UNIVERSITI PUTRA MALAYSIA

# THE USE OF LANDSAT TM IN ASSESSING FOREST AREA CHANGE IN SELANGOR, MALAYSIA

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By

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

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## ABBREVIATIONS

| | |
|---|---|
| AVHRR | Advanced Very High Resolution Radiometer |
| CTT | Computer Compatible Tape |
| CNES | French Centre National d'Etudes Spatiales |
| DOA | Department Of Agriculture |
| DTM | Digital Terrain Model |
| ERTS | Earth Resources Technology Satellites |
| FCC | False Color Composite |
| FD | Forestry Department |
| FDHQ | Forestry Department Headquarters |
| FELDA | Federal Land Development Agency |
| FOB | Freight On Board |
| F.R. | Forest Reserve |
| FRIM | Forest Research Institute Of Malaysia |
| GAC | Global Area Coverage |
| GDP | Gross Domestic Product |
| GIS | Geographical Information System |
| GNP | Gross National Product |
| HRV | High Resolution Visible |
| ITTO | International Tropical Timber Organization |
| LAC | Local Area Coverage |
| LANDSAT | Land Satellite |
| LUT | Look Up Table |
| MACRES | Malaysia Centre For Remote Sensing |
| MLC | Maximum Likelihood Classification |
| MSS | Multispectral Scanner |
| NDVI | Normalized Difference Vegetation Index |
| NEP | New Economy Policy |
| PFE | Permanent Forest Estate |
| RBV | Return Beam Vidicon |
| RCFM | Regional Centre For Forest Management |

| | |
|---|---|
| SFD | Selangor Forestry Department |
| SFM | Sustainable Forest Management |
| SPOT | Systeme Pour l'Observation de le Terre |
| TM | Thematic Mapper |
| VI | Vegetation Index |

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

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

**Faculty : Forestry**

The rate of development due to industrialization and human settlement in the state of Selangor has accelerated tremendously in recent years, with a corresponding escalation in the rate of depletion of the forest areas. This trend has given rise to fears of impending depletion of forest areas and considerable concern for environmental stability and quality. Under these circumstances, the need for conservation and effective management of the forests in Selangor is imperative and cannot be under emphasized. One fundamental set of tools crucial in assessing forest cover changes will be the data provided by remote sensing. This study was undertaken to assess forest area changes in Selangor using satellite remote sensing technology. Detection of forest area change was performed using multitemporal LANDSAT data taken in 1993 and 1996, with the support of existing land use, topographic, and forest resource maps. The data were initially analyzed using Normalized Differences Vegetation Index (NDVI) in order to get a preliminary scenario of the change in forest

cover. The data were then classified using Maximum Likelihood Classification (MLC) and overlaid to generate forest change. A total of 39 ground reference points were selected randomly and visited in ground truthing work. Results from this ground truthing showed that forest types can be identified and discriminated easily in LANDSAT TM data.

The study quantified that within 1993 to 1996 the loss of inland forest was about 2 824.5 ha which implies 941.5 ha per year of inland forest have been converted to other land use types. Peat-swamp forest and mangrove forest have also been reduced by 655.2 ha and 4 738.5 ha, which account for an annual loss of 218.4 ha and 1 579.5 ha, respectively. This means a total of 8 218.2 ha of forest areas in Selangor have been converted to other land use types between 1993 to 1996, which implies an annual loss of about 2 739.4 ha, with an accuracy of 84.2 percent. Factors causing forest cover changes include industries, human settlement, logging activities, aboriginal areas, agricultural, recreation and tourism, livestock and illegal settlement areas.

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

**PENGGUNAAN LANDSAT TM BAGI MENILAI PERUBAHAN KAWASAN HUTAN DI SELANGOR, MALAYSIA**

Oleh

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**Fakulti : Perhutanan**

Dewasa ini, kadar pembangunan perindustrian dan kawasan penempatan di Selangor semakin bertambah, mengakibatkan kemerosotan terhadap kawasan-kawasan hutan. Keadaan ini telah mencetuskan kebimbangan terhadap kemerosotan kawasan hutan ini dan pertimbangan yang sewajarnya harus diberikan terhadap kestabilan dan kualiti alam sekitar. Dalam keadaan ini, keperluan kepada pemuliharaan dan keberkesanan pengurusan hutan di Selangor adalah sangat dikehendaki. Salah satu daripada alat yang penting dalam penilaian perubahan kawasan hutan adalah data yang dibekalkan oleh alat penderian jauh. Kajian ini dijalankan untuk menilai perubahan kawasan hutan di Selangor menggunakan satelit penderiaan jauh. Pengesanan perubahan kawasan hutan diadakan menggunakan data LANDSAT multitemporal yang diambil

pada tahun 1993 dan 1996, dengan bantuan peta gunatanah, topografi dan sumber hutan.

