LAND CLASSIFICATION USING BLACK AND WHITE AERIAL IMAGE OF SABAH TEA PLANTATION

RAJESWARY D/O GUNASESARAN

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UNIVERSITI MALAYSIA SABAH

2006

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of Sabah Tea Plantation.

rjana Muda Sains dengan Kepujian (Teknologi Tumbuhan)

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ABSTRACT

Assessment of aerial image is an alternative technique for satellite based remote sensing in tropical region where gives unclouded clear image for land classification purpose. The aerial image firstly digitalized, geocoded, orthorectified and system trained to recognized signature for supervised classification of land use in Sabah Tea Plantation, aided with ground truthing method. There are six classes identified and map of land class produced by Arcmap. The proportion of virgin rainforest at 17.90%, followed by pasture at 17.90 %, secondary forest at 15.98%, road at 13.64% and the proportion of building at 15.55%. The boundaries of vegetation and land used area defined with high precision with aerial image analysis using ERDAS IMAGINE 8.5. Ground truthing and geocoded data assessed for detect the location and land changes. As conclusion aerial image is suitable method for land classification in tropical region compare to satellite image with error cause by cloud cover. Aerial image are easy to analyzed, cheap and clear where application have great advantages in agricultural sector. The assessment aerial image produced more accurate and efficient land classification map for further agricultural management in Malaysia.

ABSTRAK

Penganalisaan, fotografi udara adalah teknik alternatif kepada imej satelit yang mengandungi ralat yang besar disebabkan lapisan awan yang tebal di kawasan tropika. Fotografi udara didigitalkan, digeokodkan, geometrik dibetulkan dan sistem diarahkan untuk mengesahkan penanda bagi klasifikasi berarah berlaku untuk menentukan jenis penggunaan tanah dibantu dengan kaedah kajian penerokaan tanah. Sebanyak enam kelas jenis penggunaan tanah dikenalpasti dan peta pengelasan tanah dihasilkan melalui perisian ArcMap. Bahagian hutan dara adalah, 19.39 % diikuti dengan kelas pastura, 17.90 %, hutan sekunder, 15.98 %, tanaman teh, 17.55 %, jalan, 13.64 % dan bangunan, 15.55 %. Sempadan bagi vegetasi didefinisikan dengan kejituan yang tinggi dengan menggunakan perisian ERDAS IMAGINE 8.5. Kaedah kajian penerokaan tanah dilakukan dan data yang bergeokod digunakan untuk menentukan lokasi penanda kelas. Kesimpulanya, penggunaan fotografi udara hitam putih sesuai bagi kajian pengelasan tanah di kawasan tropika berbanding dengan imej satelit yang mengandungi ralat disebabkan oleh liputan awan yang tebal. Data fotografi udara adalah murah, senang dianalis dimana pengaplikasian bermanfaat tinggi dalam bidang pertanian . Penggunaan fotografi udara dapat menghasilkan peta klasifikasi yang jitu dan berkesan bagi pengurusan pertanian di Malaysia.

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LIST OF ABBREVIATIONS & SYMBOLS

^{0}C	Degree Celsius
%	Percentage
^{2}	per-Square
$\sum$	Total
$\surd$	Sigma
i	GCP number
m	Meter
n	Number
T	Total RMS error
X	Coordinate X
Y	Coordinate Y
m/s	Meter per-Second
ha	Hacter
nm	Nanometer
μm	Micrometer
mm	Millimeter
XRi	The X Residual for GCPi
YRi	The X Residual for GCPi
GCPi	Input Ground Control Point
XRi^2	The X Residual for GCPi per-Square
YRi^2	The Y Residual for GCPi per-Square
Y	Retransformed Coordinates Y
IR	Infrared
E	East
N	North
RMS	Root Mean per-square
DEM	Digital Elevation Model
GCP	Ground Control Point
GIS	Geographical Information System
GPS	Global Positioning System
UMS	Universiti Malaysia Sabah

