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USING PEAT SHRUB FOR AGRICULTURE LIKELY REDUCES CO₂ EMISSIONS AND IMPROVES LOCAL LIVELIHOOD

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SUMMARY

Indonesia has around 4 Mha of degraded peat shrub from a total of about 15 Mha peatland nationally. These lands emit CO₂ and are fire prone. Using them for productive uses may not only reduce both problems, but also promises livelihood to local communities. We evaluated the net present values, CO₂ emissions and opportunity costs (OpCosts) of different land uses on peatland in Riau, Jambi, West Kalimantan, Central Kalimantan and Papua Provinces, Indonesia from September 2012 to August 2013. In general the benefits from utilizing peatland for agriculture were so high, especially for rubber and oil palm which create high pressures to use peatland. The net present value (NPV) under oil palm plantation ranged from USD 827 to 2515 ha⁻¹ yr⁻¹ and under rubber plantation in Central Kalimantan was around USD 4081 ha⁻¹ yr⁻¹. The OpCost of not using peat shrub to rubber was USD 132 (Mg CO₂)⁻¹; a value unaffordable for compensation by any carbon market mechanisms. At the Papua site, converting peat shrub into sago plantation resulted in negative OpCosts, meaning that it reduced CO₂ emissions, as well as generated income. By utilization of peat shrub or productive uses, coupled with a strict control of conserving natural peat forest, the country's chance of success in protecting peat forest and hence reducing emissions from peat forest conversion will likely increase.

Keywords: *degraded peatland, opportunity cost, CO₂ emissions, rubber, peat shrub, oil palm*

INTRODUCTION

Indonesia has about 15 million ha of peatland (Ritung *et al.*, 2011) which is the largest among tropical countries. It is under high pressures for various uses, most of which require drained condition. At the same time its conservation as natural undrained forest is also vital for conserving carbon and maintaining environmental quality. When the peat forest is cleared and drained, its function will change from storage to a source of carbon (Jauhiainen *et al.*, 2012; Drösler *et al.*, 2013). Drained peatlands are also subjected to subsidence and are prone to fire (Stephens and Stewart 1969; Hooijer *et al.*, 2012; Aich *et al.*, 2013; Wösten *et al.*, 2008). However, not all of the drained peatland are productive. Roughly 4 million ha is degraded and being idle. They are covered by shrub, grasses or ferns (Gunarso *et al.*, 2013; Agus *et al.*, 2014). Some of the idle land is in transition for some kind of agriculture, while some others are idle because of insecure status or are within forest jurisdiction. This research was aimed at evaluating the economic and environmental tradeoffs of using peatland, especially the degraded ones, for agriculture.

MATERIALS AND METHODS

The evaluation of land cover of Indonesian peatland was adapted from Agus *et al.*, (2014). These data were generated from 2011 Landsat TM interpretation. Field research was conducted at five sites, each in Riau, Jambi, West Kalimantan, Central Kalimantan, and Papua Provinces. The Riau site represented very deep (4-6 m deep) peat and was used for smallholder oil palm plantation. The Jambi site represented moderately deep (1.5-4.5 m deep) peat and also used for smallholder oil palm plantation. The Central Kalimantan site represented very deep peat (4-6 m) and was used for smallholder rubber plantation. The West Kalimantan site was moderately deep (3-4 m deep) peat and was used for annual food and horticultural crops, while the Papua site was shallow (2-3 m deep) peat and was used for sago forest. Treatments in the former four sites were various kinds of ameliorants including barnyard manure, dolomite, "peat fertilizer" (steel sludge enriched with phosphate rock), Trichoderma and a control. They were arranged in a completely randomized block design with four to five replications. Treatments and the number of replications slightly varied across sites.

For the calculation of net CO₂ emissions as caused by land use and land use changes, two sources of emissions were taken into account; peat decomposition and biomass loss. Peat fire is an important source of CO₂

emission, especially from peat shrub, but was not included in this calculation. For the Riau and West Kalimantan sites, CO₂ emission from peat decomposition was measured using 25 cm diameter by 22 cm tall closed chambers and the gas concentration was measured monthly using an Infrared CO₂ Gas Analyzer (IRGA) as explained by Marwanto and Agus (2014), Dariah *et al.* (2014), and Husnain *et al.* (2014). For the other sites CO₂ peat emissions were based on the IPCC default values (Dröslér *et al.* 2014). Emission from biomass loss due to land use change was assessed using the biomass carbon stock difference using default values (Agus *et al.* 2014 & 2013; IPCC 2006).