Data ini pada mulanya dianalisa menggunakan keadah Normalized Difference Vegetation Index (NDVI) untuk mendapatkan gambaran awal mengenai keadaan perubahan kawasan hutan yang berlaku. Data ini kemudiannya diklasifikasikan menggunakan kaedah Maximum Likelihood Classification (MLC) dan ditindankan untuk memperoleh perubahan kawasan hutan. Sebanyak 39 titik sampel di lapangan telah dipilih secara rawak dan dilawati semasa kerja-kerja di lapangan. Keputusan daripada kerja-kerja lapangan ini menunjukkan bahawa jenis-jenis hutan boleh dikenalpasti dan dibezakan dengan mudah menggunakan data LANDSAT TM.

Kajian ini mendapati bahawa di antara tahun 1993 dan 1996 terdapat kemerosotan hutan darat sebanyak 2 824.5 ha iaitu 941.5 ha setahun kawasan hutan darat telah ditukar menjadi lain-lain jenis guna tanah. Hutan paya gambut dan paya laut juga telah berkurangan sebanyak 655.2 ha dan 4 738.5 ha, di mana jumlah kemerosotan tahunan adalah sebanyak 218.4 ha setahun bagi hutan paya gambut dan 1 578.5 ha setahun bagi hutan paya laut. Ini menunjukkan bahawa di antara tahun 1993 dan 1996 sebanyak 8 218.2 ha daripada luas hutan di Selangor telah ditukarkan menjadi lain-lain jenis guna tanah, di mana kemerosotan tahunannya

adalah sebanyak 2 739.4 ha setahun, dengan ketepatan sebanyak 84.2 peratus. Faktor-faktor yang menyebabkan perubahan kawasan hutan ini adalah termasuk perindustrian, kawasan penempatan, kegiatan pembalakan, kawasan untuk orang asli, pertanian, kawasan rekreasi dan pelancongan, ternakan dan kawasan setinggan.

# CHAPTER I

# INTRODUCTION

## General

Tropical rain forest thrives in the warm, wet environment of the humid tropics. It has high rainfall and moderately high temperatures throughout the year. The high rainfall, generally averaging 1 800 to 4 000 mm per annum and at least 1 200 mm results from the ascent of warm moist air due to thermal convection and the meeting of the two sets of trade winds that flow towards the equator from subtropical latitudes (30-40° North and South). The fairly even distribution of solar radiation during the year leads to constant high temperatures with little variation; mean monthly temperatures are generally 24-28°C (Grainger, 1993).

Malaysia is divided into three distinct regions; Peninsular Malaysia (P. Malaysia), encompassing twelve states, and the states of Sabah and Sarawak in northern Borneo. Forest endowments vary greatly between these areas, and state governments are largely autonomous in managing land and forest. The total area of natural forest in Malaysia as at the end of 1994 was estimated to be 19.0 million ha or 58.0 percent of the total land area, with the proportion of forested land being higher in Sabah and Sarawak than in P. Malaysia (Abdul Rashid and Koh, 1996)

The tropical rain forest of Malaysia is one of the oldest and highly complex ecosystem which is rich and varied in plant and animal life. The forest plays a significant role in economic development of the country, especially in foreign exchange earnings, government revenues, the development of local wood-based and related industries and employment. Apart from these, the forest maintains environmental stability of the country and is a store house of plant and animal species in such a way their richness and diversity have been considered to be the centre of origin and diversity of many present day and future crop plants (Chin and Lai, 1993).

Although the tropical rain forest of Malaysia is generally taken to be synonymous with the species-rich lowland and hill dipterocarp forests that extend over large parts of the country, there are other forest types such as the montane forest, mangrove and peat-swamp forests. In 1994, forest cover of P. Malaysia extended over an area of about 6.0 million ha., constituting 45.6 percent of the total land area (Anon, 1994).

The forest resources in Malaysia have been systematically managed for the sustained production of timber and other services. The two most prominent and current management approaches by the Forestry Department are the Malaysian Uniform System (MUS) and the Selective Management System (SMS). The MUS is basically a system which converts the virgin tropical lowland forest which is rich, complex multi-species and multi-aged forest to a more or less even-aged forest containing a greater proportion of the commercial species. The MUS is achieved by felling all trees exceeding

45 cm dbh for selected species and abounding the forest to natural regeneration through growth of seedlings. This may be followed by systematic poisoning of "defective relics and non-commercial species" to 15 cm dbh (Thang, 1987). The mangrove forest areas are also being managed to achieve maximum sustained yield of wood for charcoal, fuel wood and poles. The mangrove rotation cycle varies from 20 to 30 years.

In order to manage natural resources efficiently, concerned agencies as well as the Forestry Department (FD), Forest Research Institute of Malaysia (FRIM), Regional Centre for Forest Management (RCFM) and Malaysia Centre for Remote Sensing (MACRES) have focused attention on developing more effective techniques for monitoring and surveying of tropical forest. One of the present technologies being used in Malaysia is remote sensing. However, although the government is aware of its potential and usefulness, remote sensing technology is still in its infancy. To date, only few studies have been carried out on the use of practical remote sensing method in monitoring forest resources, especially in detecting forest disturbances and cover types, rates of deforestation, and assessment of logged-over forest for forest plantation development planning (Abdul Haye, 1993; Mohd. Rasol, 1994; Zulhazman, 1995).

