UNIVERSITI PUTRA MALAYSIA

FOREST COVER CHANGE DETECTION AND WATER YIELD RELATIONSHIP IN SEMENYIH AND LANGAT WATERSHED USING REMOTE SENSING TECHNIQUE

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By

MOHD. HASMADI ISMAIL

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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بِسْمِ اللهِ الرَّحْمٰنِ الرَّحِيْمِ

SPECIAL DEDICATION

All praise and glory are expressed to Allah S.W.T for His blessings and strengthen me to complete this thesis

Utmost gratitude to my parents, Ismail Yusuf and Jemilah Yusof for your patience, faithfully and never ending prayed for my success

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To my love one in life and faithfully fiancee ***"Princess Nurkasih"*** *(Nor Safarina Ismail)* who is always on my side, never ending support and patience and understand that this success means her success too…

"Tiadakah kamu mengetahui bahawa kerajaan langit dan bumi adalah kepunyaan Allah? Dan tiada bagimu selain Allah seorang pelindung mahupun seorang penolong"
(Al-Baqarah : Ayat 107)

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 water supply and its quality would be a worrying situation in the region where there is rapid urbanization, industrial and agriculture development. Lack of proper planning in land use especially in the forest watersheds may lead to the problem of insufficient water supply to the nation. One of the major water supply areas facing problem of water shortage is the Hulu Langat watershed, where the critical recession of water resources at the end of 1990's has been the main drawback of environmental changes in the area. The general objective of this study was to develop a technique of Landsat TM modeling that provides spatial information on the current land use trend in Hulu Langat catchment and its vicinity using remote sensing technology. The specific objectives were as follows: (1) to identify and quantify forest cover depletion surrounding the two dams using three different years of satellite data (1993, 1996 and 1998); (2) to determine the causes and factors influencing water yield in Semenyih and Langat dam and; (3) to map the water turbidity in Langat and Semenyih dam by remote sensing technique with 30m spatial

resolution. Based on the comparison between two multi - temporal imagery of 1993 and 1998, primary forest cover area decreased from 9,316 to 6,818 ha, agriculture/ secondary forest area increased from 1,391 to 1,670 ha, urban/clear land increased from 265 ha to 427 ha, and water bodies decreased from 489 ha to 430 ha. The annual percentage of deforestation in the study area was about 0.054 percent per ha per year and the total deforestation was 2, 497.5 ha from 1993 to 1998.

The application of density slicing and contrast stretching techniques to the water portions is promising and showed discrete turbidity ranges coded by grey level or color. Consequently, using visual interpretation of the image and the analysis of the scattergram analysis, four segmentation of water turbidity class in both dams namely 12-13 DNs (>9.1 FTU), 9-11 (7.1-9.0 FTU), 4-8 DNs (5.1-7.0) and 1-3 DNs (<5.0 FTU) were mapped out. From the land cover classification, it was found that the overall accuracy of the generalized land cover map has been observed for each year (1993, 1996 and 1998) was 88.84 percent, 91.52 percent and 87.69 percent, respectively. From the satellite imageries it can be concluded that most of the forest cover decline is due to agricultural activities, timber harvesting and construction of new road network. This study implies that satellite remote sensing technique can be successfully used as a monitoring tool for assessing forest cover loss in a large area and as predictive tool for managing water resources in watershed especially, in spatial mapping of water turbidity levels in big dams. From regression analysis, water yield in Langat and Semenyih dams is positively correlated with vegetation cover at the significance level of 0.01 and 0.05, respectively. However, the temperature and rainfall are not correlated with water yield in both dams.