For the calculation of the Net Present Values (NPV), three kinds of data were used: crop yield, costs associated with land clearing and soil and crop management (including costs for harvest), and revenue at farm level. For oil palm plantation, the first four year fresh fruit bunch (FFB) yield was based on the actual field data and for the life-cycle yield, an *ex-ante* estimation was conducted using the curve of Sutarta and Rahutomo (2013). The lowest case FFB yield scenario of this curve ($Y = -0.1403 x^2 + 4.164 x - 1.664$; $R^2 = 0.8494$) was used since we classify peatland as sub-optimal land with low productivity.

Data of the farm inputs were a combination of farmer interview and direct recording of costs associated with treatments. Oil palm revenue was based on the actual (2014 to early 2015) FFB prices. The opportunity costs (OpCosts) of emission reduction was defined as the forgone benefits of not using the land for agriculture divided by the difference in the amount of CO₂ emissions associated with peat oxidation and carbon stock changes.

RESULTS AND DISCUSSION

From the 15 Mha Indonesian peatland around 8.3 Mha is covered by forest. About 1.5 Mha has been used for plantations (including oil palm plantation) and about 0.7 Mha is used for annual food and horticultural crops. Degraded peatland comprised about 4 Mha which are mainly covered by shrub, imperata grass, and ferns. These degraded lands have a good potential for agricultural developments for enhancing livelihood and minimizing environmental impacts, instead of using natural forests for agriculture.

1. Crop Yield

Table 1 shows different responses on crop yield of different amelioration and fertilization treatments. In Jambi, oil palm FFB yield increased with the application of manure indicating insufficiency and/or incompleteness of macro and micro nutrients in the soil since only N, P and K fertilizers were provided under the control treatment. Likewise, the use of "peat fertilizer" and oil palm empty fruit bunch (EFB) increased FFB yield more than 50%. In the Riau location, treatments did not affect crop yield, and this seems to be due the addition of not only N, P, and K, but also magnesium (Mg), copper (Cu) and boron (B) in the control treatments, such that the addition of either manure or EFB did not contribute to the improvement of crop yield. For rubber in Central Kalimantan, only N, P, K was used as the Control treatment and amelioration treatments did not affect crop yield, indicating a high tolerance of this crop to low fertility. For the West Kalimantan site, the non-significant response to amelioration appears to be related to the high fertilizer residue of past cropping. Another observation from Table 1 is that the levels of crop yield on the peat were comparable to those of mineral soils.

Table 1. Mean crop yield under different treatments and different sites.

Treatment	FFB in Jambi (6 yr old oil palm)	FFB in Jambi (6 yr old oil palm)	5 yr old rubber latex in C. Kalimantan	Corn grain yield in W. Kalimantan
	Mg ha ⁻¹ yr ⁻¹			Mg ha ⁻¹ season ⁻¹
Top dressing (Control 1) ¹⁾	11.4 a	18.5 a	3.8 a	2.7 a
Peat fertilizer	17.4 ab	19.3 a	4.6 a	3.8 a
Manure	18.8 b	19.6 a	4.3 a	3.0 a
EFB/Mineral soil	17.7 ab	20.1 a ²⁾	2.9 a ³⁾	
Dolomite				3.5 a
Control 2 ⁴⁾				3.4 a

¹⁾Control 1 = top dressing fertilizer in accordance with the local recommendation; ²⁾EFB = empty fruit bunch; ³⁾Mineral soil; ⁴⁾Control 2 = combination of dolomite and Trichoderma

