REMOTE SENSING TECHNOLOGY FOR MANGROVE FOREST MAPPING: BANGGI ISLAND.

AIMIMULIANI ADAM

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SCHOOL OF SCIENCE AND TECHNOLOGY
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MARCH 2006

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REMOTE SENSING FOR MANGROVE FOREST MAPPING, BANGGI ISLAND

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HS 2003-3255

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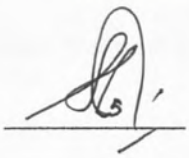
   (Dr Shahbudin Saad)



2. EXAMINER 1

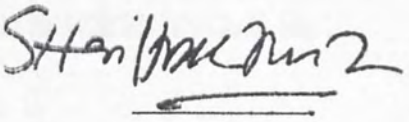
   (Ms Ejria Saleh)

3. EXAMINER 2

   (Dr Bernadette Mabel Manjaji)

4. DEAN

   (SUPT/KS Prof Madya Dr Shariff A.K Omang)



Assalamualaikum w.b.t

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ABSTRAK

Kajian mengenai pemetaan kawasan paya bakau dengan menggunakan teknologi penderiaan jarak jauh dan GIS telah dijalankan di Pulau Banggi, Kudat. Objektif kajian ini adalah untuk memetakan kawasan paya bakau di Pulau Banggi dengan menggunakan imej satelit SPOT 5 pada tahun 2003 dan mendapatkan jumlah keluasan bakau kawasan tersebut. Perisian ERDAS IMAGINE 8.5 telah digunakan sepenuhnya dalam memproses imej digital. Prosedur pemprosesan imej yang digunakan ialah imej pra-pemprosesan, imej 'enhancement', pengklasifikasian imej dan 'accuracy assessment'. Kajian ini telah menghasilkan sebuah peta yang menunjukkan kawasan paya bakau di Pulau Banggi dengan peratus kejituan ('accuracy assessment') sebanyak 83.89%. Keputusan kajian menunjukkan jumlah keluasan hutan paya bakau adalah seluas 6750 hektar, yang mana merangkumi 15% daripada jumlah keluasan keseluruhan kawasan Pulau Banggi. Penggunaan teknologi penderiaan jarak jauh dan GIS bukan sahaja amat berguna dalam menghasilkan peta bagi kawasan paya bakau tetapi juga dapat menjimatkan kos dan masa. Applikasi teknologi penderiaan jarak jauh dan GIS ini juga dapat menghasilkan output dengan peratus kejituan yang tinggi sekiranya pemprosesan imej satelit dilakukan dengan teliti dan 'groundtruthing' dijalankan.

ABSTRACT

A study of mangrove forest mapping using remote sensing and GIS technology was conducted in Banggi Island, Kudat. The objectives of this study were to map mangrove area in Banggi Island using SPOT 5 image for year of 2003 and to determine the total area of mangrove area. ERDAS IMAGINE 8.5 software was fully used for digital image processing. Some of the important procedure were applied are image pre-processing, image enhancement, image classification and accuracy assessment. This study produced a mangrove forest map of Banggi Island with accuracy assessment of 83.89%. A total mangrove area of 6750 hectares can be determined. Mangrove forest area covers 15% of total Banggi Island area. Remote sensing and GIS technology are very useful tools and is also a time saving and cost effective method for mapping mangrove forest. In addition, remote sensing and GIS application can produce output with high accuracy if the image processing procedure is done correctly and the groundtruthing is carried out.

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°	degree
E	east
km	kilometre
km^2	kilometre square
m	meter
µm	micrometre
nm	nanometer
N	north
%	percent
Sq	square

CHAPTER 1

INTRODUCTION

1.1 An introduction

Although remote sensing has been introduced for quite a long time in Malaysia, the knowledge and information of satellite technology application in various fields of study especially in oceanography are still lacking. Realizing the paucity of the data and information on this field, the study of remote sensing technology for mangrove mapping is carried out in Banggi Island. Banggi Island is chosen as it is rich with mangrove species in Sabah.

