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RESEARCH PAPER

Potential Biomass Evaluation on Forest Plant Stands In Aceh Province, Indonesia: A Case Study of Forest Product Utilization Permit for Cultivated Forest Area by PT. Acehnusa Indrapuri

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Abstract – Development of industrial forest plantation currently has a primary function to produce timber for the fulfillment of the pulp and paper industry raw matter. In times of growing trees plantations have the ability to absorb carbon dioxide gases (CO_2) in the atmosphere throught the process of photosynthesis which builds biomass stands and produce oxygen gases (O_2). The potency of forest stands biomass and build a model standing stock biomass using the Normalized Difference Vegetation Index (NDVI) value from Satellite Imagery was investigated. Types of crops grown in Forest Product Utilization Permit for Cultivated Forest Area in PT.Acehnusa Indrapuri are *A.mangium* and *E.urophylla* plantations with area approximately 15,500.59 ha. The results showed the biomass content at the lowest value 16.81 tons per hectare with the NDVI Value of 0.342 whereas the highest content of biomass amounted to 145.750 tons per hectare in NDVI value 0.813. The content of plant biomass of forest stands can be expected by NDVI values using the model equation $Y = 250.32 X^2 - 15.221X - 3.3623$ with R^2 of 97.27%.
Keywords: satellite imagery, NDVI Value, *A. mangium*, *E. urophylla*,

Introduction

The amount of organic matter stored in forest stand biomass per unit area is the main points of the forests productivity in the context of forest biomass measurement. Forest stands biomass can provide important information in the expected magnitude of the potential for carbon dioxide (CO_2) sequestration by trees in a forest area. In addition to the process of absorption of CO_2 in the atmosphere by forest stands is a potential increase in revenue for the forestry sector in Indonesia as well as encouraging the sustainable forest management and carbon trading.

AcehPprovince has approximately 3,549,813 ha of rain forest areas, which consists of 119,310 ha of nature reserves, 860,719 ha of nature conservation area, 86,704 ha of hunting park area 1.8445 million ha of protected forest area and 638,580 ha of production forest area (Ministry of Forestry and Plantations, 2000). With the enactment of the Instruction of the Governor of Aceh Number: 5/INSTR/2007 dated June 6th, 2007 about Logging Moratorium in Aceh Province are enacting policies suspension of all logging activities originating from natural forests and preferably within the forest area. Based on this policy Aceh Province has considerable potential in following the process of carbon trading. To support the implementation of carbon trading process are required data and information content of carbon sequestration from forest areas that can be obtained from estimating the content of the biomass of forest stands in both natural and plantation forests.

Forest plants in general have the primary function as a producer of wood raw material for the fulfillment of the forest industries. Beside that forest plantation development has other functions, namely as an absorber of CO_2 gases in the atmosphere, producing oxygen gas (O_2), set the ground water system and other ecological benefits. During the cycle of planting, stands in the forest plants are able to absorb CO_2 in the atmosphere and are able to recycle greenhouse gases other locations in the atmosphere through the process of photosynthesis that produces oxygen (O2) and biomass forest stands. The potential of plantations in the process of absorbing CO2 from the atmosphere varies according to species, age classes, and the wide spacing of the plant canopy. Notohadiningrat (1992) classify the logging cycle plants into three groups i.e.: forest plantations as a timber producing energy by cutting cycle 5-8 years, producer of wood pulp (pulp) with a cycle of 10-15 years and a producer recycling timber with 20-30 years. In this regard it is necessary to study the potential of biomass content stored in forest stands of plants during the harvest cycle

The content of biomass of forest plantation can be calculated by using the method of harvesting trees (conventional method), but this method has the disadvantage that: high cost, need lots of labor, small area coverage and long time of implementation, so it has not been able to providing the data and information of standing biomass which are quickly and accurately. It is necessary for the calculating the content of biomass of forest plantation that have a broad area coverage, labourless , costless in a short time, by using *Normalized Difference Vegetation Index* (NDVI) values from satellite imagery.

