UNIVERSITI PUTRA MALAYSIA

ASSESSMENT OF FOREST COVER CHANGES USING LANDSAT TM FOR LANGKAWI ISLANDS, MALAYSIA

HASZULIANA BTE MOHD. HASSAN

ASSESSMENT OF FOREST COVER CHANGES USING LANDSAT TM FOR LANGKAWI ISLANDS, MALAYSIA

By

HASZULIANA BTE MOHD. HASSAN

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Forestry Universiti Putra Malaysia

June 1999

ACKNOWLEDGEMENTS

Praise to the Allah Almighty for His blessings which enable me to complete this thesis. I would like to express my deepest appreciation to my Supervisor, Prof. Capt. Dr. Kamaruzaman Jusoff for his invaluable guidance and constructive criticisms throughout this study.

Sincere thanks is also due to Prof. Dr. Nik Muhamad Nik Ab. Majid and Assoc. Prof. Dr. Azizi Muda for their useful comments.

Special appreciation to the Director of Malaysian Center for Remote Sensing (MACRES), Mr. Nik Nasruddin Mahmood for kindly allowing the use of necessary facilities and materials during image processing and also his invaluable comments and ideas on writing this thesis. My gratitude to Mr. Shamsuddin Omar who was always ready to help.

Sincere thanks is also dedicated to my beloved family and to Zulhazman Hamzah for his support .

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

CCT	Computer Compatible Tape
DOA	Department Of Agriculture
ERTS	Earth ResourcesTechnology Satellite
FCC	False Color Composite
FELDA	Federal Land Development
F.R.	Forest Reserve
GIS	Geographical Information Systems
IFOV	Instantaneous fields of view
MACRES	Malaysian Center For Remote Sensing
MLC	Maximum Likelihood Classification
MSS	Multispectral Scanner
PC	Principal Component
PCA	Principal Component Analysis
PFE	Permanent Forest Estate
RBV	Return Beam Vidicon
SPOT	Satellite Probatoire d' Observation de la Terre
TM	Thematic Mapper

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science.

ASSESSMENT OF FOREST COVER CHANGES USING LANDSAT TM FOR LANGKAWI ISLANDS, MALAYSIA

By

HASZULIANA MOHD.HASSAN

June 1999

Chairman : Professor Capt. Kamaruzaman Jusoff, Ph.D.

Faculty : Forestry

One of the major environmental issues today is the rapid conversion of tropical forest to agriculture, pasture, human settlement, urban area, and many other land uses. Under these circumstances, the need for conservation and effective management of forest is imperative. One of the present technologies being used in the monitoring of environment changes is remote sensing. This study was undertaken to verify the suitability and capability of LANDSAT TM in monitoring forest changes on Langkawi Islands. Detection of forest cover change was performed using multi temporal LANDSAT data taken in 1992 and 1996, with the support of existing land use, topographic, and forest resource maps. The data were classified using maximum likelihood classifier (MLC) and overlay to generate forest change. Principal component analysis (PCA) was also used to detect changes where the multi temporal of six bands data were combined and treated as a single 12-dimensional data. A new set of images were obtained from a PCA color composites of PC2, PC3 and PC4 and were then classified using supervised classification to detect forest changes.

It was found that MLC and PCA gave high overall accuracy of 90 per cent. However, MLC was found to be more accurate because of its better delineation along the forest cover changes in multi temporal data. The study quantified that the rate of deforestation of Langkawi Islands is about 235.18 ha/yr with an accuracy of 93 per cent. Factors causing forest cover changes include the expansion of tourism industry, encroachment of forest areas by local people and development of socio-economic activities such as residential areas, road network, quarries, jetties and agriculture.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk mendapatkan ijazah Master Sains.

PENILAIAN PERUBAHAN HUTAN MENGGUNAKAN LANDSAT TM DI PULAU LANGKAWI, MALAYSIA

Oleh

HASZULIANA MOHD. HASSAN

Jun 1999

Pengerusi : Profesor Kapt. Kamaruzaman Jusoff, Ph.D.

