ERRATA

INDONESIAN JOURNAL OF GEOGRAPHY

Volume 42, Number 1 June 2010

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The Editor

ISSN 0024-9521
IJG Vol. 42, No. 1, June 2010 (59 - 68)

INDONESIAN JOURNAL OF GEOGRAPHY

CARBON GAS CALCULATION AS A RESULT OF LANDUSE CHANGE BY USING MULTI TEMPORAL LANDSAT TM 7 IMAGES OF 1992-2007 IN LIMA PULUH KOTA REGENCY

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ABSTRACT

The objective of this research is to map landcover change, and released carbon emission in Lima Puluh Kota Regency and Payakumbuh Municipality since 1992 – 2007 by using rapid assessment approach based on Multi Temporal Landsat TM 7 Images (1997-2007) of the Remote Sensing Technology. The findings present nine landcover classifications identified in Lima Puluh Kota Regency and Payakumbuh Municipality. The current largest landcover change areas are Primary Forest, and Secondary Forest. Land cover change in Lima Puluh Kota Regency and Payakumbuh Municipality during the period of 1992 – 2007 indicates even distribution of biomass content in both areas. In total, land cover change since 1992 - 2007 in Lima Puluh Kota Regency and Payakumbuh Municipality contributes to the release of 1,141,458,592 tons of carbon or 76,097,239 tons of carbon per year, with 4,185,348,171 tons of CO_2 emissions. The data suggest that during that period, both areas contributed 279,023,209 tons of CO_2 as greenhouse gas affecting the Earth's temperature which then led to global warming.

Keywords: land cover, biomass, carbon , landsat image TM 7

INTRODUCTION

CO_2 is one of the important greenhouse gases of which rate is increasing along with the earth's natural resources exploitation, including in forestry sector. Contribution of forestry sector to global emission was reported in the Inter-governmental on Panel Climate Change (IPCC) which then responded by the 13th Conference of Parties (COP), United Nations Framework Convention on Climate Change (UNFCCC), taking place in Bali, in December 2007. Based on the report of IPCC, around 20% of CO_2 emissions in the world per year come from tropical deforesting. This percentage does not differ from what was expressed by [*Baumert et al,* 2006]. It is also by research result [*Houghton,* 2005) suggesting that in between 1980 and 1990, tropical deforestation released 24 billion tons of carbon to the atmosphere.

In Indonesia, Natcom in [*KNLH*, 2007] mentions that around 60% of Indonesia's greenhouse gas emissions come from land use, land use change, and forestry (LULUCF). Based on the data from the Forestry Department, in 2007, Indonesia's forest occupies a total area of 120.35 million ha which consists of: Productive Forest (48%), Conservation (17%), Protected forest (28%), and Productive Forest of the Conservation (7%). In the meantime, 53.9 million ha of the total area experience various levels of degradation which spreads over conservation forest (11.4 million ha), protected forest (17.9 million ha), and productive forest (24.6 million ha).

Forest land cover has always depleted from time to time due to the conversion of the land use, affected by the establishment of conservation (expansion of new regency, agriculture, plantation, development of settlement, and infrastructure), over cutting, illegal logging, and forest fire, which then lead to deforestation. Degradation of forest land cover contributes to the low absorption and storage of greenhouse gases. It intensively occurred during the period of 1997-2000, when 2.83 million hectares of area (forest and non forest) experienced degradation each year, with Sumatra island experienced the greatest degradation (1.15 million ha per year) [*KNLH*, 2007].

Limapuluh Kota Regency and Payakumbuh Municipality are two areas in the West Sumatera Province which still possess abundant forest area. Meanwhile, forest areas adjacent to the Riau Province have depleted drastically and become some serious matter since it threatens the existence of forests in Limapuluh Kota. [*WWF*, 2008] reports that in 25 years (1982 - 2007), Riau Province lost 4 million hectares of forest. They have turned into coconut plantation, wood crop for papier mache, and settlement.

