CURRENT ISSUES OF TROPICAL PEATLAND IN INDONESIA

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ABSTRACT

Indonesia has peatland occupying over 20 million hectares, about 10% of its total land areas, spreading in Sumatra, Kalimantan, and Papua islands. Quite vast expanses of the peatlands have been reclaimed by government for rice cultivation in transmigration projects and by private companies for forest and oil palm plantations. This paper discusses topics of carbon stock and emission in conjunction to wise utilization of peatlands in Indonesia. Discussed topics include figures of estimate of carbon stock and emission and the approaches as well, to seek for the truth if Indonesia is really in third position of carbon emitter countries, by reviewing some related publications being widely referred. Following the discussion, reviews on peatland utilizations have been made in Indonesia are described to frankly show any successful and unsuccessful of the utilizations. All the discussions and reviews are always based on a pure scientific thinking, hindering any noise of certain interest.

Keywords: *tropical peatland, carbon stock, CO_2 emision, oil palm plantation, forest plantation.*

INTRODUCTION

Indonesia possesses a considerable expanse of peatlands that mostly spreading in Sumatra, Kalimantan, and Papua islands. The expanse counts to approximately 20 million hectares, about 10% of the total lands of the country or about 6-7% of the total peatlands of the world. The Indonesian peatlands, however, count as the largest expanse of tropical peat among other tropical countries including Malaysia that possess peatlands of about 2.5 million hectares at second position.

Tropical peat has great difference with that of temperate peat in that it composed of woody organic decay instead of spaghnous material. This difference remarkably determines other characteristics; such as bulk density. Tropical peat has a much lower bulk density than that of temperate peat. The difference is certainly important to be well considered. Some of programs of utilizing peatlands in Indonesia that had been undergone with technical supervision from peat scientists of the temperate countries had mostly failed; resulted in severe environmental problems instead, such as fire and its carbon emission as well. The failure is, among others, certainly attributable to a lack of consideration on nature and properties of the tropical peatlands.

Utilization of peatland in Indonesia was started at 18th century by people of two ethnic groups, i.e. Bugis from South Sulawesi and Banjar from South Kalimantan who had utilized some of the peatlands at eastern coast of Sumatra island for growing rice as well as various annual crops and coconut. Cities of Tembilahan, Kuala Tungkal and Kuala Enok, for example, were originally peat swamp forests where the two ethnic people had come to and started living in with the above agricultural activities. This fact had become an inspiration for Indonesian government to utilize peatlands for expansion of paddy field since other flat and water abundant areas were already limited.

Development of paddy fields on peatlands had started expansively by Indonesian government in 1969 through the so-called transmigration program. One of the main purposes of this program is to resettle poor and landless people from dense Java and Bali into much less dense areas in other islands like Sumatra, Kalimantan and Sulawesi. Unfortunately the peatland development projects have mostly ended up at failure including the most recent big one, a one million hectares Mega Rice Project (MRP) in Kalimantan in 1997. Productive rice fields intended by the project could not be eventually created; the lands were drastically changed into worse condition instead. Peat layers that have original 2-3 m thickness at the upper part of the land was after a view years land cultivation found as much more tinny layers or even are not exist anymore. Disappearance of peat layers had led former underlain mineral sediment emerging to the surface. Sulphidic material containing sediment, which has a potency to form acid sulfate soil, and quartz sand dominated sediment are dominant types of peat underlain sediments of coastal peatlands. The lost of peat was mainly due to an intensive decomposition in addition to fires which are attributable to wrong drainage system, in that the system had resulted in an exsessive drying of the peat. In addition to such expansive failure of the MRP, at about the same years there were also significant numbers of utilization of peatlands for plantation of perennial crops, where fire was intensively used in land preparations. These fires have resulted in huge haze that certainly have endangered people health and disturbed transportation systems of not only Indonesia but also the neighboring countries, i.e. Malaysia, Singapore, and Brunei.

The MRP being repeatedly used by world experts of peat and environmentalists, as a tremendous example of deteriorating effect of utilizing peatlands, in criticizing Indonesia for the expansive use of peatlands. Their critic emphasized on carbon emission. With this critic they are arguing against utilization of peatlands in Indonesia for agriculture including fast growing tree plantation for pulp industries and especially oil palm plantation. An estimation made by Page *et al.* (2001) that was reanalyzed by Hooijer *et al.* (2006) shows that the carbon emission from burned Indonesian peatlands is about 3 Gt CO_2 yearly. This figure put Indonesia at third position of the biggest carbon emitter under the US at the top and China at second position.

