REDUCING EMISSIONS FROM PEATLAND DEFORESTATION AND DEGRADATION: CARBON EMISSION AND OPPORTUNITY COSTS

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SUMMARY

The approximately 20% of CO_2 emissions that are lost as a result of forest and peatland degradation have been neglected in the purview of climate change mechanisms. This paper gives an estimate of CO_2 emissions from different land use systems and the corresponding opportunity costs for avoided deforestation of Indonesian peatlands. Increase in CO_2 emission from peatland is usually preceded by deforestation and peatland fires. Subsequent land management systems determine the rate of emission. Oil palm requires drainage to about 80 cm depth and this leads to below ground CO_2 emission of about 73 t ha^{-1} yr^{-1}. Taking into account emission from forest clearing and sequestration in the crop biomass, the net CO_2 emissions from oil palm plantation is about 87 t ha^{-1} yr^{-1}. Some practices, for example, the 'sonor' system, which involve burning of surface peat for rice cultivation can lead to CO_2 emissions as high as 112 t ha^{-1} yr^{-1}. Several other farming systems tolerate shallow or no drainage and thus have lower emissions. In preparation for the Climate Change Conference of Parties in Bali in December 2007 an overview has been made of the 'opportunity costs' of avoided emissions from peatland degradation. The 'opportunity cost' of avoided emissions from peatland degradation is about \$0.08 t^{-1} CO_2-e in the sonor rice system but as high as \$3.4 t^{-1} CO_2-e in oil palm plantation. These are below the emission reduction credits range of \$4 to \$18.

Keywords: opportunity costs, agriculture, peatland fires, drainage, oil palm, REDD

INTRODUCTION

Several years ago the international science community established that about 20% of global CO_2 emissions are generated through land use change and the conversion and degradation of forests. Indonesia is generating emissions of 3,014 Mt CO_2e yr^{-1} from land use land use change and forestry (LULUCF), which is about 6 times higher than its emissions from the energy sector only. Peatland degradation and fires emit about 2,000 Mt CO_2 each year; 1,400 Mt of which is released from forest and peatland fire and the other 600 Mt is from peat degradation following removal of the forest (Hooijer *et al.* 2006). While the Clean Development Mechanism (CDM) of the Kyoto Protocol makes some allowance for afforestation and reforestation, it has so far excluded avoided deforestation.

Much deforestation is actually planned by land managers and governments because it leads to land uses with higher economic returns. Completely avoiding deforestation would require offset payments that are not feasible under present circumstances. Negotiating intermediate targets for "partial deforestation" of a particular landscape would be very complex, but the global climate change community is increasingly recognizing that it must address the challenge of reducing emissions from deforestation and degradation (REDD). From the economic perspective, a carbon market for peatland is realistic if payment for conserving peatland for carbon is significantly higher than the opportunity cost.

This paper discusses the potential emissions from different land use and land management practices and estimates the opportunity costs of avoided deforestation from selected land use and management practices.

MATERIALS AND METHODS

This study was based on literature review, discussion with experts and farmers, spatial data analysis and ground truthing. The ground truth and soil sampling for analysis of carbon density by soil depth and peat maturity as well as discussion with farmers on management practices were conducted in Bulungan District, East Kalimantan and in Pesisir Selatan District, West Sumatra in April and May 2007.

Estimate of net emissions

Net emission, E, from a system can be estimated as:

$$E = (E_a - S_a) + (E_{bb} + E_{bo}) \quad [1]$$

where

E_a = Emission from above ground (mainly caused by biomass burning).
S_a = Carbon sequestration into the above ground biomass.
E_{bb} = Emission from below ground burning
E_{bo} = Emission from below ground oxidation

Sequestration in the below ground (organic matter addition) in most cases is negligible.

For calculating E_a, a production cycle is assumed as long as 25 yr, resembling that of oil palm. When a wetland (logged over) forest with C density of about 200 t ha^{-1} (Rahayu *et al*. 2005) is deforested, almost all of the carbon is likely to be emitted over the 25 yr period through burning and decomposing. The E_a is then 8 t C or about 29 t CO_2-e ha^{-1} yr^{-1}. This annual average value was applied for all evaluated land uses.

