**UNIVERSITI PUTRA MALAYSIA**

# QUANTIFYING DEFORESTATION IN PERMANENT FOREST RESERVE (PFR) IN NORTHERN KELANTAN USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

**IWAN SETIAWAN**

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**By**

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

**Faculty : Forestry**

A study was carried out to monitor and quantify deforestation using remote sensing and GIS in the Permanent Forest Reserve (PFR), in northern part of Kelantan, Malaysia (latitudes 04°30'N to 06°15'N and longitudes of 101°20'E to 102°40'E). The PFR boundary map published by Kelantan State Forestry Department in 1989 was digitized using ARC/INFO 3.4.2 GIS software and used as basic data in the study. A Landsat TM image of 1997 of northern part of Kelantan (127/56 path and row) was enhanced, classified and vectorized using PCI 6.2 and ER Mapper 6.0 software to monitor and quantify deforestation. The extent of the forested area extracted from the Landsat TM images of 1997 was about 329,349.23 ha. Results indicated that about 73,236.16 ha of the PFR area had been converted into non-forestry purpose within eight years (1989-1997). The rate of deforestation was 2.27% per year. The PFR's area extent declined from 402,585.39 ha in 1989 to 329,349.23 ha in 1997. The change from forest into mixed crop or rubber within eight years (1989-1997) was estimated to be 19,252.07 ha. However, about

53,984.09 ha of forest were changed into shrubs, while approximately 1,178.49 ha of forest were changed into grassland/open areas.

Deforestation was mostly located close to transportational features like roads, logging roads and rivers. The forest's accessibility plays an important role to support the presence and extent of deforestation. Generally, the deforested areas were located in radius of 1 km from the roads, rivers or both. Although, the Landsat TM image was not capable to differentiate between rubber and secondary forest or shrub, the deforested areas were detected easily using this image. This indicated that remote sensing and GIS techniques are reliable methods in the detection, monitoring and quantification of deforestation and the extent of forested areas. Persistent cloud-cover over the southern part of the study area was unavoidable problem. The use of high-resolution radar satellite data was recommended in future study in order to avoid the atmospheric or climatological interference.

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

**PENGUKURAN PELUPUSAN HUTAN DI DALAM HUTAN SIMPAN KEKAL DI BAHAGIAN UTARA KELANTAN MENGGUNAKAN PENDERIAAN JAUH DAN SISTEM MAKLUMAT GEOGRAFI (GIS)**

Oleh

**IWAN SETIAWAN**

**Februari 2001**

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Satu kajian untuk memantau dan mengukur pelupusan hutan menggunakan pederiaan jauh dan GIS telah dijalankan di hutan simpan kekal (HSK), bahagian utara Kelantan, Malaysia (garis lintang 04°30'U ke 06°15'U dan garis bujur 101°20'T ke 102°40'T) di mana kegiatan pelupusan hutan telah dilaporkan. Peta sempadan HSK berkenaan yang diterbitkan dalam tahun 1989 oleh Jabatan Perhutanan Negeri Kelantan telah "didigitalkan" menggunakan perisian GIS ARC/INFO 3.4.2 dan digunakan sebagai data asas kajian ini. Satu imej Landsat TM (127/56) tahun 1997 untuk kawasan utara Kelantan telah dipertingkatkan, dikelaskan dan "divektorkan" menggunakan perisian-perisian PCI 6.2 dan ER Mapper 6.0 untuk tujuan pemantauan dan pengukuran pelupusan hutan. Keputusan telah menunjukkan dengan jelas bahawa seluas 73,236.16 ha kawasan HSK telah ditukar kepada penggunaan bukan-hutan dalam jangka masa lapan tahun (1989-1997). Keluasan kawasan berhutan yang diperolehi dari imej 1997 Landsat TM adalah dianggarkan 329,349.23 ha. Kadar pelupusan hutan adalah 2.27% setahun. Keluasan kawasan HSK berkurang dari 402,585.39 ha dalam tahun 1989 kepada 329,349.23 ha dalam

tahun 1997. Perubahan daripada hutan kepada tanaman campuran atau getah dalam jangka waktu lapan tahun itu (1989-1997) dianggarkan sebanyak 19,252.07 ha, yang mana 53,984.09 daripada hutan telah ditukar ke belukar, sementara 1,178.49 ha untuk hutan telah ditukar ke kawasan terbuka atau padang rumput.

