UNIVERSITI PUTRA MALAYSIA

DETERMINATION OF CHLOROPHYLL-a AND TOTAL SUSPENDED SEDIMENT USING AIRBORNE REMOTE SENSING DATA

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By

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

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DEDICATION

All praise and glory are expressed to the Almighty Lord for His blessings and graciousness that strengthen me to complete this thesis.

Utmost gratitude to my parents, Jasni Ismail and Salmah Alias for their patience, faith and undying support for my success.

Beloved big families in Selangor and Melaka for inspiring me all the time

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Finally, to my dearest wife "Mah" (Siti Asmah Hj. Ahmad), my loving daughter "baby umai" (Siti Humaira Akmalhisham) and my loving new born baby (Muhammad Fawwaz Akmalhisham)who are always by my side, thank you for your never ending support, patience and encouragement.

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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March 2007

Chairman : Professor Shattri Mansor, PhD

Faculty : Institute of Advanced Technology

The objective of this study are to derive the pattern of Chlorophyll-a (Chl-a) and Total Suspended Sediments (TSS) distribution as well as to built and integrate the Chl-a and TSS graphical models to a sub-system that can be utilized to generate the distribution maps of those parameters. The Chl-a and TSS modeling were generated from MASTER airborne data over the Kuala Terengganu coastal region. They were extracted by the empirical approach where the recorded reflectance of MASTER data was coincided to *in situ* data during the overpass. A linear coefficient of correlation R^2 gained for Chl-a was 0.5839 from the band ratio of 1/2 and for TSS was 0.4382 from the band 8. This weak interaction was resulted due to the limited sampling points and restricted sea surface region in the study area. These models were then integrated into IMAGINE image processing software through an automated processing sub-system that was created to hold on Chl-a and TSS modeling.

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

PENENTUAN KLOROFIL-a DAN KANDUNGAN SEDIMEN TERAMPAI MENGGUNAKAN DATA PENERBANGAN PENDERIAAN JAUH

Oleh

AKMALHISHAM BIN JASNI

March 2007

Pengerusi : Profesor Shattri Mansor, PhD

Fakulti : Institut Teknologi Maju

Objektif kajian ini adalah untuk mendapatkan corak taburan Klorofil-a (Chl-a) dan Kandungan Sedimen Terampai (TSS) serta membina dan mengintegrasikan model grafik Chl-a dan TSS ke dalam suatu sub-sistem supaya boleh digunakan untuk menjana peta taburan parameter-parameter tersebut. Permodelan Chl-a dan TSS dijanakan daripada data MASTER di kawasan perairan Kuala Terengganu. Ia diekstrak melalui kaedah empirikal di mana pembalikan data MASTER yang direkod diseiringkan dengan data lapangan ketika laluan pesawat. Nilai pekali hubungan linear R^2 untuk Chl-a yang didapati adalah 0.5839 daripada nisbah jalur 1/2 dan bagi TSS adalah 0.4382 daripada jalur 8. Hubungan yang lemah ini terhasil disebabkan titik sampel yang terhad dan kawasan permukaan laut yang terbatas di dalam kawasan kajian. Model ini kemudiannya diintegrasikan ke dalam perisian pemprosesan imej IMAGINE melalui suatu sub-sistem pemprosesan automatik yang dibina untuk menyimpan permodelan Chl-a dan TSS.

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Lastly, the author would like to express his sincere appreciation to his family especially to his lovely wife for their undying love, patience, encouragement and continuous supports during the course of the study.

I certify that an Examination Committee met on 19th March 2007 to conduct the final examination of Akmalhisham bin Jasni on his Master of Science thesis entitled "Application of Master Imagery in Determination of Chlorophyll-a and Total Suspended Sediment" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Putra Malaysia (Higher Degree) Regulation 1981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committees 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: 17 JULY 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.

