Spatial Model of above Ground Carbon Distribution of Mangrove in Wildlife Reserve of Karang Gading dan Langkat Timur Laut using Landsat 8 Satellite Imagery

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Abstract: Wildlife reserve of KarangGading dan Langkat Timur Laut (KGLTL) in North Sumatra Province is conservation forest area where mangrove forest is the dominant type of land cover. Mangrove forest is important ecosystem because mangrove have rich-carbon stock, most carbon-rich forest among ecosystems of tropical forest. This research was based on the lack of information on the carbon stock distribution in Wildlife reserve of KGLTL. The objective of this study was to formulate the mangrove above ground carbon stock estimation model using landsat 8 satellite imagery, as well as to develop a carbon stock distribution map based on the selected model. The study found that the normalize different vegetation index(NDVI) has a considerably high correlation with the above ground carbon is 0.8280. On the basis of the values of aggregation deviation, mean deviation, bias, root mean square error, paired sample t test, and R^2, the best model for estimating the mangrove above ground carbon is -172.00 + 552.89 NDVI with the R^2 value of 68.48%. Potency of above ground carbon in Wildlife reserve of KGLTL is 10.71 to 122.10 ton per ha.

1 INTRODUCTION

Mangrove ecosystem have many functions of ecological and economical, so mangrove ecosystem is important coastal ecosystem (Barbier et al., 2008). Mangrove have rich-carbon stock about 1023 Mg (*Megagram*) C ha^{-1}, most carbon-rich forest among ecosystems of tropical forest (Donato, et al., 2011). The carbon sequestered in vegetated coastal ecosystems, especially mangrove forests, salt marshes and seagrass beds called blue carbon (Mcleod et al., 2011).

The conversion of mangroves to other land uses occurs mostly in the East Coast of North Sumatra, such as at Wildlife reserve of KGLTL in Deli Serdang and Langkat regency. Besides being rich in marine products, Wildlife reserve KGLTL is also an important habitat for various types of waterbirds and has been identified as one of the migratory bird habitats. The existence of mangrove forests in Wildlife sanctuary of KGLTL continues to experience pressure in the form of deforestation. The results of the study mention that the rate of mangrove deforestation in Deli Serdang Regency was <1% while in Langkat Regency it was 2 - 3% per year (Basyuni and Sulistiyono, 2018). Deforestation of mangroves causes C emissions of 0.02 - 0.12 Pg (Petagram) per year, which is estimated to be equivalent to 10% of emissions from deforestation globally (Donato et al., 2011).

The utilization of remote sensing technologies such as the use of Landsat 8satellite imagery can be used to estimate the distribution of above ground carbon in mangrove ecosystem. Among of mangrove biomass estimation methods are based on vegetation indices (Hamdan et al., 2013; Wicaksonoet al., 2011; Winarso et al., 2015). This research was based on the lack of information on the carbon stock distribution in Wildlife reserve of KGLTL. The objective of this study was to formulate the mangrove above ground carbon estimation model using landsat 8 satellite imagery, as well as to develop a carbon stock distribution map based on the selected model.

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2 MATERIALS AND METHOD

2.1 Study Area

This research was conducted in Wildlife reserve of KGLTLwith the total area of 13,542.37 ha. The geographical location of Wildlife reserve of KGLTL lies between 3º51'30" – 3º59'45" North Latitude and 98º30' – 98º42' East Longitude. Wildlife reserve of KGLTL was located in Deli Serdang and Langkatregency of North Sumatra Province (Figure 1).

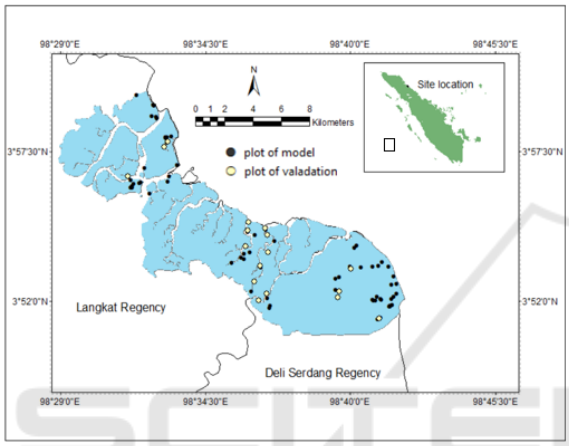


Figure 1: Location of site research

2.2 Analysis of Land Cover and NDVI

The material of this study was landsat 8 satellite imagerypath/row of 129/057 acquisition on 22 February 2018 which was downloaded from USGS. Data of Deli Serdang and Langkat regency administration were obtained from Central Agency on Statistics in 2010. The method of onscreen digitalizing is used to analyze of land cover classification. Land cover validation was done by confusion matrix to get the overall accuracy and kappa precision.