Pelupusan hutan kebanyakannya tertumpu kepada kawasan-kawasan berhampiran sumber fisikal bercirikan pengangkutan seperti jalan raya, jalan balak dan sungai. Kebolehcapaian kawasan hutan memainkan peranan penting untuk menyokong kehadiran dan keluasan pelupusan hutan. Secara amnya, kawasan-kawasan yang telah dibalak terletak dalam lingkungan 1 km dari jalan raya, sungai atau kedua-duanya. Walaupun imej Landsat TM tidak boleh membezakan antara getah dan hutan sekunder atau belukar, kawasan-kawasan yang telah dibalak boleh dikesan dengan jelas menggunakan imej ini. Ini menunjukkan bahawa teknik penderiaan jauh dan GIS adalah kaedah-kaedah yang boleh dipercayai dalam pengesanan, peninjauan dan pengiraan keluasan kawasan berhutan dan pelupusannya. Awan-awan yang sentiasa hadir di bahagian selatan kawasan kajian menunjukkan perlunya untuk memperolehi sumber-sumber data radar yang tidak diganggu oleh keadaan atmosfera atau cuaca untuk kajian masa hadapan.

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science.

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# CHAPTER I

# INTRODUCTION

## General

The forests of Peninsular Malaysia are a major renewable natural resource, which make a significant financial contribution to the economy. Forested areas of Peninsular Malaysia cover 5.8 million ha which is equivalent to 44% of the land area. From the total forested areas, 5.3 million ha are designated as Permanent Forest Reserve (PFR) or Wildlife Reserve, including Taman Negara (The National Park) (Anon, 1993). It plays an important role in the ecological environment of the country. The function of tropical rain forest is not only limited for producing timber but also for environmental stability, erosion control and provision for numerous social needs and has largely contributed to its socio-economic development. The present area, however, has been extensively cleared mainly for conversion into agricultural lands, mining activities, recreational, and industrial development and indiscriminate logging, especially in the lowlands where only patches of primary forest still remain.

The degraded forest areas will take a longer time to revert to economically productive forests, even with the normal silviculture treatments and enrichment planting with indigenous species. On the other hand, some programs of reforestation and plantation have been conducted during the last few years.

Environmental problems including deforestation, soil erosion, salinity, prolonged drought and floods have become increasingly recognized in the past 20 years. However it is only in recent years that the magnitude of economic and social costs has been widely recognized. The lack of recognition and in many cases, the effects of actions taken without adequate knowledge have often adversely affected the environment. Environmental conservation and restoration has become a government policy in almost every country. The dimensions of conservation and restoration action vary considerably according to the local situation, and are largely determined by the available resources. Amelioration approaches being addressed include revegetation, rehabilitation, reclamation, management systems, establishment of protected areas and control of forest encroachment (Pinoyopusrerk, 1998).

The development of land use is rapidly changing due to economic improvements. The availability of the most recent land use information is very useful and necessary for administration, monitoring and management for decision making and planning. With advanced technology of remote sensing and GIS, the mapping process can acquire spatial information more efficiently, quickly and easy to re-check.

Remote sensing and GIS have become important tools to inventory and monitor natural resources. Forest inventory is the procedure for obtaining information on the quantity and quality of the forest resources and other characteristics of the land area. Monitoring the changes in forest resources is done to maintain current inventories, test the implementation of policies and analyze trends for planning purposes.

## Problem Statement

Many ecosystems are subjected to increase degradation in one way or another by encroachment from man. In the case of tropical humid forest, it is rapid loss is due to many causes especially conversion to agriculture, settlements, and industrial development. Land is one of the basic natural resources for development and progress. However, the impact of world population increase and demand for timbers had resulted to a certain extent, the shrinkage of forestlands particularly in the tropics. Lately, to some extent much of the forestlands were degraded. The major causes of forestlands degradation are fairly well understood. The main concern here are those areas within the Permanent Forest Estate (PFE) which had been resulted from encroachment, shifting cultivation, uncontrolled exploitation of timber. Major change in land use within environmental, social, economic condition may limit option for use of land resources. In Malaysia, the need for new dimension of land mapping is getting more important. The demand for storage, analysis and display of complex and voluminous environmental data in recent years is increasing.

