season further worsening land degradation. Meanwhile, the remaining peat swamp forest in the core area of the Biosphere Reserve is subject to il'ogal logging activities.

Degraded forestland requires rehabilitation of wide range of characteristics and functions, ft is i i-; to fcziprovc biological and habitat diversity at the landscape scale, increase commercial values lor timber and types and amount *of* non timber products, improve forest functions, such as wate- storage, water balance, sequestration of carbon, fire protection, and climate mitigation (Kobayashi 2004, 2005).

In case of biosphere reserve, conservation and sustainable rehabilitation efforts should be important to be promoted due to as following; 1) large degraded pcatland and forest areas due to high fire intensity, poor canal drainage and illegal logging activities, 2) forest encroachment and conversion, 3) problems in livelihoods for local people, and 4) the important to rehabilitate carbon sequestration and protection of remaining peat carbon stocks. Three keys issues in sustainable rehabilitation of degraded tropical forest lands; promoting local participation, livelihood needs, and institutional arrangements. This paper highlighted currently results of rehabilitation experiments including to estimate amount of sequestered carbon, survival rate, relative growth rate, and discuss future working in order to continue efforts to promote conservation and sustainable rehabilitation in biosphere reserve

2 Site Description and Methods

The area of study is located at Giam Siak Biosphere Reserve of Riau Province in the coastal cast of Sumatra Island. Riau province covers an area of about 9 Mha. Having the largest pcatland area in Sumatra, Riau province plays a very significant role to the local environment as well as global environment. The strategic position of Riau province in relation with other ASEAN countries makes its environmental role in the region even more important, especially regarding transboundary haze pollution and illegal logging.

The Giam Siak Biosphere Reserve has a total area of 698,663 ha is located between 0°44-1°1 IN and 0°ll'-102°10'E in two districts (Bengkalis and Siak) and one city (Dumai), in Riau Province, Sumatra Island, Indonesia. Topographically, most of the terrain is at altitudes of 0-50 m a.s.l. The climate is tropical and is influenced by the ocean; the average annually temperature is 28°C (range 26°C- 32°C). Rainfall varies from 1,349 to 4,078 mm year"[1]; the rainy season is usually from September to January and the dry season from February to August (MAB Indonesia 2008, BPS Riau 2008). The average temperature was 29°C in Bukit Batu Area during almost 1.5 years monitoring.

The Forest block >.f HuKit Batu wildlife reserve was firstly declared by the Forestry Ministry through a letter of decree Number. 173/KPTS-II/1986 in June 6, 1986 and finally declared by Ministry of Forestry and Plantation through Number 482/KPTS-II/1999 in June 29, 1999.

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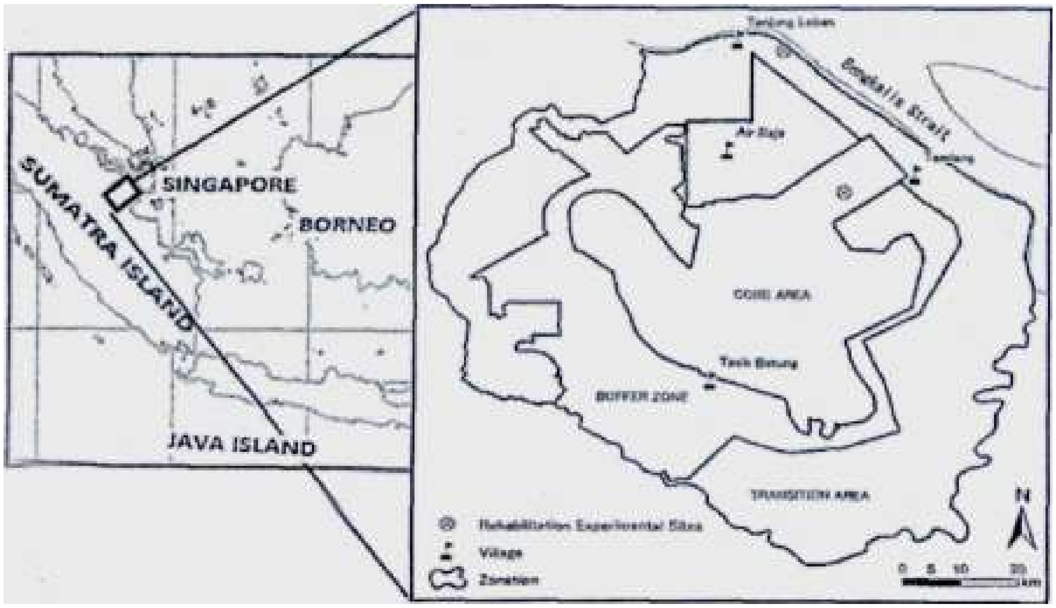

Fig 1. Study area and rehabilitation experimental sites.

