THE POTENTIAL OF SATELLITE IMAGERY IN SOIL COMPACTION STUDIES FOR IMPLEMENTATION OF PRECISION FARMING

By

NORASMANIZAN BT ABDULLAH
1031210458

A thesis submitted in fulfillment of the requirements for the degree of Master of Science (Environmental Engineering)

School of Environmental Engineering
UNIVERSITI MALAYSIA PERLIS (UniMAP)

2013

THE POTENTIAL OF SATELLITE IMAGERY IN SOIL COMPACTION STUDIES FOR IMPLEMENTATION OF PRECISION AGRICULTURE

NORASMANIZAN ABDULLAH

UNIVERSITI MALAYSIA PERLIS

2013

ACKNOWLEDGEMENT

ALHAMDULILLAH, I am thankful to the Almighty Allah, for with His blessings this master research finished successfully. Indeed, with His blessings, i'm able to get strength, guidance and faith to finish this research.

I would like to express my deepest appreciation to my supervisors, Mrs Ayu Wazira Azhari and Assoc. Prof. Dr. Mahmad Nor Jaafar for the guidance, materials and advices throughout the course of this work. They have spent a lot of time in guiding my research work and checking my thesis.

A million thanks to all UniMAP's staffs and lecturers especially the School of Environmental Engineering who are always sharing ideas, knowledge and skills with me. Also not forgetting the Dean of School of Environmental Engineering for his moral support and his attention to all environmental postgraduate students. My gratitude also goes to all the agencies and departments whose supplies the data for this research project.

Thanks to my friend as we always discuss together and give me support when facing problems. Last but not least, I want to thank my siblings, my beloved parents, Siti Fatimah Binti Draman and Abdullah Bin Razali @ Mohd Ghazali, also my husband Mohd Sabri Hussin, a great thanks for all their sacrifices and patience during the completion of my research project.

TABLE OF CONTENTS

PAGE

CHAPTER 2: LITERATURE REVIEW

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

μm	Micrometer
2D	Two Dimensional
ANOVA	Analysis of Variance
AOI	Area of Interest
ArcGIS	GIS software products produced by Esri
ARSM	Agency of Remote Sensing Malaysia
ARVI	Atmospherically Resistant Vegetation Index
AutoCAD	Computer Aided Design or Computer Aided Drafting software
AU	Astronomical Units
B	Blue Band Reflectance
BSI	Bare Soil Index
CI	Cone Index
COST	Improved Image Based Dark Object Model
CWC	Critical Water Content
d	Earth Sun Distance
DInSAR	Differential Interferometry
DIP	Digital Image Processing
DN	Digital Number
DAO	District Agriculture Office
DOA	Department of Agriculture
ENVI	Environment for Visualizing Images

EVI	Enhanced Vegetation Index
EOS	Earth Observation Satellite
ERDAS	Remote Sensing software designed by ERDAS. Inc
F	Test Statistic
F.A.O	Framework for Land Evaluation
ft	Feet
g	gram
G	Green Band Reflectance
GCP	Ground Control Point
GIS	Geographical Information System
GPS	Global Positioning System
ha	Hectare
ISODATA	Interactive Self Organizing Data Analysis Techniques
JERS-1	Japanese Earth Resources Satellite 1
JUPEM	Department of surveying and mapping
Kpa	Kilopascal
L	Soil Brightness Correction Factor
LANDSAT	Land Remote Sensing Satellite
LUTS	Land Use Types
m	Meter
MBD	Maximum Bulk Density
Mpa	Megapascal
MSS	Multispectral Satellite Scanner

MRSO	Malayan Rectified Skew Orthomorphic
MSAVI	Modified Soil Adjusted Vegetation Index
NASA	National Aeronautics and Space Administration
NDVI	Normalize Difference Vegetation Index
NDMI	Normalize Difference Moisture Index
NDWI	Normalize Difference Water Index
NPK	Nitrogen Phosphorus Potassium
NIR	Near Infra-Red Band Reflectance
NCRAN	Natural Resources Canada
OSAVI	Optimized Soil Adjusted Vegetation Index
P	Significance Level
PSI	Pound Square Inch
R	Red Band Reflectance
RGB	Red Green Blue Band Reflectance
RMSE	Root Mean Square Error
RS	Remote Sensing
R^2	Coefficient of Determination/Square Correlation Coefficient
SAR	Synthetic Aperture Radar
SATVI	Soil Adjusted Total Vegetation Index
SAVI	Soil Adjusted Vegetation Index
SMGM	Soil moisture Gaussian model
SPSS	Statistical Package for the Social Sciences
SPOT	Satellite Pour l'Observation de la Terre

SRI	Simple Ratio Index
SWIR	Short Wave Infra-Red Band Reflectance
TIR	Thermal Infra-Red
TM	Thematic Mapper
USGS	United States Geological Survey
USDA-ARS	United States Department of Agriculture's Agriculture Research Service
UTM	Universal Transverse Mercator
WGS	World Geographic System

Potensi Imej Satelit dalam Kajian Pemadatan Tanah untuk Pelaksanaan Perladangan Tepat