S_a is assumed negligible in annual crop based systems. A mature oil palm plantation contains about 100 t C (Tomich, 1999), which corresponds to *Sa* of about 4 t C or 15 t CO_2-e ha^{-1} yr^{-1}. S_a for rubber is assumed to be equal to oil palm.

E_{bb} is significant in some systems such as the ‘sonor’ system. Widespread fires in the wetland of South Sumatra and Lampung in the El Niño periods of 1991, 1994 and 1997/98 were partly a result of *sonor*; a traditional system of wetland rice cultivation. *Sonor* is practised by using fire during prolonged droughts of five to six months (likely in the El Nino years, every four years). As the wetlands dry out, surface vegetation is burned and rice seeds are broadcast on the ash-enriched peat soil. This became more common as the incidence of droughts increased, new areas became accessible through canals, and new migrants also adopted the practice (Chokkalingam, *et al.*, 2006). Since the peat is dry during the long dry season, fire can easily burn a layer of peat exceeding 10 cm. If it is assumed that 10 cm of surface peat burns in four years then 2.5 cm of peat is burned in one year under the sonor system. For other annual crops, such as maize, with occasional burning of crop residues, a burning depth of 1 cm per year is assumed.

With peat bulk density ranging from 0.10 to 0.34 t m^{-3} and organic C content ranging from 0.3 to 0.5% (w/w) (Wahyunto *et al.*, 2003 and 2004), then carbon density in a one metre layer of peat ranges from 530 to 1260 t ha^{-1} or 900 t C ha^{-1}, or 9 t ha^{-1} cm^{-1} on average. E_{bb} from the sonor systems then is about 22.5 t C or 83 t CO_2-e ha^{-1} yr^{-1}. For annual upland crop it is about 33 t CO_2-e ha^{-1} yr^{-1}.

E_{bo} estimates from different literature sources vary widely. Some show CO_2 emission as low as 4 t ha^{-1} yr^{-1} from paddy field with drainage depth of 10 cm and as high as 127 t ha^{-1} yr^{-1} from drained secondary forest with drainage depth of 38 cm. Despite the variation, Hooijer *et al*. (2006) suggested CO_2 emission of about 0.91 t ha^{-1} yr^{-1} per cm drainage depths ranging from 25 to 110 cm. This relationship is used in this paper. Based on field observation and various literature the drainage depths for sonor, annual upland crops, lowland rice, rubber and oil palm are 10, 30, 10, 20 and 80 cm, respectively.

Estimate of opportunity costs

Opportunity costs or the cost for avoided deforestation are estimated based on the net profit per unit area per unit time divided by net carbon emission per unit area per unit time. These opportunity costs are compared with the current carbon credits to evaluate the feasibility of REDD though a carbon trading mechanism.

RESULTS AND DISCUSSION

Using Equation [1] and the various assumptions mentioned in the previous section, partition of emission and sequestration of selected land uses can be calculated (Figure 1).

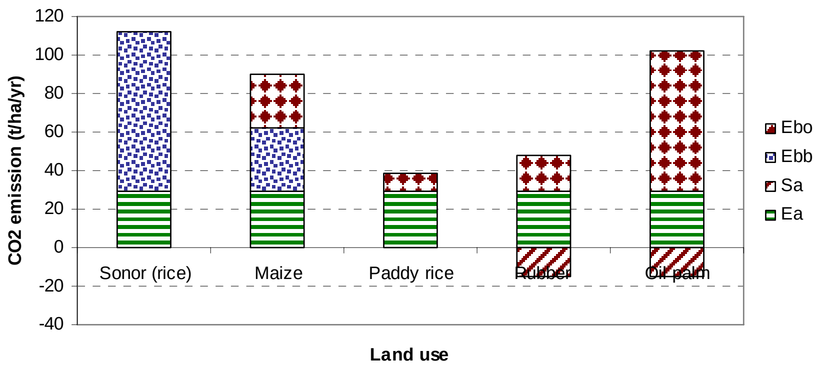

Figure 1. Emission from above ground biomass burning during deforestation (E_a), sequestration into the above ground biomass (S_a), emission from peat burning (E_{bb}), and emission from below ground oxidation (E_{bo}) of selected land uses on peatland.

