UNIVERSITI PUTRA MALAYSIA

ESTIMATION OF ABOVE-GROUND BIOMASS OF OIL PALM TREES USING PHASED ARRAY L-BAND SYNTHETIC APERTURE RADAR DATA

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By

VEENA SHASHIKANT

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

January 2014

DEDICATION

Dedicated to my beloved father

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science.

ESTIMATION OF ABOVE-GROUND BIOMASS OF OIL PALM TREES USING PHASED ARRAY L-BAND SYNTHETIC APERTURE RADAR DATA

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VEENA A/P SHASHIKANT

January 2014

Chairman : Assoc. Prof Abdul Rashid Mohd Shariff, PhD
Faculty : Engineering

Quantification of Above Ground Biomass (AGB) over oil palm plantation is essential for a wide range of modern day research and management demands. Spatial distribution information of oil palm plantation AGB is therefore important for the palm oil industry. In this study, the oil palm plantation in Perak, Malaysia was assessed to obtain the AGB information. Lack of biomass information due to the uncertainties and cost has limited its determination and changes over the years. Hence, this research studies the quantification of AGB of oil palm plantation. In a tropical country such as Malaysia, cloud covers are hindrance to visible light sensing. For that reason, all types of Synthetic Aperture Radar (such as Phased Array type L-band Synthetic Aperture Radar (PALSAR)) sensor is an added advantage to overcome the cloud problem to analyze the biomass of the oil palm plantation. Ground data of oil palm biomass for age of 6, 8, 10, and 12 years old are trees compared to the estimated AGB using PALSAR data with all polarizations. Four filters were applied on the PALSAR images and compared among the four window sizes which were 3x3, 5x5, 7x7 and 9x9. The filters used in this study were Gaussian low, Gaussian high, Laplacian and Median filter implemented in PALSAR data with HH, HV, VH and VV polarimetry bands. Speckle suppression index was applied to check the filters' efficiency and thus selection of model building. A valid model was constructed to show the VV polarization degree of relationship between the field data results and filtered PALSAR data of biomass. The model developed had an R^2 value of 0.90, between the VV backscattering against the AGB values. This model was subsequently validated and found to have an accuracy of 85%.This study can be useful to the management of the logging cycle and the volume of the harvested biomass in the felling season in the oil palm plantations.

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

RAMALAN BIOMASS ATAS TANAH UNTUK POKOK SAWIT OLEH PHASED ARRAY L-BAND SYNTHETIC RADAR APERTURE, PALSAR

Oleh

VEENA A/P SHASHIKANT

Januari 2014

Pengerusi : Prof. Madya Abdul Rashid Mohd Shariff, PhD
Fakulti : Kejuruteraan

Kuantifikasi Biomas Atas Tanah (BAT) di ladang kelapa sawit adalah penting untuk pelbagai penyelidikan moden dan permintaan pihak pengurusan. Oleh itu, maklumat mengenai taburan ladang kelapa sawit BAT adalah penting bagi industri kelapa sawit. Dalam kajian ini, ladang kelapa sawit di Perak, Malaysia telah dipilih untuk mendapatkan maklumat BAT. Kekurangan maklumat tentang biomas kerana ketidakpastian dan kos telah terhad selama ini. Dalam sebuah negara tropika seperti Malaysia, awan menjadi penghalang kepada penderiaan cahaya yang boleh dilihat. Sensor '*Phased Array L-Band synthetic aperture radar (PALSAR)*' adalah satu kelebihan untuk mengatasi masalah awan untuk menganalisis biomas ladang kelapa sawit menggunakan penderiaan jarak jauh. Data BAT kelapa sawit yang meliputi umur 6,8,10 dan 12 tahun dibanding dengan anggaran BAT oleh PALSAR untuk semua polarisasi. Empat penapisdigunakan atas imej PALSAR dan kemudian dibandingkan antara saiz empat tingkap, 3x3, 5x5, 7x7 dan 9x9. Penapis yang digunakan dalam kajian ini adalah Gaussian rendah, Gaussian tinggi, Laplacian dan median dalam PALSAR data iaitu HH, HV, VH dan VV polarisasi. Indeks Penindasan Belu telah digunakan untuk membolehkan memeriksa kecekapan penapis seterusnya pembentukan model. Model sah telah dibina untuk menunjukkan tahap polarisasi VV hubungan antara keputusan data lapangan dan ditapis data biomas PALSAR. Model yang dibangunkan mempunyai nilai R^2 sebanyak 0.90, antara backscattering VV terhadap nilai BAT. Model ini kemudiannya disahkan dan didapati mempunyai ketepatan 85%.

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I certify that a Thesis Examination Committee has met on 10 January 2014 to conduct the final examination of Veena a/p Shashikant on her thesis entitled "Estimation of Above-Ground Biomass of Oil Palm Trees using Phased Array L-Band Synthetic Aperture Radar Data" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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INTRODUCTION

1.1 General

1.1.1 Scenario of Oil Palm Plantation in Malaysia

The oil palm tree, *Elaeis guineensis jacq.* (Figure 1) originates from West Africa which was introduced to Malaysia, then Malaya, by the British in early 1870's as an ornamental plant. The cultivation of oil palm increased at a fast pace in early 1960s under the government's agricultural diversification programme, which was introduced to reduce the country's economic dependence on rubber and tin (The Oil Palm Tree, 2006). Malaysia is one of the largest producers and exporters of palm oil in the world (Pool R, Workshop Summary). Therefore, the industry provides employment to more than half a million people and income to an estimated one million people.

