UNIVERSITI PUTRA MALAYSIA

FOREST FIRE HAZARD RATING ASSESSMENT IN PEAT SWAMP FOREST USING INTEGRATED REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM

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By

SHERIZA BINTI MOHD RAZALI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

January 2007

DEDICATION

This thesis is dedicated to my parents Aminah Warmin and Mohd Razali Yop who have supported me all the way since the beginning of my studies.

Also, this thesis is dedicated to my loving husband Zaidi Mat Daud who has been a great source of motivation and inspiration.

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

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Chairman : Associate Professor Ahmad Ainuddin Nuruddin, PhD

Faculty : Forestry

Forest fire can be a real disaster, regardless of their causes, be it human activity or nature. While it is difficult to control nature, it is possible to map different hazard levels thereby minimizing fire hazards and avoid potential damage. Satellite data plays an important role in detecting and mapping forest fires, involving different types of vegetation. This study was conducted with two objectives: first by applying remote sensing techniques to delineate fuel types map and burnt areas in peat swamp forest; secondly was to develop a fire hazard modelling and mapping of fire hazard rating areas using the Geographical Information System (GIS).

A fire prone peat swamp forest located in Penor, Pahang was selected for the study. A colour composite image from Landsat Thematic Mapper (TM) was transformed using Tasseled Cap Transformation (TC) and a fuel

types map was produced. Roads and canal were digitized and developed as layers using ArcGIS 8.2. These layers were composite and four categories of forest fire hazard ranging from extreme to null were automatically derived. The final forest fire hazard rating map is presented in ArcView 3.1.

In conclusion, almost 50% of the study areas were classified as ‘low’ hazard and only 10% of the areas were classified as ‘extreme’ hazard. As a result, the fire hazard map can be used for better forest fire management activities for that area.

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

PENILAIAN TAHAP BAHAYA KEBAKARAN HUTAN DI HUTAN PAYA GAMBUT MENGGUNAKAN INTEGRASI TEKNIK PENDERIAAN JAUH DAN SISTEM MAKLUMAT GEOGRAFI

Oleh

SHERIZA BINTI MOHD RAZALI

Januari 2007

Pengerusi : Profesor Madya Ahmad Ainuddin Nuruddin, PhD

Fakulti : Perhutanan

Satu kebakaran hutan boleh menjadi satu tragedi samada disebabkan faktor semulajadi atau aktiviti manusia. Walaupun sukar untuk mengawal faktor semulajadi, namun untuk memetakan tahap bahaya kebakaran hutan boleh dilakukan dengan teknologi yang ada. Ini seterusnya dapat meminimakan bahaya kebakaran dan mengelakkan potensi kerosakan. Satelit data memainkan peranan penting dalam mengesan dan memetakan kebakaran hutan yang melibatkan pelbagai jenis tumbuhan. Kajian ini telah dijalankan berdasarkan kepada dua objektif: pertama, mengaplikasikan teknik penderiaan jauh untuk menggariskan peta jenis bahan api dan kawasan terbakar di hutan paya gambut. Kedua, membangunkan satu model tahap bahaya kebakaran dan memetakannya menggunakan Sistem Maklumat Geografi.

Satu kawasan hutan paya gambut yang mudah terbakar di Penor, Pahang telah dipilih untuk kajian ini. Satu imej komposit berwarna daripada *Landsat Thematic Mapper (TM)* telah diubah bentuk menggunakan teknik *Tasseled Cap Transformation (TC)* dan satu peta jenis bahan api telah dihasilkan. Jalan-jalan dan terusan telah didigitkan sebelum dibangunkan sebagai helaian-helaian menggunakan *ArcGIS* 8.2. Helaian-helaian ini telah dikompositkan bagi menghasilkan empat kategori bahaya kebakaran bermula dari 'ekstrim' bahaya kepada 'kosong' bahaya yang telah diekstrak secara automatik. Peta akhir tahap bahaya kebakaran hutan ini telah dipersembahkan di dalam *ArcView* 3.1.

