Assessment of Above Ground Biomass in Phu Pha Wua Forest Park Kalasin Province, Thailand

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ABSTRACT

The above ground biomass (AGB) represent the living biomass and the sustaining of the forest. The objectives of this research to assess the AGB with measurements from the sampling plot using an allometric equation. In addition, to estimate the AGB with measurement and the satellite image data by using multi linear regression analysis. The independent variable of the satellite image used the normalized difference vegetation index (NDVI), soil-adjusted vegetation index (SAVI), and fractional vegetation cover (FVC). The results of the allometric equation calculated the AGB of the tree in the 62 sample plot was 79.6 Ton per hectare. The results of estimated the AGB found that the equation was y = (11705.07 * SAVI) + (-12925.7 * FVC), which the coefficients of determine R^2 was 0.85. The results estimated the AGB was 1055540.80 tCO2e in the study area.

Keywords— *above ground biomass; vegetation indices; multi linear regression model;*

I. INTRODUCTION

Carbon sequestration is the process for capture and storage the carbon from the atmosphere. This process can be storage and changing carbon stock in forest or agricultural is effect to amount of the emission or absorption of carbon dioxide CO2 in the atmosphere. The emission reduction of greenhouse gas (GHG) in the atmosphere is called for in Kyoto Protocol [1]. In Thailand, it recognizes the importance of solving global warming problems from climate change. By promoting projects that can help reduce GHG emissions according to a clean development mechanism. The Thai Cabinet's resolution approved the establishment of the Greenhouse Gas Management Organization as public organization in accordance with the law on public organization on May 15, 2007, the public organization entitled "Thailand Greenhouse Gas Management (Public Organization)", called "TGO" [2]. The TGO has organized to monitor and evaluate the certified projects. The objective of TGO to promote project development and the marketing certified GHG is the information center about the GHG operation situation.

This article focuses on the estimate of carbon sequestration in term of above-ground biomass (AGB). The AGB carbon pool consists of all living vegetation above the soil, inclusive of stems, stumps, branches, bark, seeds and foliage. The biomass of a tree is the sum of the biomass of its roots, trunk, branches, leaves and reproductive organs- flowers and fruits [3]. The different approached for assessment of carbon sequestration based on field measurement, remote sensing and geographical information systems (GIS) have been applied for AGB estimation [4]. Remote sensing has enabled us to monitor natural resources on a continental, even on a global scale. It is also the only realistic and cost-effective way of acquiring data over a large area [5]. Also, [4,5] they are presented the summary of the techniques for above-ground biomass estimation based on the remote sensing method from high, medium and coarse resolution data.

The main objective focused on the spatial regression model to estimate AGB according to the parameters derived from the remote sensing imagery. The parameters are based on vegetation indices including NDVI, soil-adjusted vegetation index (SAVI), and fractional vegetation cover (FVC) from the remote sensing imagery. The multi-linear regression model to estimate AGB with the vegetation indices.

II. MATERIAL AND METHODS

A. Study area and data collection

1)Study area

The study was implementation in PhuPhaWua Forest Park, Kalasin province, Thailand shown in fig 1. The study area (16.534385 N, 104.189437 E) covers approximately 7.84 sq.km.
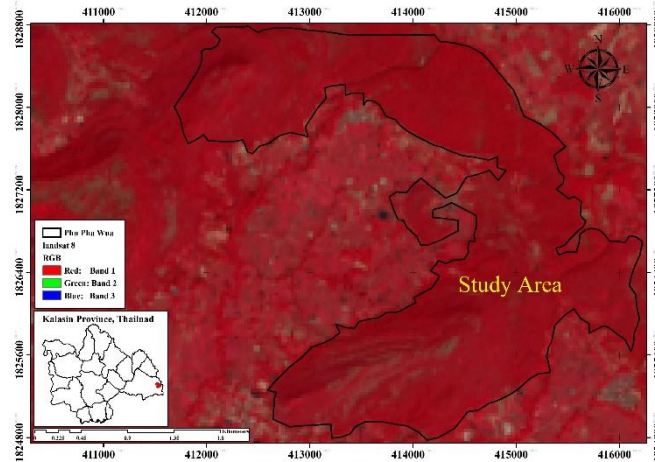

Fig 1. The study area,   PhuPhaWua Forest Park, KalasinProvince, Thailand.

2) Data collection

The study site is located in PhuPhaWua Forest Park, Kalasin province, Thailand which containing various forest types. The sampling plot was the enumeration of randomly sample plots using the stratified random method. The number of permanent sampling plots in the sample tree is a total of 62 plots, by each plot has a dimension of 40 m. × 40 m. and all of the trees in the plot are measuring heights of trees at 1.30 meters and recording names, sizes, and heights of trees [6].

