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STUDY ON APPLICATION OF GEOGRAPHICAL INFORMATION SYSTEM (GIS) FOR ESTABLISHMENT OF BIOMASS CLASSIFICATION TO SUPPORT IMPLEMENTATION OF CLEAN DEVELOPMENT MECHANISM

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ABSTRACT

A research to study biomass classification by using GIS has been conducted at forest area in Ambon, Province of Maluku. The aims of this research were to find out composition of forest vegetation with its distribution, to determine biomass potency distribution of vegetation and to make classification of biomass potency, air temperature and light intensity distribution. This research used survey method. The vegetation biomass was measured by using allometric and weighted scoring method. By using GIS, definite score can be formatted. The result showed that composition of forest vegetation could be determined, and its biomass potency could be measured and presented on digital map. The digital map of biomass potency, air temperatures and light intensity distribution can be arranged successfully with 3 classifications: low 0.15 ha (17%), moderate 0.31 ha (37%) and high 0.39 ha (46%).

Keywords: biomass classification, LULUCF, CDM, GIS, allometric equation

INTRODUCTION

Indonesia has committed to participate on "*Greening Earth Canopy for Bluer Sky in the World*" through Indonesia's strategy for Reducing Emission from Deforestation and Degradation+ (REDD+) and Clean Development Mechanism (CDM). REDD+ Program in Indonesia has started with the development of Demonstration Activities (D.A.) of REDD+ in some districts or regencies in big island. If the D.A. can be done well and succeed, REDD+ program can be continued to mechanism of carbon trade in the international markets in the world. The Forestry CDM is a partnership between developed country and developing country to reduce Green House Gases (GHG) emission through forestry activity: afforestation and reforestation. The mechanism is one of the Protocol's "project-based" mechanisms; in that the CDM is designed to promote projects that reduce emissions and this mechanism is based on the idea of emission reduction "production" (Toth, 2001). Indonesia with mega biodiversity had opportunity to develop Forestry CDM because Land Use, Land Use Change, and Forestry (LULUCF) project can be implemented on CDM after the 7th Conference of Parties (COP) in year 2001 at Marrakesh, Morocco.

According to Stern (2007), LULUCF has contributed 17-20% to the concentration of GHG in atmosphere and climate change. This figure is bigger than global forest area in the world, particularly in comparison with the existing tropical forest that is only around 10% out of global forest area in the world (Indartik *et al.*, 2009). Climate change affects natural resources and the lives of communities particularly the ones whose living depends on the forest resources. They have to adapt to the existing change in order to survive (Sylviani and Sakuntaladewi, 2010). Therefore, REDD+ and Forestry CDM is important to handle climate change. The forests comprise a large portion of the global land and that they play a very significant role in the global carbon cycle. It is logical to examine how forest management practices could affect reductions in carbon emissions. According to Liu and Han (2009), the forest management practices that maintain and increase forest area, reduce natural disturbances in the forest, improve forest conditions, and ensure the appropriate and timely transfer of carbon into wood products lead to increasing overall carbon storage, thereby

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reducing carbon in the atmosphere. Scope of Forestry CDM or D.A.-REDD+ was very complicated by many aspects that should handle not only economics but also ecology and socio-culture. In this case, application of integration Remote Sensing (RS), Geographical Information System (GIS) and Global Positioning System (GPS) and ground survey is needed. Many researches regarding biomass measurement have been done i.e. application of allometric method for vegetation growth measurement (Parresol, 1999), estimation of biomass and stored carbon in the industrial forest plantation and its potency to absorb atmospheric CO_2 (Hardjana, 2010), estimation of total above ground biomass of *Intsia* sp. genera in West Papua tropical forest (Maulana and Pandu, 2010), simulated effects of logging on carbon storage in dipterocarp forest (Pinard and Cropper, 2000) and also to estimate carbon potency of dead wood (Brown and Roussopolos, 1974), etc. Unfortunately, biomass classification-based research by using GIS is still very limited. Therefore, study on application of GIS and RS for biomass mapping to support CDM and REDD+ should be done.