Land cover data will give contribution to determination of surface biomass value for every type of land cover by using result of calculation at plot scale conducted in Indonesia, making use of GIS-based multi temporal images from the year of 1992 - 2007. Meanwhile, the method employed to measure carbon reserve at each sample ploting in a certain area was measuring biomass in the sample area. Research on carbon measurement is hoped to give information which leads to giving suggestion for designing environmental policy for the agenda of minimizing global warming effect as well as to provide valuable piece of information to carbon trading world.

CO_2 emissions into the air as a result of land cover change can be predicted through rapid assessment by calculating biomass value using remote sensing based on various assumptions and simplification. For example, if there is no exploitation of biomass from crop residues to make furniture, construction material, or other goods, then forest land cover will not be grouped based on forest type and accumulation of the vegetation species. It must be confessed that by using this approach, overestimation or underestimation will likely to happen, as a result of error propagation. However, estimation of carbon emission by using such approach can bring value as expressed by WWF Indonesia, RSS GMBH GERMAN, and Hokkaido Agricultural University Japan in their technical report [*WWF*, 2008] as follows: *"All calculations had to rely on assumptions and simplifications. Several sources of uncertainty lead to a propagation of errors. We did not add error margins to our estimations, as the level of error of our calculation component is not precisely quantifiable. Each component of our calculations contributes to the total uncertainty. However, considering and reflecting on all errors we are convinced that the order of magnitude of the emission estimate are correct".*

THE METHODS

Visual interpretation of Landsat image had been done to determine location of samples in primary forest, secondary forest, stripper bush, farm, coppice, bush, rice field, and open land so that at every location of sample, data of digital number (DN) in each channel (band) could be obtained. The channels applied are 1, 2, 3, 4, 5, and 7. Stepwise linear regression was done to obtain equation between DN in each channel and biomass value as follows:

$B_{ij} = a + bTM_1 + cTM_2 + dTM_3 + eTM_4 + fTM_5 + gTM$

Where: B_{ij} = biomass value at pixel in line-i column-j

TM_1 until TM_7 = digital number (DN) at every channel 1 until 7

a, b, until g = constant

Thereby transfer of biomass value from value DN at landscape scale can be done from each function for image Landsat 1999 and 2007. Biomass assessed as the result of equation of regression can only be applied for land cover class which was not identified at interpretation process.

Here in after result of linear regression equation calculation was done by standardization of the spread between the minimum and maximum biomass value. By using minimum biomass value equal to zero hence the equation below was obtained:

$B_{ij\text{-}x} = (B_{ij} - B_{ij\text{-}min}) / (B_{ij\text{-}max} - B_{ij\text{-}min} / b_{max})$

Where:
- $B_{ij\text{-}x}$ = biomass value at pixel in line-i column-j after standardization
- $B_{ij\text{-}min}$ = biomass minimum value at pixel in line-i column-j result of equation (1)
- $B_{ij\text{-}mix}$ = biomass maximum value at pixel in line-i column-j result of equation (1)
- b_{max} = biomass maximum value from literature at outside primary /secondary forestry (table 1)

Carbon makes up 50% of surface biomass [*Montagnini and Porras*, 1998; *Kurz and Apps*, 1999; *Losi et al.,* 2003; *Montagu et al.,* 2005]. Release of carbon from biomass into atmosphere is carbon-oxygen compound forming greenhouse gas in the form of CO_2. By adopting the method chosen by US, [*DOE,* 1998] the conversion of value C carbon into CO_2 bases was done by converting the molecule, from CO_2 ratio weight to C weight (44/12).

RESULT AND DISCUSION

Calculation of biomass was done by using orthogonal transformation (tables 3). Biomass value for each pixel was based on measurement of an area of 30 m^2 (0.09 ha), converted into ton/pixel. For unclassified pixel resulted from linear regression calculation with six image channels as independent variables, standardization to get 71 ton/ha (6.39 ton/pixel) of maximum value was then done.