To study rehabilitation, we selected two types of degraded peat swamp forest: First, a moderately degraded logged-over peat swamp forest located at a river basin of Bukit Batu in a core area of Giam Siak Biosphere Reserve; second, a severely degraded area in Tanjung Leban Village in a transition zone of the Reserve. The geographical location of the logged-over forest is 01°23'24.4"N, 101°5r59.PE and the degraded area is 01°38'9.8r'N, 101°46·13.8"E. This paper highlighted the currently monitoring results of rehabilitation study in the logged-over forest (Figure 1).

Methods

Wc started to produce seedling using three methods as following cuttings, wildings, and seed germination since in February 2010. The main purpose is to establish a production nursery for native tree seedlings that are suitable for the rehabilitation of logged-over forest in Bukit Batu Conservation Areas including pcatland area in Tanjung Leban Village severely degraded by fire. In this activities involving local villagers of Tanjung Leban Village. We also laid wildings of some tree species on the forest floor directly after taking them from their original location (e.g. *Palaquium sumatranum-Bak\m, Cratoxylon arborescens-Geronggnng, Palaquium* frwrdb'z-Suntai and *Tetramerista glabra-Vunak).* Seedlings of *Dyera lowii* was purchased in private company supplier. These were all to assure a continuous supply of seedlings for rehabilitation.

Treatments to be taken for gap planting. The gap size of each planting area was 10 m x 10 m. There were 25 gaps planted with *Dyera lowii* and six gaps of mixed tree species (e.g. *Dyera* *lowii, Palaqui: surmatriranum, Palaquium burckii, Calophyllum lowii, Cratoxylon arboresecens,* and *Tc.tramera gllabnra).* These tree species were all determined to be suitable for the site conditions as \\\ as 1 hawing economic value.

For biomi andl caarbon monitoring, five plots of 1 Ox 10m in Bukit Batu forest block were selected. Treenecices with DBM>3cm were identified for biomass and carbon storage estimation. We used the increment in the diameter of tree species to estimate the change in biomass, carbon storage and carbon sequestration. Total aboveground biomass in each plot was also estimated using an allometric equation developed by Brown (1997). The Allometric equation was developed for tropical forests using data collected by several authors from different tropical countries and at different times. The allometric equation is:

$$Y=\exp(-2.134+2.53*\ln(D)) \qquad (1)$$

Where Y= total above-ground biomass in kg/tree; and D=diameter at breast height (DBH in cm). The above ground carbon storage was calculated by assuming that the carbon storage is 0.5 of the total above ground biomass (Brown & Lugo. 1982, Brown *et al.* 1989, Houghton *et al.* 1997). For the quantification of carbon sequestration during a period of time, the most common method is based on the amount of carbon fixed in biomass at a certain time, usually the end of a rotation period. This was referred to here as "carbon fixed" and it can be exemplified as the amount of carbon stored in planted trees at a certain time t after planting.

The growth was analyzed based on girth increment of survive trees. Growth rate was calculated as relative growth rate (RGR) using formula of Kohyama and Hotta (1986): RGR= (In GOO-ln G99)/t, where G99 and GOO arc girth breast high in first and second measurement respectively, and t is period ofstudy.

To promote conservation and sustainable rehabilitation efforts we have discussed and earned further responds from State Agency for The Conservation of Natural Resources (BBKSDA) Riau and The Indonesian Institutes of Sciences (LIPI). They establish programs in Temiang Village since 2010. BBKSDA Riau is working on creating a model of "Conservation Village" and LIPI is working for the implementation of "Biovillage Concept". "Conservation Village" refers to the socio-economic empowerment of human communities inhabiting the viccinities of protected areas through the provision of alternative livelihoods in order to prevent encroachments into the protected areas. "Biovillage Concept" refers to the application of low-cost but innovative technology to optimize the utilization of local biological resources, such as for the production of food and generation energy that sustain the basic needs of local people.

