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BIODIVERSITY AND CARBON STORAGE IN THE TROPICAL PEAT SWAMP FORESTS IN RIAU BIOSPHERE RESERVE, SUMATRA INDONESIA

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SUMMARY

The Gi am Siak Kecil-Bukit Batu Biosphere Reserve covers a total area of 698,663 ha. It is unique because 75% of its total area is covered by peatland. Poor management and land conversion, however, resulted in a loss of almost *300,000* ha of natural peat swamp forest from 1998 to 2002. Moreover, forest fires occur annually, especially in the dry season due to draining for agriculture as well as illegal logging activities. In this study, we characterized the peat swamp forest ecology and assessed natural regeneration processes. Next, we clarified the amount of above and below ground carbon in various land uses. Then we conducted rehabilitation activities of degraded logged-over forest using tree species endemic in the area and which have economic importance to the local community.

Mixed Peat Swamp Forest and Bintangur Forest, which have distinct dominant species, floristic composition, diversity, and local environment characteristics, were identified as the main forest types in the biosphere reserve Our measurement of above and below carbon show varying amounts of above carbon storage under different forest land uses. In particular, our measurement of below carbon is generally higher compared to other earlier studies conducted in other peat swamp forests in Southeast Asia. Our initial rehabilitation efforts demonstrate that some indigenous species of peat swamp forests (i.e., *Cratoxylom arborescens, Dyera lowii, Callophyliim lown, Palaquium sumatranum, Palaquium burckii* and *Tetramerisla glabra)* have good potential to improve both ecosystem services as well as provide timber and non timber forest products for local communities. Based on our study, we proposed a sustainable management model of the Biosphere Reserve.

KEY WORDS: Biosphere reserve, biodiversity, carbon storage, peat swamp forest, rehabilitation

INTRODUCTION

The Sumatran peat swamp forests are located on live remaining large forest blocks in Riau province. One of these is in the Giam Siak Kecil-Bukit Batu, which is known as Riau's Biosphere Reserve with 698,663 ha total area (WWF 2008, MAB 2008. Jarvie et al. 2003). Its main purpose is for conservation and sustainable development of the area. The landscape was divided into three zones: core, buffer and transition. The core area is set aside for forest conservation, while the buffer and transition areas are allocated for economic activities. The Biosphere Reserve is unique because 75% of its total area is covered by peatland. Poor

management and land conversion, however, resulted in a loss of almost 300,000 ha of natural peat swamp forest from 1998 to 2002. Moreover, forest fires occurred annually, especially in the dry season, and the remaining peat swamp forest was subject to illegal logging activities and natural disturbances. A significant part of the core and buffer areas have also been converted by the villagers into jungle rubber gardens and oil palm plantations.

The objectives of this study are to a) clarify the ecological characteristics of remaining peat swamp forests; b) estimate the above and below ground carbon stored in peat swamp forest and developed peatland areas; c) rehabilitate degraded logged over forest and peatland areas, and d) discuss the promotion of ecosystem services and rural livelihoods.

RESEARCH METHODS

We conducted three interrelated studies. In the characterization of the peat swamp forests, we conducted a survey of six permanent monitoring plots in each of 0.5 ha subplots in natural and disturbed forest from 2009-2010. Three plots were located in natural peat swamp forest and the remaining three plots were in logged-over peat swamp forest, wind-disturbed forest, and burnt forest. Within each of the monitoring plots, we established a 25^25 m sub-plot in which the DBH of all trees higher than or equal to (>) 3 cm was recorded. Voucher specimens of plants were sent to the Ecology Laboratory of Riau University for identification and verified at the Herbarium Bogoriense in LIPI, Cibinong, Indonesia

Above ground biomass and carbon storage was observed in 0.5 ha from 25x25 m plots for each type of the following forests: natural forest, logged over forest and wind disturbed forest in total are of three (3) ha. The measurement of trees with DBH>3 cm was based on allometric equation calculations. For the estimation of below carbon, peat samples were taken from depths of 0-20 cm, 20-40 cm and 40-60 cm. Drilling was used to determine peat depth. The C content analysis was done in the Soil Laboratory of Bogor Agriculture University. Bulk density was analyzed in the Ecology Laboratory of Riau University.

