Restoration on Degraded Peat Swamp Forest Ecosystem in Riau, East-Sumatra, Indonesia

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Abstract

The first step of restoration study was carried out in degraded peat swamp forest ecosystem in Bukit Batu Forest Block and Tanjung Leban village of Riau Biosphere Reserve started in June 2010 until now. The land use, land use change and forestry (LULUCF) on this ecosystem leads to a loss of carbon, biodiversity and hydrology buffers functions. To address these problems, restoration are urgently required. In case of biosphere reserve, we conclude reasons that restoration should be important to be done; (1) Large degraded peatland and forest areas due to high fire intensity, drainage and illegal logging activities. (2) Forest encroachment and conversion, (3) Problem on natural regeneration processes, (4) Need to promote sustainable livelihoods for local communities and bio-resources conservation, and (4) the important rehabilitation of carbon sequestration and protection of remaining peat carbon stocks. The objective of study: 1) vegetation rehabilitation and restoration of hydrology, 2) promotion of sustainable livelihoods for local communities and bio-resources conservation, e.g. using multi purpose tree species, e.g. timber forest product (TFP) and non timber forest product (NTFP), 3) rehabilitation of carbon sequestration and protection of remaining peat carbon stocks, 4) discussions for innovative financial mechanism, e.g. REDD+, multi donor thrust fund, and private sector taxes (CSR, Corporate Social Responsibility).

Keywords: Biosphere reserve, biomass and peat carbon content, economic incentives and bio-resources conservation, restoration, tropical peat swamp forest ecosystem.

Introduction

One of the major land types in Southeast Asian is peatlands. They cover approximately 25 to 35 M.ha. in the region with the majority in Indonesia, Malaysia and Thailand. In Indonesia, Malaysia, and Brunei Darussalam they form more than 10% of the land area of the country (Page et al. 2008, 2011; htpp://www.aseanpeat.net).

Peat swamp forests ecosystem play a critical role in the economy and ecology of the region- providing timber and non-timber forest products, water supply, flood control and many other benefits. They also play a very significant role of global significance in storing an estimated 50.4 Gt of carbon or approximately or equivalent of 96.6% of the global tropical peat C store (Page *et al* 2008, 2011, http://www.aseanpeat.net).

Peatland in Indonesia mainly distributed in Sumatra (4.7–9.7 Mha), Kalimantan (3.1–6.3 Mha), and Irian Jaya (8.9 Mha) (Silvius 1989, Rieley *et al*. 1996a). In Sumatra the largest area of peat land was located in Riau with extent was 4.04 Mha as being classified as Sumatran peat swamp forest eco-region, includes the Giam Siak Kecil-Bukit Batu, which officially declared as Biosphere Reserve in 2009 (Jarvie *et al*. 2003, MAB Indonesia 2008, WWF 2008) with a total area of more than 700,000 ha.

Deforestation and degradation occurred mostly on very deep peat swamp forest ecosystem in Riau, it almost around 33,044 ha yr^{1} of totally 71,177,4 ha yr^{1} or even had been lost of 1 M.ha. during 1990 to 2007 (Murdiyarso *et al*. 2008). The land use, land use change and forestry (LULUCF) on this ecosystem leads to a loss of carbon, biodiversity and hydrology buffers functions.

The integrity of the biosphere is under threat, due to land conversion, forest-land fire, and logging activities. Analysis of LANDSAT satellite images indicates that forest cover decreased from about 600,000 ha in 1985 to 350,000 ha in 2002 (Jarvie *et al*. 2003). The ongoing development of large areas of peatland as timber estates, illegal logging activities and palm oil plantations on a landscape scale constitutes a serious threat to the peat swamp forest ecosystem. A large area of the buffer zone had been developed as an industrial timber estate (195,259 ha or 88%) and production forest (27,167 ha or 12%), while the development of the peatland area in the transition zone focused on palm oil plantations, agriculture, and housing (304,123 ha) and industrial timber estate (5,665 ha) (MAB Indonesia 2008).

From 1999 to 2009, the peat swamp forest of the Bukit Batu Wildlife Reserve was subject to illegal selective logging of trees species with high-quality timber, such as *Shorea* spp, *Tetramerista glabra*, *Gonystylus bancanus*, *Palaquium sumatranum*, *Palaquium burckii*, *Durio acutifolius*, and *Koompasia malaccensis*. In 2009, the logging activities decreased, and they stopped completely by the beginning of 2010, especially in the along of main river basin of Bukit Batu river. Unfortunately degradation of forest area continued where in along of river basin side has been converted rubber jungle garden by local villagers. Some of old local people used to cultivate rubber trees as marking their land. Currently the younger follow to plant rubber trees. Hence the problem between local people and forestry department will increase after that due to

claim of land owner status. In the other hand our hypothesis that the successfully restoration program will be useful to minimize conflict between forestry department and villagers in the future.