1.1 Mangrove forest

Mangroves are groups of highly evolved halophytes occupying the intertidal zone in estuaries, lagoons and coastal mud flats in tropical and sub tropical zone. Mangroves are remarkably tough and can tolerate with wide range of salinity. According to UNDP/UNESCO (1984), mangroves can still survive in water up to hundred times saltier than most other plants can tolerate. They are also able to live in the environment where the sediments are soft and poor in oxygen.

Mangroves cover a total area of 6,410 km^2 along 52% of the Malaysia's coastline. Peninsular has about 1,400 km^2 of mangroves, Sabah 3,654 km^2 and Sarawak 1,356 km^2 (MICZM, 2004). Mangroves play multidisciplinary roles in nature, such as helping in soil formation by trapping debris, serve as a sieve for rich organic soil washed down through river system into sea, and provide appropriate ecosystem and refuge for various marine organisms and also birds. It is also act as a barrier against soil erosion and storm between the land and sea, thus maintaining an ecological balance with its surrounding. Besides, mangroves also improve water quality by extracting nutrients from potential eutrophic waters.

Due to domestic, industrial, agricultural and aquacultural development, approximately 35% of mangrove forests in Peninsular Malaysia have decreased, especially on the west coast. Mangrove forests are continually being lost at a national rate of 1% a year (MICZM, 2004). As seen in these statistics, we should change some perception that mangroves are more profitable to be developed rather than to let them grow. We should worry about the lost of mangrove forests. This is the reason for this study is conducted.

1.2 Remote sensing and applications

All the mangrove species have their own characterization where this can be used to map and identify them using remote sensing. Remote sensing is the science of acquiring information about earth's surface using a device that is not physical or in intimate contact with it (from aircraft or satellite). This is done by sensing and

recording reflected or emitted energy and processing, analyzing and applying that information (Muhamad Hj. Jaafar, 2005).

Remote sensing enables to undertake repeat observations and monitoring the study area over a time scale. By using remote sensing, we can know the condition without visit the area. It also allows us to do observation over broad area. All these make us save cost and time for data sampling.

Each sensor has different capability to get data from many fields, such as meteorology, agriculture, forestry and oceanography. Here are few examples of satellites that have been use to get an image, such as Landsat (Thematic Mapper; TM and Multispectral scanner; MSS), SPOT (Multispectral and Panchromatic) and NOAA. This final year project is focusing on mapping mangrove forest using SPOT.

Image Analyst study the remotely sensed data and attempt through logical process in detecting, identifying, classifying, measuring and evaluating the significance of physical and the object study, their patterns and spatial relationship (Abdul Malek, 2005). ERDAS IMAGINE 8.5 software is used for this digital image processing. This software is chosen rather than other software because it is user friendly especially for early learner.

The lack of up-to date and accurate data poses planning problems to conservation and management of mangrove species. Although there are no drastic changes in the mangrove forest area on Banggi Island, we should take early action before something bad happens in future. Conflicting land-uses such as fishing, cutting

of mangroves for different use, salt mining and various marine activities are likely to exhaust the mangroves resources. Realizing to these matters, the study of mangroves mapping using remote sensing technology is considered vital to be carried out. The output of this study hopes to benefit other researchers in their future research.

1.3 Objectives

The main objectives of this study are:

1. To map mangrove forest area of Banggi Island using SPOT.
2. To determine total mangroves area of Banggi Island.

1.4 Study area

The study area is located on Banggi Island, in the district of Kudat, on the northern part of Sabah. It is situated at latitude 7.25 °N and longitude 117.15 °E. Banggi Island covers a total area of about 440.7 sq km. It shoreline lies about 121.3 km including seashore, mangrove forest, mudflat and rocky shore (figure 1.1).

Banggi Island is chosen because currently there is a project conducted by Borneo Marine Research Institute. This study will provide some information for that project.

