Abstract No: A-170

MUTUAL INTERDEPENDENCE BETWEEN REWETTING, AFFORESTATION AND FIRE PROTECTION IN TROPICAL PEATLANDS

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SUMMARY

Peat surface moisture was significantly higher in the forest comparing that of grass land. This high moisture in the forest will be important for prevent easy igniting of surface peat. To control the carbon emission by peat fire and microbiological decomposition from tropical peatlands, the efficiencies of rewetting peatlands by rising groundwater level, controlling peat fire by firefighting, recovering forest were evaluated with some outcomes of the JST-JICA SATREPS project ―Wild Fire and Carbon Management in Peat-Forest in Indonesia". Carbon emission by peat fire after the rising groundwater level with dam construction is estimated to be 76% of that before dam construction. The extinguish rate by firefighting is directly affected on the decreasing rate of carbon emission from peatlands. Using relationship between the net ecosystem CO2 exchange (NEE) and groundwater level (Hirano, *et al*., 2012), the amount of carbon emission from the un-drained forest was estimated to be decreased to 27% by rising the annual mean groundwater level from 0.2 m to 0.1 m.

***Keywords**: groundwater level, canopy density, peat moisture, carbon emission*

INTRODUCTION

Soil moistures of surface layer in tropical peatland are different with the canopy density of trees at the sites. And the moisture has a relationship with the occurrence of peat fire (Adi Jaya *et al.,* 2011). The one dimensional tank models were applied to estimate the difference of surface peat moisture in open grass land and dense forest. The surface peat moisture in open grass land has been dried by evapotranspiration from surface layer in three month after the last rainfall. But the surface peat moisture in the forest was not so dry (Takahashi, *et al*., 2013). The higher moister content of surface peat layer in the forest means that forest recovery on peatland is one of keys for pear fire prevention.

Rewetting of peatland by rising groundwater level is the most important and basic method for peat fire prevention (Takahashi *et al*., 2011). The most of peat fire is caused by human carelessness. The extinction of fire in early stage is the most important to prevent the surface fire spread to peat fire.

The outline of scenario of carbon management is mentioned and the reduction of carbon emission from peatlands was roughly estimated in this paper.

THE EFFECT OF FOREST CANOPY ON PREVENTION OF PEAT FIRE

Peat moisture in the fields

i. Study sites for peat moisture measurement

Two sites with different surface cover and land use were set-up for measurement of peat surface moisture in the tropical peatland of Central Kalimantan. The first site was a peat swamp forest (NF) without large effect of canal in the Sebangau Nature Laboratory. The second site was the open grass land area with small tree cover after peat fire (OG).

ii. Measurement of peat moisture

Measurement of peat moisture was carried out using DL6 with Theta Probe (ML2x) sensor. The sensor was buried in peat at depth of 5 cm**.**. The data was recorded at 1 hour interval. The groundwater level logger(DL/N70 STS) was deployed at the same locations. The measurement was conducted for 2 years, starting from 1st June 2011 until 13 August 2013.

iii. Annual change of the surface peat moisture in the fields

Moisture of surface peat layer in the forest is clearly higher than that in the grassland during dry season in 2011 and 2012 (Figure1). The dry seasons in both years were not so longer than that in 2009 then the moisture of the surface peat in grassland was not lower than 0.4. But the surface peat moisture in the open grassland OG was decreased very soon after rainfall. On the other hand, it in the forest, NF, was decreased slowly. The difference of the decreasing speed of peat moisture in both sites was caused by the difference of strength of solar radiation on the ground surfaces. From this result, we can conclude that the forest canopy has an important role to keep the surface peat in wetter condition.

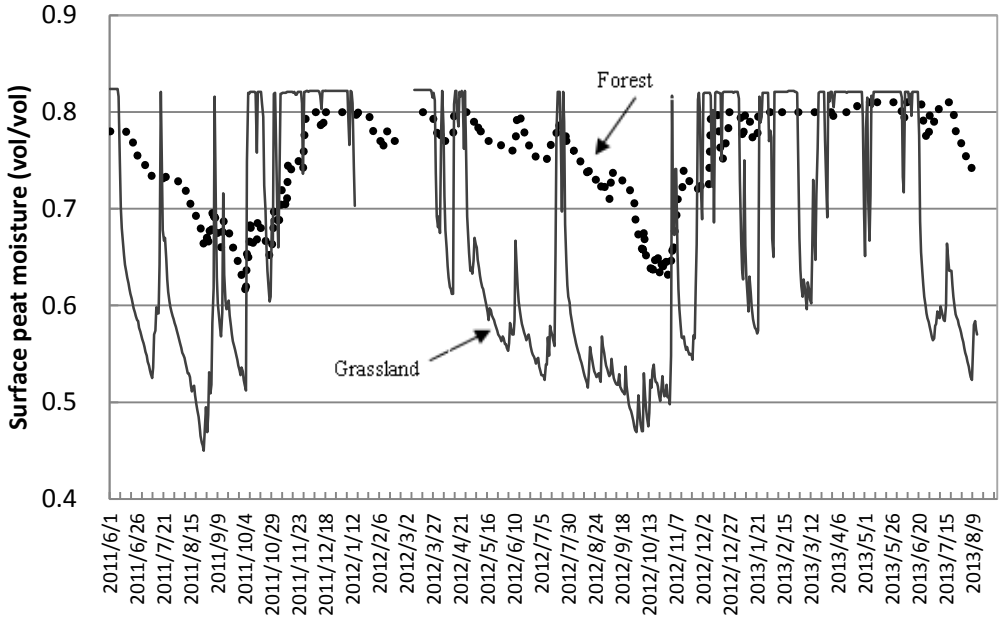

Figure 1: Annual changes of the moisture of surface peat layers in a grass land and forest

