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MONITORING LAND USE CHANGES USING REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM (GIS) IN GUA MUSANG, KELANTAN, MALAYSIA

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BY

SOMKHIT SENTHAVY

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Special Dedication

Utmost gratitude to my father and mother for your patience, faithfully and never ending prayed for my success

Also to my beloved wife "Mrs. Keo Senthavy" and sons "Smith Senthavy and Sacksith Senthavy" who are always on my side, never ending support and inspire in me all the time.

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

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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 (RS) and geographical information system (GIS), the mapping process can acquire spatial information more efficiently, timely and easy to recheck. This study was undertaken to detect land use change by integrating RS and GIS technologies in northern part of Gua Musang district, Kelantan state. The objective of this study was to assess the usefulness of integrating remotely sensed data with GIS for land use change detection. The specific objective is to quantify and map the land use change in northern part of Gua Musang district. In order to acquire land use changes data, a set of Landsat Thematic Mapper (TM) dated May 1990 and July 1997 with scale of 1 : 150,000 in hard copies were acquired. Land use classes were interpreted into maps and the maps were checked on the field for ground truth. The land use map data were then transferred directly into the computer via

ARC/INFO and ARC/VIEW software. The land use data were digitized in ARC/INFO, overlaid and analyzed in ARC/VIEW. Ground result showed that the total overall map accuracy was 86.54%. Shrub (bushy/lalang) increased by 181.14 % from 1990 to 1997 (13,757.35 ha), while newly cleared areas, rubber, and oil palm increased by 91.37 % (402.48 ha), 45.19 % (6,791.68 ha) and 44.72 % (7,812.66 ha), respectively. On the other hand, other land use classes such as mixed horticulture, diversified crops, urban and paddy also increased by 38.82 % (327.27 ha), 11.95 % (71.95 ha), 10.30 % (73.63 ha) and 4.70 % (12.79 ha) respectively. However, undisturbed and disturbed forest were reduced by 8.10 % (19,271.35 ha) and 27.70 % (9,978.45 ha) during the same period. Shrubs significantly showed an increasing trend of land use while forest areas are decreasing in area compared to other land use classes. Rapid land use change took place in the northern part of Gua Musang district whereby, nearly 36 % of the changes was in terms of shrub, oil palm and rubber land use conversions. The method used and the results obtained strongly suggest that the integration of remote sensing and GIS offer very promising opportunities for land use change detection and mapping.

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

PEMANTAUAN PERUBAHAN GUNA TANAH MENGGUNAKAN REMOTE SENSING DAN SISTEM MAKLUMAT GEOGRAFI (GIS) DI GUA MUSANG, KELANTAN, MALAYSIA

Oleh

SOMKHIT SENTHAVY

Disember 2000

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

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Pembangunan guna tanah sedang pesat berubah disebabkan kemajuan ekonomi. Ketersediaan maklumat terkini tentang guna tanah adalah berguna dan perlu untuk pentadbiran, pemantauan dan pengurusan untuk membuat keputusan dan perancangan. Dengan teknologi maju remote sensing (RS) dan sistem maklumat geografi (GIS), proses pemetaan boleh memperoleh maklumat reruang dengan lebih efisien, cepat serta mudah disemak. Kajian ini telah dijalankan untuk mengesan perubahan guna tanah dengan menggabungkan RS dan GIS untuk bahagian utara daerah Gua Musang, negeri Kelantan. Objektif kajian ini adalah untuk meninjau kebolehgunaan penggabungan data penderiaan jauh dengan GIS untuk pengesanan perubahan guna tanah. Objektif khususnya adalah untuk mengira dan memeta perubahan guna tanah di bahagian utara daerah Gua Musang. Untuk memperolehi data perubahan guna tanah, satu set Landsat Thematic Mapper (TM) bertarikh Mei 1990 dan Julai 1997 dan cetakan pada skala 1 : 150,000 telah digunakan. Kelas-kelas guna tanah telah diinterpretasikan ke dalam peta-peta dan peta-peta berkenaan telah disemak di lapangan untuk pengesahan. Data guna