Over the past 10 years until now peat fires occurred regularly in the biosphere reserve. Peat swamp forests under natural conditions are very resistant to fire due to naturally high water tables. They are only vulnerable to above and below ground fires when water levels fall due to drainage or during severe droughts. Once the peat soil has been drained it is very vulnerable to fire (http://www.aseanpeat.net).

To address these problems, restoration are urgently required. In case of study areas in biosphere reserve, we conclude reasons that restoration should be important to be done;

1. Large degraded peatland and forest areas due to high fire intensity, drainage and illegal logging activities.
2. Forest encroachment and conversion.
3. Problem on natural regeneration processes.
4. Need to promote sustainable livelihoods for local communities and bio-resources conservation.
5. The important rehabilitation of carbon sequestration and protection of remaining peat carbon stocks.

The objective of study: 1) vegetation rehabilitation and restoration of hydrology, 2) promotion of sustainable livelihoods for local communities and bio-resources conservation, e.g. using multi purpose tree species, e.g. timber forest product (TFP) and non timber forest product (NTFP), 3) restoring carbon sequestration and protection of remaining peat carbon stocks, 4) discussions for innovative financial mechanism, e.g. REDD+ scheme, multi donor thrust fund, and private sector taxes (CSR, Corporate Social Responsibility).

2. Sites and Methods

The study was conducted in Riau Biosphere Reserve, Indonesia. The Riau Biosphere Reserve is located in two districts, Bengkalis and Siak, and one city Dumai, in Riau, Sumatra Island, Indonesia. The total area is 698,663 ha, of which 75% is covered by peatland. The reserve is located between 0°44'–1°11'N and 0°11'–102°10'E. The uniqueness of this biosphere is that it is a vast landscape consisting of a unique

hydrological network of small lakes and streams and remaining natural peat swamp forest. The dominant natural ecosystems are peat swamp forests surrounded by different types of land use, such as production forests, degraded/abandoned lands, industrial plantations (timber and palm oil), agricultural lands, and settlements. Topographically, most of the terrain is at altitudes of 0–50 m asl. The climate is tropical and is influenced by the ocean, and the temperature averages between 26°C and 32°C. The rainy season is from September to January, with rainfall of 804–4,078 mm/year. The dry season is from February to August (MAB Indonesia 2008).

We selected two restoration experimental sites in Riau Biosphere Reserve as following are: 1) logged over forest in Bukit Batu conservation areas, and 2) three distinct degradation levels of peatland areas due to severe fire in Tanjung Leban Village. We also set up simple nurseries in forest area, in Temiang, and Tanjung Leban Village. Hydrology restoration carried out by establishing block canal in Tanjung Leban Village. The our hypothesis are re-wetting the peat is an important key to vegetation restoration and protection of remaining peat carbon stocks.

3. Results

Survival rate and growth six typical canopy species

In general, survival is high ranging 57.14% to 100% after five months of planting in all tried rehabilitation techniques. The highest tree species survival of normal-gap planting was *Palaquium burckii* and *Cratoxylon arborescens* with about 100% survival, then followed by *Tetramerista glabra* with 96.2% survival. The lowest of survival was *Dyera lowii* with 69.1% survival from a total of 450 tree species.

Five months after trying a gap-hill planting method showed high survival rate in all of tried tree species range 75.3% to 100%. The species with the highest survival rates are *Palaquium sumatranum* (100%) and *Cratoxylon arborescens* (100%), followed by *Tetramerista glabra* (96.3%) and *Palaquium burckii* (88.2%) respectively. The lowest survival rate was *Dyera lowii* (75.3%). Whilst the line-hill planting method the highest survival rate was *Palaquium sumatranum* and *Callophyllum lowii* with 100% survival, then decreasing survival rate in line-normal planting method with about 74.19% then 57.14% survival respectively.