Fakulti : Perhutanan

Salah satu isu alam sekitar yang sering diutarakan dewasa ini ialah pembukaan hutan tropika untuk dijadikan kawasan pertanian, perternakan, perumahan, perbandaran dan pelbagai guna tanah yang lain. Dalam keadaan ini, konservatif dan pengurusan hutan yang efektif amat diperlukan. Salah satu teknologi masa kini yang digunakan untuk pengawasan perubahan alam sekitar ialah penderiaan jauh. Kajian ini dijalankan untuk mengenalpasti kesesuaian dan keupayaan penderiaan jauh satelit LANDSAT TM dalam mengawasi perubahan hutan di Pulau Langkawi. Pengesanan perubahan kawasan hutan dijalankan dengan menggunakan data multi temporal LANDSAT TM yang diambil pada tahun 1992 dan 1996 dengan sokongan dari peta guna tanah, topografi dan sumber hutan. Data tersebut diklasifikasikan menggunakan Maximum Likelihood Classifier (MLC) dan telah di tindankan untuk mengesan perubahan hutan. Principal Component Analysis (PCA) juga digunakan untuk mengesan perubahan hutan ini di mana data multi temporal yang mengandungi enam band digabungkan menjadi satu data yang

mempunyai 12 dimensi. Satu set imej yang baru diperolehi dari komposit warna PC2, PC3 dan PC4 di mana ia kemudiannya diklasifikasikan menggunakan supervised classification untuk mengesan perubahan hutan.

Didapati kedua-dua teknik MLC dan PCA menunjukkan ketepatan yang tinggi sehingga 90 peratus. Walaubagaimanapun, MLC didapati lebih tepat berbanding dengan PCA kerana teknik ini memberikan gambaran garisan kawasan hutan yang lebih menonjol dalam penggunaan data multi temporal. Kajian ini mendapati bahawa kadar penyahutan di Pulau Langkawi adalah 235.18 ha/tahun dengan ketepatan 93 peratus. Faktor yang mempengaruhi pembukaan kawasan hutan di Pulau Langkawi ialah perkembangan pesat industri pelancongan, pencerobohan kawasan hutan oleh penduduk tempatan dan pembangunan sosio-ekonomi seperti pembinaan kawasan perumahan, jalinan jalan raya, kawasan kuari, jeti dan kegiatan pertanian.

CHAPTER I

INTRODUCTION

General

Tropical rain forests are the richest ecosystems that the world has ever known. They cover only seven percent of the world's land surface yet they probably contain over half of the species of plants and animals on earth. This rich assembly of species provides a great variety of foods, medicines, industrial products as well as environmental services such as flood control, soil protection and climate regulation. The land that the forests occupy, and the value of just one of their many useful products, that is timber, are the reasons why they are rapidly decreasing.

Malaysia has been fortunate to be endowed with extensive areas of valuable natural tropical rain forests with are extremely complex ecosystems and are richer in tree species than in similar areas of Africa and south America. They are, in fact, the richest community known anywhere in the world and the flora estimated to compromise 8,000 species of flowering plants, of which 2 500 are tree species, 90 of them reaching harvestable sizes of at least 45 cm diameter at breast height. Of these 890 species, a total of 408 been marketed to international markets under the Malaysian Grading Rules. In

addition, well over 800 species of non-flowering plants have also been recorded (Thang, 1993).

Malaysia has perhaps the finest record of forest management of any tropical countries, and is the only one undertaking significant programs of silvicultural treatment (Collins *et al.*, 1991, Schmidt, 1991). Dipterocarps, which dominate the forests of Southeast Asia, have a number of characteristics that allow foresters to manage these forest resource bases through intensive forest management and development, as well as to the modernization of forest industries to produce higher value-added products.

It is reasonable to predict that tropical forest resources will continuously contribute significantly to socio-economic development of this country. However, Malaysia is also fully aware that the conversion of land for this purpose has been carried out at the expense of the forests. Over the period 1983-1995, the total forested land in Peninsular Malaysia has been reduced to 5,991 389 hectares (ha) or 45.52 percent from 6,373, 064 ha or 48.14 percent of its total land areas (Anon, 1995). The loss of 3,820,000 ha of forested land was mainly due to agricultural, urban and infrastructurally development and the construction of hydroelectric dams (Thang, 1993).