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AKMALHISHAM BIN JASNI

Date: 30 MAY 2007

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ALT	Altitude
ASF	Ames Airborne Sensor Facility
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
ATM	Airborne Thematic Mapper
AVHRR	Advanced Very High Resolution Radiometer
AZI	Azimuth
CASI	Compact Airborne Spectrographic Imager
Chl-a	Chlorophyll-a
CZCS	Coastal Zone Color Scanner
CZ-IMS	Coastal Zone Information Management Sub-system
DEG	Degree
DN	Digital Number
E_d	Total Incident Irradiance
EML	Erdas Macro Language
ESA	European Space Agency
ETM+	Enhanced Thematic Mapper Plus
FOV	Field of View
GCPs	Ground Control Points
GIS	Geographical Information System
GLI	Global Imager

GPS	Global Positioning System
GUI	Graphical User Interface
HDF	Hierarchical Data Format
HH	Hour
IFOV	Instantaneous Field of View
IRS	Indian Remote Sensing Satellite
km	kilometer
LAT	Latitude
LONG	Longitude
L_{up}	Upwelling Radiance
L_w	Water Leaving Radiance
m	meter
MACRES	Malaysian Center for Remote Sensing
MASTER	Modis-Aster
MESSR	Multispectral Electronic Self-Scanning Radiometer
MERIS	Medium Resolution Imaging Spectrometer
MicroSAS	Micro Surface Acquisition System
MIR	Middle Infra Red
MM	Minute
MODIS	Moderate Resolution Imaging Spectroradiometer
MOS	Marine Observation Satellite
MOS	Modular Opto-electronic Sensor

MSL	Mean Sea Level
MSR	Microwave Scanning Radiometer
MSS	Multi Spectral Scanner
NASA	National Aeronautics and Space Administration
NDCI	Normalized Difference Chlorophyll Index
nm	nanometer
NOAA	National Oceanic and Atmospheric Administration
OCI	Ocean Color Imager
OCTS	Ocean Color Thermal Sensor
R^2	Coefficient of Correlation
RADAR	Radio Detection and Ranging
Ref	Reflectance
RMSE	Root Mean Square Error
RRS	Remote Sensing Reflectance
SAR	Synthetic Aperture Radar
SeaWiFS	Sea Viewing Wide Field of View Sensor
SLAR	Side Looking Airborne Radar
SML	Spatial Modeling Language
SNML	Spatial and Numerical Modeling Laboratory
sol	Sun at Zenith Angle
SPOT	*Satellite Pour l'Observation de la Terre*
SS	Second

SWIR	Short Wave Infra Red
TIR	Thermal Infra Red
TM	Thematic Mapper
TSS	Total Suspended Sediment
UPM	Universiti Putra Malaysia
US	United State
UTM	Universal Transverse Mercator
VNIR	Visible Near Infra Red
VTIR	Visible and Thermal Infrared Radiometer
WGS	World Geodetic System
ZEN	Zenith
µm	micrometer

CHAPTER 1

INTRODUCTION

1.1 General

The coastal zone is the most intensively used area compared to all other areas settled by humans in the world. In the next several years, more people will live in the coastal zone. For these reasons, coastal resources will continue to be, and are being placed under multiple, intensive and often competing pressures. These pressures on the coastal zone will certainly be more intensive in the future. The use of techniques which attempts to assist in managing the many conflicts in a sustainable way will therefore become increasingly important in both developed and developing countries (Kay and Alder 1999).

Various approaches from conventional to recent technology have been applied to monitor and manage this critical region. One of the modern techniques that are increasingly accepted by many scientists and engineers is remote sensing. Remote sensing plays an important role in coastal area management by providing a synoptic view of the landscape. Such view is partially impossible to be obtained by conventional *in situ* measurements, thus remote sensing offers a way to manage it. Remotely sensed imagery has been used to map coastal areas and their components such as water quality,

bathymetry, coastal dynamics, bottom features terrestrial and marine habitat and some coastal hazards.

The use of this method has become more important in understanding the behavior of coastal environments because of its capacity to provide both spatial and temporal information. An example of the usage of remotely sensed image data is in the monitoring of water bodies including the monitoring of high concentrations of sea surface temperature, chlorophyll and suspended sediments in coastal waters.

Moreover, the importance of remote sensing imagery and derived products for showing coastal and marine spatio-temporal trends on longer time scales are widely recognized, especially in relation to climatic variability. This applies to features on both sides of the land-sea boundary such as chlorophyll and sedimentation.