This paper discusses topics of carbon stock and emission and wise utilizations of peatlands for forest and oil palm plantations with respect to especially water management and peat subsidence.

Carbon Stock and Emission

Estimations of the expanse of total peatland areas in Indonesia show different results that vary between 16-26 million hectares (Table 1). This variation reflects differences of definition and method of the estimations.

Table 1. Distribution and area of peatlands in Indonesia (Wetlands International. 2006)

Author/Sources	Peatland distribution and area (million ha)				Total
	Sumatra	Kalimantan	Papua	Other	
Driessen (1987)	9.70	6.30	0.10	-	16.10
Puslittanah (1981)	8.90	6.50	10.90	0.20	26.50
Euroconsult (1984)	6.84	4.93	5.46	-	17.20
Soekardi & Hidayat (1988)	4.50	9.30	4.60	<0.10	18.40
Deptrans (1988)	8.20	6.80	4.60	0.40	20.10
Subagyo *et al.* (1990)	6.40	5.40	3.10	-	14.90
Deptrans (1990)	6.90	6.40	4.20	0.30	17.80
Nugroho *et al.*(1992)	4.80	6.10	2.50	0.10	13.50*
Radjagukguk (1993)	8.25	6.79	4.62	0.40	20.10
Dwiyono & Racman (1996)	7.16	4.34	8.40	0.10	20.00
Wetlands International (2002)	7.20	5.80	8.00	-	21.00

*not including peatland associated with saline land and floodplain (2.46 milion ha)

By delineating peat distribution based on peat depth and decomposition stage using remote sensing image, which was completed with a ground check for peat depth, decomposition stage and bulk density at some points representing each delineation unit, and a laboratory analyses of carbon content of samples representing each peat decomposition stage (fibric, sapric, hemic), Wahyunto and Suradiputra (2008) have estimated carbon stock of peat in Indonesia and showed that the stock in Sumatra and Kalimantan counts to a total of 33,558 Gt. Since the image was supposed to be used as an aid in delineating spatial distribution based on reflection of surface characteristics of the peatlands, then the delineation does not necessarily coincide with distribution of the peat depth, decomposition stage, and bulk density. This inaccuracy, suggests that the above estimation approach, as well as the results, is scientifically unacceptable. Yet the approach and the results seem to be used as reference ever since and no more scientifically acceptable approach has been developed.

The MRP has been coincided with long period of dry season of El-Nino in 1997 so that the fires were continuous and extending during the year. Carbon emission in Indonesia has become a great concern ever since this prolonged fires. Page *et al.* (2001) have made a calculation to estimate carbon emission related to the MRP fires based on field data of a block named Block C having total area of 383,800 hectares with dominating peatland area of 337.632 hectares (Table 2). The fires have damaged 48% the peatland area equivalent to 54.7% of the total areas of this block. The calculated total carbon loss of this block is 0.06-0.07 Gt. The same calculation was done for the entire MRP area (988,568 hectares) and of the whole study area (area of 2,491,619 hectares including the MRP area and surroundings). Carbon loss of each is respectively 0.15-0.18 Gt and 0.24-0.28Gt.

Table 2. Effects of the 1997 fires on peat carbon stores (Page *et al.*, 2001)