The rehabilitation activities include seedling production through wildings, cuttings and seed germination; enrichment planting methods using line and gap planting method; followed by biomass and carbon monitoring from five plots of 1 Ox 10m. We used the increment in the diameter of tree species to estimate the change in biomass, carbon storage and carbon sequestration.

RESULTS AND DISCUSSION

Mixed Peat Swamp Forest and Bintangur Forest, and and details of their distinct dominant species, floristic composition, diversity, and local environment characteristics were obtained. These data could have important implications for future restoration, rehabilitation or conservation efforts by helping to decide which species to plant and how to consider natural succession. It was also important in the conduct of the succeeding study to measure below and above ground biomass and carbon storage for each selected land use. The comparison of the amount of above and below ground carbon in various land uses is shown in Table 1. The amount of carbon is generally much higher belowground than above ground in all land uses.

The largest amount of below-ground carbon of 5981 Mg C ha"[1] is found in fogged-forest areas, followed by peadands under Acacia plantations with 5775 Mg C ha" . The lowest belowground carbon is in oil palm plantation of around 3900 Mg C ha"'.

Generally, it was shown that the remaining natural peat swamp forests store huge above and below carbon, even higher than in other peat swamp forests. The results highlight the uniqueness of the Biosphere Reserve and especially its importance in worldwide efforts to reduce forest carbon emissions.

Table 1. Above and below ground carbon storage in different land uses on peatland in Rjau Province, Sumatra, Indonesia

Land Uses Cover	Above Ground Carbon Storage	Below Ground Carbon Storage (Mg	Concentration of Carbon	Bulk Density (gem"[3])	Peat depth (Metre)
Natural Forest	94.25	4200	0.56	0.125	6
Logged Over	71.5	5981	055	0.145	7.5
Disturbed Forest	26.75	4731	0.57	0.083	10
Rubber Garden		4032	0 56	016	4.5
Acacia Plantation	42.57*	5460	0.56	0 15	65
Oil palm	35 8*	3960	0.55	012	65

'Based from odicr studies - rubber (Palm *et al.* 2004), Acacia (MasnpaUn *et al* 2010), oil palm (Murdiyarso *et al.* 2010).

We propose three ways to improve diiar xurrent status: conservation and stopping further forest conversion, natural regeneration and rehabilitattcnn. The stopping of further forest conversion implies the need to designate boundaries and emforce them. There is a conflict between the government and some villagers who wanted KO utilize designated conservation areas. This conflict needs to be resolved through the preparation of a management plan that addresses both integrity of the forest as well as the livelihoods of the villagers. Natural regeneration is an option for a faster recovery of forest vegctid1im[l]aifter.anv disturbance. Injle case of canopy species that could hardly undergo natural regeneration, some iVorm of hunun-assisted regeneration is needed. Rehabilitation targets the areas that could hardily undergo natural regeneration and would need human intervention such as planting.

We illustrate the logical framework of the activities conducted in this study as -well as t|$_s$ direction of actions to conserve the remaining natural forests, regenerate and rftfajfrllJfBll the degraded peat swamp forest for the promotion of ecosystem services and rural livelitioods in Giam Siak Kecil-Bukit Batu Biosphere Reserve (Figure 1).