Carbon emission discharged into the air as a result of land use change could be seen by comparing biomass with carbon emission the year of 1992 and 2007. Each biomass and carbon emission volume for the year 1992, 2007 and period 1992-2007 is described as follows:

1. Images interpretation result of biomass in Lima Puluh Kota Regency and Payakumbuh Municipality during 1992.

Tabel 1. Biomass in Kabupaten Lima Puluh Kota and KOta Payakumbuh at period 1992.

Land use	Sum	Hectare	Biomass
Clouds	233396	21005.6400	0.0000
Stripper Bush	192906	17361.5400	1232669.3400
Primary Forest	1311149	118003.4100	62724712.5855
Secondary Forest	397854	35806.8600	12085889.4558
Farm	340620	30655.8000	1716724.8000
Open Land	294102	26469.1800	0.0000
Settlement	295423	26588.0700	0.0000
Rice Field	126299	11366.9100	170503.6500
Bush	2914	262.2600	3147.1200

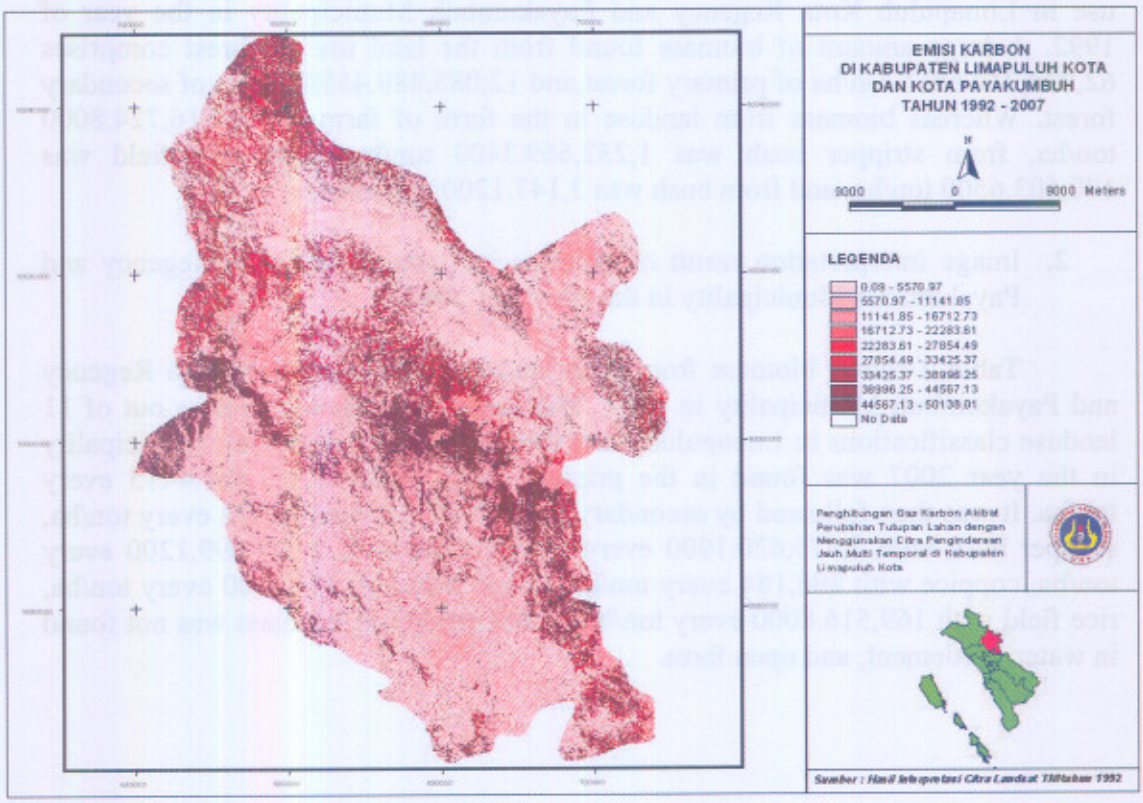
Based on the data in table 1, we can see a number of biomass in each land use in Limapuluh Kota Regency and Payakumbuh Municipality in the year of 1992. A large amount of biomass found from the land use of forest comprises 62,724,712.5855 ton/ha of primary forest,and 12,085,889.4558 ton/ha of secondary forest. Whereas biomass from landuse in the form of farm was 1,716,724.8000 ton/ha, from stripper bush was 1,232,669.3400 ton/ha, from rice field was 170,503.6500 ton/ha, and from bush was 3,147.1200 ton/hectare.