Materials and Methods

The research was conducted in the area of forest plantations license for utilization of plantation timber (IUPHHK-HT) PT. Acehnusa Indrapuri at Block Batee Raya, Geulanggang and Utung Camah in Aceh Besar District for 12 months from August 2010 to July 2011. Types of stands were *A. mangium* and *E. urophylla*. The Landsat ETM 7 Path 131 Row 056 acquiring on 22 September 2009 and diameter measurements tallysheet stand breast height (dbh) were used in this study. The Landsat imagery data sets do image processing and transformation performed to obtain NDVI value, using the equation (Rouse *et al, 1974* in Dahlan, 2005).

$$NDVI\ Value = (NIR\text{-}red) / (NIR+red)$$

Where :
NDVI = Normalized Difference Vegetation Index Value,
NIR = Near Infrared (IR near / band 4),
Red = Red Band (band 3).

Once the vegetation index (NDVI) Value has obtained, be setting an example plot for 30 pieces. All trees within the sample plots were measured diameter breast height (dbh ≥ 10 cm diameter). Calculation of forest plantation stand biomass were standing stock biomass plant above ground level of each species of plant, using the equation.

- *A. mangium (Heriansyah et al in Dahlan, 2005)*: $W = 0{,}0323\ (D^2)^{1{,}3758}$
- *E. urophylla* : (Onrizal *et al,* 2005): $W = 0{,}0678\ D^{2{,}5794}$

Where, W = Biomass (kg) and D = Diameter at breast height (cm)

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Results and Discussion

Geometric correction and Vegetation index

Based on the correction of point belt (ground control points) of the satellite imagery on path 131 row 056 through the map of company has been corrected in 2008 has produced an RMS error average of 0.15. This shows that the accuracy between the connective point in the satellite image is quite good. . In this stage the determination of the 20 points of GCP in both images to produce an output of a matrix containing the coordinates of a point belt of the two digital images data that has been geometrically corrected.

Based on the results of the transformation of the NDVI Value, obtained in the range of NDVI Values of the image study site. For an NDVI values have a positive index are identify that area have vegetations include: grasslands, shrubs, grass, farm, orchard or forest. (Table 2).

Biomass Estimation /Calculation

Forest plant species grown in IUPHHK-HT PT. Acehnusa Indrapuri Mimosaceae (*Acacia mangium*) and Myrtaceae (*Eucalyptus urophylla*) with a single age class (KU) which is KU III (plant age ± 15 years). The content of total biomass of forest stands of plants in IUPHHK-HT PT. Acehnusa Indrapuri a low of 16.81 tons per hectar in NDVI value 0.342, whereas the highest content of biomass reached 145.75 tons per hectar in the NDVI value of 0.813 (Table 3). This is in agreement with Handoko (2007) who has studied the forest biomass of *A. mangium* at age class of 10 years with the growing capability class 2 (bonita) is equal to 136.85 tons per hectar and 146.40 tons per hectar in 10-year age classes with bonita 3. Wicaksono (2004) was also obtain a similar finding, where the estimation of standing biomass content of *A. mangium* in IUPHHK-HT PT. Musi Persada Forest in South Sumatra Province, at the age of 8 years of 166.2 tons per hectar. The content of the biomass of forest stands is almost equal with the research Supendi (2007) in the hot jungle in Cambodia, with the content of stem biomass reached 145 tons per hectar. The content of the biomass of stands in IUPHHK-HT PT. Acehnusa Indrapuri much lower than the biomass of trees in primary forest in the forest Village of Aro, Jambi reached 348.02 tons per hectare and almost the same as the content of the biomass in the forest logged in 1998 is amounting to 189.26 tons per hectare (Tresnawan and Rosalina, 2002). Heriyanto and Siregar (2007) states that the content of biomass or carbon in the plants illustrates the ability of the binding of CO_2 from the atmosphere. Most of the carbon going into an energy for life processes of plants and some will go into the plants structure and become part of the plants, substances such as cellulose. The relationship between NDVI values with biomass stands in IUPHHK-HT PT. Acehnusa Indrapuri was presented Figure 1.

Table 1. Point belt of Position Matrix of Satellite Imagery with IUPHHK-HT PT. Acehnusa Indrapuri's Map has been corrected.