tanah kemudiannya dipindahkan secara langsung ke dalam komputer menggunakan perisian ARC/INFO dan ARC/VIEW. Data guna tanah itu telah didigitalkan dalam ARC/INFO, ditindih kemudian dianalisa dalam ARC/VIEW. Keputusan lapangan menunjukkan bahawa jumlah ketepatan keseluruhan peta adalah 86.54 %. Kawasan belukar (semak/lalang) telah meningkat sebanyak 181.14 % dari 1990 ke 1997 (13,757.35 ha). kawasan baru dibuka getah dan kelapa sawit telah meningkat sebanyak 91.37 % (402.48 ha), 45.19 % (6,791.68 ha) dan 44.72 % (7,812.66 ha) masing-masingnya. Sebaliknya pula, kelas-guna tanah seperti pertanian campur, tanaman pelbagai, perbandaran dan padi turut meningkat masing-masingnya sebanyak 38.82 % (327.27 ha, 11.95 % (71.95 ha), 10.30 % (73.63 ha dan 4.70 % (12.79 ha). bagaimanapun, hutan dara dan telah dibalak menyusut sebanyak 8.10 % (19,271.35 ha) dan 27.70 % (9,978.45 ha) masing-masingnya dalam jangka waktu yang sama. Kawasan belukar menunjukkan pola peningkatan guna tanah yang nyata sementara kawasan hutan menyusut dalam keluasannya dibanding dengan kelas-kelas guna tanah lain. Perubahan guna tanah yang pesat telah berlaku di utara daerah Gua Musang, di mana hampir 36 % daripada perubahan guna tanah adalah kepada belukar, kelapa sawit dan getah. Kaedah yang telah digunakan dan keputusan yang diperolehi menunjukkan bahawa penggabungan penderiaan jauh dan GIS menawarkan peluang-peluang yang cerah untuk pengesanan dan pemetaan perubahan guna tanah.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AIFM	Associazione Italiana di Fisica in Medicina
AVHRR	Advanced Very High Resolution Radiometer
CCT	Computer Compatible Tape's
DGPS	Differential Global Positioning System
DMSP	Defense Meteorological Satellite Program
DOD	Department of Defense
ERTS	The Earth Resources Technology Satellite
FAO	Food Agriculture Organization
FCC	False Color Composite
GAP	Geographic Applications Program
GCP	Ground Control Points
GDOP	Geometric Dilution of Precision
GEMS	Global Environment Monitoring Systems
GIS	Geographic Information System
GPS	Global Positioning System
HCMM	Heat Capacity Mapping Mission
IFOV	Instantaneous Field of View
ILWIS	The Integrated Land and Water Information System
IR	Infrared
LANDSAT	Land Satellite
MACRES	Malaysia Centre for Remote Sensing
MIR	Medium Infrared
MSS	Multi Spectral Scanner
NASA	National Atmospheric and Space Administration
NCGIA	National Center for Geographic Information Analysis
NDVI	Normalized Difference Vegetation Index
NIR	Near Infrared

NOAA	National Oceanic and Atmospheric Administration
NRSA	National Remote Sensing Agency
RBV	Return Beam Videocon
RS	Remote Sensing
RSO	Rectified Skew Orthomorphic
SAR	Synthetic Aperture Radar
SIS	Spatial Information Systems
SPANS	Spatial Analysis Systems
SPOT	Satellite Probatoire d' Observation de la Terre
SVs	Space Vehicles
TIR	Thermal Infrared
TM	Thematic Mapper
TNGPS	Trimble Navigator Global Positioning System
TV	Television
UNEP	United Nation Environment Program
UNESCO	United Nations Educational Scientific and Cultural Organization
USGS	United States Geographical Survey

CHAPTER I

Introduction

General Background

The total land area of Peninsular Malaysia is approximately 13.2 mil. ha, of which 5.97 mil. ha or 45.3 percent is forested. The total area of Kelantan State is about 14,922 km^2 and is situated in the north-eastern part of Peninsular Malaysia. It consists of 10 districts and the total population is about 1,288,362. Gua Musang is one of the districts with a population of about 143,258 covering a total area of 8,108 km^2 (810,400 ha).