Secara kesimpulannya, hampir 50% kawasan kajian telah diklasifikasikan sebagai 'rendah' bahaya dan hanya 10% kawasan kajian diklasifikasikan sebagai 'ekstrim' bahaya. Peta bahaya kebakaran boleh digunakan untuk aktiviti pengurusan kebakaran hutan yang lebih baik untuk kawasan ini.

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First and foremost, I would like to express my most sincere and deepest gratitude to my supervisor, Associate Professor Ahmad Ainuddin Nuruddin, for his helpful advices, constructive criticisms and patience encouragement throughout the study.

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Finally, I would like to convey my utmost gratitude to my husband Mr. Zaidi B. Mat Daud and families who have been patient and faithfully praying for my success.

Not forgotten are friends who had contributed and assisted me toward the accomplishment of this study.

I certify that an Examination Committee met on 12 January 2007 to conduct the final examination of Sheriza Mohd Razali on her Master of Science thesis entitled “Forest Fire Hazard Rating Assessment In Peat Swamp Forest Using Integrated Remote Sensing and Geographical Information System (GIS) Technique” in accordance with Universiti Pertanian Malaysia (High Degree) Act 1980 and Universiti Pertanian Malaysia (High Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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Date: **8 March 2007**

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

SHERIZA MOHD RAZALI

Date: **24 January 2007**

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LIST OF ABBREVATIONS/NOTATIONS/GLOSARRY OF TERMS

AIFM	ASEAN Institute of Forest Management
ANDES	Asia Pacific Network for Disaster Mitigation using Earth Observation Satellite
ASMC	ASEAN Specialized Meteorological Centre
AVHRR	Advanced Very High Resolution Radiometer
AVI	Advanced Vegetation Index
ATSR	Along Track Scanning Radiometer
B	Band
BI	Bare Soil Index
C	Combination
CORINE	Coordination of Information on the Environment
DN	Digital Number
EGIS	Environmental Geographical Information System
ENSO	El Nino-Southern Oscillation
ERDAS	Earth Resources Data Analysis System
ERS	European Radar Satellite
ETM+	Enhanced Thematic Mapper
EQR	Environmental Quality Report
FARSITE	Fire Area Simulation
FBP	Fire Behaviour Prediction
FCD	Forest Canopy Density
FDI	Fire Danger Index
FFPCP	Forest Fires Prevention and Control Project

FFRM	Forest Fire Risk Mapping
FHC	Fuel Hazard Component
FHRI	Fire Hazard Rating Index
FPL	Forest Products Laboratory
FRIM	Forest Research Institute of Malaysia
FWI	Fire Weather Index
GCP	Ground Control Points
GFMC	Global Fire Monitoring Centre
GIS	Geographical Information System
GPS	Geographical Positioning System
GSO	Gramm-Schmidt Orthogonalisation
HRV	High Resolution Visible
IFFN	International Forest Fire News
IRS	Indian Remote Sensing Satellite
JOFCA	Japan Overseas Forestry Consultants Association
LKPP	Lembaga Kemajuan Pertanian Pahang
LUCCAS	Land Use and Cover Change Analysis Software
MACRES	Malaysia Centre for Remote Sensing
MIR	Middle Infrared
MLC	Maximum Likelihood Classifier
MSS	Multispectral Scanner
NBR	Normalized Burnt Ratio
NDVI	Normalized Different Vegetation Index
NOAA	National Oceanographic and Atmospheric Administration

RGB	Red Green Blue
RMSE	Root Mean Square Error
RSO	Rectified Skewed Orthomorphic
SAR	Synthetic Aperture Radar
SDI	Soil Dryness Index
SPOT	*System pour I' Observation de la Terra*
SI	Shadow Index
SSI	Scaled Shadow Index
TC	Tasseled Cap
TI	Thermal Index
TM	Thematic Mapper
Ts	Temperature surface
USDA	United State Department of Agriculture
VCR	Vegetation Cover Ratio

CHAPTER 1

INTRODUCTION

1.1 Introduction

In many countries, fire is still used as a tool in agricultural practices and also for other development project (AIFM, 1996). However, forest fires have caused extensive damage and destruction to life and property. They could also affect vegetation cover, soil, water quality and microclimate.