No.	Tie Point	Cell-X	Cell-Y	Latitude East	Longitude North	RMSE
1.	1310560002	2212.00	4342.98	5.553210	95.297773	0.22
2.	1310560003	4395.00	5000.01	5.372539	95.887605	0.11
3.	1310560006	2351.99	4371.98	5.545198	95.335632	0.12
4.	1310560008	4641.99	4933.99	5.390107	95.954488	0.19
5.	1310560010	2514.00	4858.99	5.412969	95.378951	0.12
6.	1310560020	3372.99	5282.01	5.297331	95.610861	0.20
7.	1310560033	4486.01	4872.00	5.407115	95.912380	0.09
8.	1310560036	3160.00	5160.01	5.330648	95.553386	0.19
9.	1310560041	4000.00	4369.00	5.544082	95.781566	0.24
10.	1310560057	2595.00	4070.99	5.626552	95.401727	0.13
11.	1310560067	4705.99	4995.00	5.373490	95.971715	0.24
12.	1310560080	2685.99	4859.99	5.412513	95.425487	0.12
13.	1310560083	4199.00	4485.00	5.512383	95.835252	0.17
14.	1310560099	2438.99	4440.01	5.526665	95.359104	0.06
15.	1310560100	4421.00	4934.00	5.390394	95.894721	0.09
16.	1310560104	2522.99	4642.00	5.471800	95.381618	0.05
17.	1310560143	2350.01	4237.00	5.581807	95.335235	0.16
18.	1310560111	4255.00	4566.00	5.490355	95.850296	0.13
19.	1310560133	3473.00	4169.00	5.598956	95.639225	0.27
20.	1310560137	4171.01	5041.00	5.361709	95.826974	0.11
			Average			0.15

Table 2. The range of NDVI values and the number of plot samples in image path 131 row 056 in the area of plantation forest IUPHHK-HT PT. Acehnusa Indrapuri.

No.	Range of NDVI	Number of Record	Hectars	Number of Plot
1.	No Data	149	633,15	0
2.	$0 \leq$ NDVI $< 0{,}100$	8	1,18	3
3.	$0{,}100 \leq$ NDVI $< 0{,}200$	94	100,09	3
4.	$0{,}200 \leq$ NDVI $< 0{,}300$	346	177,90	3
5.	$0{,}300 \leq$ NDVI $< 0{,}400$	839	317,99	3
6.	$0{,}400 \leq$ NDVI $< 0{,}500$	1.836	841,80	3
7.	$0{,}500 \leq$ NDVI $< 0{,}600$	3.175	1.921,34	4
8.	$0{,}600 \leq$ NDVI $< 0{,}700$	3.958	5.026,00	4
9.	$0{,}700 \leq$ NDVI $< 0{,}800$	1.011	6.376,97	4
10.	$0{,}800 \leq$ NDVI $< 0{,}900$	549	104,17	3
11	$0{,}900 \leq$ NDVI $< 1{,}000$	0	0	0
	Total	11.816	15.500,59	30

Table 3. Average of stand biomass per hectar on each value NDVI

Range of NDVI	Values of NDVI	Biomass of stand (Ton/ha)		
		Acacia mangium	*Eucalyptus urophylla*	Total
0 ≤ NDVI < 0,100	0.074	0.00	0.00	0.00
0,100 ≤ NDVI < 0,200	0.152	0.00	0.00	0.00
0,200 ≤ NDVI < 0,300	0.249	0.00	0.00	0.00
0,300 ≤ NDVI < 0,400	0.342	8.01	8.80	16.81
0,400 ≤ NDVI < 0,500	0.455	28.05	21.89	49.94
0,500 ≤ NDVI < 0,600	0.545	39.01	24.65	63.66
0,600 ≤ NDVI < 0,700	0.653	74.35	38.28	112.63
0,700 ≤ NDVI < 0,800	0.752	76.12	40.73	116.85
0,800 ≤ NDVI < 0,900	0.813	93.60	52.15	145.75

Based on the results of the analysis of physical and chemical soil properties showed that the soil under stands of *A. mangium* has a fine structure with a permeability value of 3.04 cm per hour (medium), while the ground beneath stands of *E. urophylla* has a structure with permeability value of 1.55 cm per hour (slow) so that the water above the soil surface under the stand of *A. Mangium* faster than soak into the soil beneath stand of *E. urophylla*, but it is also known as soil organic ingredients: Organic C, total N and phosfor under stand of *A. mangium* is equal to 3.86%, 0.14% and 9.28 ppm respectively. It was higher than under a stand of *E. urophylla* 2.65%, 0.12% and 3.35 ppm respectively. This indicates that the soil condition under the stand of *A. mangium* is more fertile than soils under stands of *E. urophylla*. De Wait and Chave (2004) reviewed the relationship between forest biomass with soil type and fertility, where forest biomass was increased with the increasing of soil fertility. More complete results of the analysis of physical and chemical properties of soil under the stand *A. Mangium* and *E. urophylla* presented in Table 4 and Table 5.