Malaysia has achieved a significant socio-economic progress with the abundance of natural land resources. However, like many other developing countries, it still faces the processing needs to develop these resources to further improve the quality of life in the increasing demand and population (Sixth Malaysia Plan, 1990)

The progress of research and development through remote sensing technology has performed a new dimension of analyzing patterns of land use or mapping the land. The use of remote sensing utility such as aerial photographs and satellite images has

become an essential roll in collecting land information or primary data. Remote sensing technology can make one of the biggest and most significant contribution in the area of land use in collecting data (Anderson et al., 1976).

Remote sensing techniques have proven useful for gathering information about natural resources on a large-scale basis, such as for the whole country. The Malaysian Ministry of Agriculture has been using aerial photo interpretation for land use mapping for Peninsular Malaysia. With the increasing availability of high resolution satellite imagery, and as the land information handling capabilities within the country is modernized, it is opportune to explore the potential of remote sensing and geographical information system (GIS) for information gathering and updating of its resources.

Change detection is a process for determining and evaluating differences in a variety of surface phenomenon over time. Detecting, describing and understanding changes in physical and biological processes and regulating the Earth's system is of considerable interest to ecologists and resource managers. Change detection studies recognize the abiotic and biotic components of the spectral and temporal changes that are occurring within ecosystem (Mouat et al., 1993).

The use of expert systems to detect change automatically in an image with very little human interaction is still in its infancy. In fact, most scientists attempting to develop such systems, employ and gathered many of the change detection algorithms. Wang (1993) used a pre-processor to perform (1) image differencing, (2) create a change mask using principal components, (3) perform automated fuzzy supervised

classification, and (4) extract attributes. Possible urban changes areas were then passed to a rule based interpreter which produced a change image.

Some land cover types are static, that is, they do not change over time. But some land cover is dynamic, changing rapidly. It is important that such changes be inventoried accurately so that the physical and human processes at work can be more fully understood (Jensen, 1996). Therefore, it is not surprising that significant effort has gone into the development of change detection methods using remotely sensed data (Jensen, 1996).

Geographical Information System (GIS) is rapidly becoming a standard tool for the management of resource and currently, it is difficult to think of resource planning without it. The availability of combining the utility of remote sensing and GIS to produce a land use data, can greatly alter the important information needs for administration, management and development in the process of decision making, planning and monitoring.

GIS is a new technology that has became an important tool for analyzing and transferring spatial data information from the surface of the earth to sheet of papers (Burrough, 1986). The spatial information data from remote sensing can be analyzed using sophisticated GIS hardware and software computer system. This provide faster and more efficient acquisition of such information to the users of such practices.

It would be expected that to use computer-assisted mapping would accompany or be accompanied by the use of computer-assisted techniques for processing of remotely sensed data. However the use of remote sensing techniques other than aerial photography for land use mapping is at present still experimental. Some of the issues to be faced, particularly in the developing countries are as follows:

(i) The utility of remotely-sensed data such as satellite imagery for land cover mapping, particularly with respect to specificity and classification accuracy;

(ii) Registration with former maps for detection of land use changes and for related spatial analyses on the GIS;

(iii) Availability and timeliness of remotely-sensed data for a complete coverage of peninsular Malaysia, if not the whole country.