The purposes of the research were (1) to find out composition of forest vegetation with their distribution and position and to determine biomass potency distribution; (2) to find out air temperatures and light intensity distribution and to make classification of biomass potency by using GIS and to arrange the database regarding forest biomass potency; (3) to use the availability of database of biomass classification to support LULUCF activities for CDM and REDD+.

MATERIALS AND METHODS

The study area is located at the forest area of Faculty of Agriculture, Pattimura University in Ambon with the total area of 0.85 ha. The research was conducted from May to November of 2010. Material of this research comprised all vegetation in the forest area in each level of vegetation growth including forest floor i.e. grass, shrubs and herbs or thick bush, dead wood and litters. This research used equipment of ground survey such as biomass sample collection and biomass measurement and spatial analysis for biomass classification (PC with ARCVIEW-ARC INFO). Biomass analysis and its spatial analysis were done at Laboratory of Biology and Laboratory of Forest Planning, Pattimura University. This research used survey method in which all of the vegetation was measured and recorded based on their position.

Estimation method of poles and trees biomass has been measured by using allometric equations from Brown and Schroder (1999): $Y = \exp[-2.289 + 2.649 * \ln(DBH) – 0.021 * (\ln(DBH))^2]$ and for dead wood from Brown and Roussopolos (1974): $\text{Volume } (m^3/ha) = \pi^2 * (D1^2 + D1^2 + ...+ Dn^2) / (8 * L)$. Kwatrina *et al.* (2005) has recommended to use the allometric equation with DBH only as a variable because it was easy to measure and generally available in standard forest inventory. The grass, shrubs, herbs and litter of forest floor were measured by harvesting their material in ring sample plot 0.5 m^2 (IPCC-NGGIP, 2003). The shrubs and herbs were classified into 5 height classes i.e. class I (<10 cm), II (10-19 cm), III (20-29 cm), IV (30-39 cm) and V (>40 cm). Each class used 3 sample plots as replication.

The average of each biomass of the grass, shrubs, thick bush and litters was calculated by statistical calculations: $X = \sum Xi / n$. Air temperature and light intensity measurement were established at unshaded area, medium shaded area and full shaded area with 3 times observation. Value of the potency of biomass, air temperature and light intensity distribution was established based on method of weighted scoring from measurement results of ground survey. It was continued by spatial analysis with classification by using 7 parameters i.e. tree species and their distribution, potency of biomass of vegetation growth level, potency of seedling, grass, shrubs, herbs biomass, and potency of litters, potency of dead wood, air temperature and light intensity distribution.

Furthermore, these parameters were valued by using scoring system. Weighted scoring was established based on classification of 4 main factors i.e. classification of trees distribution and all biomass vegetation, litter and dead wood, classification of air temperature and light intensity. The establishment of value of biomass potency distribution used expert adjustment with Total scores = (35 x class of trees distribution) + (35 x class of biomass potency of vegetation, litters and dead wood) + (30 x class of air temperature distribution) + (30 x class of light intensity distribution). These parameters were produced by operation of layers and attribute data. Each layer was overlaid to another layer and from this activity, polygons at definite score can be formatted. This score showed status of biomass potency distribution. Based on score calculation, the amount of biomass potency distribution can be formatted by using this formula: Score range = (highest score - lowest score) /amount of class. The final result of this scoring mechanism was 3 levels of biomass potency distributions i.e. low (≤ 530), moderate (531— 779) and ≥ 780 (high). Analysis of biomass potency, air temperature and light intensity distribution was presented in Figure 1.

