Estimation of Aboveground Biomass at Species Level in Tropical Rain Forest Using High Resolution Remote Sensing Satellite Data

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Keywords: Aboveground Biomass; species; remote sensing

ABSTRACT – The estimation of aboveground forest biomass at species level is crucial due to the high variability in tropical forest tree species. Therefore, this study aims to estimate aboveground biomass (AGB) at different tree species by using remotely sensed data. The study was carried out at Forest Research Institute Malaysia (FRIM), Kepong Selangor. High resolution WorldView-2 satellite image was used to classify tree species based on nearest-neighbor method, where the AGB was estimated by using classical allometric equation. A number of sample trees were measured on the ground and five species were chosen namely *Neobalanocarpus heimeii, Dryobalanops aromatica, Dryobalanops oblongifolia, Shorea bracteolata*, and *Dipterocarpus baudii,* respectively. Classification of these species was based on spectral signatures measured on the leaves samples by using spectroradiometer. Correlation analysis was applied to estimate the AGB at individual stand from spectral bands and vegetation indices derived from the images. The result indicated that the polynomial function produced the best correlation between NIR2 and AGB with a coefficient of determination (R^2) of 0.685 and RMSE at ±2.539. As a conclusion, this study successful to show that Worldview-2 satellite image able to be used to estimate aboveground biomass at different species at high density tropical rainforest.

1. INTRODUCTION

In recent years, tree biomass estimation has been becoming critically important as the climate is changing and the earth becomes warmer due deforestation and forest degradation. Aboveground biomass (AGB) of forests is one of the key parameters for carbon accounting. Houghton [1] stated that it also plays crucial roles in mitigating effects of climate change and control the global carbon balance. Remote sensing has been recognized as one of the primary spatial inputs for this process [2-3].

This study has been carried out to provide information on AGB at different tree species by using multispectral WorldView-2 data. Thus, this study is executed according to the following objectives; (i) to delineate trees species by using WorldView-2 data, (ii) to estimate AGB of the trees, and (iii) to map tree species and AGB in the study area.

2. METHODOLOGY

Five dominant tree species in the experimental plot of study area (FRIM, Kepong Selangor, about 30 ha) were selected which are Keladan (Dryobalanops oblongifolia), Kapur (Dryobalanops aromatica), Meranti Pa'Ang (Shorea bracteolata), Chengal (Neobalanocarpus heimeii), and Keruing Bulu (Dipterocarpus baudii). While, allometric function that developed by Chave et al. [4] was used to estimate AGB of the trees.

Subsequently, WorldView-2 satellite image processing comprised of radiometric calibration, geometric correction, image-mosaic and image subset.

Furthermore, regression equations were developed using single bands and vegetation indices (VIs) as independent variable and the AGB (ton/ha) as dependent variable. The estimation of biomass data were obtained from experimental plots and the trees species were randomly selected which consisted of 23 numbers of trees. Five types of models, comprised both linear and non-linear functions were derived, which were exponential, linear, logarithmic, polynomial and power. The correlation with the highest coefficient of determination (R^2) values was chosen to estimate the AGB in the entire of study area.

3. RESULT AND DISCUSSION

3.1 Biomass estimation

Biomass measured in the field using allometric equation from Chave et al. [4] was regressed against spectral bands and VIs that derived from Worldview-2 image. While, this study successfully determined that NIR2 spectral band showed the highest values for R^2 (0.685), and lowest values for MAPD (23.931) and MRPD (9.729), respectively. Subsequently, the NIR2 regression model is been deployed for biomass estimation in forest of FRIM, Kepong, Selangor.

3.2 Tree species classification

The classification method requires the formation of

a training sample for each species of trees. The classes were identified with five types of tree species. 70% of training samples from total number of trees were used. In order to execute the tree species classification, the image has undergo tree crown delineation process to locate individual tree. Then, nearest-neighbor was used to produce the tree species classification using mean spectral reflectance. The tree species distribution map at FRIM forest is shown in Figure 1.