Peat moisture and ignition

The dry bulk density of tropical peat in the basin and dome area is 98.4±22.3 kg m^{-3} (Shimada *et al.*, 2001). The dry bulk density of 100 kg m^{-3} was used to convert the peat moisture from the gravimetric density to volumetric/bulk density. According to Jaya *et al.,* (2012), analyzing the relationship between number of fire spot observed by MODIS and peat moisture in a forest revealed that the critical moisture of peat for ignition was around 0.15 in volumetric moisture. The probability of ignition of the upper sphagnum also increases at around 0.15 in volumetric moisture (Babrauskas, 2003). From the moisture behaviors of surface peat layers in the forest and the open grassland, the forest canopy is very important to keep the surface peat in wet and to prevent the surface peat ignition

CONTROLS OF CARBON EMISSION BY REWETTING AND FIRE MANAGEMENT

The rising of groundwater level by construction of dams in the canal

Ishii *et al.* (2012) conducted very precise measurements of water level in the canal, groundwater level in the peat dome in the north of block C, the Mega Rice Project area. The effect of dam construction on the groundwater level was calculated using MODFLOW model. The groundwater level near the center of the target area, where was the top of peat dome, rose around 1 m at near the canal and 0.2 m at 400 m far from the canal after dam construction. The effect of rising groundwater level on the carbon emission was evaluated using the relationship between the annual lowest groundwater level and the amount of carbon emission from MRP area shown in Figure 2.

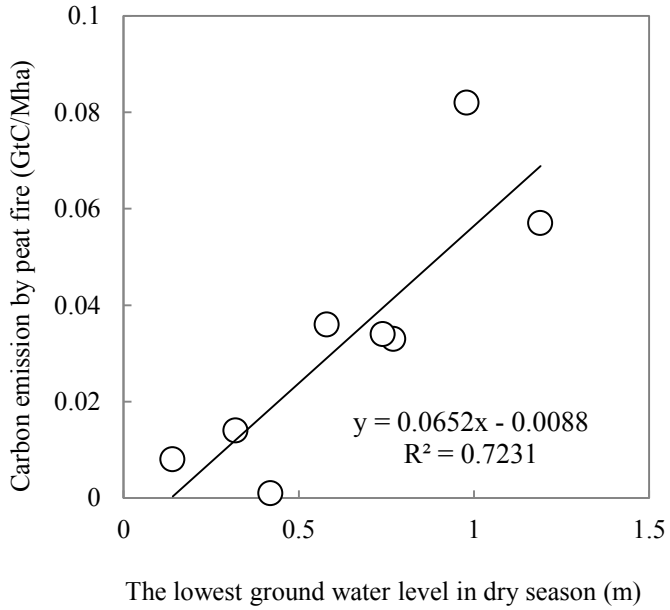

Figure.2: The amount of carbon emission by peat/forest fire relating to the annual lowest groundwater level in a peat swamp forest in Central Kalimantan. Groundwater level was measured at the site in the Sebangau National Park, named Plot-1b and located 2°19'15.80"S, 113°54'4.10"E in coordinate. The amount of carbon emission was estimated using the number of fire spot in the Mega Rice Project area by Dr. Indra Putra.

The effect of rising groundwater level on carbon emission by fire was estimated for the area 1 km far from the canal. The area was divide into 4 zones namely Zone A: from the canal to 100 m far from canal, Zone B: from 100 me to 200 m, Zone C from 200 m to 500 m and Zone D from 500 m to 1000 m. The mean groundwater level I each zone was used the values along the line $X_0 - X_0$‘ in Figure 3. The amount of carbon emission was calculated by using the regression formula shown in Figure 2 and Table 1.

The amount of carbon emission after dam construction in Zone A decreased to 46.4% of that before dam construction. The ration of carbon emission after the dam construction was 66.0% in Zone B, 71.8% in Zone C, 90.6% in Zone D.

Around 50% of carbon emission by peat/forest fire in the area from canal to 200 m far from canal can be decreased by dam construction. Most of peat/forest fire is generally occurred in the area along road and canal with human errors. Decreasing of carbon emission by fire in the zone along the canal will make a ripple effect on carbon emission far from the canal.