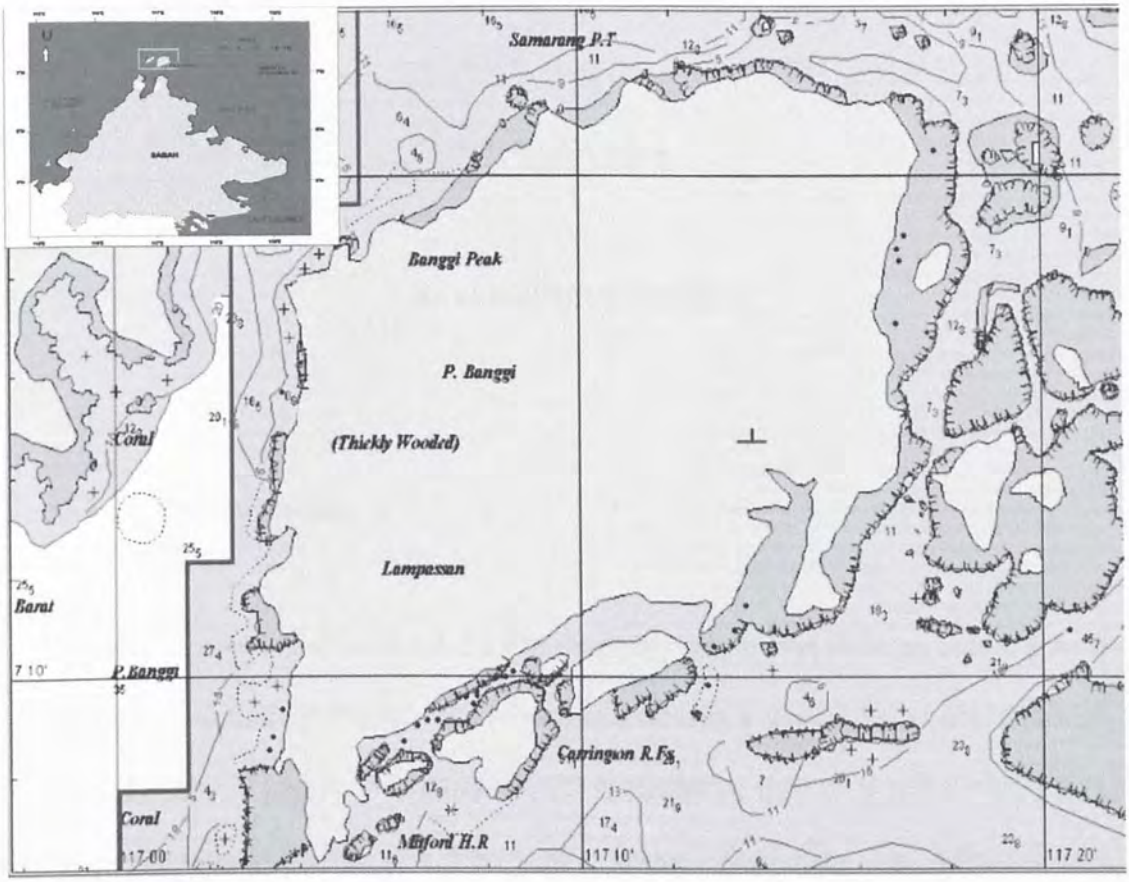

Figure 1.1 Banggi Island

CHAPTER 2

LITERATURE REVIEW

2.1 Remote sensing

Remote sensing is the science and art in obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation (Lillesand and Kiefer, 1987). It is also broadly defined as a process of gathering information about objects from a distanced based on the electromagnetic energy reflected or emitted by that objects (Gang and Agatsiva, 1992). Satellite remote sensing data can provide natural resources managers and planners with periodic information on location and status of the resources.

Morley (2005) said the definition of remote sensing is the measurement and analysis of electromagnetic radiation reflected from transmitted through or absorbed and scattered by the atmosphere, the hydrosphere and by materials at or near the land surface, for the purpose of understanding and managing the earth's resources and environment. In addition, Colwell (1983) explained that remote sensing is the acquisition of data about an object or scene by a sensor that is far from the object aerial photography, satellite imagery, and radar are all forms of remotely sensed data.

Remote sensing also refers to the process of obtaining information about the Earth's surface from remote locations, such as satellites, aeroplanes or shuttles. Remote sensing technologies can provide vast amounts of digital information, which is being increasingly used in environmental management. The large-scale spatial information provided by satellites is particularly useful in areas like the Northern Territory because it can provide information about areas which are vast and often inaccessible. Remotely sensed images can be compared over time to enable temporal comparison (NASA, 2005).