From the diagram, the fust level shows the different land cover as well as *their* different levels of degradation (wherein without intervention, the natural forests could gradually be converted into degraded or waste lands - as indicated by the dotted lines). As we have identified in each chapter, these different land covers would need different management strategies. Ideally, the remaining natural forests should be conserved, the secondary forests allowed to regenerate and the degraded peat lands rehabilitated back into natural forests planted with endemic and economically valuable tree species, agroforestry, or even as agriculture or plantation areas. Implementing these management strategies, however, is not

easy. These have to be founded on the reality that there are already villagers in the area who are dependent on the peat swamp forests for their livelihoods. Strategies, therefore, will need the participation of the villagers. In particular, an "interactive participation" by the local community is vital where the villagers have important role in the decision-making and as well as take a leading role in the activities. This will happen only when strategies address not just the conservation or rehabilitation of the peat swamp forests but especially the peoples' livelihoods.

We have made such consideration early in our rehabilitation activities wherein we planted tree species which have both economic values (i.e. timber and non-timber forest products) and ecosystem services values such as *Dyera lowii, Tetramerista glabra, Callophylum lowii, Palaquium sumatranum, Palaquium burckii, and Craloxylon arborescens.* More than their potential to generate income from carbon storage and other ecosystem services, these trees can be cut and sold on the timber market, both on the international or the domestic market especially considering that there is a decreasing supply in timber given the increasing demand for building materials, furniture use or handicraft use because of strict controls on logging. Moreover, various non-timber forest products are provided by these different species such as seeds of *Palaquium sumatranum* to produce oil for cooking, white latex from *Dyera lowii* and *Payena lerii,* and bark of'*Alseodaphne ceratoxylon* used as mosquito repellant.

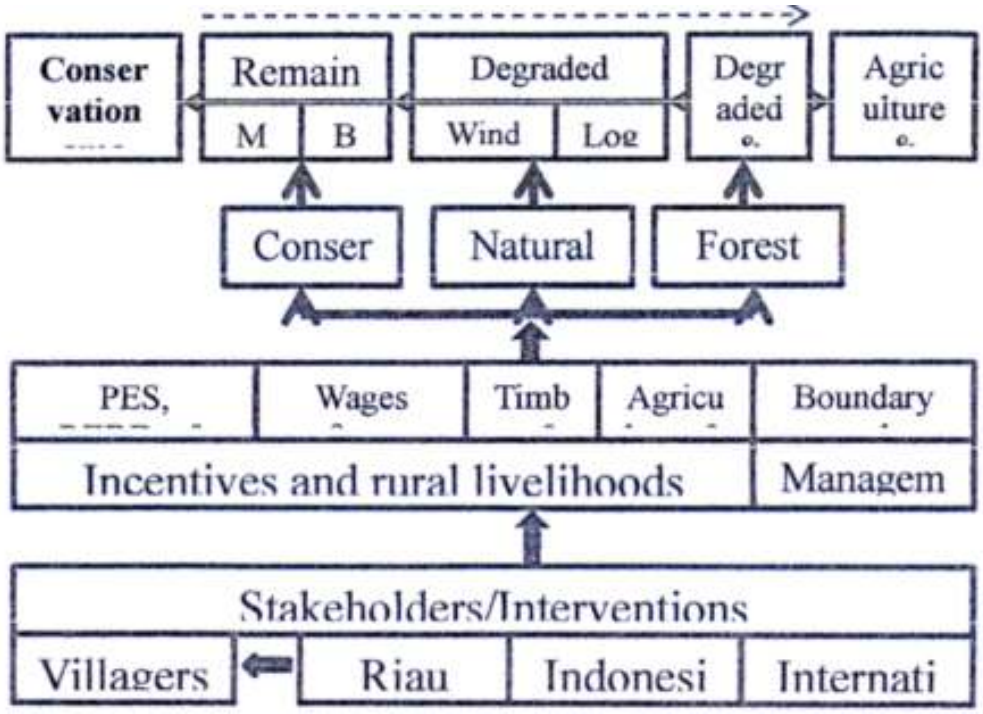

Figure 1. A sustainable management model of the Biosphere Reserve

It would be ideal if die above economically important but endemic tree species could be planted by die villagers themselves. However, the planting of these species is limited by the presence of other alternative tree crops such as rubber and oil palm. The wider planting of these species should then be supplemented by incentives in cash (i.e. wages from rehabilitation) or in kind through the provision of other alternative livelihood strategies, or a combination of these. Financial incentives are especially important to induce peoples' participation in rehabilitation efforts, in addition to the provision of information and technical