UTM	Universal Transverse Mercator
DIAL	Differential Absorption Lidar
IFOV	Instantaneous Field of View
ITBC	Institute of Tropical and Biology Conservation
NOAA	National Oceanic Atmospheric Administration
SSNM	Site Specific Nutrient Management
SPOT	French Satellite System Probatoire de Observation la Terre
ASTER	Advanced Spaceborne Thermal Emission Reflection Radiometer
AVHRR	Advanced Very High Resolution Radiometer
LIDAR	Light Detection and Ranging
MODIS	Moderate Resolution Imagine Spectrometer
MACRES	Malaysian Center of Remote Sensing

CHAPTER 1

INTRODUCTION

1.1 Overview

Remote sensing is a tool for obtaining information of an area without physical contact with it (Hossain *et. al.*, 2003; Wulder & Franklin, 2003) and able to define information about earth's surface and global change (Howard, 1991). Currently remote sensing technology is new paradigm in nature inventories and applied in various disciplines such as agriculture, geology, meteorology, forestry and oceanography.

In agriculture, the adoption of remote sensing technology develops new crop management strategies and believes to give high profitability. Remote sensing has been used to detect of field variability and optimizing input application in crop management (Haneklaus & Schnug, 2002) which technology targeted to enhance productivity effectively and environmental stewardship. In the last 10 years the remote sensing technology is a core of precision farming where improving efficient of methods, timing, and rate of fertilizers application with low environmental pollution by considering soil and climatic conditions (Srinivasan, 1998).

However, the use of remote sensing in agriculture has been facing many obstacles in the last 15 years and report claimed that only 1% of farmer's communities are using the technologies in Europe. In most tropical regions various diversity in local site conditions and agronomic practice within and between regions have happened more on the implementation. But in Malaysia adoption of remote sensing technology show improve environmental management strategies and resulting effective decision making (Syed Abdullah, 1982). The potential benefit of remote sensing technologies in Malaysian agricultural sector summarized as economical benefit by increasing yield, reduction of inputs and environmental benefit (Haneklaus & Schnug, 2002).

The implementation remote sensing in the tropical region like Malaysia has some limiting factors. The limited factors defined as unfavorable climatic condition, lack of local technical expertise, data availability, quality, cost, time, farm size, heterogeneity of cropping system and perception of user (Mohd. Noor and Gassner, 2005). Despite the factors listed above, the assessment of aerial image may be reliable data timely, cost effective, available and suitable for tropical climatic condition. Adoption of aerial image aided by remote sensing technologies has a great potential in agricultural strategies planning and helps systematic decision making. Assessment of aerial image provides easily accessible clear data without climatic error and directly applicable to field without interferences from the cloud cover. Utilization of aerial image in agriculture is an alternative tool for local State Departmental with low technical expertise by minimizing advanced computer literature workforce as used in satellite image interpretation.

Based on the easy and cheep access of aerial image data from local government agencies like The Lands and Surveys Department which extend over many districts. Perceptions of using aerial image convinced of benefits by providing systematic data that possibly can easily understood by local farmers and plantations. Considering the farm size and heterogeneity of cropping system, aerial image is applicable even to small size farm or large scale farm size by adjusting flight planning according land size (Srinivasan 1998). The aerial image can access to all types of crops including oil palm, paddy, coffee, rubber and other because the type vegetation clearly has defined in aerial image. The utilization of aerial image have multiple role that can used in various field planning like crop identification, irrigation, harvesting, land use classification, crop growth, disease identification, and pesticide application (Marshall & Lee 1994).

The research works define as improving the efficiency of remote sensing technology in tropical region and to introduce suitable technology for local farmer considering local site conditions and limiting factors. The work aims to maximize the utilization of aerial image in agricultural management and adopt an alternative remote sensing technology that reliable and suitable for Sabah or Malaysia. This research defines the potential of aerial image in agricultural land classification for further planning and management taking Sabah Tea Plantation at Nalapak as a case study area. The objectives of this research are:

1. To asses the suitability of aerial image to detect differences in land cover.
2. To produce thematic maps of land use classification based on aerial image.
3. To classify types of agricultural land use using aerial image.

CHAPTER 2

LITERATURE REVIEW

2.1 History of Remote Sensing and the Malaysian Perspectives

The Remote Sensing technology is used as early as 1839 with invention by camera in military for identification of enemies' position and strategic target. In the other hands, environmental remote sensing started with the use of bivarion pigeon, balloon and aero plane since 1909. Not until 1972 where low resolution weather satellites launched for the first time called Landsat TM series. Landsat 1 was launched by the US in 1972 followed by seven more Landsat TM platforms in different years.

