STUDY ON LAND-USE AND LAND COVER CHANGE (LUCC) AND GREEN HOUSE GAS (GHG) EMISSION

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Time series of Landsat imagery of Pasir Mayang, Jambi-INDONESIA from 1993 – 2000 were utilized to investigate the magnitude of LUCC. The analysis result was integrated with biomass survey and GHG emission measurement. Simple up-scaling method was applied to estimate the above ground biomass loss and soil surface GHG emission. Result showed that LULC caused biomass decrease and GHG emission increase.

Key words : LUCC, GHG, Aboveground Biomass

BACKGROUND

Deforestation, conversion of forest into non-forest land cover, have been occurring at a dramatic scale around the world. It was estimated that the tropical forest was deforested by 6 – 16.8 million hectares per year (Grainger, 1993; Barbier et al, 1991; Myers, 1994). Based on data comparison in 1985 (RePPProT, 1985) and in 1997 (Dept. of Forestry, 1997), three main islands of Indonesia(Sumatera, Kalimantan and Sulawesi) have loss its forest for about 20.24 million hectares or 1.6 million hectares per year (2.26 % per year).

Since forest hold most carbon in terrestrial ecosystem, the loss of forest will significantly contribute to the increase of atmospheric carbon dioxide. Moreover, deforestation (land-use/land cover changes) also results in emission changes of other greenhouse gases, such as carbon dioxide, nitrous oxide and methane. However, there is considerably uncertainty in the figures, since limited information on its mechanism and measurement, especially in tropical Asia Pacific region (Tsuruta, 1999). Measuring and estimating the amount of GHG emission to the atmosphere within specific area are part of important issues within IPCC.

The research aimed at regional estimation of aboveground carbon stock, its conversion into GHG through biomass burning and soil surface green house gas emission changes, using combination of Geographical Information System and Remote Sensing. As a case study land-use/land cover change between 1993 to 2000 of Pasir Mayang, Jambi Province, Indonesia will be evaluated.

II. STUDY AREA

The study area is located in Jambi Province, between 0^{o} 45’ and 2^{o}’00 latitude south; 101^{o} 30 and 102^{o}30’ longitude east (Fig. 1). The total area is about 89,697 hectares

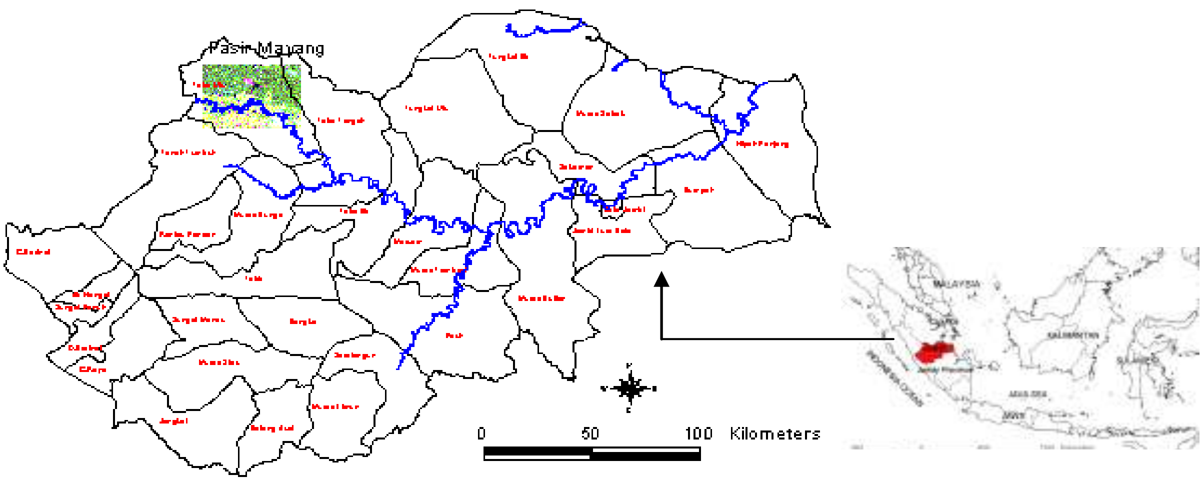

Fig.1. Location of Pasir mayang, Jambi Province

III. METHODS

3.1. Landsat images interpretation

Flowchart of the analysis step is presented in Fig. 2. Landsat images taken in 1993,1999 and 2000 were processed individually to produce land-use and land cover change. Standard procedure of image rectification and supervised classification was performed. Due to clouds and shadows interfere, land-use and land cover data in 1999 and 2000 were merged in order to get better information. Finally, information on aboveground carbon stock, emission ratio, and flux of GHG (Methane, Carbon dioxide and Nitrous oxide) from field measurement were combined for estimating above ground stock changes, emission of GHG from biomass burning and emission of GHG from soil surface under different land-use/land cover.