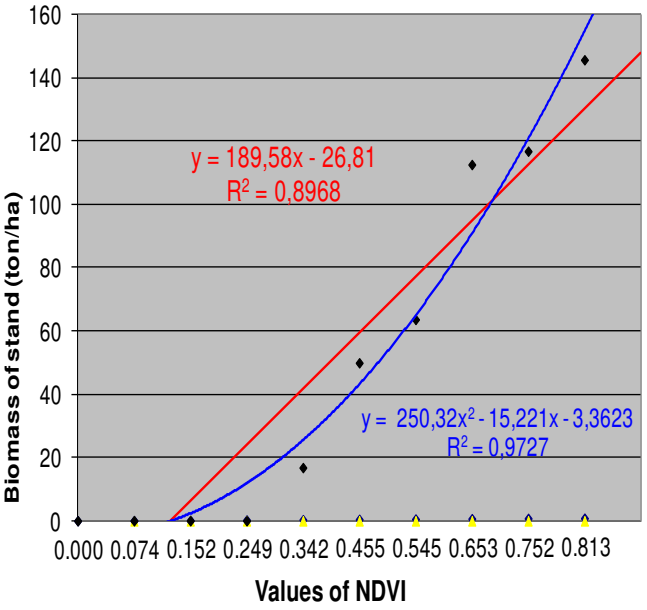

Figure 1. NDVI values relations with forest biomass of Forest Plantation

Table 4. Results Analysis of Soil Physical Properties

Stands	Fractions (%)				Permeabilitas		Structure	
	Sand	Silt	Clay	Very fine of sand	cm/hour	Criteria	Types	Class
Acacia mangium	21	35	35	9	3,04	Moderate	Glob	Fine
Eecalyptus urophylla	20	28	44	8	1,55	Rather Slow	Glob	Moderate

Table 5. Results Analysis of Soil Chemistry Properties

Stands	pH	C- Org	N-Total	P- Av	K	CEC	BS
Eucalyptus urophylla	5,38	2,65	0,12	3,35	0,26	18,33	34
Acacia mangium	5,94	3,86	0,14	9,28	0,35	24,22	45

Where : C-org (C-organic), P-Av (P-Available), CEC (Cation exchange capacity), BS (Base saturation)

Differences standing biomass content between *A. Mangium* and *E. urophylla* in forest plantations in IUPHHK-HT PT. Acehnusa Indrapuri can be caused by several factors, for instance: tree density and species, diameter and condition of the trees grow. Based on field data collection showed that the NDVI value of 0.074, 0.152 and 0.24 indicate the plant condition was opened land with overgrown shrubs and saplings *A. Mangium* and *E. urophylla*, whereas the NDVI value of 0.342 showed, the density of canopy cover was relatively small diameter trees within the rocky soil conditions. This is in agreement with Dahlan (2005) that the content of the tree biomass was strongly influenced by the diameter and density of trees. However, the density factor does not give the total content of biomass if the diameter of tree is small. Furthermore Dahlan (2005) states that the total content of biomass above the soil surface was also influenced by the type of vegetation, soil fertility and disturbance (pest diseases an theft of trees), while according to the Supendi (2007) stated that the biomass of forest stands are also influenced by the age of stands forests, historical development of vegetation, stand composition and structure of the stand. Satoo and Madgwick (1982) in Tresnawan and Rosalina (2002) stated that the density of stands is one of the factors that influence the amount of biomass. Further Tresnawan and Rosalina (2002) explained that the variation of biomass of individual trees is also strongly influenced by the distance between individual trees or the density of individual.