B. Above-ground biomass (AGB) from field survey

The analysis of above ground biomass of trees had used the allometric equation developed for local plants in Thailand [7]. The method was used to estimate the above ground carbon capture as shown in the equation [8].

$$W_s = 0.396(D^2H)^{0.933}$$
$$W_b = 0.349(D^2H)^{1.030}$$
$$W_l = (28/(W_s + W_b + 0.025))^{-1}$$
$$W_t = W_s + W_b + W_l$$

Where

W_t is the total of tree (kg);
W_s is the weight of the stem (kg);
W_b is the weight of branches (kg);
W_l is the weight of leaves (kg);
D is the diameter at breast height (cm);
H is the tree height (m).

C. Spatial analysis of AGB base on statistical regression model

The remote sensing data with the estimated AGB was based on field measurements from the survey sampling plots. The spectral information from the image can be approximated by the AGB by using the spatial analysis based on the regression model. This research focused on vegetation indices and fractional vegetation cover (FVC) for the estimated AGB base on the statistical regression model.

1) Vegetation Indices

The normalized difference vegetation index (NDVI) and the soil-adjusted vegetation index (SAVI) was used to improve the ability to separate healthy vegetation from other land cover types. In their original equations, they provide normalized values in the interval from −1 to 1. These vegetation indices have the advantage of being less dependent on illumination and having a good discrimination between different land cover types. They show higher values for vegetation, positive low values for water and bare soils and negative index values for clouds. The NDVI is a normalized ratio of NIR (near infrared) and Red (red band) defined as [9]:

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

The SAVI was developed as a modification of the NDVI defined as [10]. The structured of the SAVI similar to the NDVI which includes a correctio factor of the near infrared band (L) [11] following:

$$SAVI = \left[\frac{NIR - Red}{NIR + Red + L}\right](1 + L)$$

Where

       NIR is the near infrared band;
       Red is the red band;
       L is the soil brightness correction factor being equal 0.5;

2) Fractional vegetation cover (FVC)

FVC has been traditionally estimated from remote sensing data using empirical relations with vegetation indices [12,13] defined as:

$$FVC = \frac{NDVI - NDVI_s}{NDVI_v - NDVI_s}$$

Where $NDVI_v$ correspond to representative values of $NDVI_{max}$;
         $NDVI_s$ correspond to representative values of $NDVI_{min}$;

3) Statistical regression model

A model for identifies the relationship between a dependent variable and independent variables is namely the regression analysis. A model can be solving the hypothesized, and estimates of the parameter values are used to develop many models for estimated regression equation [14-16]. In this study, the NDVI, SAVI, and FVC were defined as independent variables, and ABG was defined as the dependent variable. The multi-linear regression model equation defines as:

$$Y = a + bX_1 + cX_2 + dX_3 + \ldots$$

Where

       Y defines the dependent variable;
       X_1, X_2 and X_3 define independent variables;
       a, b, c, d define constants.

III. RESULTS AND DISCUSSION

A. Estimation of carbon sequestration from field survey

Total carbon storage of forest ecosystem in study area calculated through allometric equations. The allometric equation for estimation between the various parameter such as the diameter at breast height, the height of the tree, total height of the tree, the weight of the stem, the weight of branches, and the weight of leaves. The results of the data collected from the field surveyed sample plot and the allometric equation were applied to field measurements to estimate the AGB of the tree for the sample plot. The results found that the total number of 4682 trees in the 62 sample plots and the calculated the AGB of the tree in the sample plot using the allometric equation was 79.6 Ton per hectare.

B. The results of spatial analysis of AGB base on statistical regression model

Multiple linear regression analysis has been used for the estimation of AGB with the Sentinel-2 image variable, including NDVI, SAVI, and FVC to calculated the potential variable of AGB estimation. The results of the relationship between the independent variable with the linear regression model and the multi linear regression model following:

1) Spatial analysis of AGB base on statistical regression model

The results of the linear regression model between the AGB values from the data measurement with 62 sampling plots with the NDVI. The regression equation for estimated of the AGB value using vegetation indices, the linear regression equation is:

$$y = 537.589 * NDVI$$

The value indicates that $R^2 = 0.86$ of the coefficients of determine. The results of the analysis shown in Fig 2.
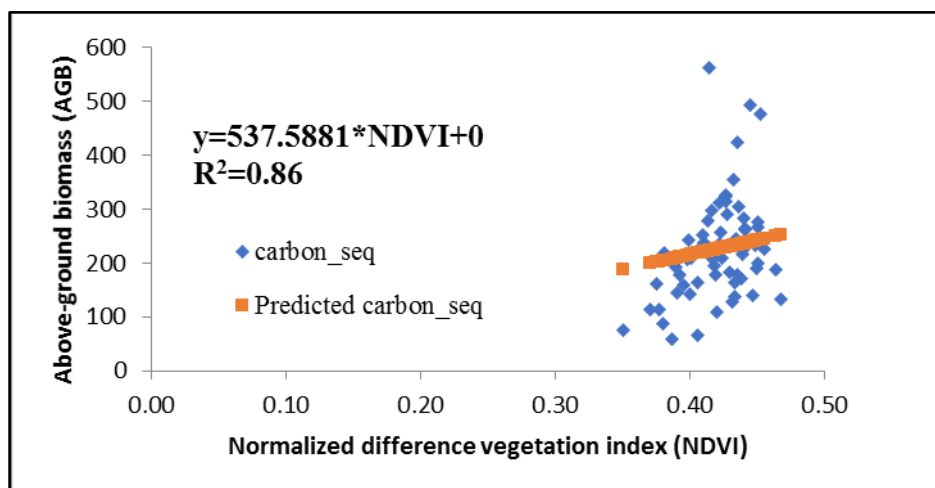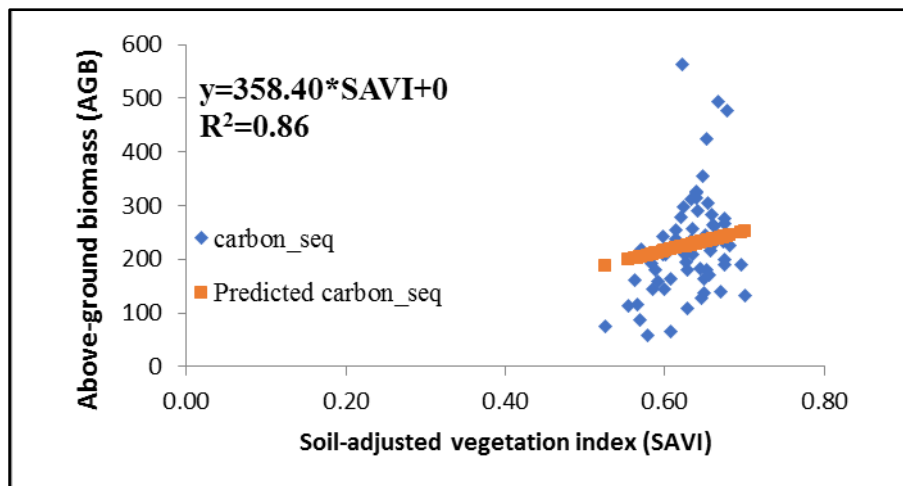

Fig 2. Regression coefficient between the AGB values and NDVI

The results of the linear regression model between the AGB values from the data measurement with 62 sampling plots with the SAVI. The regression equation for estimated of the AGB value using vegetation indices, the linear regression equation is:

$$y = 358.40 * SAVI$$

The value indicates that $R^2 = 0.86$ of the coefficients of determine. The results of the analysis shown in Fig 3.

Fig3. Regression coefficient between the AGB values and SAVI

The results of the linear regression model between the AGB values from the data measurement with 62 sampling plots with the FVC. The regression equation for estimated of the AGB value using vegetation indices, the linear regression equation is:

$$y=358.40*FVC+0$$

The value indicates that $R^2 = 0.85$ of the coefficients of determine. The results of the analysis shown in Fig 4.
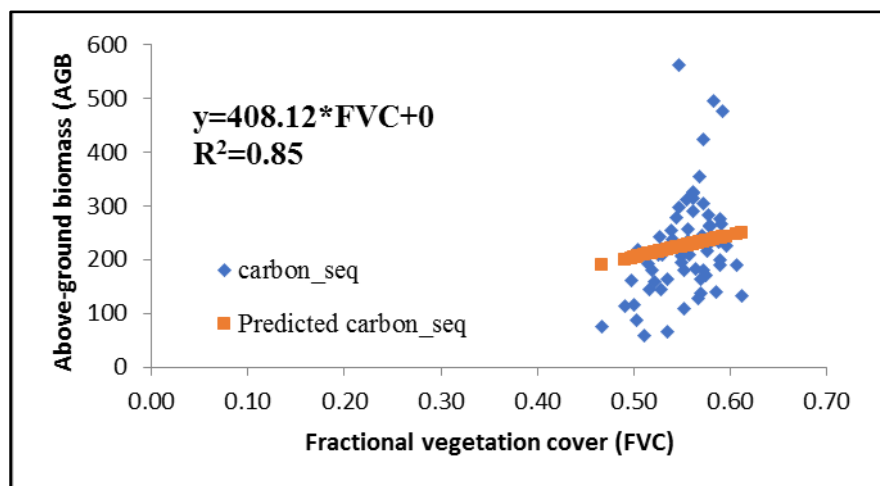