Therefore, development of methods to characterize the state and interaction of coastal water to remotely sensed image particularly in monitoring of chlorophyll and sedimentation concentration patterns and estimation of their constituents are challenging topics.

1.2 Statement of the Problem

There is growing awareness among the Malaysian public that the environment is a vital part of our lives. It is important for Malaysian to come with consistent and comprehensive action to conserve natural resources, tackle pollution problems and phase out unsustainable practise and technologies. The country's marine ecosystem, among the world's richest in terms of biodiversity is rapidly deteriorating. For example, the coral reefs which are essential breeding and nursery areas for many types of fish, are being exploited by commercial and tourism purposes, at the same time the concentration of phytoplankton and chlorophyll that most always for fish feeding also reduced, threatened by siltation and sedimentation caused by development project.

The use of conventional technique such as cruise observation certainly has limited contribution in order to solve the problem stated. For example, synoptic chlorophyll and sedimentation mapping from this particular technique has not been feasible due to the dynamic condition like as strong winds, rain, long-shore transport and else (Stabeno et al., 2004). Nevertheless, remote sensing in this application is able to manage this problem particularly in mapping of chlorophyll and sedimentation at single time scale for the entire study area. This study was focused to the use of remote sensing technique from an airborne platform in relation to retrieve Chlorophyll-a

(Chl-a) and Total Suspended Sediment (TSS) pattern and distribution from the data called Modis-Aster (MASTER).

In this study, the Kuala Terengganu coastal area had been chosen as a study area. It is among the most popular vacation and tourism zones in the country. In parts of its coastal zones, there are also large scale fishery activities and security-defences oriented, but other areas are supposed to be in a relative untouched status. Different ecosystems and their variability habitats are related to different tolerance and response to factors such as land reclamation activities, sediment load (turbidity), nutrient availability, currents and tides. These factors should be considered by the municipal and government for the duration of upgrading the area so that any error can be reduced or totally be avoided.

1.3 Objective

The goal of this study was to gain an advantage to the use of MASTER imagery in coastal zone management which was focused to two objectives as identified below:

1. To derive the pattern of Chlorophyll-a and Total Suspended Sediments distribution.
2. To built and integrate the graphical models as a sub-system that can be utilized to generate the distribution maps of Chlorophyll-a and

Total Suspended Sediments.

1.4 Scope of the Study

In order to achieve the objectives, the study was focused on these specific areas.

1. An airborne sensing data called Modis-Aster (MASTER) data was used. The data was obtained from PACRIM 2000 campaign coordinated by National Aeronautics and Space Administration (NASA) and Malaysia Center for Remote Sensing (MACRES).
2. The Chlorophyll-a and Total Suspended Sediment distribution were extracted base on empirical relationship between MASTER data and field data.
3. The graphical models and sub-system developed were integrated into image processing software Imagine 8.6, running under Window Operating System.

1.5 Thesis Structure

Chapter 1 (Introduction) reviewed to the introduction of coastal zone information management. The objectives and the scopes of the research were briefly described.

Chapter 2 (Literature Review) presents the past-related research by scientists in coastal zone information management and oceanography using an airborne remote sensing techniques.

Chapter 3 (Methodology) was contained the investigations of chlorophyll and sedimentation mapping. Methodology of the research and field data measurement was also discussed. Details about the Coastal Zone Information Management Sub-system (CZ-IMS) that had been integrated in to Imagine 8.6 were also included.

The results of this study were presented in Chapter 4 (Results and Discussion). This chapter had addressed the results of oceanography parameters extraction namely Chlorophyll-a and Total Suspended Sediment. The discussion of the results of those parameters had also been included. The validation of Chl-a and TSS had also been performed which were compared to Landsat & ETM+ (Enhanced Thematic Mapper plus). Next, the result and discussion of Coastal Zone Information Management Sub-system (CZ-IMS) also had been presented here.

Chapter 5 (Conclusions and Recommendations) gave the overall ending stages, which summarizes the overall results and recommendations onto this application of an airborne remote sensing for Chlorophyll-a and Total Suspended Sediment studies.