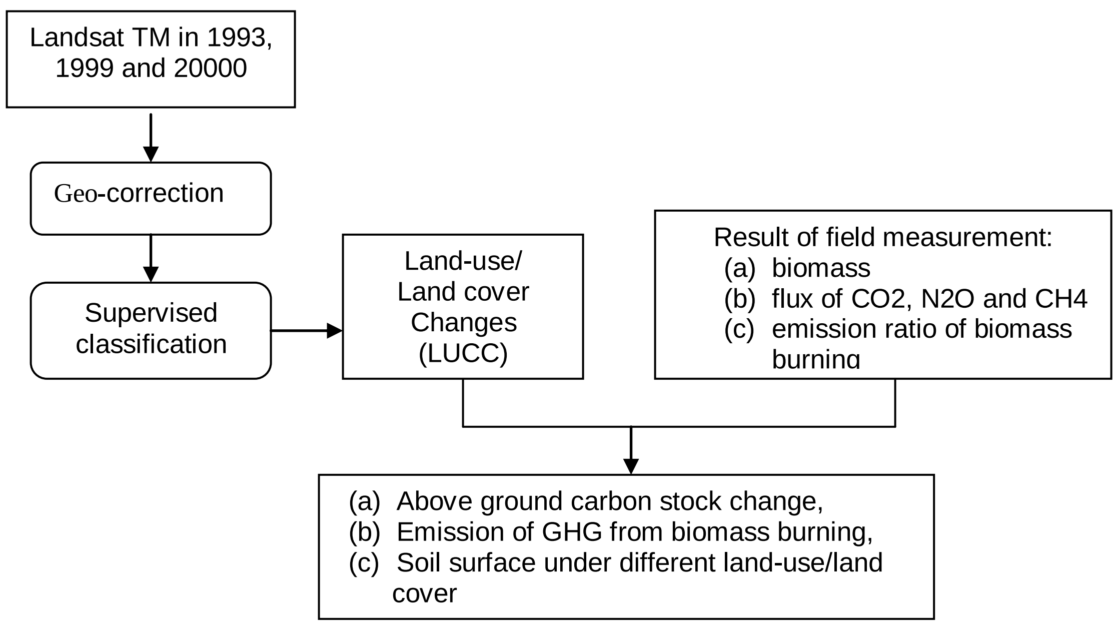

Fig. 2. Flowchart of Analysis Step

3.2. Aboveground carbon stock data

Sample materials of the vegetation component were collected. The vegetation component taken from the tree stage (dbh > 30 cm) and pole stage (dbh 10 - 29.99 cm) were leaves, branches, twigs, stem woods, stem barks and roots. Whereas, for sapling (dbh 3 - 9.99 cm) and seedling stages (height $\leq$ 1.5 m) the vegetation components are mainly leaves, stems and roots. All materials taken from the plot were chemically analyzed in the laboratory.

Weight of sample components of the tree and pole i.e. stems, branches, twigs, leaves and roots were estimated by using equation developed by Kira and Iwata (1989) Table 1. Tree biomass for one-hectare plot was calculated by multiplying biomass of each tree with the number of tree per hectare. The same method is applied for poles, saplings and seedlings.

Table 1. Alometric function for calculating biomass of tree and pole.

Tree parts	Equation
1. Stem weight (WS)	$0.0396\ (D^2H)^{0.9326}$
2. Branch weight (WB)	$0.006002\ (D^2H)^{1.027}$
3. Branch weight (WB)*	$0.003487\ (D^2H)^{1.027}$
4. Leaf weight (WL)	$\frac{WS}{13.75 + 0.025\ WS}$
5. Leaf weight (WL)*	$\frac{WS}{2.5 + 0.025\ WS}$
6. Root weight (WR)	$0.0264\ (D^2H)^{0.775}$

Source :
Kira, Tatuo and Keiji Iwata. 1989. Nature and Life in Southeast Asia Volume IV, 1989. Fauna and Flora Research society, Kyoto, Japan.
Notes : Weight = kg, D = diameter (cm), H = height (m), * = for pole stage

3.3. Soil Greenhouse gases flux measurement.

Flux of carbon dioxide, nitrous oxide and methane of soil surface were measured at various land-use/land cover types in order to obtain the estimates of diurnal emissions. The emission rates indicated by changes of methane concentration per unit time (dC/dt) were developed by plotting the analyzed air samples collected using closed-chamber method at 10 – minute intervals. The Flux density is calculated as follows (Khalil *et. al*., 1991).

$$\phi = \rho \ V \ (M/NoA) (dC/dt) \times 6 \times 10^{-5}$$

ϕ = Methane, Nitrous oxide or carbon dioxide flux ($mg/m^2/hr$), ρ = Air density (mol/m^3), V = Chamber volume (m^3), M = gas molecular weight (g/mole), A = Chamber basal area (m^2), dC/dt = emission rate (ppbv/minute), obtained from consecutive measurement.tain the estimates of diurnal emissions

Soil GHG emission were conducted by Impact Center of South East Asia, National Institute of Agro-environmental Sciences, Japan; Forestry and Forest Product Institute, Japan; and National Institute for Resources and Environment, Japan.