Opportunity costs

Financial analysis of the sonor system is presented in Table 1. For oil palm plantation in Jambi, the estimate of annual benefit was \$146 ha^{-1} (Tomich, 1999), which seems to be very low. Recently, farmers in Pesisir Selatan District, West Sumatra claimed that they earned annual income of more than \$1200 ha^{-1} yr^{-1} during the peak production years (6 to 20 years after planting). If it is assumed that 50% of income during this peak production years is used for various costs and investments and ignore the first and the last five years' production during the 25 yr cycle, then the average annual profit is \$360 ha^{-1} yr^{-1}.

Table 2: Net carbon emission, benefit and opportunity costs of selected land uses.

Table 1. Financial analysis under the 'sonor' system.

Item	Value
Gross revenue ($ ha^{-1} yr^{-1})	26
Cost of current inputs ($ ha^{-1} yr^{-1})	1
Cost of labor ($ ha^{-1} yr^{-1})	17
Hired labor (%)	65
Residual Profit ($ ha^{-1} yr^{-1})	8
Average area per Household (ha)	11.7
Residual Profit per Household ($ HH^{-1} yr^{-1})	94
Hired Labor ($ ha^{-1} yr^{-1})	13
Income ($ ha^{-1} yr^{-1})	12
Income per Household ($ yr^{-1})	140
Average Yield (t ha^{-1})	1.33
Average rice price ($ t^{-1})	79

Table 2. CO_2 emission, annual profit and opportunity costs for avoided deforestation under the *sonor* and oil palm plantation

Farming system	CO_2 emission	Profit	Opportunity cost
	t ha-1 yr-1	$ ha^{-1} yr^{-1}	$ t^{-1} CO_2-e
Sonor	112	8	0.07
Oil palm (Jambi)	87	146	1.68
Oil palm in Pes. Selatan	87	360	4.12

The opportunity costs as shown in Table 2 are lower than the carbon price of $4 to $18 t^{-1} CO_2. Opportunity costs of more efficient systems may exceed the $4 value. The lower the opportunity cost, the more feasible the carbon trading scheme through REDD will be although, in this calculation, the transaction costs of the carbon market need to be taken into account.

CONCLUSIONS

The examples used in this paper shows the relatively low opportunity costs and high emission rates from deforestation and degradation. Therefore, reducing emission from peatland deforestation and degradation through payment transfer should be seriously considered in the next round of debates on climate change mitigation.

REFERENCES

Chokkalingam, U., Suyanto, S., Permana, R.P,, Kurniawan, I/. Mannes, J., Darmawan, A., Khususiyah, N. and Susanto, R.H. (2006) Community fire use, resource change, and livelihood impacts: The downward spiral in the wetlands of southern Sumatra. *Mitigation and Adaptation Strategies for Global Change.* 12,

Hooijer, A., Silvius, M., Wösten, H., and Page, S.E. (2006) *Peat-CO_2, Assessment of CO_2 Emissions from drained peatlands in SE Asia.* Delft Hydraulics report Q3943.

Rahayu, S., Lusiana, B., and van Noordwijk, M. (2005) Above ground carbon stock assessment for various land use systems in Nunukan, East Kalimantan. pp. 21-34. In: Lusiana, B., van Noordwijk, M., and Rahayu, S. (eds.) *Carbon Stock Monitoring in Nunukan, East Kalimantan: A Spatial and Modelling Approach.* World Agroforestry Centre, SE Asia, Bogor, Indonesia.

Tomich, T.P. (1999) Agricultural Intensification, Deforestation, and the Environment: Assessing Trade offs in Sumatra, Indonesia. *Proceedings of the International Symposium "Land Use Change and Forest Management for Mitigation of Disaster and Impact of Climate Change",* Bogor, 19-20 October, 1999. pp. 1-27.

Wahyunto, Ritung, S. and Subagjo, H. (2003) Map of Peatland Distribution Area and Carbon Content in Sumatra. Wetland International-Indonesia Program and Wildlife Habitat Canada (WHC).

Wahyunto, Ritung, S., Suparto and Subagjo, H. (2004) Map of Peatland Distribution Area and Carbon Content in Kalimantan. Wetland International-Indonesia Program and Wildlife Habitat Canada (WHC).