Optical data approach is commonly used to derive vegetation indices for mangrove biomass estimation (Hamdan et al., 2013; Wicaksono et al., 2011; Winarso et al., 2015).The formula for getting NDVI values is:

NDVI = (band 5 - band 4)/(band 5 + band 4) (1)

Where :

Band 4: digital number (DN) of red band

Band 5: digital number (DN) of near infrared

2.3 Estimation of Carbon Stock Distribution

Collecting data to determine amount of above ground biomass obtained by taking direct measurements in the field using a sample plot of 20 x 20 m. Placement of sample plots was done by purposive sampling while still considering the distribution and representation of the sample. Measurements of above ground biomass are carried out on vegetation with diameters more than 10 cm. The value of the above ground carbon is 50% of the above ground biomass. Measurements of above ground biomass were measured using the equation developed by Komiyama (Komiyama et al., 2005)with the equation:

$$W\text{top} = 0.251\rho D^{2.46} \quad (2)$$

Where :

Wtop = above ground biomass (ton/ha)

D = diameter of breast height (cm)

ρ = wood density (g/cm^3)

Regression analysis using ordinary least square (OLS) was used to determine the relationship between above ground carbon stock (y) and NDVI value (x). Testing of OLS regression requirements such as data normality tests and heterokedasitas tests is carried out on above ground carbon. Regression models used in this study were:

1. Linear : $y = a + bx$ (3)

2. logarithmic : $y = a + b \ln x$ (4)

3. Power : $y = a\, x^b$ (5)

4. Eksponensial : $y = a\exp^{bx}$ (6)

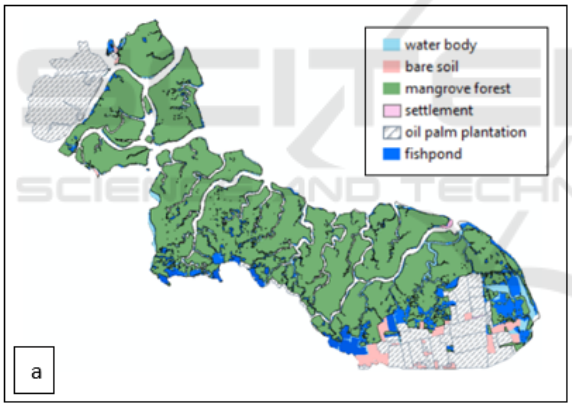
Validation tests were carried out to determine the deviation of the estimated above ground carbon from regression model with above ground carbon from field. The model validation test was built using paired samples t -test, aggregate deviation (AD), relative deviation (SR), root mean square error (RMSE) and bias (e). The number of sample plots used to build model of carbon distribution is 45 plots while the number of plots for validation tests is 18 plots.

3 RESULT AND DISCUSSION

3.1 Land Cover and NDVI

The composition of the land cover distribution in Wildlife reserve of KGLTL based on landsat 8 satellite imagery (Figure 2a) wasthe area of land cover water body 631.73 ha (4.66%), bare soil 317.56 ha (2.34%), mangrove forest 9,929.44 ha (73.32%), settlement 13.25 ha (0.10%), oil palm plantation 2,422.29 ha (17.89%) and fishpond 228.10 ha (1.68%). The validation test of land cover analysis in Wildlife reserve of KGLTL showed overall accuracy 92.40 % and kappa accuracy 89.7 %, respectively. This result showed the classification of land cover in Wildlife reserve of KGLTL which produced is good.

The results of the land cover classification in Wildlife reserve of KGLTL are used as a basis for determining NDVI distribution in mangrove forests. Estimation value of NDVI distribution in mangrove forest shows the values range between 0.31 to 0.54 (Figure 2b).