There is a growing awareness of tropical forest's importance and prudent measures have been undertaken to ensure its conservation and management. Malaysia has made serious efforts of this respect, even without any pressure from international agencies. Thus, the forest of Malaysia is

managed under strict and technically sound forest management objectives to ensure sustainable timber production, the conservation and protection of biological diversity, the rational and sustainable utilisation of the biological resources, the maintenance of an equable climate, and ecological and environmental balance as sound environmental conservation is a prerequisite for sustainable forest production. Consequently, the need of reliable technology to assess the status of forest is important. Hence, the use of satellite imageries in forestry in Malaysia is gaining momentum in recent years as there is a need to monitor and control the effects of irreversible forest land use changes on the environment, as well as, the need to ensure optimum use of a given forest land.

Satellite remote sensing has become a powerful and sometimes indispensable tool for forest resource inventory, monitoring and management as well as for other development purposes. It provides a reliable and fast information within affordable costs for quick decision making (Kamaruzaman and Jalil, 1993). Through the use of successive satellite imageries ongoing forest resources information for a particular forest can be obtained.

Studies conducted in Malaysia have shown that forest depletion and disturbances such as conversion to agricultural crops, abandoned land and bare soil, as well as, recently logged-over forest areas especially those that had been intensively harvested could be detected and mapped from LANDSAT and SPOT data. In fact, through the integration of remote sensing and Geographic Information System (GIS), LANDSAT TM imageries were

able to update Forest Resources Map of scale 1:250 000 that were produced under the second forest inventory of Peninsular Malaysia, for example; the Lesong Forest Reserve covering an area of 62,270 ha in Pahang, for the years 1982 and 1988 (Zahriah *et al.,* 1989), and for the Ulu Langat and Sungai Lalang Forest reserves, covering an area of 32,310 ha in Selangor, for the years 1982, 1988 and 1990 (Zahriah *et al.*, 1991).

Moreover, the Forestry Department had set up a continuous forest monitoring system integrating remote sensing and GIS. This is to enable its Headquarters to update continuously the forest resources of Peninsular Malaysia using ERDAS image analysis system and ARC/INFO GIS database (Thang, 1993). This would enhance the capability of Malaysian government to monitor the changes in forest land use patterns, in minimizing the adverse effects of such irreversible changes on the environment. In this regard, for Malaysia, the long-term viability for sound management of its forests will be one that balances the needs of the economy, environment and ecology.

Statement of Problem

One of the major environmental issues today is the accelerating conversion of tropical forest to agriculture, pasture, human settlement and many other land uses. The pattern of change in tropical forest brought about by many different agents operates at different spatial scale; some effect individual trees, others the whole population; and some may effect a part or all

of the forest. The depleted and secondary forests are rapidly increasing in extent as a result of human activities all over the tropics.

The exploitation of forest resources for Malaysian natural forest has started long time ago. In the case of Langkawi islands, the total forested land is getting smaller and smaller each year, giving away to agriculture, human settlement, development and logging activities.

In a fast developing island, such as Langkawi, a rapid rate of natural resource exploitation is often necessary for socio-economic advancement. The forest harvest generates much needed funds for development while the land provides opportunities for gainful employment and creation of new wealth. However, this trend has given rise to fears impending forest areas crisis and considerable concern for environmental stability and quality. Under these circumstances, the need for conservation and effective management of forest in Langkawi is imperative.

One of the present technologies being used in the inventory of natural resources in Malaysia is remote sensing. Remote sensing technology has now been increasingly accepted as the technology that facilitates faster and more up-to-date monitoring of the earth atmospheric system (Chong *et al*., 1991). It also serves as an early warning system, which enables the resource manager to react quickly to the rapidly changing environment, especially prevalent where human activities often modify the landscape and the renewable resources. This study intends to verify the suitability and capability of one type

of satellite remote sensing data i.e. LANDSAT TM in monitoring forest changes.

Objectives

The primary objective of this study is to assess the suitability of satellite remote sensing data i.e. LANDSAT TM in monitoring the status of forest resources in Langkawi islands. The secondary objectives of the study are four folds:

i. To identify and quantify the extent of forest cover in Langkawi islands.

ii. To identify and quantify the changes in forest cover.

iii. To determine the factors influencing forest changes.

iv. To produce the latest forest map status of Langkawi islands.