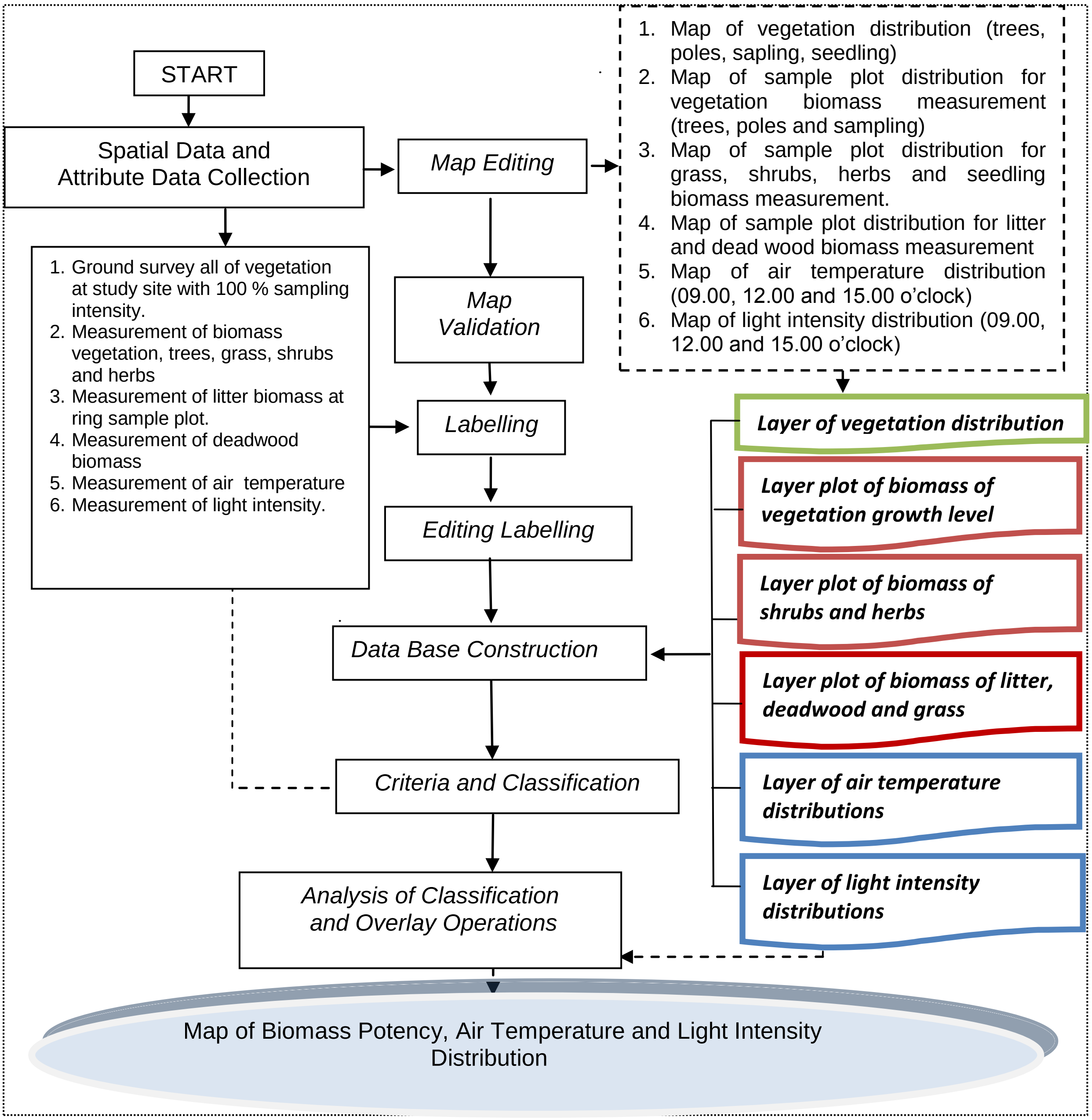

Figure 1. Scheme of analysis method based on the flow chart

RESULTS AND DISCUSSION

Based on the ground survey with 10 strips of observation or plot line at study site, it could be found 94 trees and 16 poles and their position could be characterized as cluster distribution. The tree species at study site were *Tectona grandis, Samanea saman, Theobroma cacao, Pterocarpus indicus, Fillicium decipiens, Protium javanicum, Anthocephalus cadamba, Cassia siamea, Swietenia mahagoni, Adenanthera pavonina, Agathis alba, Eusideroxylon zwageri, Casuarina sp. dan Metroxylon sp.* It is reflected that initial planting at study site used specific pattern. Dominant species of shrub and thick bush were *Eupatorium odorarium, Ficus septicum*, *Mimosa pudica* and for grass were *Cyperus rotundus*, *Imperata cylindrica*, *Catharanthus roseus* and *Acalypha australis* which covered all of forest area. Based on the ground survey with 10 strips of observation, the biomass potency distribution could be found as follows: trees 1.557 kg and poles 16 kg. The trees with big diameter had biomass higher than little trees in each plot line. The position of trees and poles distribution was recorded and presented as digital point maps by using GIS. The average shrubs and thick bush biomass potency for 10, 20, 30, 40 and 50 cm in height was 298.9, 554.7, 552.9, 429.0 and 708.4 g respectively. Biomass potency of shrubs and thick bush with 10 to 50 cm in height tended to increase. This situation indicated that high shrubs and thick bush had higher biomass than that in low shrubs and thick bush. The average grass biomass potency in open area was 322.0 g and in under forest stand was 207.6 g**.** Grass in open area had dry weight higher than that in under forest stand and this situation showed that grass could be grown well only in open area and it was grouped on intolerant species. The average litter biomass potency under trees and under poles was 688.5 and 362.5 g, respectively. The average deadwood biomass potency was 0.41 m^3/ha.

