on 5 November 2014 causing the loss of five lives and cause damages to many house and other facilities. Following the news related to this issue, the Ministry of Natural Resources and Environment (NRE) set up an Inquiry Committee on the Issue of Land Opening for Illegal Agriculture in Cameron Highlands (Berita Harian, 2015). The government, through the NRE will continue close monitoring and comprehensively reviewing the illegal logging activities in Peninsular Malaysia, as well as take action under the National Forestry Act 1984 in the fight against illegal logging in the country.

Berita Harian (2015) also reported that according to the Ministry of Natural Resources and Environment, the air monitoring at the Cameron Highlands program is continuous throughout the year. This shows the Government's proactive actions in addressing illegal logging and forest encroachment. This development clearly shows the government's commitment to ensure that the sustainability of natural resources and the environment is always guaranteed. This monitoring warned farmers in the agricultural lands in Cameron Highlands that the Government is serious about the issue of logging and illegal land clearing.

Geographic Information System (GIS) and remote sensing technology are widely used to monitor natural disasters such as landslides and flash floods because they do not only produce an image of the monitored area but can also speed up the process of getting information on the incident. With the diversity of types and variations of scale remote sensing data, a few parameter maps can be produced, which emphasizes the movement of large distribution map (Jasmi, 1997).

GIS can also help in terms of processing speed, analysis of the danger zones and prediction of sudden hazards and disasters. In addition, GIS serves as an excellent imaging tool for monitoring purposes because of its ability to manipulate spatial data in large quantities and provide a visual result of manipulation.

In Malaysia and other tropical countries, cloud cover is a major problem in acquiring clear images. This is because the satellite's sensors are unable to penetrate the clouds and thick fog. There are some areas that are so hard to get a clear image as they are always covered by cloud and fog. This problem also occurs if the data is obtained during the monsoon season.

Satellite imagery is particularly useful in planning and overseeing a wide area, for example, to obtain an image of a region, district, state and country. But for a small area such as a county, town, township, and farm the use of satellite images is less practical and economical. Another alternative that can be used is by using the small aircraft, LIDAR and UAV.

This technology can be used to obtain images for areas that are difficult to reach such as forests and hilly areas. Furthermore, the use of UAV can provide cheap and simple system for engineering organizations for the purpose of high-frequency aerial photogrammetric survey. Advantages of using UAVs like fly below the cloud enables better image quality than satellite images as well as lower operating costs than conventional aircraft.

### **1.3 Aim and Objectives**

The aim of this study is to assess the capability of high-resolution satellite and unmanned aerial vehicle (UAV) to detect land cover changes in Cameron Highlands. The objectives of this research are:

1. To produce land cover maps in Cameron Highland from different satellite images and UAV images.
2. To analyze the efficiency of land cover changes map derived from classification of high-resolution satellite images and UAV mapping.
3. To verify the land cover changes map with reference to the available land use map in Cameron Highland.

### **1.4 Scope of Study**

The study area for this research is a part of Tanah Rata, Cameron Highlands which is located at the northwestern tip of Pahang. Cameron Highlands is one of the main tourist centers in the highlands of Malaysia. Its temperature is between 10<sup>0</sup>c to 20<sup>0</sup>c. This area is covered by forests, agricultural areas, developed areas and also dams and rivers. Recently, there have been many land use changes in the study area which caused some disasters. Therefore, remote sensing and GIS technique were used in this study area to detect the changes.

For this study, the high resolution satellite images that were used are IKONOS and QuickBird. This research investigated the suitability of the high spatial resolution satellite data in mapping land cover changes. The high- resolution image data is expected to provide more accurate land use classification. UAV is another platform to be used, and

imageries captured by it are preferred over data captured using a conventional aircraft. There are wide ranges of UAV developed for mapping purposes. The available land use map that was provided by the Jabatan Perancangan Bandar dan Desa (JPBD) was used as a reference. Land use maps derived from temporal satellite images and UAV were compared with the existing land use map based on the level of similarity.

In this study, the fixed-wing UAV was used as a platform for data collection. The software used for UAV data processing is Agisoft Photoscan that can be used to generate orthophoto image. The satellite images and UAV orthophoto image were classified. For classification process, object based classification was used to extract land cover information. E-cognition software was used for the segmentation and classification processes. Meanwhile, ArcGIS software was used for data analysis for producing land cover change maps and calculating the area of change.

## **1.5 Significance of Study**

Land use is the aspect that could be the cause in of natural disasters and impact on the activities of soil for a duration of time. Hence, awareness of the influence of land use on the part of the principle requires more attention by stakeholders, individuals and communities involved. Therefore, the existing geographic information as a factor that needs to be considered in the preparation of a plan of development in highland areas like Cameron Highlands is necessary and very important. This is to ensure that the development carried out will not cause damage to areas. In the process of preparing a plan of development in an area, among the aspect that needs to be known is land use and land cover in the area.

This study contributes in showing how effective data obtained from remote sensing techniques and UAV can provide information about land use and land cover changes in the study area. Classification of land use was generated from high resolution

satellite images to detect the changes. Land use in the study area was seen clearly when the high resolution satellite image was used. This can help to detect any changes that occur even in small areas. Furthermore, the use of high image resolution gave better accuracy of the results of classification of land use in the study area. Similarly, UAV that can capture image at low altitudes provide an advantage to capture clearly ground truth image.

It is very important to maintain the greenery of the landscape in this area. Moreover, forests are very important in stabilizing the structure of the soil in order to prevent natural disasters, in the form of landslides and flash floods, forest and land encroachment in the region. This study is expected to help certain parties such as the district office and the local authority of Cameron Highlands, Forest Department and other authorities to monitor land use changes that are taking place in Cameron Highlands.

## **1.6 Organization of Thesis**

This thesis consist of five main chapters including this first chapter (Chapter 1) covering the background of the research, problem statement, aim and objectives, scope and limitation and significant of the study.

### Chapter 2 – Literature Review

Chapter 2 reviews previous researches related to land use and land cover changes studies, application of high resolution satellite, unmanned aerial vehicle and concept of GIS and remote sensing related to this study.

### Chapter 3 – Methodology

Chapter 3 describes the research procedures and stages for the land cover change study. Precisely, it describes the technical details on the pre-processing steps, data processing of the unmanned aerial vehicle and high-resolution satellite data, classification



process and calculation of changes. The overall research methodology is shown in a flowchart. All the steps taken in this research are described based on the flowchart.

#### Chapter 4 – Result and Discussion

Chapter 4 shows the results and analysis of the research output of the processed data which are high-resolution satellite images and UAV data in accordance with the scope of the research that has been set at the beginning of the study.

#### Chapter 5 – Conclusion and Recommendation

The last chapter concludes the study; it presents the conclusions based on the achievement of the objectives. It also highlights the limitation as well as recommendations put forward for the betterment of future research.

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