2. Image interpretation result of biomass in Lima Puluh Kota Regency and Payakumbuh Municipality in the period of 2007

Table 2 shows biomass from each land use in Limapuluh Kota Regency and Payakumbuh Municipality in 2007. The largest amount of biomass out of 11 landuse classifications in Limapuluh Kota Regency and Payakumbuh Municipality in the year 2007 was found in the primary forest with 40,973,431.4415 every ton/ha. It was then followed by secondary forest with 9,858,657.2472 every ton/ha, stripper bush with 2,475,620.1900 every ton/ha, farm with 2,347,899.1200 every ton/ha, coppice with 896,184 every ton/ha, , bush with 189,316.4400 every ton/ha, rice field with 169,516.8000 every ton/ha. In the meantime, biomass was not found in water, settlement, and open farm.

Tabel 2. Biomass volume in Limapuluh Kota Regency and Payakumbuh Municipality in the period of 2007

Land use	Count	Sum	Hectare	Biomass
Water	11	7071	636.3900	0.0000
Clouds	19	233337	21000.3300	0.0000
Stripper Bush	10	387421	34867.8900	2475620.1900
Primary Forest	3	856477	77082.9300	40973431.4415
Secondary Forest	7	324536	29208.2400	9858657.2472
Farm	17	465853	41926.7700	2347899.1200
Open Land	9	275941	24834.6900	0.0000
Setlement	8	295861	26627.4900	0.0000
Rice Field	9	125568	11301.1200	169516.8000
Bush	16	175293	15776.3700	189316.4400
Coppice	12	331920	29872.8000	896184.0000



3. Biomass and Carbon Emissions discharged to the air as result of landuse change in Limapuluh Kota Regencyand Payakumbuh Municipality during the period of 1992-2007

Tabel 3. Biomass volume lost in Limapuluh Kota Regency and Payakumbuh Municipality since 1992 until 2007

Landuse	Biomass (Ton)		Change
	1992	2007	
Primary Forest	62724712.59	40973431.44	-21751281.14
Secondary Forest	12085889.46	9858657.25	-2227232.21
Stripper Bush	1232669.34	2475620.19	1242950.85
Farm	1716724.80	2347899.12	631174.32
Coppice	768460.50	896184.00	127723.50
Rice Field	170503.65	169516.80	-986.85
Bush	3147.12	189316.44	186169.32
Open Land	0.00	0.00	0.00
Water	0.00	0.00	0.00
Setlemen	0.00	0.00	0.00
TOTAL BIOMASS:	78702107.45	56910625.24	21791482.21
TOTAL CARBON:	39351053.7	28455312.6	-10895741.1
CO_2 Emission:			17121878.88

Tables 3. shows changes of biomass for each land use in Limapuluh Kota Regency and Payakumbuh Municipality in the period of 1992-2007. Out of nine classifications of landuse, primary forest contributed 21,751,281.14 ton/ha of biomass stems, secondary forest contributed 2,227,232.21 ton/ha, and rice field 986.85 ton/ha. While at the other six land use classes, absorption of biomass occurred. Stripper bush permeated 1,242,950.85 ton/ha of biomass, farm 631,174.32 ton/ha, coppice 127,723.50 ton/ha, and bush permeated 186,169.32 ton/ha. Meanwhile, biomass was not found in some other land use types. Therefore, existence of absorption and biomass release could not be identified.