According to Mastura (1999), extensive forest fires in Southeast Asia are mostly caused by land preparation practices for the conversion of forest to oil palm plantations and rubber. In Malaysia, most forest fires were caused by human activities during prolonged dry and hot weather (Ainuddin, 1998). In spite of the many incidences of forest fires, a significant amount of information are still required to understand better the impact of forest fires on the environment of Southeast Asia. The information would also help in the rehabilitation of the damaged forest caused by forest fires. One of the technologies available for forest fire and impact assessment is remote sensing.

Many studies have been conducted to develop forest fire risk hazard assessment using remote sensing (Chuveico and Congalton, 1989, Almeida, 1994, Chuveico and Salas, 1996, Castro and Chuveico, 1998, Jaiswal *et al.,* 2002, Norizan *et al.,* 2002). In 1985, Agee and Pickford

(1985), used Landsat Thematic Mapper (TM) and Multispectral Scanner (MSS) to generate vegetation and fuel map of the North Cascades National Park, in North America. Besides remote sensing technology, GIS also plays an important role in fire risk hazard assessment. Maselli *et al.* (1996) evaluated forest fire risk hazard using the analysis of environmental data and Landsat TM satellite images.

Many studies in fire risk hazard assessment have considered a wide range of hazard variables, depending on the specific characteristics of fire events in the different test sites (Poulin *et al.,* 1987). Vasconcelos *et al*. (1998) emphasized that vegetation, topography, climatology and fire history are important components of hazard in order to assess forest fire risk. The Almeida (1994) model which was adapted from Chuveico and Congalton (1989) used forest species, distances to roads, distances to the permanent rivers, slope and aspect to develop forest fire risk cartography. Groundlund *et al.* (1994) emphasized that slope, topography, soils, vegetation, hydrographic and landuse were the important factors in generating fire risk hazard assessment.

1.2 Justification

Tropical peat swamp forest is usually found in the lowland of tropical forest area. It is called 'woody peat' because it contains much woody debris. Water table is high in peat during rainy season, which prevents dead trees

from decomposition, and then produces 'peat strata'. The water table tends to drop during extreme dry season through evaporation (IFFN and GTZ, 2002). The lowering of the water table in the large inland freshwater swamps exposes the top peat layer to desiccation. During the 1982-1983 El Nino-Southern Oscillation (ENSO), a number of observations in East Kalimantan confirmed a desiccation of more than one to two metre (Johnson, 1984). Human activities due to negligence and carelessness together with ENSO have led to devastating fire in peat swamp forest (IFFN, 2000). Moreover, activities such as logging and adjacent land development often influence the water table on peat swamp (Dien Duc, 1993). The presence of road and canal in peat swamp forest has increased access to honey collectors, and hunters thus making the peat susceptible to fire.

With the advent of modern satellite technology combined with increased computer power, the danger of peat fires can be reduced. Satellite data, supplemented by ground survey and GIS can be used to establish forest fire map and fire hazard index. A study by Chuveico and Congalton (1989) used Landsat TM data to classify vegetation by fuel class then combining with elevation, slope aspect and proximity to roads, to generate a fire hazard index. The technologies can be used as a management tool in forest fire prevention and control programmes. To date little work has been done to use remote sensing and geographic information system in peak forest fire in Malaysia. Therefore, there is a need for this kind of study to be conducted here. Previously, Shasby *et al.* (1981) have

merged Landsat MSS with aerial photograph and digital elevation data to map seven fuel classes near Missoula Montana, United States. It is evident that, there exists a need for related study to be conducted in peat swamp fire prone areas.

1.3 Objectives

This study was conducted in an attempt to assess fire hazard rating in the peat swamp forest of Batu Enam, Jalan Pekan, Penor/Kuantan District of Pahang using integrated Geographical Information System (GIS) and Remote Sensing techniques. The specific objectives of this study were:

i. To apply remote sensing technique to delineate fuel types map and burnt areas in the peat swamp forest.

ii. To develop fire hazard rating assessment and produce a fire hazard map of the peat swamp forest using the GIS.