Development for Data Base for Eco-System Changes and Emission Changes of GHG Using Remote Sensing and GIS in Sumatra Island, Indonesia

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Key Words: Remote Sensing, Greenhouse effect gases, Database, Land cover changes

Abstract:
Using LANDSAT/TM data, we determined land cover changes of Pasir Mayang area, Sumatra from 1993 to 1999. The database of GHG flux measurement and land cover changes was developed, and we estimated above carbon and GHG flux changes.

1. Introduction

Deforestation, conversion of forest into non-forest land cover, especially in tropical forest area has been an international concern. It was estimated that tropical forest was deforested by 6

- 16.8 million hectares per year (Grainger, 1993; Barbier etc., 1991; Myers, 1994). Since forest hold the most carbon in terrestrial ecosystem, such changes give significant impact on the net increase of atmospheric carbon. In addition, land cover changes result in greenhouse effect gases (GHG: CO2, N2O, CH4) dynamics.

GHG emission of soil surface is influenced by several factors such as land cover types, climatic factors, biological factors and physical environment factors. Emission measurements usually are conducted at a point location, therefore problem arise when emission estimation will be used for scaling up into a broader areas. The objectives of this research was at the development of spatial database using GIS and remote sensing to assist the regional estimation of aboveground carbon stock loss and soil surface GHG emission changes caused by land cover changes. We studied land cover and GHG changes between 1992 to 1999 of Pasir Mayang area as a case study.

2. Research method

2.1. Development GHG database at Pasir Manyang area

Using LANDSAT/TM data, we determined land cover of Pasir Mayang area in 1993, 1995 and 1999. Pasir Manyang area is 84,000ha as 35km (east to west) and 24km (north to south), and is represented in Fig. 1 and 2. The estimation of total above ground carbon stock in this area was calculated by multiplying the value of ha by total area of each land cover. The same method was applied for calculating the total emission of GHG. Database was developed using ARC/Info and remote sensing analysis was performed using ERDAS/Imagine.

2.2 Biomass estimation (Above ground carbon stock)

Weight of sample components of the tree i.e. timbers, stems, branches, twigs, leaves and roots of primary forest, secondary forest and logged over forest were estimated by using equation developed by Kira and Iwata (1989). Tree biomass for one hectare plot was calculated by multiplying biomass of each tree with the number of tree per hectare.

2.3 Soil GHG flux measurement

Flux of carbon dioxide, nitrous oxide and methane from soil surface were measured at various land cover types in order to obtain the estimates of GHG emissions by the ground survey group of our collaboration project of Indonesia and Japan. The GHG flux measurement points were illustrated on LANDSAT/TM image in Fig. 2.