Nowadays, remote sensing have been used in various disciplines such as agricultural management (Bluck, 2002), vegetation and land use classification (Hvidberg, 1994; Carpenter, 1997; Marshall & Lee, 1994), land cover, wetland and estuarine landscape mapping (Correa & Adhityawarma, 2002; Zharikov *et. al*, 2005; Mathiyalagan *et. al.*, 2005), hazard monitoring and disaster prediction and geomorphology studies (Syed Abdullah, 1987), soil mineral exploitation (Cranfield *et. al.,* 2004), and forest fire detection. In the field of agriculture, remote sensing techniques are widely used to minimize field variability such as The Site Specific

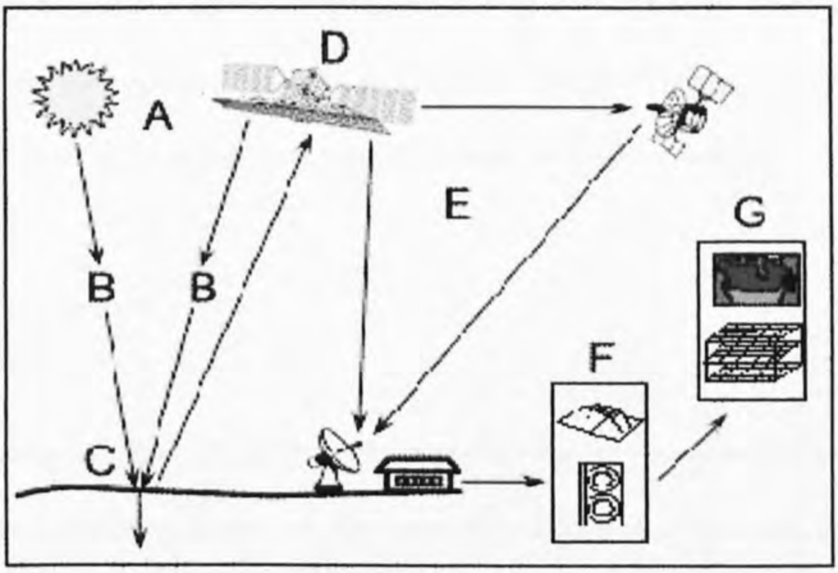
Nutrient Management (SSNM), as big part of precision farming technology (Srinivasan, 1998; Nyren & Patton, 2000; Lillesad & Kicfer, 2000; Haneklaus & Schnug, 2002; Mohd. Noor and Gassner 2005), harvesting (Bluck, 2002) and crop growth.

In Malaysia, Remote sensing data was first used for forestry applications in the 1970s (Pike, 2005). In 1982, airborne remote sensing applied in geomorphology studies of Kuala Lumpur drives information on types of landforms; morphology, geology and land cover (Syed Abdullah, 1982). In 1985, aerial photography is used for purpose of geological mapping of Parit Sulung in Peninsular Malaysia (Mat Akhir, 1985) and not until in early 1987, where satellite based remote sensing (Landsat TM) is first used studies the structural geology studies of lineament of Northwest Peninsular Malaysia (Syed Abdullah, 1987).

Recently, most research in Malaysia is done by the Malaysian Center of Remote Sensing (MACRES) where the Eighteen Conference of Remote Sensing was held in Kuala Lumpur in 1997 in order to promote operational applications of remote sensing and space technology in Malaysia (Ahmed, 2001). In Malaysia, most remote sensing work is apply on various field such as forestry, geology, meteorology, hydrology, oceanography, coastal zone and topography (Pike, 2005). However, less consideration is given to field of agriculture such as precision farming, crop identification, pest identification (Ronning, 2004) and agricultural management, even through some works have been carried out on paddy management (Smith, 2001) and recently in oil palm plantations.

2.2 Principles of Remote Sensing

Remote sensing technologies define as a process involves an interaction between incident radiation and the targets of interest, which consist four major parts like the energy sources, target, transmission path and sensor (Milne & Merton, 2004; Hossain *et. al.,* 2003). There are seven basic elements described in remote sensing (Fig. 2.1).