Today, forestland degradation is becoming a major problem threatening the sustainability of forest and its productivity potential. As of end 1989, a total of approximately 4.6 million ha of degraded secondary forests exist and distributed all over the country (Kamaruzaman and Ibrahim, 1994). Rehabilitation and management of these degraded secondary forestlands had been the focus of many meetings. Unfortunately, forest degradation issues have not been met by a commensurate number of practical initiatives aiming at planting and implementing a proper rehabilitation system. Insufficient data, financial problem and lack of specific skilled work force and appropriate technology in the agencies concerned contribute to the lack of practical implementation of rehabilitating degraded forestlands.

The total land area of Kelantan State is approximately 1,493,181 ha. Of this, 894,276 ha are forested areas of which about 626,372 ha of the total are Forest Reserves and the remainder is Government Forest and Taman Negara (The National Park). This implies that 60% of the total land in Kelantan is still forested area and of which 42% is under forest reserve (Anon, 1993).

Until 1993, a total of 48,135.50 ha of forest reserves in this state has been encroached. The main causes of forest encroachment in Kelantan are slash-and-burn (4,884 ha) and opening up of agriculture land (23,128 ha) (Anon, 1993). Due to the unavailability of data from 1993 onwards, this study is necessary to be conducted in order to monitor and quantify the rate of deforestation in Kelantan.

## Objectives of The Study

The general objective of this study is to assess the usefulness of integrating remote sensing data and GIS in quantifying and monitoring deforestation in Kelantan, Malaysia.

The specific objectives of the study are:

1. To quantify the extent of Permanent Forest Reserve (PFR) in Northern Kelantan.
2. To identify the causes of deforestation in PFR.
3. To produce a digital map of deforestation in Northern Kelantan.

# CHAPTER II

# LITERATURE REVIEW

## Deforestation

Deforestation is defined as the temporary or permanent clearance of forest for agriculture or other purposes. This is compatible with FAO's definition (Lanly, 1982). The key word here is clearance, if forest is not cleared the deforestation does not take place. Often, but not always, forest is cleared so it can be replaced by another land use, such as cattle ranching. Tropical deforestation is more a land use problem than merely a forestry problem and it usually takes place so that forest can be replaced by another land use (Grainger, 1993).

In many temperate regions of the world, forests have been severely depleted. It has been estimated that one-third of the temperate broadleaved forest have been lost since the dawn of agriculture. Continental Europe was still 90% forested during Roman times. Today, West Germany is 30% forested, Italy 27% and France 25%. In Britain, forest cover is down to a mere 9 %. Western Europe has lost almost 70 % of its forests since Roman times (Anon, 1990).

Worldwide, all tropical countries have experienced a massive increase in the rate of deforestation since the Second World War. In the early 1980s, The United Nations Food and Agriculture Organization (FAO) estimated that annual rate of deforestation was just over 100,000 $km^2$ (10 million ha) a year. However, the figure did not include area where primary forest had been degraded but not completely destroyed (for examples, areas which had been logged over but where some trees had been left standing). In 1987, FAO reassessed its figures where some 58 million ha of "productive closed broadleaved forest" were cleared, along with 13 million ha of commercially unproductive forest, making a total of 71 million ha for the period 1980-1985. That translates into an annual rate of 14.2 million ha for all forests and 11.6 million ha for productive broadleaved forest alone-the equivalent of more than 31,500 ha/day or an area the size of Great Britain a year. In 1989, the annual rate of tropical forest loss was at 142,000 $km^2$ (Anon, 1990).