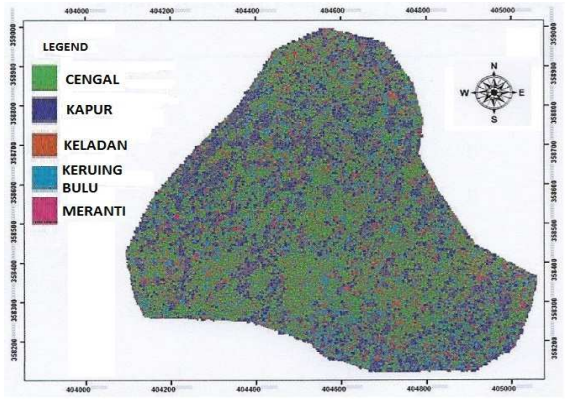

Figure 1 Tree species distribution map at FRIM forest

3.3 Estimation of Aboveground biomass at Tree Species

Based on the result, Cengal indicates the highest value of aboveground biomass estimation with 1269.01 ton and Keladan shows the lowest of biomass at 55.19 ton. Meanwhile, Kapur, Keruing bulu and Meranti showed the total aboveground biomass at 809.53 ton, 462.32 ton and 224.40 ton, respectively. Figure 2, 3, 4, 5, and 6 show the distribution of aboveground biomass at species level for FRIM forest respectively.

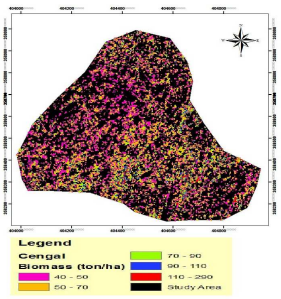

Figure 2 Biomass Estimated for Cengal

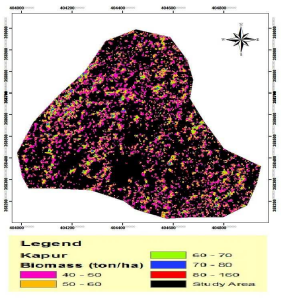

Figure 3 Biomass Estimated for Kapur

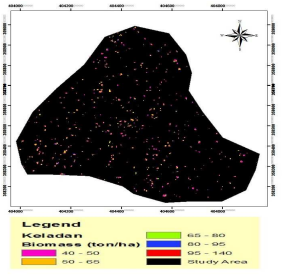

Figure 4 Biomass Estimated for Keladan

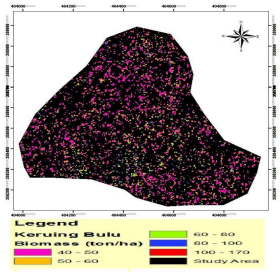

Figure 5 Biomass Estimated for Keruing Bulu

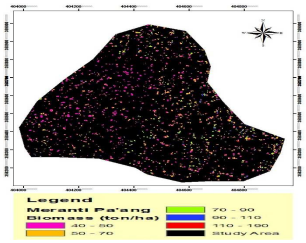

Figure 6 Biomass Estimated for Meranti

4. CONCLUSION

As a conclusion, this study had observed the distribution of tree species with their corresponding AGB in 30 ha forest of FRIM, Kepong, Selangor. Remote sensing provides a variety of methods for classifying forest communities up to species level. Remote sensing provides a synoptic view and delivers information over large areas at a high level of detail using large variety of sensors with a wide range of spatial and spectral resolution [5]. Tree species classification in this study used object-based with nearest-neighbor method with overall accuracy at 66.67%. The moderate mode classification accuracy occurred is due to insufficient data for one of the tree species in the study plot. While for AGB, polynomial regression model had found to be the most suitable model with R^2 value 0.685 for this study and was used in biomass estimation for the whole study area.

ACKNOWLEDGEMENT

The author would like to thank FRIM, Kepong, Selangor who has been directly involved and gives their full support. Deepest gratitude to Ministry of Higher Education and University Teknologi Malaysia for providing research fund under FRGS-VOT 4F336, GUP Tier 1 VOT 14H44 and GUP Tier 1 VOT 20H01 that make this research well executed.

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