Where:

A- Energy source or Illumination

B- Radiation and the Atmosphere

C- Interaction with Target

D- Recording energy by Sensor

E- Transmission, Reception and Processing

F- Interpretation and Analysis

G- Decision making or application

Figure 2.1 The elements in remote sensing system (Hossain *et. al.,* 2003)

In summary the energy source from sun refers as a source provides electromagnetic energy to the target of interest. The target defines as object, surfaces or phenomenon and water. Radiation defines as the energy travels from sun to the target through transmission path or atmosphere (Hossain *et. al.*, 2003). The interaction with energy in transmission path and target depend on the properties target and the radiation. The sensor collects and records the emitted electromagnetic radiation from target. Then, the energy recorded by the sensor has to be transmitted to a receiving and processing station where the data digitalize as image. The image interpreted and analyzed digitally and target information delivered for decision making.

2.2.1 Energy Source

Remote sensing system can be divided as passive and active system. The source of energy in passive system is the sun. The passive system detects the solar radiation that have been reflected or emitted in from the surface features. The passive system which widely used is Landsat, aerial image and SPOT satellite. In contrast, the active system is produces its own energy such as the laser, microwaves and radar sensor. These systems are very flexible and can be used in night time.

2.2.2 Target Object

The target of remote sensing refers as the phenomenon, object and an area. The phenomenon defines as fact or occurrence in nature such as forest fire and disaster. The object can be mineralization zone, forest cover or water body. Mostly the land surface process defines as the energy, water, carbon and nutrient fluxes to a regional scale. The environmental management decision refers as land use, water and land management and environmental protection (Hossain *et. al.,* 2003).

2.2.3 Electromagnetic Radiation

The basic medium of remote sensing is electromagnetic radiation that takes space as medium for energy transfer (Faughn *et. al.,* 2005). Electromagnetic radiation travel in straight line same as the speed of light at 3.00x 10^8 m/s (Giancoli & Douglas, 2000) and describes as wavelength (French, 1971; Infeld & Rowlands, 1990; Voronovich, 1998). The electromagnetic spectrum is wide range of frequencies of electromagnetic waves which can be categorizes into microwaves, visible, infrared, ultraviolet, x-ray and gamma ray (Giancoli & Douglas, 2000). The range of visible light is from 400nm to 700nm which can detect by human eye. The prism disperses the visible light into several spectral components (Fig. 2.2). The sources of electromagnetic waves are natural processes, solar energy, and emission of atom, nuclei and electron (Faughn *et. al.,* 2005).

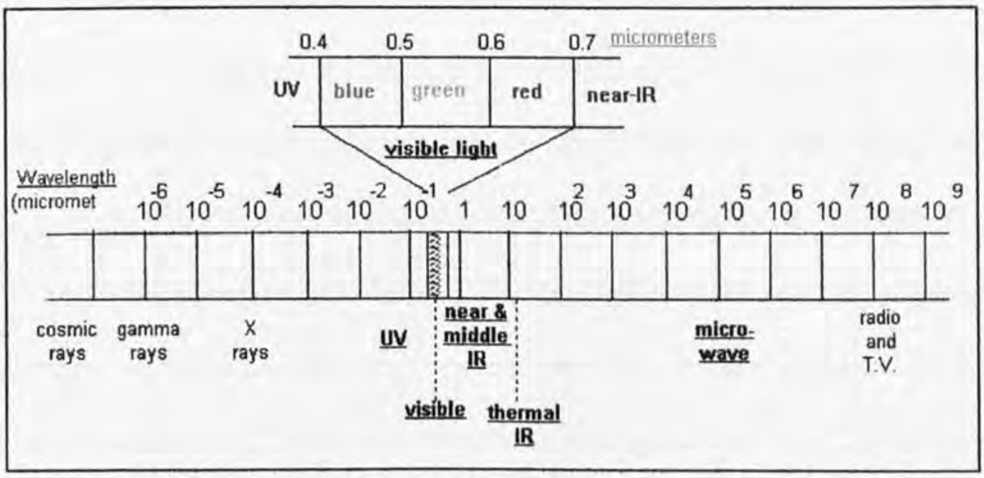


Figure 2.2 The electromagnetic spectrum (Natural Resources of Canada, 2005)

The channel emitted by band are narrow wavelength bands that been stored. The channel displayed digitally by using three primary colors: Red, blue and green (Fig. 2.3).