	Block C of MRP, 383,800 ha	Entire MRP, 988,568 ha	Study Area, 2,491,619 ha	Extrapolated values for whole of Indonesia, 190,400,000 ha		
Peatland area (ha)	337,632	854,809	2,153,304		20,072,825 (ref.4)	
Peat volume* (10^9m^3)	7.8-14.9	19.7-37.6	49.5-94.7		461.7-883.4	
Carbon store* (Gt)	0.44-0.85	1.12-2.14	2.8-5.40		26.32-50.34	
				Lower estimate	**Intermediate estimate**	**Upper estimate**
Area of fire-damaged peatland (ha)	184,564 (48.1%)	474,009 (48.0%)	729,500 (29.3%)	1,450,000	2,441,000	6,804,688
Percent of peatland area damaged	54.7%	55.5%	33.9%	7.2%	12.1%	33.9%
Peat volume loss (10^9m^3)	0.85-1.03	2.18-2.66	3.36-4.09	6.67-8.12	11.23-13.67	31.30-38.30
Peat carbon loss to atmosphere (Gt)	0.05-0.06	0.12-0.15	0.19-0.23	0.38-0.46	0.64-078	1.78-2.17
Percent peat carbon loss from store (Gt)	5.9-13.6%	5.6-13.4%	3.5-8.2%	0.8-1.8%	1.3-3.0%	3.5-8.2%
Biomass carbon loss# (Gt)	0.01	0.03	0.05	0.10	0.17	0.40
Total carbon loss (Gt)	0.06-0.07	0.15-0.18	0.24-0.28	0.48-0.56	0.81-0.95	2.18-2.57

In the same table is also written the extrapolated values for whole of Indonesia with total area of 190,400,000 hectares including 20,072,825 hectares peatlands. The table says that carbon loss of whole of Indonesia estimated by extrapolating the 33.9% damaged peatlands obtained for the study area that was based on fires in 1997 is 0.81-2.57 Gt (a range between the lowest value of the intermediate estimate and the highest value of the upper estimate).

Calculated value of carbon loss of the Block C of MRP is might be scientifically acceptable, but the value obtained for the whole 2,491,619 hectares of study area is unacceptable based on the following reasons. It should be bear in mind that inside the study area there are parts covering hundred thousand hectares, like area of Pulau Petak, Anjir Basarang, Pulang Pisau, and transmigration area of Bahaur, which had been cultivated for agriculture since long before the MRP. This fact suggests that it is hard to say that peat of those parts just lost by the fires in 1997. Therefore, saying 33.9% peatland of study area damaged by fires is certainly incorrect.

The carbon loss estimated for the whole area of Indonesia in Table 2 is, due to different reasons, also really questionable. There is no doubt that peatlands would be burned only if they are dried. But in natural condition the lands are always waterlogged or at least always moist and, therefore, hard to be burned. Peatlands will be dried if they are drained. Since massive drainages of peatlands resulting excessive peat drying were built only in certain areas, among other is in the MRP area with a finite extent however, then the rest of Indonesian peatlands are still safe from fires.

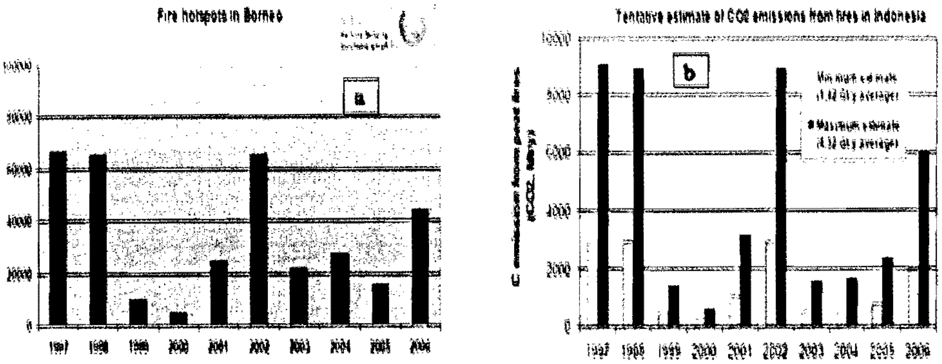

Figure 1. Hotspot data and estimated carbon emission in Indonesia (Hooijer *et al.*, 2006).

Although the above calculation and estimation of Page *et al.* (2001) are clearly seen has roughly been made, still the publication has widely caught interests especially of environmental experts. Carbon loss as high as 2.57 Gt shown in the publication was likely considered as real loss of carbon from Indonesian peatlands in 1997, and it is really an outstanding figure placing Indonesia in world third biggest carbon emitter after the US and China.

In addition to the above publication, Page with her colleagues published another estimation of carbon emission from Indonesian peatlands as published in Hooijer *et al.* (2006). They have collected data of hotpots on Kalimantan of the years 1997 to 2006 (Figure 1a) and have correlated the hotspots of the year 1997 with the carbon emission figures of Page *et al.* (2001) as shown in Figure 1 (b).