assistance to communities about the species suitable for planting, their silvicultural requirements and their market values. This would include developing a silvicultural system by which plantation can be planted with crops that mature more quickly than trees, building on traditional and modem knowledge of agro-forestry systems even including the inclusion of jungle rubber and introducing of other non timber forest products such as medicinal plants. Rehabilitation efforts should also consider water management particularly the blocking canals which would prevent the draining of the peat forest and minimizing or eliminating fire.

As Lamb (2005) has pointed out, for forest rehabilitation-reforestation to be made more attractive to rural communities, these should also be supplemented by appropriate institutional, legal and policy settings (e.g., providing secure land tenure, elimination of "perverse" incentives that favour deforestation and forest degradation, and facilitating marketing of forest goods). The facilitation of marketing is important in order to reduce the pressure for further agricultural expansion to the natural forests. Equally or even more important is the provision of secure land tenure. As was mentioned, there is a current conflict between the villagers and the government since the declaration of the area into conservation forests as access is now limited. A possible solution is the preparation of a management plan that is agreed upon by boUi villagers and local government wherein conservation, agroforest (rehabilitation with economic tree species and tree crops) and agricultural areas arc designated. However, as was earlier mentioned, the villagers would also need to get incentive not just from rehabilitation but also from forest conservation.

The possibility for some form of payment mechanisms for the ecological services from peat swamp forests. These include funding mechanisms such as various Payments for Ecosystem Services (PES). In particular, we discussed the possibility of tapping the newly proposed, aldiough still being negotiated, Reducing Emission from Forest Degradation and Deforestation (REDD) mechanism. We also considered other sources of funding such as domestic funding (e.g. GERHAN) or any odier possible sources of money as long as it will be translated in such a way that the livelihoods of the villagers are addressed and their main role in the implementation is recognized.

Initial interventions should start with strengthening rural community institutions (e.g. KMPH - Village Community Forest-Temiang's Village, and other community forests in rural areas) including enhancing their awareness of important forest functions as well as possible management arrangements under the different funding mechanisms. This would imply increasing local collaboration with our research, rehabilitation and management activities to not just make them aware but further interested in die continuation of our activities. Coming up with a common interest and understanding between the villagers and the research will be useful and important in establisliing further management options in which rural people can be done by themselves. Again, these efforts should find support from local and central government; local, national and international organizations; and from different funding schemes be it from PES, REDD+, or other voluntary or private sector sources of financing.

CONCLUSIONS

1 Conservation of peat swamp forests in the Biosphere Reserve depends upon, firstiy, protection of the remaining natural forests and, secondly, rehabilitation of degraded

secondary forests, degraded or waste peatland. The improvement of management of remaining peat swamp forests and rehabilitation should consider their unique ecological characteristics particularly the dominant tree species, fast growing species as well as below ground peat characteristics.

2. Given their unique biodiversity characteristics and high amount of stored carbon, protection of the peat swamp forests could be enhanced by adding incentives to local communities including monetary incentives from biodiversity and climate change mitigation funds.
3. The local communities should be assisted in developing dieir own peatland areas such as with planting suitable trees or even continuing their current livelihood activities in ways that have minimal damage to the natural characteristics or no significant change in the ecosystem functions of peatlands.
4. The current rehabilitation of degraded peat swamp forests and peatland areas should be extended and should involve wider community participation. Given the high cost, financing is crucial and a way forward is to optimize various sources and means of domestic funding (e.g., GERHAN= The Indonesian Movement of Forest and Land Rehabilitation) and even international (e.g. REDD+ and PES). All of this support should help establish a management model that the local community could implement and support continuously.

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