## Statement of Problems

Tropical forests are being cleared at the rate of 140 000 $km^2$ to 200 000 $km^2$ per year (Houhgton, 1990) for agriculture, timber exploitation, pasture and land speculation. The detrimental impacts of extensive forest conversion on rural communities, plant diversity, soil, wildlife, watershed and ultimately global climatic patterns are very serious. For the estimated 50.0 million people who live in the forests and who depend on the forests for their survival, the effects on them are even more immediate and tragic. Every day they witness their homes being bulldozed and their food and water supplies destroyed, whether for dam construction, mining activities, highways, or for timber extraction (Peng, 1992). The current rates of change may mean nearly complete loss of the extent of tropical forests for much of the world over the next few decades. Some countries formerly rich in forests now have little or no primary forest left.

P. Malaysia has probably the most reliable forest loss figures in Asia because most of the forest destruction is government controlled (Hurst, 1992). The total forested area in P. Malaysia is getting smaller each year, giving way to agriculture, human settlement development and logging purposes. In 1983, the total forested area was 6 373 064 ha. However, in 1993, it was reduced by 5.5 percent, to 6 024 008 ha (Anon, 1993).

The loss of 2.0 million ha. of forested land or 0.14 million ha. annually over the period 1979 to 1992 was due to agricultural development and

to a lesser extent urban and infrastructural development, and in hydro-dam construction. At the end of 1992, Malaysia had a total of 4.5 million ha. of agricultural tree crops. These are mainly rubber, oil palm, coconut and cocoa. Increasingly these crops can be looked upon as alternative sources of wood supplies especially that of rubber wood (Thang, 1993).

In Selangor, the rate of industrialisation and human settlement have accelerated tremendously, with a corresponding escalation in the rate of depletion of the forest areas. According to statistical data issued by Forestry Department of P. Malaysia, in 1993, the total Permanent Forest Estate (PFE) was 247 342 ha. However, in 1997, it was reduced by 1 percent to 246 780 ha (Anon, 1997). Being one of the most developed states in P. Malaysia, many human settlements and new townships were developed. Forest areas were also opened up for the construction of new highways. These trends which will be aggravated by the growing population and increasing industrialization, have given rise to fears of impending depletion of forest areas and considerable concern for environmental stability and quality. Under these circumstances, the need for conservation and effective management of the forests in Malaysia, with special emphasis to the state of Selangor is imperative.

One fundamental set of tools crucial in assessing forest cover changes will be the data provided by remote sensing and the data management capacity of Geographic Information System (GIS). Current trends in technology indicate that remote sensing and GIS will play a

greater role in forest monitoring. Recent advances include an increasing number of useful earth observing satellites, the advent of radar satellites, and major improvements in our ability to manage the vast quantities of data will be available to further monitor changes in the forest cover over certain period of time. Remote sensing will become increasingly indispensable in Malaysia for the effective conservation, management and development of its resources (Khali Aziz, 1991).

## Objectives

The general objective of this study is to monitor and assess forest area changes in the state of Selangor using satellite technology. The specific objectives are to:

1. identify and quantify forest changes,
2. determine the factors influencing forest changes, and
3. produce a current forest map for the state of Selangor.

# CHAPTER II

# LITERATURE REVIEW

## Forest Changes in Malaysia

The New Economy Policy (NEP) had important implications for forests because, among other things, it sought to increase access of the poor to land and to modernize rural life. One result was a great proliferation of federal and state agencies and authorities. This section focuses on the three main processes of anthropogenic forest change, namely; agricultural development, timber exploitation and urbanization. Tables 1 and 2 provide some information of forest changes and total land area in Malaysia.

Table 1: Status of Forest Changes in Malaysia (million. ha.)

| Year | Total Land Area | Forested Area | Percentage (%) | Annual Forest Change (million ha) |
|---|---|---|---|---|
| 1980 | 32.9 | 20.54 | 62.3 | nil |
| 1983 | 32.9 | 20.30 | 61.7 | -0.24 |
| 1986 | 32.9 | 20.40 | 62.0 | +0.10 |
| 1987 | 32.9 | 20.20 | 61.4 | -0.20 |
| 1988 | 32.9 | 20.10 | 61.1 | -0.10 |
| 1989 | 32.9 | 19.47 | 59.2 | -0.63 |
| 1990 | 32.9 | 19.42 | 59.0 | -0.05 |
| 1991 | 32.9 | 19.24 | 58.5 | -0.18 |
| 1992 | 32.9 | 19.21 | 58.4 | -0.03 |
| 1993 | 32.9 | 19.17 | 58.3 | -0.04 |
| 1994 | 32.9 | 18.80 | 57.1 | -0.37 |
| 1995 | 32.9 | 19.01 | 57.8 | +0.21 |
| 1996 | 32.9 | 18.87 | 57.4 | -0.14 |
| 1997 | 32.9 | 20.53 | 62.4 | +1.66 |

Source: Abdul Rashid and Koh (1996); Anon (1998)