2. Net Greenhouse gas emissions from land use change

Table 2 shows net emissions from both biomass loss and peat decomposition, mean NPV from different agricultural uses, and opportunity costs (OpCosts) associated with refraining from using either peat shrub, secondary peat forest, or primary peat forest for agricultural uses. When shrub is converted to sago plantation the estimated net CO₂ emissions was -15.4 Mg ha⁻¹ yr⁻¹ because the biomass C of sago plantation was comparable to

that of shrub, while CO₂ emission from sago plantation (5.5 t CO₂ ha⁻¹ yr⁻¹) was lower than that of shrub (19.5 t CO₂ ha⁻¹ yr⁻¹) (Drösler et al. 2014). This means that converting peat shrub to sago plantation reduces CO₂ emissions. For the Riau, Jambi and Central Kalimantan sites, our calculation shows a net positive emissions when peat shrub is converted to agriculture, implying that maintaining the shrub as is would reduce emissions, but practically no profits can be generated from the latter. When either primary or secondary peat forests were converted to agriculture, it very consistently resulted in net CO₂ emissions. Therefore, from the view point of emission reduction (and other environmental consideration), the forest covers should be protected from conversion to agricultural uses.

Table 2. Net present value (NPV) under agricultural uses; net CO₂ emissions from biomass losses or gains and peat decomposition related to land use and land use changes from either shrub, secondary forest, or primary forest to agricultural land; and opportunity costs

Treatment	Jambi (6 year old OP)	Riau (6 year old OP)	Central Kalimantan (5 year old rubber)	West Kalimantan (corn)	Papua, sago forest
NPV (USD ha⁻¹ yr⁻¹) at 10% discount factor	827	2,515	4,081	291	441
Net emissions from biomass and peat decomposition (Mg CO₂ ha⁻¹ yr⁻¹)					
Peat shrub	19.6	22.8	30.8	10.6	-15.4
Secondary peat forest	37.9	62.5	49.1	62.8	3.0
Primary peat forest	63.3	87.9	74.5	88.2	28.4
Opportunity costs [USD (Mg CO₂)⁻¹]					
	42.19	110.32	132.49	27.43	-28.62
	21.82	40.25	83.11	4.63	146.92
	13.06	28.62	54.78	3.30	15.52

USD 1 = IDR 13,000

3. Net present value and opportunity costs

Despite the emissions, the local landholders as well as the district governments regard peatland as a source of revenue and livelihood. The more intensive management of oil palm plantation in Riau gave a relatively high NPV compared to the one in Jambi with a less intensive management. Rubber in Central Kalimantan site gave the highest NPV of over USD 4000 ha⁻¹ yr⁻¹ and this seems related to the adaptability of rubber to produce under a low input system.

The trade-off of the emission level and the financial aspect is reflected by the OpCost (Table 2). In all cases conserving peat primary or secondary forests from conversion to agriculture entails high OpCosts. The high opportunity costs were generated from high NPVs, albeit a relatively high carbon saving if the forests were conserved. Low OpCosts (USD 4.63-3.30 (Mg CO₂)⁻¹) were associated with conserving peat forests from conversion to corn cultivation for the case of West Kalimantan. This was caused by a low NPV from corn and high net CO₂ emissions. Nevertheless, these levels of OpCosts are still relatively high for compensation by carbon market mechanisms. For peat shrub, the high opportunity costs of oil palm and rubber plantations translate to very small carbon saving amid the high NPVs. The negative OpCost of sago means that conversion of the peat shrub to sago plantation not only reduce CO₂ emissions, but also results in financial benefits. Thus, such conversion should be encouraged.

CONCLUSION

Satellite images shows around 4 Mha of Indonesian peatland, part of which could potentially be converted to agricultural uses without significantly exacerbating the environment relative to converting peat forests. Allowing the use of peat shrub and strictly banning the use of peat forests likely result in an overall win-win solution for the local livelihood and emission reduction.

REFERENCES

1. Agus, F., Santosa, I., Dewi, S., Setyanto, P., Thamrin, S., Wulan, Y. C., Suryaningrum, F. (eds.). 2013. Pedoman Teknis Penghitungan Baseline Emisi dan Serapan Gas Rumah Kaca Sektor Berbasis Lahan: Buku I Landasan Ilmiah. Badan Perencanaan Pembangunan Nasional, Republik Indonesia, Jakarta.