Forest land use, either primary forest or secondary contained a larger amount of biomass, compared to other landuse types. Landuse change results in the decrease in biomass. Moreover, various land use changes in Limapuluh Kota Regency and Payakumbuh Municipality during 1992 - 2007 showed even distribution of biomass as well as carbon, either even increase or decrease in each region. Assuming that the losing carbon was entirely discharged into the air, in fifteen years, Limapuluh Kota Regency and Payakumbuh Municipality discharged 17,121,878.88 tons of CO_2 to atmosphere, or 1,141,458.592 tons of CO_2 per year as greenhouse gas triggering global warming.

CONCLUSION

a. Based on remote sensing interpretation of multi temporal landsat image TM 7 for the period of 1992-2007, it is found out that there were 9 classifications of land covers. Approximately half of the land cover was found in Lima Puluh Kota Regency and Payakumbuh

Municipality in 1992, still in the form of forest area consisting of primary forest and secondary forest. Land covers which still have natural characteristics are coppice and bush. Whereas land cover for human activities had not reached a quarter of the total land area or only as much as 21.91 %, with wide concentration in farm, settlement, and rice field. Others are treated as open lands

b. Various changes of land cover in Limapuluh Kota Regency and Payakumbuh Municipality in the period of 1992 - 2007 indicate even distribution of biomass content in each region.

c. This research shows that the result of carbon gas calculation based on remote sensing technology does not have a significant different value from plot sampling calculation.

RECOMMENDATION

a. Large scale damage to the primary and secondary forest which serves as carbon producers should be stopped. To prevent forest degradation, local government as the policy maker should initiate the planting of a million trees.

b. Management of forests in peripheral areas should consider the community's vision.

c. Carbon gas calculation using remote sensing technology are effective and efficient for large areas, yet takes a great deal of time.

d. Further research with regards to global warming is needed, especially related to land use change (in this case, conversion of forest). Besides, Research on carbon emission in urban regions is also needed (e.g. emissions produced from energy in everyday use).

REFERENCES

Baumert, K.A., Herzog, T., Pershing, J. (2006). *Navigating the Numbers – Greenhouse Gas Data and International Climate Policy*. World Resources Institute. Washington, USA.

Houghton, R. (2005). *Tropical Deforestation and Climate Change*, Edited by P. Moutinho and S. Schwartzman, Instituto de Pesquisa Ambiental da Amazônia (IPAM) and Environmental Defense.

Kementrian Negara Lingkungan Hidup, (2007). *Rencana Aksi Nasional Dalam Menghadapi Perubahan Iklim.*(in bahasa).

Kurz, W.A. and Apps, M.J. (1999). A *70-year Retrospective Analysis of Carbon Fluxes in The Canadian Forest Sector*, *Ecological Applications*, vol. 9, pp. 526-547.

Losi, C.J., Siccama, T.G., Condit, R. and Morales, J.E., (2003). *Analysis of Alternative Methods for Estimating Carbon Stock in Young Tropical Plantations. Forest Ecology and Management*, 184(1-3): 355-368.

Montagnini, F. and Porras, C., (1998). *Evaluating the Role of Plantations as Carbon Sinks: An Example of an Integrative Approach From the Humid Tropics. Environmental Management*, 22: 459-470.

Montagu, K.D., Duttmer, K., Barton, C.V.M. and Cowie, A.L., (2005). *Developing General Allometric Relationships for Regional Estimates of Carbon Sequestration: An Example Using Eucalyptus pilularis from Seven Contrasting Sites. Forest Ecology and Management*, 204(1): 115-129.

WWF. (2008). *Deforestation, Forest Degradation, Biodiversity Loss and CO_2 Emissions in Riau, Sumatera, Indonesia.* One Indonesian Province's and Peat Soil Carbon Loss over a Quarter Century and its Plans for the Future. WWF Indonesia Technical Report . WWF, RSS GmBH, and Hokkaido Agricultural University.