The degradation and deforestation of natural forest in many tropical countries of the region has accelerated and increasingly eroded the forestlands. The FAO's global project, "Forest Resources Assessment 1990 Project" indicated that the annual deforestation rate increased from 2.0 million ha during 1976-1980 to 3.9 million ha during 1981-1990 in the Asia-Pacific region. In Indonesia, the latest data indicate that about 1.2 million ha of forests have been annually converted to other land uses (mainly agricultural use) according to the government land use programs. In Thailand, deforestation kept a high pace of about 0.5 million ha per year due to illegal encroachment, excessive shifting cultivation, infrastructure development, mining development, etc., and the forest coverage has dropped to 24.9 % of total land area. In Malaysia, the natural forests were reduced by 0.8 million ha during 1986-1990 due to agricultural expansion (Kashio, 1997).

As far as deforestation by countries in Southeast Asia is concerned, Thailand's forest area was depleted from 27,400,000 ha representing 53 % of its total land area in 1961, to 24,280,000 ha or 48 % of its area in 1995. Likewise in

Indonesia, the forest area has shrunk from 83 % its total land area in 1950 to about 79 % in 1995. Regarding the annual average rate of deforestation, it was found to be the highest in Thailand (2.14%), followed by Malaysia (2.10%), Vietnam (1.34%), Indonesia (0.84%) and Philippines (0.49%) (Haron, 1996).

In Malaysia, more than 2.6 % of the total forest cover was lost between 1983-1995 (Haron, 1996). Table 1 provides some information of forest changes and total land area in Malaysia. In Sarawak, about 60,000 ha of natural forest are destroyed annually due to shifting cultivation, constituting a loss of 2.7 million $m^3$ of logs (Lau, 1979 cited by Noor and Mohamad, 1998). The current trend to shorten the fallow period of shifting cultivation to 3-5 years as a result of demographic pressure could worsen the situation. Cash crops such as pepper planted on steep slopes are detrimental to the environment due to intense erosion and should be discontinued and replaced with environmentally friendly crops such as hill paddy (Noor and Mohamad, 1998).

The large-scale harvesting of mixed Dipterocarp forests in Peninsular Malaysia began in the 1960s. The major historical cause of deforestation has been the conversion of land from forest to agriculture, mining and dam and water reservoir construction. However, the rate of deforestation has been declining over the last decade due to the area set aside for conversion to agriculture being exhausted (Collins *et al.*, 1991 cited by Kamaruzaman and Abdul Manaf, 1995).

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 | +0.10 |
| 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 | -0.05 |
| 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 | -0.41 |
| 1997 | 32.9 | 20.53 | 62.4 | +1.66 |

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

## Causes of Deforestation

Shifting or slash-and-burn, cultivation has historically been the first stage in agricultural development worldwide when people make the transition from hunter gathering, which entails the hunting of animals and the gathering of fruits and other plant parts. Shifting cultivators now comprise the majority of forest dwellers, an estimated 200-300 million people. Most hunter gather in forest as well, but there are only one million pure hunter gatherers, restricted to a few isolated tribal peoples in the Congo Basin, Amazon Basin, Borneo and elsewhere (World Bank, 1978; Caufield, 1984).

The spread of people and farming techniques in forested areas is influenced by the distribution of forest in relation to populated areas and the ease of access by roads and rivers. Roads are still few and far between over large areas of the humid tropics. So rivers often remain the chief means of communication and even today permanent cultivation tends to be concentrated close to waterways. Roads also connect farmers to urban markets and promote cash crop cultivation if transport costs are satisfactory. Environmental factors such as topography and soil fertility also influence the spread of deforestation but in less predictable ways. Lowlands should ideally be more attractive for colonization than hilly areas, if they are not swampy (Grainger, 1993). Other direct causes of deforestation are the result of infrastructural development, such as hydroelectric dams, roads, housing, industrial complexes, harbors, and war (Kashio, 1997).

Grainger (1993) stated that the major underlying causes of deforestation are:

1. Socio-economic factors:
    a. Population growth
    b. Economic development
    c. Poverty
2. Physical and environmental factors
    a. Distribution of forests
    b. Proximity of rivers
    c. Proximity of roads
    d. Distance from urban center
    e. Topography
    f. Soil fertility