Based on air temperature observation in the forest area at 09.00, 12.00 and 15.00 o'clock, the average air temperature in unshaded area was 30^0 C, 36^0 C and 35^0 C, respectively; in medium shaded area was 29^0 C, 35^0 C and 33^0 C, respectively and in full shaded area was 27^0 C, 34^0 C and 31^0 C, respectively. The light intensity in the forest area at 09.00, 12.00 and 15.00 o'clock in unshaded area was 439, 522 and 118 lux, respectively; in medium shaded area was 192, 124 and 52 lux, respectively and full shaded area 20, 15 and 16 lux, respectively. Air temperature and light intensity distribution in area with forest stand density tended to decrease and conversely, area with no vegetation or in open area tended to increase. In this case, forest stands to play a role as cooler and provides shadiness and comfort.

Result of total score-based classification of biomass potency, air temperatures and light intensity distribution at study site was in three groups: Low (≤ 530) 0.15 ha (17%), Moderate (531— 779) 0.31 ha (37%) and High (≥ 780) 0.39 ha (46%). Furthermore, classification mentioned can be presented in digital map as final result of the research shown in Figure 2. The forest area blocked (Figure 2) was high score and this situation described that forest area had high biomass potency with low air temperature and low light intensity. Conversely, the forest area lightly blocked was low score and described as forest area which had low biomass potency with high air temperature and high light intensity. The result of the research can be used as emission baseline or REL establishment to support CDM or REDD+ project. The duration of those projects takes 10-20 years and the emission baseline at initial project can be used to calculate the addition and leakage of emission in period project. In other word, by using time series data of biomass classification database, addition and leakage can be implemented in LULUCF to support CDM or REDD+ project. Database of biomass classification including all of thematic map and the digital map of biomass potency, air temperature and light intensity distribution from year to year in period project can be edited easily and fast by using spatial analysis of GIS. It can be understood because a GIS is a computer system capable of gathering, storing, and analyzing geographically referenced information (i.e. biomass classification information for which the location has been identified). It combines different kinds of data, in a way that was never possible before. It also presents the information briefly and clearly in the form of a map or diagram. This makes it very easy for people to understand a lot of complicated data (FFTC, 2002).