Oil palm plantations require intensive labor and much care. Palm trees need to be protected and nurtured carefully so that they grow, develop and reach their maximum yields as quickly as possible. Good plantation management also involves protection of the oil palm throughout its life span and ensuring that other crops do not take away the water, light and soil nutrients it needs. The oil palm also needs to be protected against pests and diseases and requires the right amount of water and nutrients when necessary. Finally, it is important that leaves and bunches are cut carefully so as not to damage the plant.

Benefits of oil palm plantation with its perennial green cover and closed canopy displays the main features of a tropical rainforest. Oil palm trees are unique in a way that they have higher leaf area index that allows them to have better photosynthetic efficiency. This results in the palm trees to produce more oxygen to the air and absorb more carbon dioxide from the atmosphere. It is also a more efficient carbon sink than a tropical rainforest and helps absorb greenhouse gases.

Ravindranth (2008) mentioned that Above Ground Biomass (ABG) can be expressed as tones of biomass or carbon per hectares. AGB is the essential and visible carbon pool, and the dominant carbon pool in forest and plantations. Biomass determination of potential carbon emission that could be released to the atmostphere due to deforestation or conversion to non-forest land use. Therefore, accurate biomass estimation is necessary for better understanding deforestation impacts on global warming and enviromental degedration (Lu et al, 2002). Plant biomass represents a sink for atmospheric carbon dioxide,which is one of the most important green house gases and which assumed to contribute more than half of the global warming (Syahrinudin, 2005).

Remote sensing technology is excellent method to monitor oil palm plantation. In another research (Lu et al, 2002), mentioned that computer-prosessed remotely sensed data are the best data for economical biomass estimation in tropical regions over large areas. Although providing higher accuracy, the traditional technique based on the field measurements are costly and time consuming. Selection of appropiate biomass estimation method and use of reliable vegetation inventory data are two key factors for this purpose (Zhao M and Zhou G-S, 2005). According to Palm Oil and the Environment (2013), an oil palm plantation assimilates 44.0 tones of dry matter per hectare per year compared to 25.7 tons of dry matter per hectare per year a rainforest assimilates.

On the other hand, oil palm management has become more resourceful and cost-critical during the last decade. Cultivating oil palm not only requires the right climate and soil. Obtaining maximum yields at each production stage also depends on the quality of seeds used, a rigorous selection process of seedlings in the nursery, good soil preparation before seeds are planted, the setting up of plantations correctly and the right use of fertilizers (de Desarrollo and Pradeepkumar T, 2008).

Figure 1: Oil Palm platation

1.1.2 Remote sensing in relation to oil palm AGB

Remote sensing techniques provide an alternative to traditional methods of estimating AGB or carbon dynamic of forest and plantation. With the abilities of capturing spatially explicit information and repeatable monitoring even in remote area in a cost effective way. According to Calle FR and Rosillo-Calle F (2007), remote sensing has become popular to estimate growing stock of biomass or its productivity area.

Many researchers focused on developing the relationships between such structural parameters of forest or plantations such as basal area, biomass, crown cover, tree height or diameter at breast height in response to the electromagnetic radiation. The comparison of these relationships in different types of forest stand structures and environment conditions (soil moisture, species, crown geometry, canopy structure and others) is effective to evaluate the potential in biomass estimation. Significant developments in technologies recently have allowed a more accurate measurement at a lower cost that would increase the direction of AGB estimations in forest and plantations.

1.2 Problem Statement

The oil palm plantations in Malaysia are vital to the country's income. These plantations are all crucial in terms of its producing maximum yield that will enable the aim of the country to allow oil palm to be the main commercialized product and be the dominating exporter of palm oil. Oil palm has many products that are commercialized. Therefore, biomass determination is equally important to gain the information of the palms standing volume. Biomass estimation through destructive sampling can be costly and time consuming. Manual determination of AGB is demanding and taxing. Remote sensing approach by using satellite imagery is a good alternative to estimate AGB in plantations. However, problems faced of estimating AGB in tropical areas using optical satellite images is cloud cover issues. Some research have found out that even though cloud cover rectifications is done on the optical images, the cloud shadows issue somehow critically cannot be solved.

On the other hand, active remote sensing can address the cloud cover issue. Active remote sensing illuminates its own target and able to penetrate through the clouds. The Advanced Land Observation Satellite (ALOS) active remote sensing sensor has precise capabilities that will enable the biomass parameter to be studied**.** Estimating biomass palm trees through radar imagery will be an alternative that will faster and applicable easily. These ALOS images will be analyzed strictly in a way the image will enable interpretation of height for the oil palm plantation. The biomass estimation will then be developed. Thus, the overall status and specific oil palm AGB can be monitored.

1.3 Purpose of Study

This study investigates the determination of AGB using PALSAR backscattering. A good model of biomass estimation using radar imaging is attempted. In restricting the palm plots by age, clone, soil class and area as a constant, we can know the AGB changes. Thus, it was also provide of decision support information that can assist the management team when making critical decision which related to Oil Palm biomass.

1.4 Objectives

The specified objectives of this research are

1. To model the above ground biomass of palm trees using Phased Array L-Band Synthetic Aperture Radar (PALSAR) backscattering properties.
2. To compare Median, Laplacian, Gaussian low and Gaussian high filter for the polarimetry polarization of PALSAR.

1.5 Significance of study

This study will provide various significances to the educational and technological sector. This research involves image processing of satellite images (LANDSAT-5 and ALOS PALSAR) and spatial data filtering of the study area. The outcome of this research shows the spatial framework and its relationship with AGB of oil palm trees in Malaysia. This research follows the Kyoto protocol of IPCC (International Protocol of Carbon Credit) to estimate AGB of oil palm trees. In other words, this research is capable to feed information regarding AGB to the oil palm industry of Malaysia and internationally. The methods and techniques used in this research can provide guide to the educational and technology field to estimate AGB of oil palm trees by using remote sensing and also help the palm industry to explore the potential of AGB.

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