IV. RESULT AND DISCUSSION

4.1. Land-use/ land cover and above ground carbon stock changes

Figure 3a and 3b, show land-use/land cover patterns in 1993 and 2000, Quantitative comparison of the LUCC and above ground carbon stock is presented in Table 2.

Table 2 . Above ground carbon stock changes in Pasir Mayang between 1993 – 2000

Land-use/Land cover	Carbon stock per ha (ton)	Area (ha)		Total above ground Carbon stock in (ton)	
		1993	2000	1993	2000
Logged forest	155.2	63435.75	48121.00	9845228.40	7468379.20
Bush/Shrubs (fallow land)	15.0	9815.50	11334.00	147232.50	170010.00
Rubber and secondary Vegetation (rubber jungle)	35.5	6304.25	15764.00	223800.88	559622.00
Grasslands	6.0	3077.75	1416.00	18466.50	8496.00
Barelands	0.0	932.75	7175.75	0.00	0.00
Water body	0.0	1886.75	1642.00	0.00	0.00
Total		85452.75	85452.75	10234728.28	8206507.20

Between 1993 – 2000, logged forest and Grassland area decreased of about 15,314.75 ha and 1,661.75 ha respectively. Meanwhile rubber jungle and fallow land increased 9,459.75 ha and 1,518.50 ha, respectively. Due to this, total net above ground carbon stock of the area decreased from 10.23 million ton to 8.20 million ton, or have loss of about 2.02 ton. Most of carbon loss originated from deforestation (2.3 million ton), while carbon stock recovery came from the growth of rubber and secondary vegetation (0.34 million ton).

IPCC have divided the loss of aboveground carbon content into on site and off-site release. These two categories were classified further into direct burning (fuel wood and slash and burn agricultural) and decomposition process release of unburned biomass (Houghton *et.al*., 1996). Thus, the amount of carbon loss does not represent the amount carbon released into the atmosphere. Some amount of carbon which was lost due to direct burning (in-site burning) was released directly, however, part of carbon was released slowly through decomposition process. In the case of charcoal decomposition process will take time of about hundreds years (Houghton, et al, 1996).

To estimate carbon released directly from forest fire into the atmosphere, some assumption were made, as follows :

(a) 50 of biomass of forest were removed from the site before forest burn
(b) emission ratio per CO2 of secondary forest fire for CO, CH4, N2O, CH3Cl, CH3Br and CH3I are 0.265, 0.0093, 0.000061, 0,0000001, and 0, respectively.
(c) Gas conversion ratio from dry matter C to CO2 is 0.5

Estimation of carbon release into atmosphere from forest fire during 1993 – 2000, is presented in Table 3.

Table 3. GHG emission from forest fire

Loss of Forest	GHG emission from forest fire (ton)					
Loss of c from forest fire = 2.3 million ton c	CO	CH4	N2O	CH3Cl	CH3Br	CH3I
	160 ,486.6	3,145.5	9.2	0	0	0

4.2. Soil greenhouse gas emission changes

There is diurnal and seasonal variation of green house gas flux of soil The comparison below were made based on the average value of flux measurement conducted in November 1997 in several sites of Jambi province. The calculation results of total flux based on 1993 and 1995 land-use/land cover data for major land-use/land cover presented in Table 4.

Table 4 . Soil greenhouse gases emission changes in Pasir Mayang between 1993 – 2000

Land-use/Land cover	Carbon Dioxide (ton/hour)		Nitrous Oxide (kg/hour)		Methane (kg/hour)	
	1993	2000	1993	2000	1993	2000
Logged forest	233.467	178.482	7.102	5.429	-9,496.294	-7,259.752
Bush/Shrubs (fallow lands)	58.156	67.100	2.000	2.307	-4.406	-5.084
Rubber and Secondary vegetation (Rubber jungle)	30.348	75.917	1.301	3.254	-1.282	-3.206
Grasslands	18.870	8.724	0.344	0.159	0.000	0.000
Bare lands	6.085	45.863	0.131	0.987	-72.252	-5,444.252
Total	346.927	376.085	10.878	12.136	-9,574.234	-7,812,596

Table 2 shows that LUCC results in an increase emission of carbon dioxide (CO_2) and nitrous oxide (N_2O), meanwhile methane (CH_4) absorption decrease.

V. CONCLUSSION

Land-use/land cover changes in Jambi between 1993 to 2000 results in the loss of carbon about 2.07 millions ton, especially came from logged forest area reduction. In addition, the process also gave impacts on greenhouse gases flux of soil surface. There was an increase emission of carbon dioxide (CO_2) and Nitrous oxide (N_2O), meanwhile reduction in methane absorption. This finding reinforce the urgent need to conserve tropical rain forest, in order to reduce/ slow down the increase rate of atmospheric greenhouse gases concentration.

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