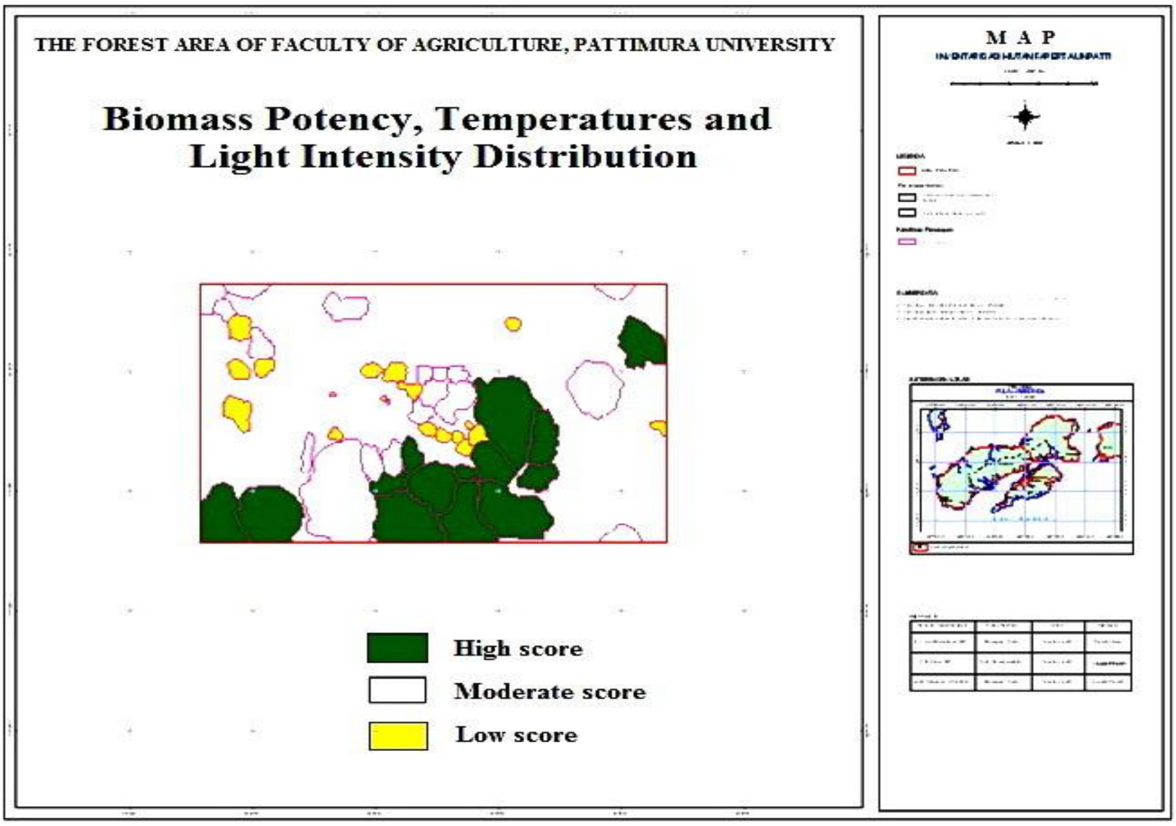

Figure 2. Digital map of biomass potency, air temperatures and light intensity distribution

CONCLUSIONS AND SUGGESTIONS

CONCLUSIONS

Vegetation distribution at forest area of Faculty of Agriculture, Pattimura University 0.85 ha had cluster distribution type with biomass potency distribution of trees 1.557 kg and poles 16 kg. Air temperature and light intensity distribution in dense forest tended to decrease and conversely, area with no vegetation or in open area tended to increase. In this case, forest stands to play a role as cooler and provides shadiness and comfort.

There were three classifications of biomass potency, temperature and light intensity distribution at study site: low 0.15 ha (17%), moderate 0.31 ha (37%) and high 0.39 ha (46%) as seen on a map namely The Digital Map of Biomass Potency, Air Temperatures and Light Intensity Distribution.

The result of spatial data and its attribute data collection at the site of this research can be used as database for many purposes to support CDM and REDD+ project, etc.

SUGGESTIONS

Considering that project duration of CDM takes 10-20 years, multiyear research is required to determine each Digital Map of Biomass Potency, Air Temperatures and Light Intensity Distribution in relation with changes in emissions reduction and enhancement of biomass or carbon stocks.

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