ABSTRAK

Objektif kajian ini adalah untuk menilai potensi imej satelit dan GIS (sistem maklumat geografi) dalam kajian pemadatan tanah dengan menyiasat pantulan spektrum dalam menghasilkan peta pemadatan tanah bagi pelaksanaan pertanian tepat. Ia menganalisis hubungan yang signifikan antara data pemadatan tanah dan data pantulan Landsat 5 TM imej. Kajian ini mengenal pasti kawasan yang berpotensi mengalami tanah padat dengan menganalisis indeks spektrum kandungan lembapan (NDMI), indeks tumbuh-tumbuhan (SAVI, MSAVI), indeks tanah (BSI). Hubungan di antara pembolehubah disiasat menggunakan pekali penentuan (R^2). Keputusan pengukuran 'gravimeter' menunjukkan ada hubungan yang signifikan terhadap kandungan air dalam pemadatan tanah. Oleh itu, data pantulan NDMI telah dikaji dan ia didapati mempunyai hubungan yang signifikan (R^2=0.755) dengan data penembusan tanah. Regresi linear 'band' SWIR juga menunjukkan korelasi yang signifikan tertinggi (R^2=0.84) dengan ($p<0.05$) berbanding dengan beberapa gelombang nampak iaitu 'Band' 1, (R^2=0.209) 'Band' 2, (R^2=0.142), 'Band' 3, (R^2=0.382) dan 'Band' 7, (R^2=0.305). Ungkapan regresi linear telah digunakan dalam meramalkan kawasan padat menggunakan 'Band Math' dan status peta pemadatan telah dicipta menggunakan kaedah geostatistik. Model matematik indeks spektrum juga menunjukkan korelasi dengan korelasi yang signifikan iaitu SAVI (R^2=0.724), MSAVI (R^2=0.725) dan BSI (R^2=0.422). Maklumat yang digabungkan daripada peta pemadatan tanah dan teknologi angkasa adalah berharga untuk petani dan penanam dalam rawatan tanah, aktiviti pembajakan dan seterusnya dalam pelaksanaan pengurusan pertanian spesifik.

The Potential of Satellite Imagery in Soil Compaction Studies for Implementation of Precision Farming

ABSTRACT

The objective of this study is to evaluate the potential of satellite imagery and GIS (Geographic Information System) in soil compaction studies by investigating the spectral reflectance in producing soil compaction maps for implementation of precision farming. It analyzes the significant correlation between soil penetration resistance data and reflectance data of the Landsat 5 TM image. This study identifies the possible areas of soil compaction by analyzing the spectral indexes of moisture content (NDMI), vegetation indexes (SAVI, MSAVI) and soil index (BSI). The relationship between variables is investigated using coefficient of determination (R^2). The results of gravimeter measurement showed had a significant relationship of water content level in soil compaction. Thus, NDMI reflectance data were studied and it was found that it had significant correlation (R^2=0.755) with soil penetration data. Linear regression of SWIR channel indicated highest significant correlation (R^2=0.84) with ($p<0.05$) compared to several channels visible band of Band 1, (R^2=0.209) Band 2, (R^2=0.142), Band 3, (R^2=0.382) and Band 7, (R^2=0.305). The expression of linear regression was used in predicting the compact area using Band Math function and the compaction status map was created using geostatistical method. The mathematical models of spectral indexes also indicated a correlation with the significant correlation of SAVI is (R^2=0.724), MSAVI (R^2=0.725) and BSI (R^2=0.422). The combined information of the soil compaction map and space technology is valuable for farmers and growers in land treatment, tillage activities and consequently in the implementation of site specific agricultural management.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Universiti Malaysia Perlis (UniMAP) has established an Agrotechnology Research Stations at Sungai Chuchoh Campus to provide research and development platform for agriculture and engineering discipline. The research station is situated 6° 39' 07" N latitude and 100° 15' 37" E longitude. The main activities are herbal farming and mango plantation. Land use for crop production is a major issue in current farming practice, especially where precision farming technology is to be applied.

This research focuses on the potential of satellite imagery in soil compaction studies using Remote Sensing and Geographical Information System (GIS). Remote sensing GIS plays an important role in environmental study and agriculture management which can be used for great varieties of application. The aim of this study is to investigate the soil compaction status by measuring soil penetration resistance for implementation of precision farming and to determine if remotely sensed images could identify compacted regions of soil compaction based on reflectance data and soil data.

In addition, the study analyses the correlation between soil compaction data and pixel value of satellite imagery. In this study, a penetrometer tool used to collect ground truth data and simultaneously recorded the coordinate using GPS handheld. A Landsat 5 Thematic Mapper (TM) of Perlis was acquired to identify possible areas of soil compaction. The correlation method analyses the identified areas of potential soil compaction using linear regression and polynomial regression. The map production of the soil compaction map can be used by the planner or farmers for site specific management practice.

Currently, Remote Sensing and GIS technologies are widely used in agriculture especially in precision farming and site specific management. There are several sensors that have been launched such as Quickbird, Ikonos, Spot, and Landsat. In this study, pre-processing part involves digital image pre-processing, digital image enhancement, digital image classification and GIS integration. During pre-processing part, the geometrically and radiometrically corrected image being applied for further analysis. Fig. 1.1 shows the study area that conducted in this research.

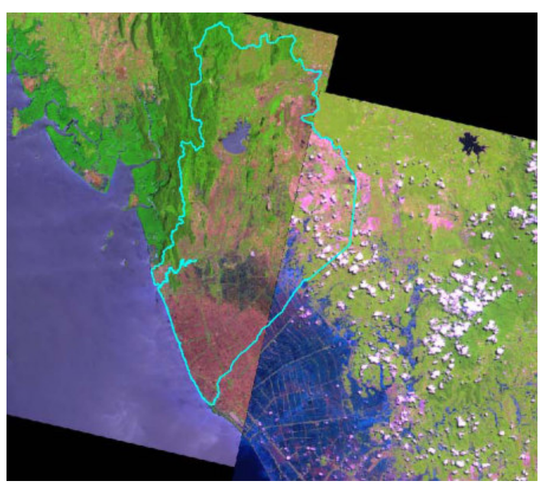

Figure 1.1: Study area of Perlis
(Source: ARSM, 2011)