Hill planting method is better method than normal planting method are shown high survival rate of planted tress. A number of factors have been identified as causes of mortality of tress. In the early establishment, some of seedling died due to wetter of

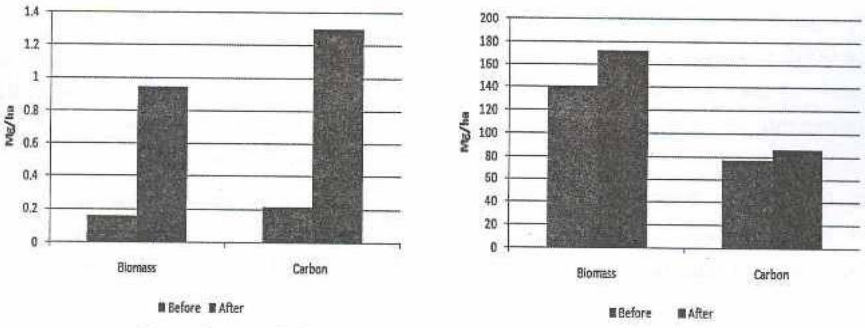
peatland. The seedling for the first stage can't be adaptive in wet situation. The other factors the seedlings is still small to transplanted on the field, such as seedlings of *Callophylum lowii*. The insect also was caused seedling of *Dyera lowii* died.

Total height and diameter increment

The average height and diameter increment from October 2010 till April 2011 are shown in Table 3. The highest growth performance is *Cratoxylon arborescens* with mean of height increment by normal planting 44.7+ 28.8, hill planting 34.4+ 14.0, and diameter increment by normal planting 0.8 + 0.16, hill planting 0.7 + 0.21. Followed by *Tetramerista glabra* with mean of height increment by normal planting 13.1+ 7.94, hill planting 15.1+ 4.68, and diameter increment by normal planting 0.6 + 0.2, hill planting 0.7 + 0.2 Seedlings from this species showed a higher survival rate (97%) than its wildlings (61%).

Total increment of above biomass and carbon content

Total amount of above biomass and carbon content are getting increasing during five months restoration done. Biomass of 0.16 Mg/ha to 0.95 Mg/ha, and carbon content of 0.22 Mg/ha to 1.3 Mg/ha in experimental sites. Whilst in the reference sites are biomass of 140.7 Mg/ha to 173 Mg/ha and carbon content of 78.2 Mg/ha to 86.7 Mg/ha. Restoration can promote the increasing of biomass percentage is 9.16% and carbon content 8.45% either by human intervention or natural regeneration processes (Figure 1).



a. Experimental sites b. Reference sites

Fig 1. Estimation above ground biomass and carbon content before and after restoration done

The Community Perception and Participation

We classified two respondents group related by their perception about restoration study. The first group are 34 respondents or 94% of totally respondents having well perception on forest restoration shown on the high scoring and category level. Most of them know the important of forest and restoration. They have reasons that forest restoration will re-establishing tree species which has been lost. The forest restoration will keep in natural condition and improve the ecological function of the forest. The respondents realized that forest should be managed in better way, such as rehabilitation or restoration program. The high number of respondents who agree to restoration degraded forest will help the similarity program will be done by Forestry Department in the future. The social aspect is very important within managing the program restoration sustainability. The awareness of villagers are one of some important factors to increase or extend the restoration of degraded forest areas in the future. However the other factors should be considered to establish restoration program largely in this areas, example determining mechanism of their participation and economy incentive for villagers. The rehabilitation processes need to be monitored longer-term for ecological and economic success (Chokkalingam 2001, Kobayashi 2007)

The second group are two persons who are fisherman, one of them are also village officer. They didn't understand what the meaning of forest restoration. Basically they think that forest is important, but after the area was declared in 1999 by Central Government, the access entering the area was limited. They can't cut trees for their building house and also restricted to open the forest to become agriculture land. The Temiang's village has long history in utilizing the area for their activities. In the field we still found the old of rubber jungle as marking for their land. The change political situation of central government where the area was not well managed in 2000 s, giving well opportunities for the people cut illegally trees, and then open the are to plant rubber jungle. For this history they claim that they should participate in determining the management of protected forest in the future.

The success of restoration program are one of some options to promote biodiversity conservation and find out the solution in an old problem between government and villagers. Basically respondents want to assure that they will be secure in their livelihood, especially they still get access for tapping rubber trees. From at this point we introduce and enhance number of tree species which has well potency for supporting their live without converting forest area through enrichment some of economically species without cutting. Some species planted which has potency for improving their income in the future, such as *Dyera lowii*, *Callophylum lowii*, and

Palaquium sumatranum will produce goods as non timber forest product.