The sensors on remote sensing platforms usually record electromagnetic radiation. Electromagnetic radiation (EMR) is energy transmitted through space in the form of electric and magnetic waves (Star and Estes, 1990). Remote sensors are made up of detectors that record specific wavelengths of the electromagnetic spectrum. The electromagnetic spectrum is the range of electromagnetic radiation extending from cosmic waves to radio waves (Jensen, 1996).

The availability of remote sensed data in digital form helps in carrying out digital image processing with the aid of image processing software. The digital image processing techniques provide flexibility in data handling due to the fact that the digital data can be numerically manipulated by using an equation or set of equations to get the desired details in graphic display (or) pictorial form for further analysis (Lillesand and Kiefer, 1987). There are many procedures available for image data manipulation. They can be broadly grouped into three categories; image rectification and restoration (also called preprocessing), image enhancement and image classification.

Satellite remote sensing has been operational for nearly two decades. However with rapid improvement in spatial and spectral resolution of data obtained in visible and near infrared region, there is a need for continuing research in the field of aquatic environment from satellite data. In addition, there is number of image processing and analytical tools like Geographic Information System (GIS) available. It provides the opportunity to overlay different layers of information obtained from satellites and other sources and optimally extract the required information.

According to Chandra et al. (1993), remote sensing and geographic information system (GIS) provides valuable aids for the purpose because RS and GIS is a fast, efficient and accurate mean of information retrieval to detect any changes continually over time. The information gained can be utilized for effective planning and management.

Data obtained from the satellite was found very useful in the study of coastal zone and marine resources. The major areas of applications included mapping of tidal wetlands, coastal land forms, suspended sediments, understanding the process of estuarine dynamics, shoreline changes, generation of coastal currents, internal waves, degradation or improvement in mangroves and coral reefs (Jayaraman, 2000).

Various reflective values of a target landscape result in different colour pixels. The reflectance changes with different structures. Pixel colours also vary between different types of vegetation. Mangrove communities stand out on the image as deep green regions parallel to the coastline. This means that satellite images can be used to delineate mangrove habitat. Taking into account the relatively small size of mangrove

ecosystem and their narrowness in coastal fridges, only high resolution satellite products can be used such as SPOT-HRV, SPOT-HRVIR, Landsat TM, IRS and many more (Blasco et al., 2001).

2.2 SPOT and its applications

The SPOT (Le Systeme Pour l' Observation de la Terre) satellite has two identical high resolution visible (HRV) sensors. The HRV sensors can be operate in two modes; a panchromatic mode and multispectral mode. A panchromatic photograph is a "black and white" photograph. Panchromatic data, with 10 m ground pixels, has high spatial resolution and low spectral resolution. But panchromatic imagery would be poor choice for vegetation mapping because of the poor spectral resolution. However, because of relatively high spatial resolution, SPOT panchromatic image would be excellent choice for mapping roads, clearcut boundaries, rock outcrops, water bodies or other high contrast features (Verbyla, 1995).