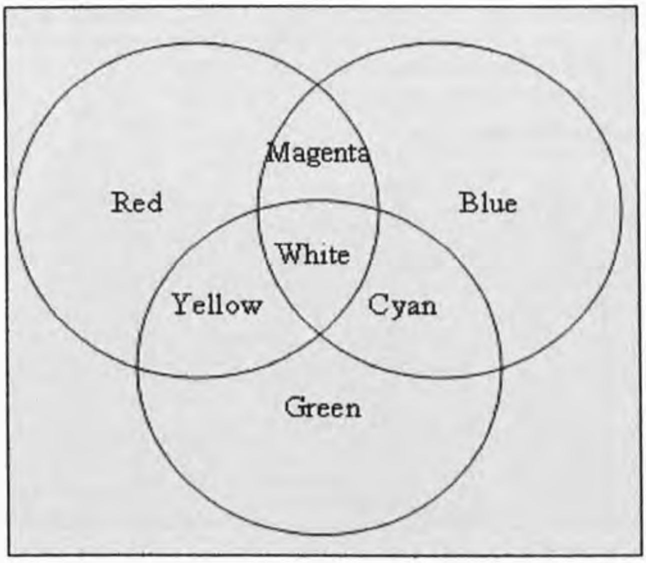


Figure 2.3 Mixing of additive color (Milne & Merton, 2004)

2.2.4 The Principles of Reflectance

The spectral reflectance defines as the ratio reflected energy to incident energy as function of wavelength. A spectral reflectance curve defines as a graph of the spectral reflectance of an object as a function of wavelength. Different object will give different reflectance at the different wavelengths (Fig. 2.4). The electromagnetic energy from the sun reflected, absorbed and transmitted depends on wavelength of the energy and characteristic of different objects (Nowatzki *et. al.*, 2004). The configuration of spectral reflectance curves provides insight characteristics of an object and influence on the choice of wavelength regions in which remote sensing data are acquired for a particular application. The relation between reflected, absorbed and transmitted energy can be determine the spectral signature of several different plants (Fig. 2.5). Generally, the configuration reflectance curve is an indicator of the type and condition of the features (Table2.1).