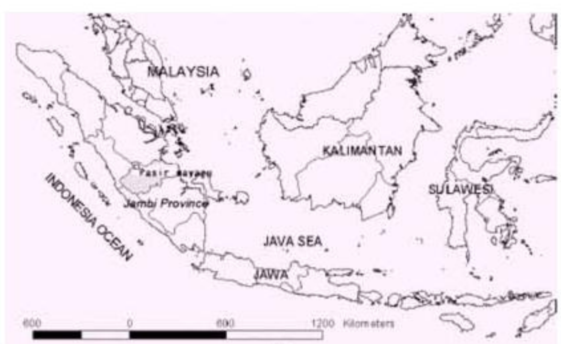


Fig. 1 Pasir Mayang area and Jambi Province

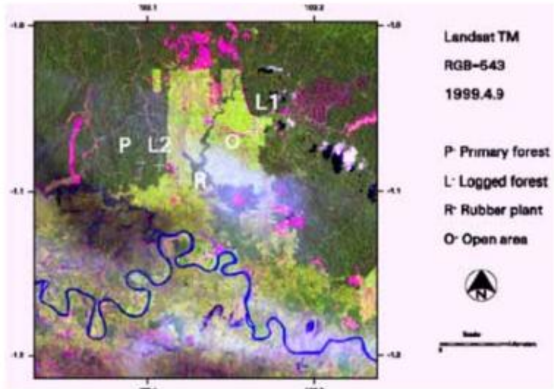
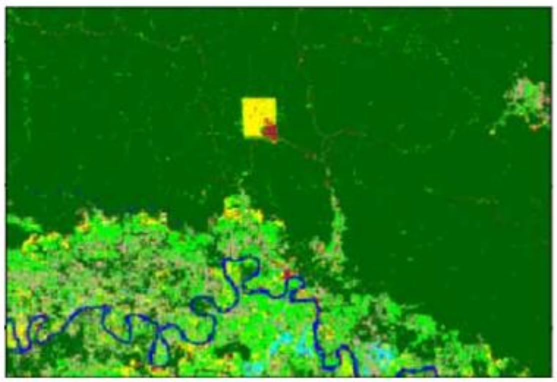
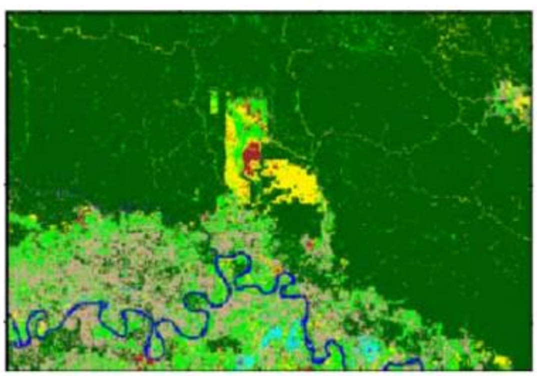


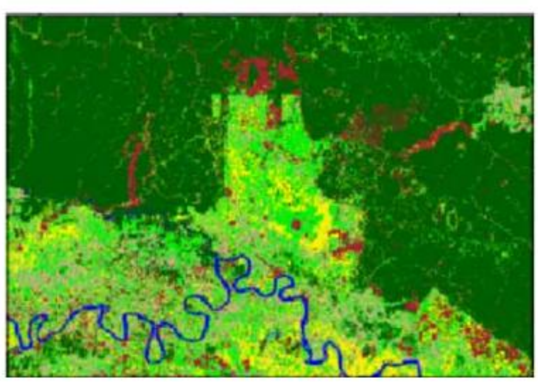
Fig. 2 Used LANDSAT/TM image and the points of GHG flux measurement