Table 1: Controls of carbon emission from peatland by peat/forest fire with dam construction and firefighting activity

	Changes of annual lowest groundwater level by dam construction				Fire fighting Extinction rate (%)		
Zone (m)	Dam	GWL (m)	C-loss (Gt/Mha)	C-loss (%)	50	70	100
A (100)	before	2.0	0.122	100			
	after	1.0	0.056	46.4	23.2	13.9	0
B (100)	before	1.9	0.115	100			
	after	1.3	0.076	66.0	33.0	19.8	0
C (300)	before	1.2	0.069	100			
	after	0.9	0.050	71.8	35.9	12.5	0
D (500)	before	1.2	0.069	100			
	after	1.1	0.063	90.6	45.3	27.2	0
Total (1000)	before		0.792	100			
	after		0.597	76.0	38.0	21.8	0

The firefighting effect on reduction of carbon emission by peat/forest fire

Pear fire occurs generally from surface fire near the canals and roads, which burns the grass and organic materials on the ground with human mistake. Therefore, the area from canal or road to 200 far from them is very important area for peat/forest fire control. Generally, fire in urban area is control by the fire service of local government whereas fire in forest area is control by firefighting team belong to the forest management bureau. Peat/forest fires occur mostly in the abandoned land which experienced peat/forest fire before. However, the severity of peat forest fire is beyond the abilities of both local government and forest bureau firefighters to control. The firefighting activity by people in local community is the most important, useful and effective for fighting on peat/forest fire. In general, the most important action for firefighting is the initial fire extinguishing. The compact firefighting system which was handled by local people is useful for the initial fire extinguishing (Takahashi *et al.*, 2013).

The effect of firefighting on carbon emission by peat/forest fire was classified to three ranks; 50%, 70% and 100% (Table 1). The peat/forest fires more than 200 m from the canal and road are mostly caused by the spreading fire from the area near canal and road. So if 50% the peat/forest fire is extinguished by local firefighting team, 50% of carbon emission will be decreased. In the case of the firefighting effects 70% and 100%, the carbon emission by peat/forest fire will be decreased with same way.

CONCLUSION

Three activities, forest recovery, rewetting and firefighting, for reduction of carbon emission from tropical peatlands were evaluated and concluded as follows:

1. Forest recovery is necessary and important to prevent the surface layer of peatland become dry and reduce the fire risk. Rising of groundwater level by constructing dams is remarkably effective in the area from canal to 200 m far from canal which also reduced the carbon emission due to peat/forest fire by 50% of that without dam.
2. Firefighting by local community on the peat/forest fire is also very important to prevent the fire spreading. If 50% of peat/forest fire in the area from canal to 200 m far from the canal is extinguished, the carbon emission by peat/forest fire will be decreased to 50% of that without firefighting.

ACKNOWLEDGEMENTS

Results shown in this paper were mainly obtained from SATREPS (Science and Technology Research Partnership for Sustainable Development) project entitled as "Wild fire and carbon management in peat-forest in Indonesia" founded by JST (Japan Science and Technology Agency) and JICA (Japan International Cooperation Agency).

REFERENCES

1. Babrauskas V (2003) Ignition handbook. Fire Science Publishers, Issaquah, USA.
2. Jaya Adi, Takada Masayuki, Hirano Takashi, Mishima Yoshio, Inoue Takashi, and Takahashi Hidenori, 2012: Moisture behavior of surface peat layer in areas of different surface cover and different ground condition during dry season in Central Kalimantan. Proceedings of International Symposium on Wild Fire and Carbon Management in Peat-Forest in Indonesia,
3. Kamiya M. and Kawabata S., 2003: Physical properties of peat in Central Kalimantan. *Proceedings of the International Symposium on Land management in Southeast Asia, Bali*, 2002, 341-345.
4. Shimada, S., Takahashi, H., Haraguchi, A. and Kaneko, M, 2001: The carbon content characteristic of tropical pets in Central Kalimantan, Indonesia: Estimating their special variability in density, Geochemistry, 53, 249-267, 2001.
5. Takahashi H., Yonetani Y. and Miyasaka H. 1998: Micrometeorological aspects of tropical peat swamp forest and farmland in Central Kalimantan, Indonesia. *Proceedings of the International Workshop on Environmental Management of Wetland Ecosystem in Southeast Asia* (Eds. Tokura, S.), 41-46.
6. Takahashi Hidenori, Usup Aswin, Hayasaka Hiroshi, Limin H. Suwido, 2003: Estimation of ground water level in a peat swamp forest as an index of peat/forest fire. *Proceedings of the International Symposium on Land management in Southeast Asia, Bali*, 2002, 311-314.
7. Takahashi Hidenori, Jaya Adi and Limin H.Suwido, 2013: Compact fire extinguishing system for firefighting teams of villages in peatland area of Central Kalimantan. *Proceedings of International Symposium on Wild fire and Carbon Management in Peat-Forest in Indonesia,* Palangka Raya, 2012, 203-206.
8. Usup Aswin, Hashimo Yoshihiro, Takahashi Hidenori and Hayasaka Hiroshi, 2004: Combustion and thermal characteristics of peat fire in tropical peatland in Central Kalimantan, Indonesia. *TROPICS*, **14(1)**, 1-19.