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

PENGESANAN PERUBAHAN LITUPAN HUTAN DAN HUBUNGAN HASIL AIR DI KAWASAN TADAHAN SEMENYIH DAN LANGAT MENGGUNAKAN TEKNIK REMOTE SENSING

Oleh

MOHD. HASMADI ISMAIL

September 2000

Pengerusi : Profesor Kapt. Kamaruzaman Jusoff, Ph.D

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Kualiti air dan bekalan air menjadi suatu kebimbangan di rantau ini kerana desakan daripada pembangunan industri, pertanian dan penempatan. Perancangan dan pengurusan yang kurang bijak terhadap penggunaan tanah di kawasan tadahan air dan menyebabkan krisis kekurangan air dan kualitinya wujud di negara ini. Kawasan tadahan air Hulu Langat dipilih di dalam kajian ini kerana ianya menjadi tumpuan bukan sahaja kerana krisis air yang melanda pada tahun 1990'an tetapi kerana ianya kaya dengan litupan hutan yang penting dalam mengawal alam sekitar. Objektif umum kajian ini adalah untuk membangunkan teknik dan model menggunakan data Landsat TM dalam menyediakan analisis reruang mengenai penggunaaan tanah di kawasan tadahan air dan sekitarnya. Manakala objektif khusus adalah seperti berikut (1) untuk mengenal pasti dan mengira kadar pengurangan litupan hutan di sekitar kedua-dua empangan Langat dan Semenyih dari tahun 1993, 1996 dan 1998; (2) untuk mengenal pasti faktor yang mempengaruhi hasil air di empangan Langat dan Semenyih dan; (3) untuk mengeluarkan peta kekeruhan air di

empangan Semenyih dan Langat secara teknik penderiaan jauh dengan resolusi 30 meter. Dari perbandingan dua imej satelit tahun 1993 dan 1998, litupan hutan primer berkurangan dari 9,316 kepada 6,818 ha, hutan sekunder/pertanian bertambah dari 1,391 kepada 1,670 ha, kawasan tepubina/tanah lapang bertambah daripada 265 kepada 427 ha dan badan air berkurangan daripada 489 ha kepada 430 ha. Kadar peratusan pengurangan hutan tahunan di kawasan kajian ialah kira-kira 0.054 peratus per ha. dan jumlah kehilangan tanah berhutan ialah 2, 497.5 ha daripada tahun 1993 sehingga tahun 1998. Tahap kekeruhan air dan taburannya boleh dianggarkan dengan kaedah pemprosesan imej ke atas data Landsat TM.

Penggunaan teknik "density slicing" dan "contrast stretching" memberikan kod julat yang berbeza dari segi warna. Dari interpretasi visual ke atas imej dan analisa "scattergram", empat segmen kelas kekeruhan air di kedua-dua empangan dapat dikeluarkan iaitu 12-13 DNs (>9.1 FTU), 9-11 (7.1-9.0 FTU), 4-8 DNs (5.1-7.0) and 1-3 DNs (<5.0 FTU). Ketepatan keseluruhan keputusan yang diperolehi dari imej tahun 1993, 1996 dan 1998 adalah 88.84 peratus, 91.52 peratus dan 87.69 peratus. Pengurangan kawasan hutan adalah disebabkan oleh aktiviti pertanian, pembalakan dan pembinaan jalanraya yang baru. Dari kajian ini teknik penderiaan jauh berjaya dan boleh digunakan sebagai alat untuk memantau kadar pengurangan hutan di kawasan yang luas dan sebagai alat untuk meramal pengurusan sumber air di kawasan tadahan, begitu juga untuk mengeluarkan peta tahap kekeruhan air di empangan yang besar. Dari analisa regresi, hasil air di empangan Langat dan Semenyih amat positif dengan litupan hutan pada paras keertian 0.01 dan 0.05. Sementara itu, taburan hujan dan suhu tidak mempengaruhi hasil air di kedua-dua empangan.

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In the name of Allah S.W.T, most benevolent, ever merciful
All praise to be to Allah S.W.T.