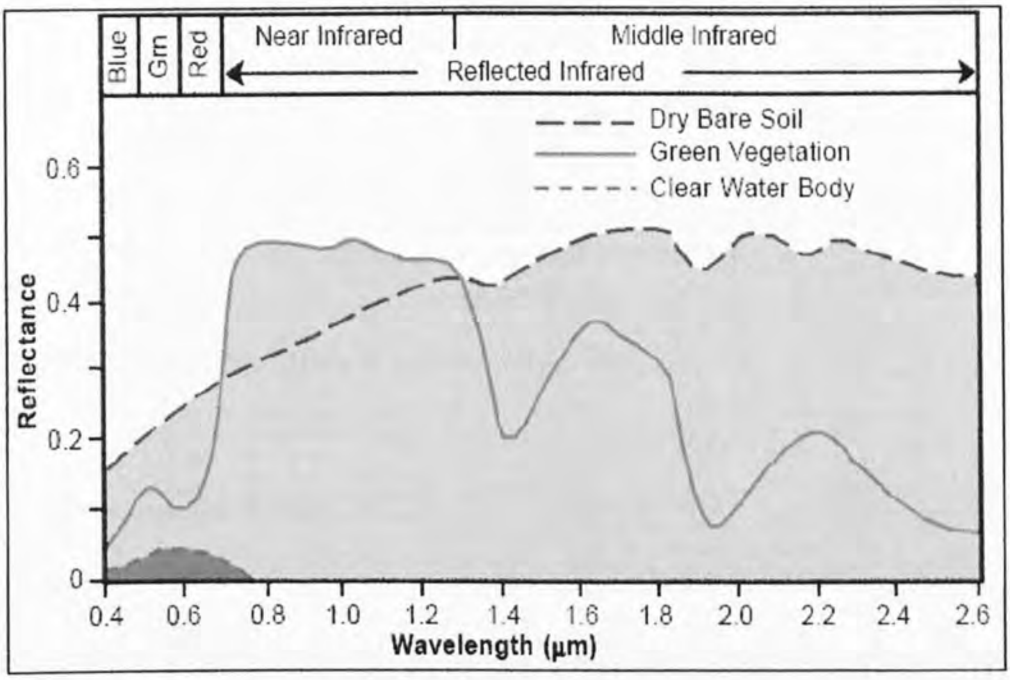


Figure 2.4 Spectral reflectance of natural materials (Smith, 2001)

Table 2.1 The principles of reflectance of several different object / target (Mangupin, 2005)

wavelength (µm)	**Principle**
0.45-0.52	Sedimentation, coniferous forest cover discrimination and soil vegetation diffrentiation
0.52-0.59	Green reflectance by vegetation, rock-soil discrimination, turbidity and bathymetry in shallow waters
0.62-0.68	Chlorophyll absorption such as plant species discrimination, differentiation of soil and geological boundary
0.77-0.86	Green biomass and moisture in vegetation, land and water contrast, landform and geomorphic studies

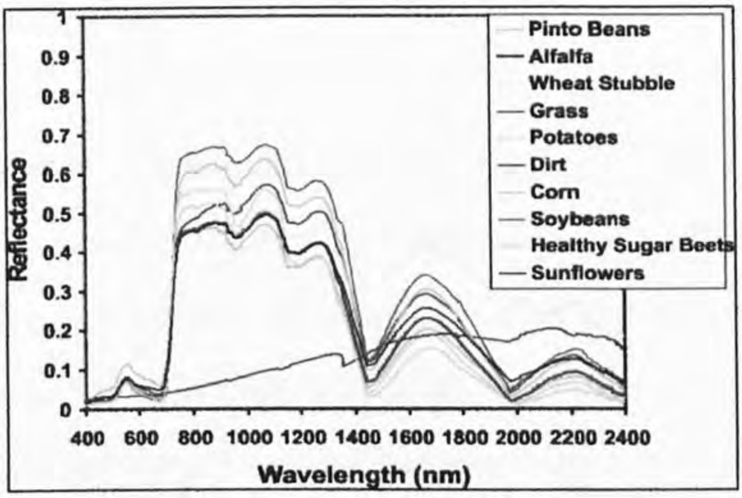


Figure 2.5 Spectral signatures of plants (Smith, 2001)

2.2.5 Transmission Path

The transmission path is the space between the electro-magnetic energy source and the target as atmosphere. The path radiance refers as portion of radiance recorded by remote sensor. The gases in atmosphere affect the absorption of solar radiance and each gas absorb energy in specific wavelength range. The remote sensors minimize the absorption and increase the transmission of radiation. Variation in atmospheric transmission is due to wavelength-selective absorption by atmospheric gaseous (Fig. 2.6).

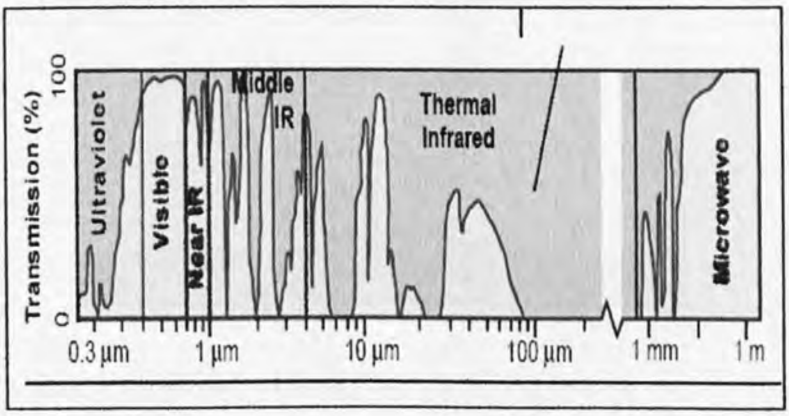


Figure 2.6 The variation in atmospheric transformation (Smith, 2001)

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