The upper estimate of carbon emission from Indonesian peatlands made by Page *et al.* (2001) is 2.57 Gt C in one year. By expressing the estimate in CO_2 as shown in Figure 1b, then the estimate carbon loss of 0.81-2.54 Gt of only the year 1997 is equal to CO_2 emission of 2970-9313 Mt. Using hotspot data in Figure 1a to extrapolate the estimate of the 1997 value into the time series has resulted that carbon emission from Indonesian peatlands during 1997-2007 varied between 1.42 and 4.32Gt CO_2 each year with the average of 3 Gt CO_2/ year (Figure 1b). This widely published tremendous figure has ever worsen Indonesian image as carbon emitter as again the biggest emitter in the world next to the US and China.

The above estimation was really made roughly and is scientifically very weak. Our argument to the estimation is as follows. They seem to have made a wrong analogy of carbon emission from peatland fire with those the emission in industrial countries. In industrial countries carbon emissions come from continuous industrial processes in which the emissions occur in all-time along with the processes. But in case of emission from peatlands, the emission will occur only if the lands are burned and once the peat has already burned out then there will no more emissions from peat, except smaller one from burned vegetation on the lands. The other thing is that the hotspot data presented in Figure 1b are actually an accumulation of lowlands and uplands, not necessarily of only hotspot on the peatlands. Correlating such hotspot data with carbon emission estimate based on only fire events in peatlands in Central-South Kalimantan

to figure out carbon emission in Indonesia every year is, therefore, quite ridiculous. If the estimate figure is supposed to be true, lets us calculate that with 3Gt CO_2 (equal to 0.8 Gt C) emission every year during 13 years of 1997 to this year (2009) then the total C emission should be counts to 10.6 Gt. Furthermore, by correlating this total figure with the carbon stocks of peatlands of Sumatra and Kalimantan calculated by Wahyunto dan Suradiputra (2008), then the 33.6 Gt C of the islands should have losing its one-third during 1997 to 2009. But it is not true at all, as the C is still there in the peatlands.

Yet the above publications are being widely referred ever since. Impact of the publications have even so strong in that they have been used as base in establishing world environmental policies, such as the REDD as presented by Boer (2007).

Peatland Utilization and the Problems

Rice and other seasonal crops

Utilization of peatlands in Indonesia was initiated by some pioneers on in general, peatlands with shallow peat at 3-5 extent from river, with which therefore the lands are still affected by tide. They built drainage canals by necessity to grow rice as well as coconut and rubber trees (Sumawinata, 1992). They have succeeded with their ways and, in turn, their success has become an inspiration for Indonesian government to extensively utilized peatlands for paddy field with the supports from domestic and foreign experts and financially from the World Bank. But due to careless selection of sites and technologies and lack of knowledge of nature and properties of tropical peatland at that time, most of developed lands eventually rest as bare lands and a quite large part of them have been changed into acid sulfate soils (Furukawa, 1994).

In fact peatlands are not thuoroughly flat as shown in Figure 2 and 3. The outer parts that are affected by tide and relatively more fertile than the rest, have commonly already used by farmers. The government then had to open the inner part having less fertile peat with fibric decomposition stage. Instead of constructing canal by necessity as did the pioneer farmes, the government had built huge canals with no water controling mechanism at all. The experts seem had put much intention to dry the lands with the canals. Water supply for the lands was supposed to come from tide, but in fact the tide has not ever reached the lands.

As a consequence of application of inappropriate water system and cultivating seasonal crops such as rice, maize and others, the lands were converted to rain-fed system. With this condition migrant farmers could only cultivate their land at rainy season leaving the lands are bare during dry season and will start to be prepared for the next cultivation at the end of dry season by commonly use fire. This land burning had certainly caused peat to gradually disappear resulting in lower height of land surfaces that in turn had made flood in rainy season. To decrease effect of such flood, then the canals were deepened. This event had repeatedly happened causing the peat to completely disappear. For area with the peat underlain sediment is mud of mangrove sediment containing pyrite minerals, then drying the sediments as the consequence of the such drainage handling had caused the pyrites to be oxidized, producing strong acid and toxic substances for plants. This case commonly is known as formation of acid sulfate soils. Most of peatland areas opened in the years of 1970 to 1997 by the government of Indonesia had faced this problem. An outstanding example is a transmigration area in Berbak

delta in Jambi developed in 1970 - 1980. We found that 10,000 hectares of the area are dominated by bare lands with shrub vegetation. Rain-fed rice fields are found only as a small part of the area and they produce less than 1 ton unhuld rice per hectare. Distribution of landuse of this area is shown in Figure 4.