3 Results and Discussions

3.1 Survival Rate

In general survival rate show decreasing in all tree species was planted. The survival rates of the seedlings for five, ten month and two years monitoring are presented in figure 2. The survival rate within five month range 70.73% to 100%, ten month after planted range 58.03 to 100%, and drastically decreased after two year planted range 35.88% to 66.66%. The total higher survival rate of tree species was *Cratoxylon arborescens, Palaquium burckii* and *Tetramerista glabra* with range 68.02% to 96.8%. The lowest of survival was *Dyera lowii* of 35.88% to 70.73%.

As was shown in the results, the survival rate of peat swamp forest species during five and ten month and two year monitoring varies between species. Species with high survival rate (68.02% to 96.8%) include *Cratoxylon arborescens, Palaquium burckii,* and *Tetramerista glabra* in both hill and normal planting method using Gap experimental. Species with low survival rate is *Dyera lowii.* Treatment to create more open gap is important for improving survival and growth this species (shown in figure 3). However this results generally show higher survival rates compared to other rehabilitation activities in these and similar peat swamp forest ecosystem areas.

In Jambi peat swamp forest, rehabilitation was carried out using the species *Dyera lowii, Combretocorpus rotundus, Palaquium sp, Shorea pauciflora, Tetramerista glabra, Melanorhea wallichii,* and *Alstonia penaumotophora.* The average survival rate ranged from 40% to 70% (Arinal & Suryadiputra 2004). In Kalimantan, rehabilitation trials indicate that *Shorea balangeran* and *Palaquium* arc best suited for replanting, as they have considerably higher survival rates (65-100%) compared to the other species (6-65%). Survival rate ranged from 65-

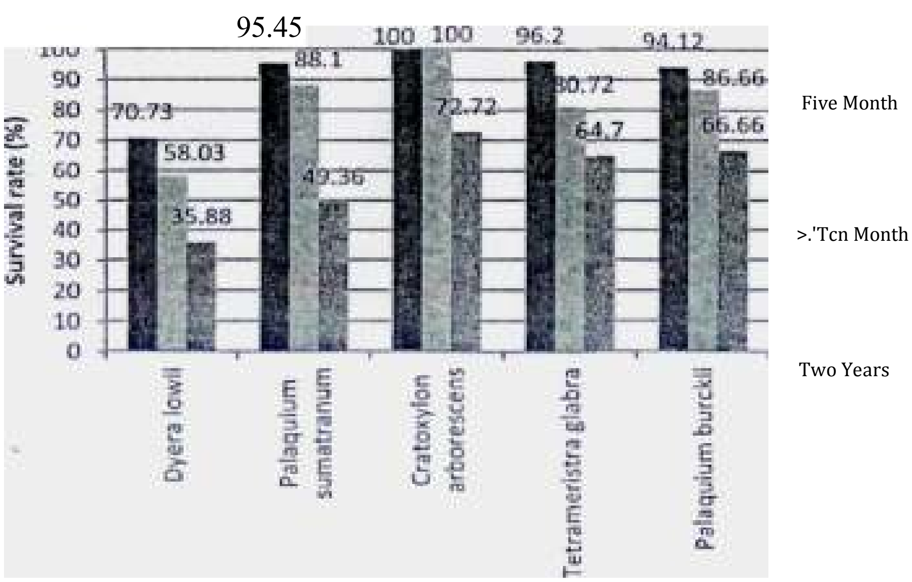

Fig 2. Survival rate of seedlings

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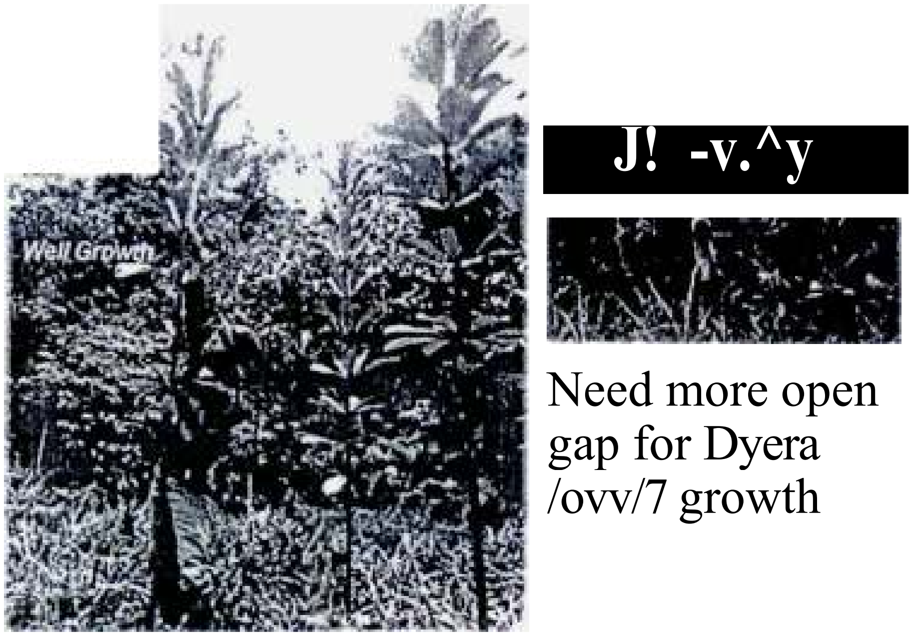