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DID	Department of Irrigation and Drainage
DN's	Digital numbers
EC	Electrical conductivity
EMR	Electromagnetic radiation
FCC	False color composite
GCP's	Ground control points
GIS	Geographic information system
GPS	Global positioning system
LUT	Look –up table
MACRES	Malaysian Center for Remote Sensing
MLC	Maximum likelihood classifier
MSS	Multi spectral scanner
NDVI	Normalized difference vegetation index
NIR	Near infrared
PFR	Permanent forest reserve
RBD	Return beam vidicon
RSO	Rectified skew othomorphic
SPOT	Satellite Probotoire d' Observation de la Terre
SPSS	Statistical package for social science studies
TDS	Total dissolved solid
TM	Thematic mapper
TSS	Total suspended solid
VI	Vegetation indices

CHAPTER I

INTRODUCTION

General

The tropical forests are undoubtedly the world's richest ecosystem and one of the most valuable natural resources in the developing countries. In Malaysia, a tropical forest not only contributes to socio-economic growth, but is also very important for protection and preservation of environment for human benefits. Forests have many tangible and intangible benefits, such as mediating climate change, preventing erosion and flooding. Besides for the animal conservation, forest material use for food, raw material, shelter, pharmaceutical, recreation and tourism.

Forest plays a critical role in maintaining ecosystem, environmental health, productivity and services. The quality of water we drink, the air we breathe, and the soil in which we grow our food crops depends on the integrity of natural ecosystem. It has long been recognized that significant role of forest in reducing erosion, preventing flood, maintaining the purity of the water, and tempering climatic fluctuation, and thus are vital to the productivity of our streams, lakes and oceans (Mohamad, 1998)

A great portion of land area in Malaysia is currently covered with forest where watershed areas are located. As reservoir of the country's water supply, approximately 97 percent of the fresh water supply for domestic, agricultural, irrigation, industrial and recreational purposes is derived from forest catchments

situated in undisturbed forest. Most of the naturally forested catchments are located in the hilly regions and mountains. Effective management and conservation of these forest catchments results in a clean and high quality water supply, reduced siltation and pollution of rivers. It is clear that developing land resources will accelerate forest exploitation and destruction, which have an adverse impact on the sensitive environment of watershed areas. To attain the achievement in socio-economic progress, Malaysia, however like many developing countries, is still faced with the pressing needs to develop these abundance of natural resources to further improve the quality of life of an increasing population and to provide the base for a stable and sustaining prosperity.

Malaysia is fully aware of the need for effective forest management and conservation not only to ensure a sustained 'tangible' supply of timber but also to maintain 'intangible' environment stability. The conservation of watershed zone at all level is fundamentally importance in the maintenance of viable land use programme by maintaining the scale in their existing range (optimum). This is generally preferable to other courses of action because it allows for continuity adaptation by process of evolution

Gradually, forest area become smaller caused by forest exploitation and destruction for intensive development purposes like agriculture, human settlement, established of industrial park and expansion of new cities. The small portion of forest remained cannot function well as a protection subsystem in the integral watershed system in new environment. As a result, the land capability to support the growth of vegetation in degraded site is diminished. Besides that, it also pollute the river, dam,

catchment, downstream and irrigation canal of the with salt. This entire situation brought a large effect not only to the communities who live around the watershed area.

For the sound implementation of forestry activities, complete, up-to-date and reliable data and information at various levels regarding the forest condition or status are essential. This timely and up-to-date information with respect to the function and mechanism of such changes are essential as it has important impact on climate and ecological complexity. From an ecological point of view, the forest plays a major role in the hydrological cycle and in recycling atmospheric carbon dioxide. They stabilized soil and prevent excess on climate through energy and water exchanges with the atmosphere are not well understood by researchers.

In recent year, Malaysia has experienced in effects of flash flood and drought. These phenomena partly have been attributed to the degradation of natural environment and water yield, possibility caused by forest clearance in the upland area in this country. These activities and their rate persist unchecked apparently, due to the unavailability of relevant, reliable and timely information on the quantitative and qualitative characteristic of forest environment. It is therefore, imperative that a faster and more efficiency system of data collection, processing, storage, retrieval and updating have to be involved. Remote sensing technology would be highly beneficial in improving the efficiency and effectiveness of thematic mapping; natural resource surveying and monitoring; observation of temporal spatial and other changes in the environment (Razani, 1985; Kamaruzaman and Haszuliana, 1998; Mohd. Hasmadi and Kamaruzaman, 1999).