(a) Land cover of 1993



(b) Land Cover of 1995



(c) Land Cover of 1995

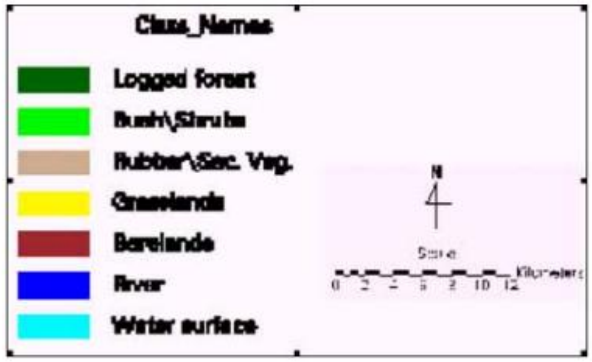


Fig. 3 Land cover maps of Pasir Manyang area and changes in 1993, 1995 and 1999

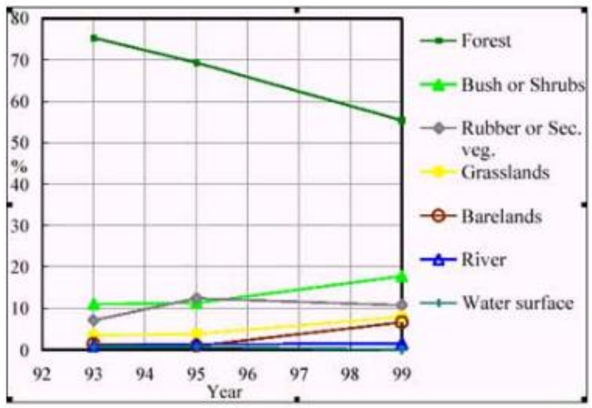


Fig. 4 Land cover changes in Pasir Mayang

3. Results and Discussion

The land cover maps of Pasir Mayang area in 1993, 1995 and 1999 were indicated in Fig. 3. Estimation of above ground carbon stock was calculated by multiplying the unit value by total area of each land cover using the land cover maps of Pasir Mayang area. The same method was applied for calculating the total emission of GHG. These results are shown as table 1, 2 and 3. Forest was the most dominant land-cover in Pasir Mayang, followed by rubber/secondary vegetation, bush/shrubs, grassland and bare land (clear cut area) (Fig. 4).

Between 1993-1995, forest area decreased of about 5,000ha, while rubber/secondary and bush/shrubs land increased. Due to this, above ground carbon stock of the area decreased from 10.2 million ton to 9.6 million ton, or have loss of about 0.7 million ton. Between 1995-1999, forest area decreased of about 12,000ha, and also rubber/secondary and bush/shrubs land increased. Due to this, above ground carbon stock of the area decreased from 9.6 million ton to 7.8 million ton, or have loss of about 1.8 million ton.

GHG flux of soil varies depend on type the site condition and season. The values of each unit were based on flux measurement conducted in November 1997 in several points of Pasir Mayang area (Fig.2). The calculation results of total flux based on 1993, 1995 and 1999 land cover data for major land cover presented in Fig. 4. Comparison of the total GHG flux of the three periods of time studies could not be performed since there are still no information on GHG flux of soil surface under cash crops plantation and secondary forest. However, it seems that the conversion of natural forest will cause on the decrease of methane gas absorption and induce the increase of nitrous oxide and carbon dioxide flux emission as Fig.5.

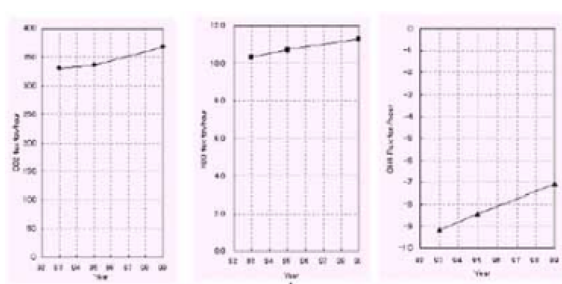


Fig. 5 GHG flux changes in Pasir Mayang area between 1993 and 1999

Table 1 Above carbon stock and total GHG flux in Pasir Mayang area on 1993

	Area		Carbon Stock		CO2		N2O		CH4	
	ha	(%)	Ton/ha	Total ton	Mg/m2/h	Ton/hour	Mg/m2/h	Ton/hour	Mg/m2/h	Ton/hour
Forest	83239	75.3	155.2	9814615	352.3	222.8	10.7	6.8	-14.33	-9.1
Bush or shrubs	9230	11.0	15.0	138446	580.7	53.6	20.0	1.8	-0.04	0.0
Rubber or Sec ve	5996	7.1	35.5	212858	473.6	28.4	20.3	1.2	-0.02	0.0
Grasslands	2888	3.4	6.0	17325	603.6	17.4	11.0	0.3	0	0.0
Barelands	1146	1.4	0.0	0	624.9	7.2	13.4	0.2	-7.42	-0.1
River	892	1.1								
Water surface	610	0.7								
Total	84000	100.0		10183244		329.4		10.3		-9.2

Note :

- Above ground biomass was estimated using the data of BIOTROP, Indonesia.
- The calculation of GHG fluxes was based on mean value of 10 months (10 time) measurement.
- The measurements were made in Jan., Feb., Mar., June, July, Aug., Sep., Oct., Nov. and Dec

Table 2 Above carbon stock and total GHG flux in Pasir Mayang area on 9195

Table 1 Above carbon stock and total GHG flux in Pasir Mayang area on 1993

	Area		Carbon Stock		CO2		N2O		CH4	
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