Fig 4. Regression coefficient between the AGB values and SAVI

2) The relationship of linear regression model with the satellite image variable

A multiple linear regression analysis was conducted with 62 sampling plots was observed that the vegetation indices variables including NDVI, SAVI and FVC, were significant at the 95% confidence level. The results show that the multi linear regression equation for estimated of the AGB value using vegetation indices, the multi linear regression equation is:

$$y = (11705.07 * SAVI) + (-12925.7 * FVC)$$

The value indicates that $R^2 = 0.85$ of the coefficients of determine. The results of the analysis of the variance in the model show in Table 1.

Table 1 ANOVA table of the multi linear regression model.

	df	SS	MS	F	Significance F
Regression	3	3216200.36	1072066.79	193.266197	3.7395E-30
Residual	60	499238.937	8320.64895		
Total	63	3715439.29			

C. Estimated the AGB using multi linear regression model with remote sensing data

The multi linear regression model applied to estimate of carbon sequestration in the PhuPhaWua Forest Park, Kalasin province. The results of spatial mapping of AGB shown in Fig 5 and the results of estimated the AGB was 1055540.80 tCO_2e.
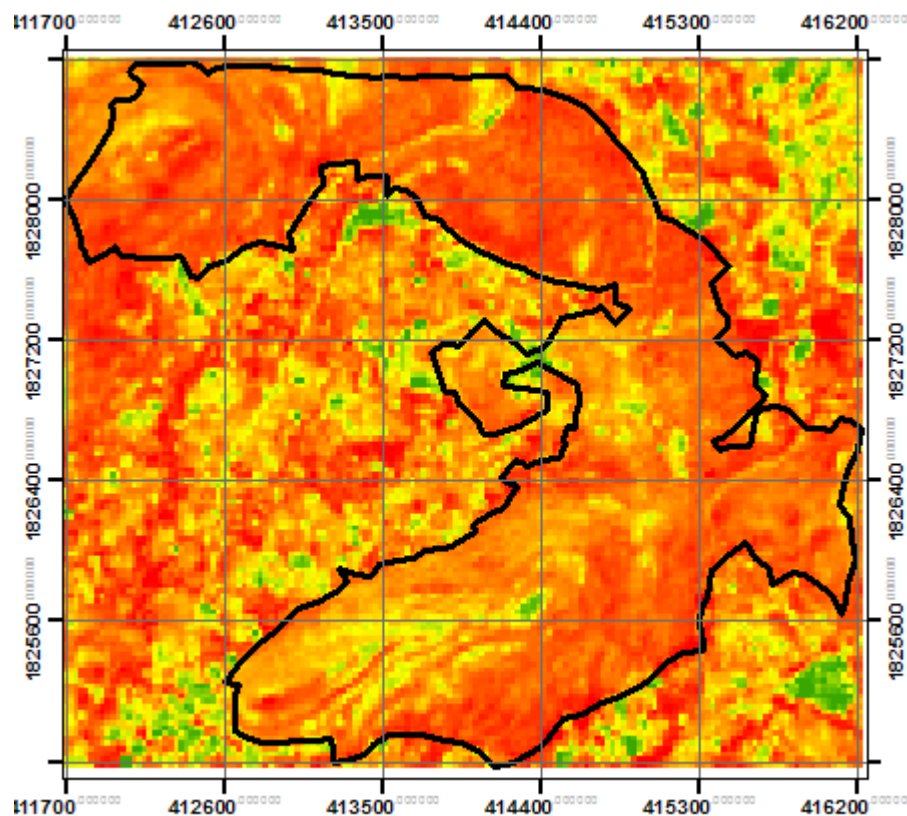

Fig 5. Estimated AGB values mapping using multi linear regression model

IV. CONCLUSION

The estimated of forest AGB in Phu Pha Wua Forest Park Kalasin Province, Thailand. The data collection forms the measurement the value of AGB of permanent sampling plots is a total of 62 plots. The results of field surveyed found that the total number of 4682 trees could be divide into tree and sapling tree. The calculated the forest AGB used the allometric equation was 79.6 Ton per hectare. The multi linear regression was built using these field measurements and satellite image data including NDVI, SAVI, and FVC of Sentinel-2 imagery. The results demonstrated that multi linear regression model are the optimized for estimated the AGB with the coefficients of determine. The relationship of the satellite variable of multi linear regression model show that the NDVI index was not significant for estimated the AGB values. The result of the multi linear regression show that the SAVI index was positively correlated with AGB in study area.

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