Statement of Problem

Currently, with the decreasing lowland forest in Malaysia, timber harvesting will inevitably be pushed to the hilly areas, which are watersheds and head stream sites. Kamaruzaman and Nik (1992) stated that mechanical destruction appears particularly in the construction of forest road. Another researcher, Zulkifli (1986) stated that major disturbance has been identified in soil erosion problem and sediment production in the river sources. Clearing of forest cover could disturb the water balance, which will subsequently affect river flow, ground water flow and water quantity and quality.

As water is one of the important resources, the demand for adequate water of an acceptable quality at the right place and time has become a problem in Malaysia. In 1986, the domestic and industrial water consumption is estimated at about 1, 277 million m^3 /year (Sieh, 1986) and the overall water demand is growing at about 4 percent annually and projected to be about 20 billion m^3 and the irrigation demand to about 13.2 billion m^3 in year 2020. The annual water demand in 1990 was 1.4 percent, and by the year 2020 will be about 3 percent of the water resources base (Keizrul and Juhaimi, 1996). This increment causes some problem in rural and urban areas, where the water supply is not readily available. This is due to the variability of rainfall in forest catchment from year to year. In addition, water quality of some rivers has deteriorated due to development activities in the catchment areas that often rendered water unfit to use.

Many researchers agree with these problems (Hamilton, 1983; Don, 1986; Shuttleworth *et al*, 1990). Intensive logging activities using mechanized machine have adverse impact on the soil physical properties such as dry bulk density, total pore space, aeration porosity, available water holding capacity, saturated hydraulic conductivity and resistance to penetration (Kamaruzaman, 1991). According to Fox (1972), soil damage through tractor logging in Sabah was estimated at about 20% of the total area harvested. Meanwhile, Marn and Jokker (1982) observed that the occurrences of bare soil increase from 13 percent to 41 percent as the basal area of trees removed increased 1.2m^2 /ha to 7.2m^2 /ha. in logging of tropical high forest.

Deforestation and forest degradation are often caused by a combination of action and influence. FAO (1998) reported that some causes are natural such as fire, disease and weather-induced stress, but more often they result from human activities (e.g. land clearing for agriculture, overgrazing, over-extraction of timber and harmful logging practices). The main cause of deforestation in Malaysia is clearing the forest land for cultivation and agricultural project (Khairi and Abdul Hamid, 1985). This can be accepted if the cleared land is converted to permanent agriculture. However, much of the land being cleared is too steep for cultivation, too closed to the hill headwater and was transformed to settlement park and this eventually to be risky to hydrological cycle. In highly sensitive areas, deforestation and forest degradation can lead to spring drying up and to desertification (FAO, 1998). Moreover, this type of practice has been proven to be very destructive to the water resources.

In recent years, awareness of environmental problem and issue among the people in the country has increased tremendously. The latest information about variables of land cover and the nature of transformation of land cover would be a valuable guide for formulating appropriate policies and effective implementation for natural allocation and a under aspect of its utilization and management.

The loss of natural forest may take many forms but the extinction of watershed system is the most critical and irreversible. There has been significant reduction in percentage of the watershed areas and the most common reason is cutting down of forest and polluted wetlands due to changes in land use.

The water supplies in generally a problem in the region where there is rapid urbanization, industrial and agriculture development. Improper land use planning especially in the forested watershed zone will cause a worse situation to the ecology and hydrology environment. Watershed management planning in intensively managed, as found in the hilly areas in Malaysia, is undoubtedly a very complex task (Paso, 1990).

Although the forest lands always accept the pressure from the developers, watershed management planning should have to take into account a great amount of information. Forest inventory is a conventional method for obtaining the required information and supplying it to the planners and managers for make decision. With increasing and often conflicting demands for resource use, the agency need current, reliable information in order to make sound decision. Like other land management agencies, it needs timely and accurate information about the location, quantity,