Problem Statement

The land use and land cover change are often found, including transformations from rural land uses to residental, commercial, industrial and recreational uses. These changes can be monitored using remotely sensed data (in combination with ground survey), either by photo interpretation, enhanced false-color composite imagery from different dates or by digital analysis of the imagery using change detection techniques (Quarmby, 1989). Land use information is one of the essential tools for nearly all land development activities efforts. Changes in the use of land are to large extent, a reflection of how society responds to socio-economic, institutional and management practices.

The development of a country is usually dependent on rational utilization of their natural resources, for economic advancement. In overall planning at the national level, vital decisions have to be made regarding development, conservation and utilization of available resources and for priorities investments and efforts to derive maximum benefits. The impact on land use and land cover changes, especially in terms of changes from forest cover to other land cover, has been one of the important issues on land use change research. In the primitive times when there was little human population and low level of economic activity, deforestation was not a problem because the natural regeneration of forest was adequate to cover for any loss of forest by the human beings.

In Malaysia, land use has undergone many changes particularly after the country achieved its independence. Land use changes were driven by a number of economical, socio-political and biophysical factors. Over the last two decades, the evolution of land use became drastic in the urban and rural areas. Especially, more land areas have been displaced or converted to non-agricultural activities particularly for industry, housing and commercial activities. Land use and land cover are continuously changing, both under the influence of human activities and nature resulting in various kinds of impacts on the ecosystem. These impacts have the potential to significantly affect the sustainability of the agricultural and forest systems. The most important factor in the modification of the land cover and its conversion is the human activities.

The knowledge of land use and land cover is important for many planning and management activities concerned with the surface of the earth. Land use information is one of the essential tools for nearly all land development activities. Changes in the cover

have important implications on a range of issues, such as biosphere-atmosphere interactions, endangered species and genetic diversity associated with changing habitats, soil conditions, water and sediment flows and sustainable use of natural resources in the development process of human societies (Turner et al., 1994).

Major changes in various land use categories for period prior and up to 1990 in Peninsular Malaysia were reported by Ministry of Agriculture, Malaysia. A total of 5.22 million ha has been opened for development of which 4.9 million ha were under agriculture and about 7.6 million ha under forest, shrubs and swamps. The land use and cover maps of Peninsular Malaysia produced in 1974 by the Malaysian Ministry of Agriculture were based on visual interpretation of aerial photos. By then, the Ministry had acquired a COMARC GIS for digitizing the interpreted maps and to serve as a data retrieval facility whereby maps of any selected area can be plotted on demand with area summaries (Wong, 1976).

The use of remote sensing techniques other than aerial photography for land use mapping is at present still experimental. The first issue would hopefully be facilitated with the impending functioning of Malaysian Center for Remote Sensing for centralized acquisition of remotely sensed data and the second issue in terms of research and data acquisition effort is nevertheless important in view of a potentially growing user community with data needs for a wide range of GIS applications. Therefore, technologies such as remote sensing and GIS can be applied for monitoring land use changes. The remotely sensed data of satellite images can provide timely, reliable, cost competitive and quick information on dynamic condition of the land use, which are

essential in the forecasting and appraisal of land use changes which are useful in decision making (Wan Yusoff, 1988). GIS can solve than in systems that handle just attribute or spatial data alone, users can interrogate geographical features displayed on a computer map and retrieve associated attribute information for display or further analysis. Maps can be constructed by querying or analyzing attribute data and new sets of information can be generated by performing spatial operations such as polygon overlays on the integrated data set.

One fundamental set of tools crucial in assessing land use and land cover changes will be the data provided by remote sensing and data management capacity of Geographic Information System (GIS). Current trends in this technology indicated that remote sensing and GIS will play a greater role in land use change 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 land use and cover certain period of time. Remote sensing will become increasingly indispensable in Malaysia for the effective conservation, management and development of its resources (Khali, 1991)

Objective

The objective of this study is to asses the usefulness of integrating remotely sensed data (Landsat TM) with GIS for land use change detection. The specific objective is to quantify and map the land use change in northern part of Gua Musang District, Kelantan State between 1990 to 1997.