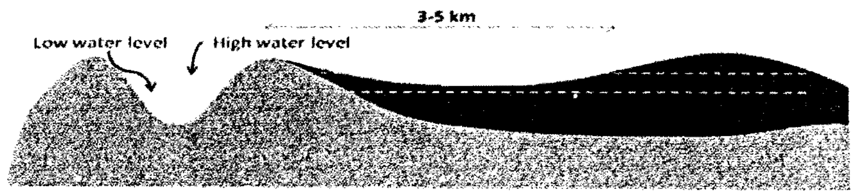

Figure 2. Geomorphology model of tropical peat swamp showing tide affected part used by pioneer farmers and the untouch dome part

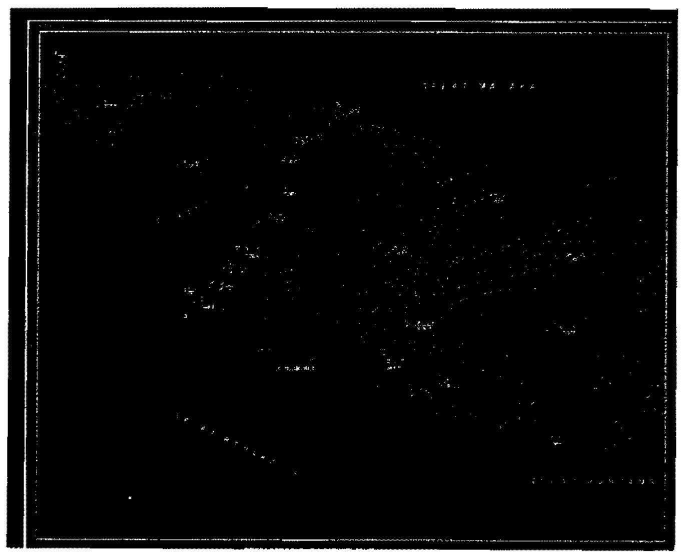

Figure 3. Topographic map showing dome-shaped peatland of peatland areas of Bengkalis Island, Riau (Source: Pusat Sumberdaya Geologi, 2007).

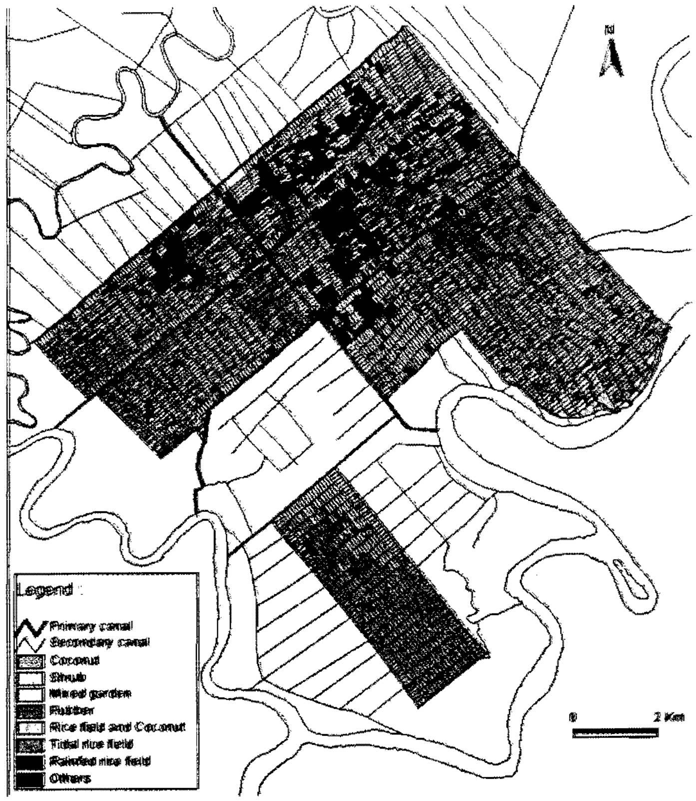

Figure 4. Landuse map of ex-transmigration area of Berbak Delta in 2004.