4. Discussions and Conclusion

From the beginning restoration experiments done, local villagers could be involved by collecting seeds-wildings-cuttings, seedlings-nurseries maintenance, land preparation, and transplanting tree seedlings. They can get not only an economic incentive from those activities, but also knowledge and awareness for forest conservation efforts. In the near future local villagers can get more income from gathering latex of Jelutung trees (*Dyera lowii*), seeds of Balam trees (*Palaquium sumatranum*), and some of villagers can continue carry out carbon dynamic monitoring as local partners. The establishing such kind of those systems are well steps to promote innovative financial mechanism, and finally security of their sustainable livelihoods. In addition successful vegetation rehabilitation can be also used to minimize occurring conflict between forestry department (BBKSDA Riau) and local villagers in Bukit Batu conservation area. Even though strengthening local institution as well as extending the capability of rehabilitation programs are strongly required to achieve whole purposes completely.

Large peatland and forest degradation in biosphere reserve needs a great deal of restoration that requires international efforts. The majority of those peatland areas is un-sufficient managed and likely to be eligible for "strict" REDD project activities. The priority to demonstration activities of REDD scheme my be designated in areas with low level of threat and high level of carbon density (Murdiyarso *et al*, 2008). In case of biosphere reserve we purpose in Bukit Batu Conservation areas, and even possible in all of core area which extent are approximately 178,722 ha of totally areas. In the other hand the local government and company can optimize to restoration efforts in transition area of biosphere reserve by using local budget and CSR schemes. The further identified demonstration areas should consider the capacity of the stakeholders and also the typology of peatland used in considering pilot project of REDD+Schemes (Murdiyarso *et al*, 2008).

We identified three important stake holders which have different functions for supporting restoration on biosphere reserve. In the village they established the forest conservation community group (KMPH in Temiang Village, and KMLHG in Tanjung Leban Village). The others stakeholders which are important for involving and supporting more restoration efforts the following are local and central government, i.e. BBKSDA (Conservation Agency) Riau, BLH (Environmental Agency) and Forest Agency at Provincial and District level of Bengkalis and Siak District.

The financial support mechanism is seen as major concern to improve the restoration capacity in biosphere reserve. The variety of donors such as Netherlands, Norway, Australia, Germany and the World Bank have indicated interest to finance REDD pilot initiatives in Indonesia peat swamp forests and degraded peatlands (Silvius *et al*, 2008). The pilot project of REDD+ scheme are still ongoing done on degraded peatland areas in South Sumatra by supporting the GIZ of Republic Federal German. In near future for continuously the restoration efforts of degraded peatland and forest areas requires wider stakeholders involvement and improve the management strategy of Riau Biosphere Reserve that will be more attractive to invite variety donors.

The success of restoration can be used to promote sustainable livelihoods for local community, bio-resources conservation and carbon sequestration mechanism. However the promotion of innovative financial mechanism should be done to extend the capacity of restoration program in biosphere reserve in the future.

Restoration experiments are continuing for both in Temiang and Tanjung Leban Village, planned to be establishing more canal block, monitoring water table level and trees growth, estimation above ground biomass and carbon content, transplanting seedling trees, and taking the soil sample for estimation of peat carbon content.

We concluded restoration experiments of logged over forest in Bukit Batu conservation areas after one year as following as:

1. *Cratoxylon arborescens* can be promoted to become promising species used to vegetation rehabilitation in more open areas and heavily or even severely degraded peatland areas. *Tetramerista glabra* is one of some tree species which have high timber quality. In the other hand natural capability of this species is very low. By promising results of restoration studies that bio-resources conservation in peat swamp forest ecosystem can be promoted by using *Tetramerista glabra*, and other species which have high survival rate, e.g. *Palaquium burckii*, *Palaquium sumatranum*, *Callophylum lowii*, and *Cratoxylon arborescens*.
2. Total amount of above biomass and carbon content are getting increasing during five months restoration done. Restoration can promote the increasing of biomass percentage is 9.16% and carbon content 8.45% either by human intervention or natural regeneration processes
3. Identified there are three factors which can play an important role on

supporting restoration programs in the future in biosphere reserve, as follow: 1) village communities group e.g. KMPH in Temiang Village and KMLHG in Tanjung Leban Village, 2) government institutions, e.g. BBKSDA Riau, Forest Agency, BLH district and provincial level, and, 3) financial support mechanism e.g. REDD+, multi donor thrust fund, and private sector taxes (CSR programs, e.g. Sinar Mas Forestry Group).

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