CHAPTER II

LITERATURE REVIEW

Changes in Tropical Forest Environment

Environmental change is an enduring facet of human history. Vegetation, soils, fauna, water, climate, landforms are all the major components of the biosphere which have been profoundly altered by human activities. In the mid latitudes, for example, cultivated landscapes and urban system sprawl over regions where once great forests held sway. Little of the natural vegetation remains (Aiken and Leigh, 1992).

In the beginning of the last decade it was realized that changes in tropical forest cover occur at an accelerated rate and the proportion of the area under tropical forest cover has continually declining during the recent years. The nature and dimension of the problem has caught global attention not only due to economic reasons but also due to ecological considerations since forests are predominantly ecological units which may be effecting the stability of the biosphere.

Definition

What is tropical rain forest? The term 'rain forest' has been established in the literature that it is retained in the broad sense. Schimper (1903) noted that rainforest is `evergreen, hygrophilous in character, at least 30m high, rich in thick-stemmed lianas, an in woody as well as herbaceous epiphytes'.

The more recent and similar definition is that of Baur (1964), who terms it as 'a closed community of essentially but not exclusively broadleaved evergreen hygrophilous trees, usually with two or more layers of trees and shrubs and with dependent synusiae of other life forms such as vines and epiphytes. It includes the characteristic vegetation of the humid tropics even where this has a somewhat seasonal climatic regime, as well as those of moist elevated areas of the tropics'.

Myers (1992) defined tropical forest as 'evergreen or partly evergreen forests, in areas receiving not less than 100 mm of precipitation in any month for two out of three years, with mean annual temperature of 24-plus °C and essentially frost-free; in these forests some trees may be deciduous; the forests usually occur at altitudes below 1300 m'. In short, tropical rain forest is characteristic natural vegetation of the humid per low latitudes. It laid between 28° 27' north and 23° 27' south contains about 40% of the earth's surface. About 50% of the global forests are located in the tropics. The rest are found in the extra tropical latitudes (UNEP, 1980).

Forested land is 'deforested' in the sense that the forest vegetation is removed and does not spontaneously return by regeneration and succession back to the previous state (Bruenig, 1985). This happens in the following circumstances:

1. The forest vegetation and site are completely destroyed by a singular event which is so disruptive and massive that it creates conditions which preclude spontaneous recuperation. Examples are landslides, lava flow and repeated spontaneous fire.
2. A singular disturbances of a fast-acting factor is followed by a continued disturbance by the impact of another factor. Examples are the opening of forests by selective logging, which is followed by cropping, grazing or burning by accident or for hunting purposes.
3. A slow-acting exogenous factor impinges on the system and gradually reaction builds up through first a latent, and then a chronic phase until an additional fact-acting factor initiates the acute phase of collapse. Examples are emission or internal production and accumulation of ecologically-active chemicals (such as pollutants, allelopathic substances, and humid acids) which are amplified by the interacting effects of climatic or other extremes (drought, pests, diseases, fire and soil erosion).

In all other cases of disturbance, 'destruction' will be followed rapidly by restoration of the forest through succession.

Scale Of Forest Changes

Worldwide, all tropical countries have experienced a massive increase in the rate of deforestation since Second World War. Many countries which are now virtually stripped of their forests were once heavily forested. Tropical Asia's forests and woodlots covered an estimated 569,000,000 ha in 1850. This, has been reduced to some 493,000,000 ha by 1950, representing a reduction in forested area by approximately 14 percent during 100 years. From 1950 to 1980, or within 30 years, the forested area had shrunk further by 15.8 percent (World Resources Institute and International Institute For Environment And Development,1987).

According to Kashio (1993), 16,900,000 ha of closed and open forests were cleared annually in tropical countries during the 80s, at a rate of 0.9 percent per year (Table 1). This is to be compared with the estimate of the deforestation rate during the late 70s of the 11,300,000 ha (or 0.6 percent) per year as cited in the 1980 Forest Resources Assessment (FAO, 1981).

The rate of destruction of forests thus accelerated enormously during the second half of the Twentieth Century. By region, the rate of elimination of forest resources was more than six times as high in southern Asia as a whole as it was in Southeast Asia (Thapa and Weber, 1990).