Perennial Plants

Large extents of utilization of peatlands for perennial plants by private companies started since a development of plantation of hybrid coconut in Riau at the end of 1980's. Following thereafter are development of oil palm and fast growing trees plantation such as *Acacia crassicarpa*. The last is known as Hutan Tanaman Industri (HTI) in Indonesian that literally means industrial forest plantation. Up to present, about 1-1.5 million hectares peatland of Indonesia have already used for the plantations.

In comparison to condition of the expansively opened peatlands by the government of Indonesia for annual crops described above, the peatlands cultivated for the plantations showing much better condition. After about 20 years plantation there is no single report of damaged and eventually bared lands of the plantation areas. It is a big different with those of the government projects of peatlands for annual crops where there are a lot of land damages after 10-15 years mainly due to formation of acid sulfate soils causing the lands are eventually left bared.

The above big difference is strongly attributable to the difference in water management. The government project had never managed water table of the canals and of the cultivation lands. In this case the water management was carried out only up to the canals construction and just let the water to flow by nature. But in water management of the plantation of private company there is construction of water gates attached to the canals to control water table of plantation lands. At the beginning, water gates were only constructed at the outlet end of the canal as connection to the river. Facts that peat is extremely porous and the land has a dome shape are gradually have been considered by the company then, so they have made effort to implement water management in more detail spacing. For example, in one HTI area in Riau water controls were built at every 0.5 to 1 m height difference, about one control at every 1-2 km. For transportation within the plantation areas, they built roads for main access and the canals are used for only secondary transportation. To minimize fires and subsidence water table are set as high as possible but the water does not limit plant rooting. The maximum water table applied in plantation area of oil palm and industrial trees are about 80-100 cm. Personal communication with an expert of one private company of HTI we know that with that water table the company could produce an MAI 25-27 m^3 a year. An *Accacia crassicarpa* plantation that has a density of 0.65 g/cc would in six months produce about 80-100 ton/hectares of woods for pulp.

Even with such good management, there are still peat subsidences at a rate of 4 cm/year during the first plantation cycle. Hopefully, in the following cycles the rate of subsidence would decrease. The peat subsidence is frequently interpreted as a loss of peat due to peat decomposition that release carbon to the atmosphere. This interpretation is not always true as there is a possibility that a subsidence might be caused by compaction as reported by Kool *et al.* (2006).

Theoretically compaction can be estimated based on a change in value of bulk density of peat. Unfortunately measuring bulk density of tropical peat is extremely difficult due to high variation of particles of tropical peat. The particle of tropical peat varies from a few cm to very fine sizes. In addition, value of tropical peat bulk density is quite low and for the upper part (surface) the value greatly varies about 0.07-0.3 g/cc. This fact suggests that even we get a bulk density counts to 30% higher, it is still difficult to say that the subsidence have really happened. This unclear phenomenon has led some experts of peat or environmentalists to simply think that a height decrease of peatland surface under cultivation is a subsidence, and a subsidence means a peat loss.

Utilization of peatland in Indonesia for oil palm plantation has already quite expansive. Some reports about Indonesian and Malaysian production of oil palm on peatland say that with good management, especially of water management, the production could exceed those of the plantation on upland mineral soils. Oil palm yield on upland are seasonally fluctuated in that it will always drop after dry seasons. Another important management of oil palm plantation on peatland is fertilization in that it has a higher complexity than that of the upland. Time and method of fertilization, as well as dosage of fertilizer of especially micro nutrients, should be effective enough. Well managed plots of plantation are reported to produce 24-27 ton fruit bunch /hectares. There is another important note, however, that productivity of the plants on peatland at age 4-5 years is lower than that of the upland.

CONCLUSIONS

Here are some important remarks for the above review and discussion, as important notices of a hope that wise uses of peatland will soon come true:

- Not all peatland utilizations are successful, nor are unsuccessful.
- Reports in any publications must be carefully and wisely considered and cited.
- Utilization of peatlands for plantation (palm oil and industrial plants) is not taboo, as long as good managements are practiced.
- Water management in peatland management play great role to support for successful and sustainable peatland utilization.

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