The NDVI's values of 0.455 to 0.813 have a relatif large density and diamater of stands and soil conditions has no rocky, so that the growth of *A. Mangium* and *E. urophylla* were good condition. This is in agreement withDe Wait and Chave (2004) who reported that the forest biomass will increase with the increasing soil fertility. Figure1 provides information of a correlation between the values of NDVI with biomass of stands. Using the equation $Y = 250.32\ X^2 - 15.221\ X - 3.3623$ with a value of coefficient of determination (R^2) of 97.27%. The biomass per hectare of standing stock has increased in accordance with the increase in NDVI values. Siregar (2007) stated that the potential of biomass is extremely high showing the potential of high carbon content. High content of biomass is the role of forests for carbon conservation and is one form of environmental services. Based on the content of biomass per hectare can be known to the entire content of forest biomass plant in IUPHHK-HT PT. Acehnusa Indrapuri as in Table 6.

Table 6. Content of Forest Biomass Plant in IUPHHK-HT PT. Acehnusa Indrapuri

Range of NDVI	Values of NDVI	Area (ha)	Biomass (Ton)		
			Acacia mangium	*Eucalyptus urophylla*	Total
0 ≤ NDVI < 0,100	0,074	1,18	0,00	0,00	0,00
0,100 ≤ NDVI < 0,200	0,152	100,09	0,00	0,00	0,00
0,200 ≤ NDVI < 0,300	0,249	177,90	0,00	0,00	0,00
0,300 ≤ NDVI < 0,400	0,342	317,99	2.547,10	2.798,31	5.345,41
0,400 ≤ NDVI < 0,500	0,455	841,80	23.612,49	18.427,00	42.039,49
0,500 ≤ NDVI < 0,600	0,545	1.921,34	74.951,47	47.361,03	122.312,50
0,600 ≤ NDVI < 0,700	0,653	5.026,00	373.683,10	192.395,28	566.078,38
0,700 ≤ NDVI < 0,800	0,752	6.376,97	485.414,96	259.733,99	745.148,95
0,800 ≤ NDVI < 0,900	0,813	104,17	9.750,31	5.432,47	15.182,78
Total		14.867,44	969.959,43	526.148,08	1.496.107,51

The potential of biomass content of *A. Mangium* and *E. urophylla* stand in the study area was 1,496,107.51 tons. NDVI values of 0.653 and 0.752 for both species contain the greatest biomass which is 566,078.38 tons and 745,148.95 tons, respectively, or reached 87.64% of the total biomass. This is due to the total area of NDVI values of 0.653 and 0.752 have an area of 5026.00 ha and 6376.97 ha, respectively, while the total area of forest plantations in IUPHHK-HT PT. Acehnusa Indrapuri reach 15,500.59 ha. Kusmana (1993) in Supendi (2007) stated that the factors that can affect the biomass of forest stands are: composition, structure, quality and density of the stands. Further Supendi (2007) stated that the biomass of forest stands can affected the increasing of the structures of stands and the age in line. Siregar (2007) stated that the distribution of diameter of the trees on forest stands in Gede Pangrango National Park is closely linked with the average of the estimates biomass of stands, where the diameter of the trees is the main component that determines the amount of biomass and carbon content of forest stands. Darusman (2006) in Bismark *et al* (2008) says that the amount of biomass in a region derived from the production and biomass density inferred from measurements of diameter, height, weight and density of each species of the trees (number per unit area). Biomass and carbon sequestration in tropical forest are the main services of forest besides of others biophysical potential, where the potential of forest biomass that is absorbing and storing carbon for reduction of CO_2 level at the atmosphere. The direct benefit of forest management in an optimal form of timber is only about 4.1%, whereas in the optimal function of biomass and carbon sequestration by forest reached 77.9%.

Conclusions

The NDVI value of 0.342 has the lowest standing stock biomass potential that is equal to 16.81 tons per hectare, whereas the NDVI value of 0.813 has the highest standing stock biomass potential that is equal to 145.75 tons per hectare. The potential total biomass of plantation forest of *Acacia mangium* and *Eucalyptus urophylla* in IUPHHK-HT PT. Acehnusa Indrapuri are 1,496,107.51 tons and can be expected by NDVI values by using the equation $Y = 250.32\ X^2 - 15.221X - 3.3623$ with R 2 of 97.27%.

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