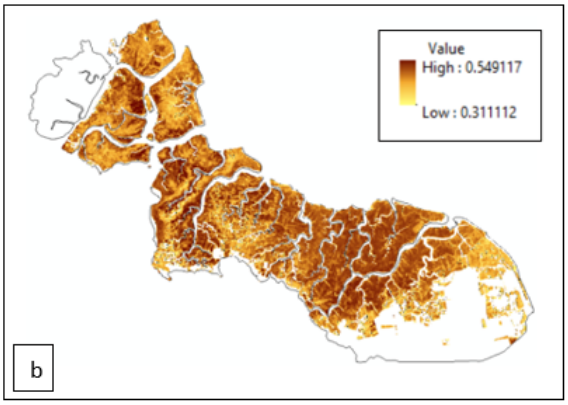


Figure 2: Land cover (a), NDVI distribution (b) in Wildlife reserve of KGLTL in 2018

3.2 Carbon Stock Distribution

The statistical test and validation test of above ground carbon distribution model can be seen in Table 2. The use of NDVI in the four regression models in table 2 can be used to estimate above ground carbon distribution (sig of anova<0.05). Based of R^2 value, linear regression model is the best model for estimating the above ground carbon distribution with the highest R^2 value of 68.48%.

The results of validation test using paired samples t test on four regression models showed no significant difference between the measurement data in the field with estimated data from the model (sig of paired sample t test > 0.05). The result of RMSE test showed that the linear regression model has smallest RMSE value while the logarithmic model has the highest value. This shows the RMSE value based on the linear model is the best model. The results of testing the bias value showed the power model is the best model because it has the smallest bias value of 47.341.

Table 2: Result of statistic model and validation

No	Model	Sig of anova	R^2	Sig of t paired	RMSE	Bias	AD	RD
1.	$y = 552.89x - 172$	0.000	68.480	0.993	10.505	55.927	0.042	8.953
2.	$y = 2945.9x^{4.6272}$	0.000	68.210	0.826	12.692	47.935	0.004	17.196
3.	$y = 226.04\ln(x) + 257.58$	0.000	67.210	0.687	37.424	58.176	0.044	7.319
4.	$y = 0.4788e^{11.154x}$	0.000	67.490	0.755	12.364	47.341	0.005	17.531

The results of testing the aggregate deviation values of all models have a qualifying value because they are in the range of -1 to 1. While the results of testing the relative deviation values of linear models and logarithmic models is qualified, while the power

and exponential models do not qualified because they have values above 10%.

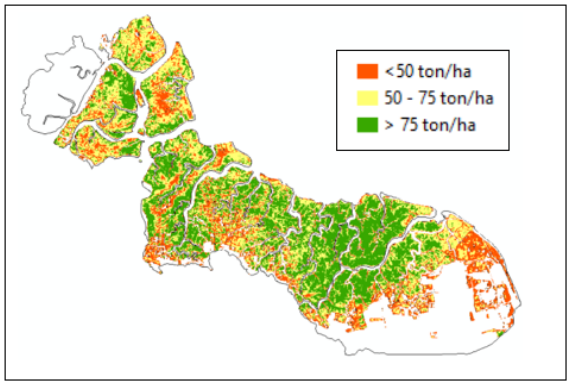


Figure 3: Above ground carbon distribution in Wildlife reserve of KGLTL in 2018

Based on the results of statistical test of models and validation tests, the linear model is the best model that can be used to estimate the distribution of above ground carbon in Wildlife reserve of KGLTL. The results of above ground carbon distribution in Wildlife reserve of KGLTL can be seen in Figure 3. Based on the linear regression model, distribution of above ground carbon in Wildlife reserve of KGLTL can be classified into 3 classes: class < 50 (ton/ha) covered 1,863.63 ha, class 50 -75 (ton/ha) covered 3,396.43 ha and > 75 (ton/ha) covered 3,581.82 ha.

This study resulted high correlation between NDVI and field biomass and have good correlations between vegetation indices and field biomass according to another research(Wicaksono et al., 2011 and Hamdan et al., 2013).The similarity of the characteristicsof research location may be one of the causes. Meanwhile, the empirical algorithm is usually site specific that might not be applicable at different part, even in the same country (Winarso et al., 2015).

4 CONCLUSIONS

The utilization of NDVI on Landsat 8 satellite imagery can be used to estimate the above ground carbon distribution in Wildlife reserve of KGLTL. The best regression model for estimating above ground carbon distribution in Wildlife reserve of KGLTL is linear regression model with R^2 value of 68.48%. Wildlife reserve of KGLTL has above ground carbon stock level between 10.71 to 122.10 ton/ha.

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