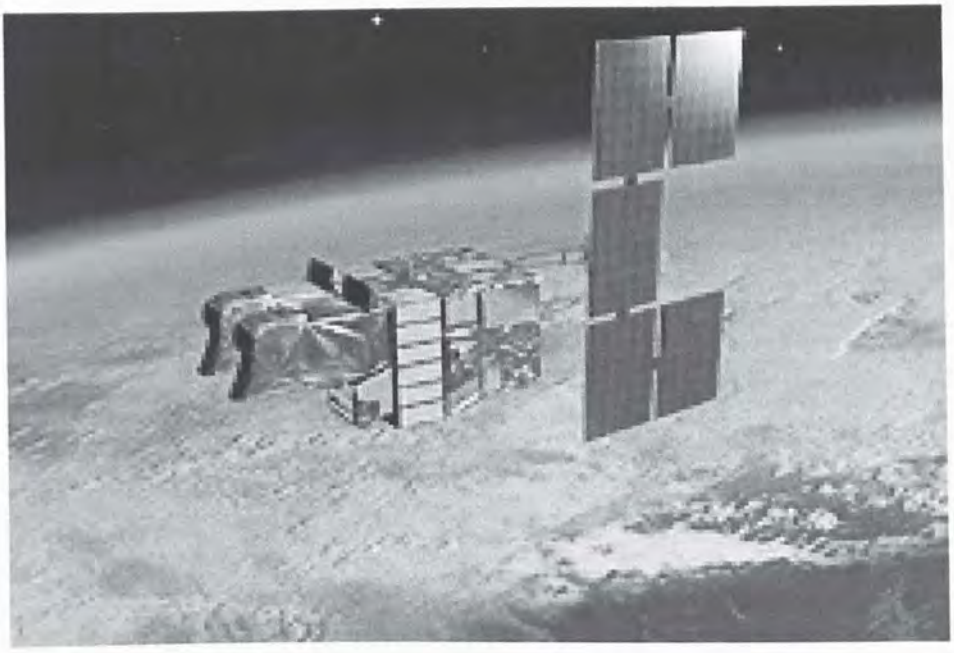

Figure 2.1 SPOT satellite (from Satellite Imaging Corporation, 2006)

SPOT XS, or multispectral, has 20 x 20 m spatial resolution, 8-bit radiometric resolution, and contains 3 bands (Jensen, 1996). The bands are within the green, red and near-infrared spectral regions. Table 2.1 showed information about these bands. These spectral bands are narrower than the SPOT panchromatic bands and therefore have higher spectral resolution. SPOT multispectral images have relatively high spatial resolution (20 m pixels). However, according to Verbyla (1995), SPOT multispectral data currently lack mid- infrared bands which may be important for mapping moisture or shadow-related features. Also it lacks a thermal band, which is critical in some applications such as mapping lake water temperature zones.

Table 2.1 SPOT 5 bands and functions (from ERDAS, 1997).

Band	Region	Wavelength (μm)	Function
1	Green	0.50 – 0.59	This band corresponds to the green reflectance of healthy vegetation.
2	Red	0.61 – 0.68	This band is useful for discriminating between plant species. It is also useful for soil boundary and geological boundary delineations.
3	Reflective infrared	0.79 – 0.89	This band is especially responsive to the amount of vegetation biomass present in a scene. It is useful for crop identification and emphasizes soil/crop and land/water contrasts.

The SPOT satellite system is unique in that it has pointable mirrors which allow for flexible user-specified ground coverage. This high temporal resolution is important for monitoring events such as flooding or forest fires. These pointable mirrors also allow images to be acquired at different angles; overlapping SPOT images can be viewed with a stereoscope in three dimensions (similar to aerial photograph).

SPOT-5 consists of two high resolution geometric (HRG) instruments which replaced the HRVIR (high resolution visible and infrared) system. These systems are designed to provide higher spatial resolution (5 m, instead of 10 m) in panchromatic mode; 10 m (instead of 20 m) resolution in green, red and near infrared bands; with 20

m resolution maintained in the mid-IR band due to limitations imposed by the geometry of the charge coupled device (CCD) sensors used in this band. SPOT 5 satellite characteristics are shown in the table below.

Table 2.2 SPOT 5 characteristic (from Satellite Imaging Corporation, 2006)

Launch Date	May 3, 2002
Launch Location	Guiana Space Centre, Kourou, French Guyana
Orbit Altitude	822 Km
Orbit Inclination	98.7°, sun-synchronous
Speed	7.4 Km/second – 26,640 Km/hour
Equator Crossing Time	10:30 a.m. (descending node)
Orbit Time	101.4 minutes
Revisit Time	2-3 days depending on Latitude
Swath Width	60 Km x 60 Km to 80 Km at nadir
Metric Accuracy	<50-m horizontal position accuracy (CE90%)
Digitization	8 Bits
Resolution	Pan: 2.5m from 2 x 5m scenes Pan: 5m (nadir) MS: 10m (nadir) SWI: 20m (nadir)
Image Bands	Pan: 480 - 710 nm Green: 500 - 590 nm Red: 610 - 680 nm Near IR: 780 – 890 nm ShortWave IR: 1,580 – 1,750 nm

Mangrove forest is similar to other humid tropical forest types as it can be detected from space using optical sensor imagery, with sufficient accuracy concerning their limits and density with high resolution instrument (Blasco et al., 1997; Hill, 1999). According to Chandra et al. (1993), SPOT HRV data is extremely good for

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