2. Agus, F., Gunarso, P., Sahardjo, B.H., Harris, N., van Noordwijk, M., and Killeen, T.J. 2013. Historical CO₂ emissions from land use and land use change from the oil palm industry in Indonesia, Malaysia and Papua New Guinea. *In* Reports from the Technical Panels of RSPOs 2nd Greenhouse Gas Working Group. T. J. Killeen and J. Goon (eds.). Roundtable on Sustainable Palm Oil, Kuala Lumpur, Malaysia. pp. 65–88.
3. Aich, S., McVoy, C.W., Dreschel, T.W. and Santamaria, F. 2013. Estimating soil subsidence and carbon loss in the Everglades agricultural area, Florida using geospatial techniques. *Agriculture, Ecosystems & Environment*, 171: 124–133. doi:10.1016/j.agee.2013.03.017.
4. Dariah A., Marwanto, S., & Agus F. 2014. Root- and peat-based CO₂ emissions from oil palm plantations. *Mitig. Adapt. Strateg. Glob. Change*, 19:831–843. DOI 10.1007/s11027-013-9515-6.
5. Drösler, M., Verchot, L.V., Freibauer, A., Pan, G., Wang, C., Evans, C.D., Bourbonniere, R.A., Alm, J.P., Page, S., Agus, F., Hergoualc'h, K., Couwenberg, J., Jauhiainen, J., Sabiham, S. 2013. "CHAPTER 2: Drained Inland Organic Soils." *In* 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, IPCC, Geneva.
6. Gunarso, P., Hartoyo, M.E., Agus, F., and Killeen, T.J. 2013. Oil palm and land use change in Indonesia, Malaysia and Papua New Guinea. *In* Reports from the Technical Panels of RSPOs 2nd Greenhouse Gas Working Group, T.J. Killeen and J. Goon. Roundtable on Sustainable Palm Oil, Kuala Lumpur, Malaysia. pp. 29–64.
7. Hooijer, A., Page, S., Jauhiainen, J., Lee, W.A., Lu, X.X., Idris, A. and Anshari, G. 2012. Subsidence and carbon loss in drained tropical peatlands. *Biogeosciences* 9 (3): 1053–1071. doi:10.5194/bg-9-1053-2012.
8. Husnain, H., Wigena, I.G.P., Dariah, A., Marwanto, S., Setyanto, P., and Agus, F. 2014. CO₂ emissions from tropical drained peat in Sumatra, Indonesia. *Mitigation and Adaptation Strategies for Global Change* 19 (6): 845–862. doi:10.1007/s11027-014-9550-y.
9. Jauhiainen, J., Hooijer, A., and Page, S.E. 2012. Carbon Dioxide emissions from an *Acacia* plantation on peatland in Sumatra, Indonesia. *Biogeosciences* 9(2): 617–630. doi:10.5194/bg-9-617-2012.
10. Marwanto, S. and Agus, F. 2014. Is CO₂ flux from oil palm plantations on peatland controlled by soil moisture and/or soil and air temperatures? *Mitig. Adapt. Strateg. Glob. Change*, 19:809–819, DOI 10.1007/s11027-013-9518-3.
11. Ritung, S., Wahyunto, Nugroho, K., Sukarman, Hikmatullah, Suparto, Tafakresnanto, C. 2011. Peta lahan gambut Indonesia skala 1:250.000. Kementerian Pertanian, Jakarta.
12. Stephens, J.C., and Stewart, E.H. 1969. Effect of climate on organic soil subsidence.. *Agricultural Research Service, U.S.D.A. Ft. Lauderdale, Florida, USA*, 647–56.
13. Sutarta, F. S. and Rahutomo, S. New standart for FFB yield of IOPRI's planting material based on land suitability. Indonesian Oil Palm Research Institute. Medan. (unpublished)
14. Wösten, J.H.M., Clymans, E., Page, S.E., Rieley, J.O. and Limin, S.H. 2008. Peat–water interrelationships in a Tropical peatland ecosystem in Southeast Asia. *Catena* 73 (2): 212–224. doi:10.1016/j.catena.2007.07.010.