Fig 3. Survival and growth *of Dyera lowii* in different gap plot condition.

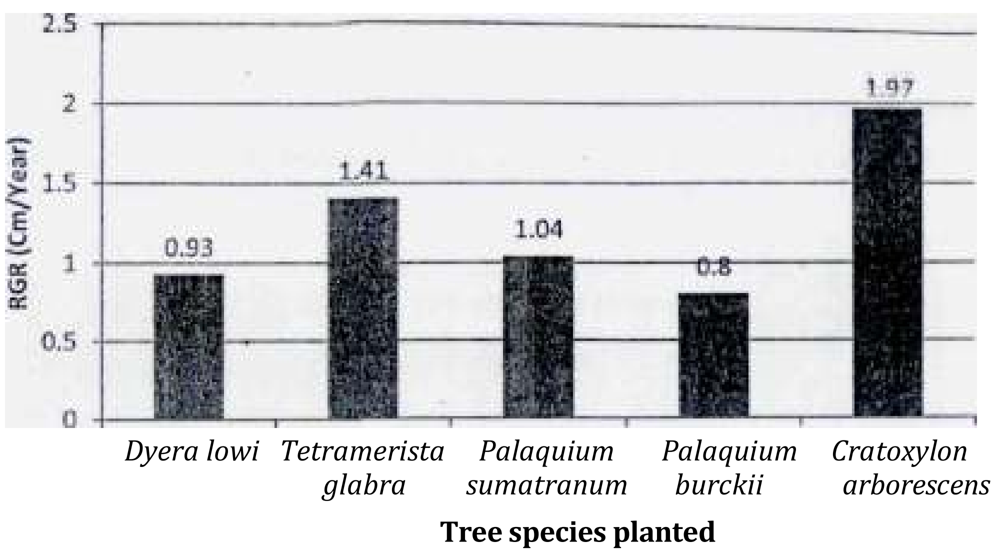


Fig 4. Relative Growth Rate (RGR)

85 % one year after planting in Kalimantan (Takahashi *et al.* 2001). Causes of mortality included tree fall and drought (Lian 2008). Survival rate and growth of planted seedlings in a degraded forest usually differ among species even in the same taxonomic group (Suzuki & Jacalncl986).

3.2 Relative Growth Rate (RGR)

Growth rate of five typical tree species recorded within 31 plots of 0.31 ha were shown in Figure 4. The highest growth-rate was *Cratoxylon arborescens* (1.97 cm year^{-1}) followed by *Tetramerista glabra* (1.41 cm year^{-1}).

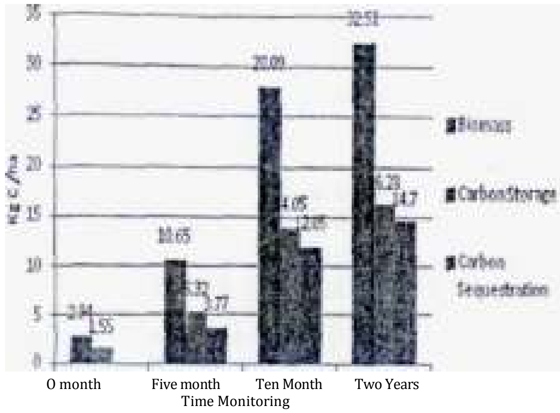
As shown in Figure 5, growth performance of mixed tree species in Gap Planting method. Some typical canopy species of peat swamp forest are promising used to rehabilitate in logged over forest areas. *Tetrameristra glabra, Palaquium burckii and Xylophia havilandii* will grow veil in more open gap plots. In .addition keeping wet condition on the forest floor will be suitable for them to continuously growth. This results show that level degradation of peat •iwamp forest ecosystem and selection of suitable tree species will influence vegetation rehabilitation efforts to be succeed.

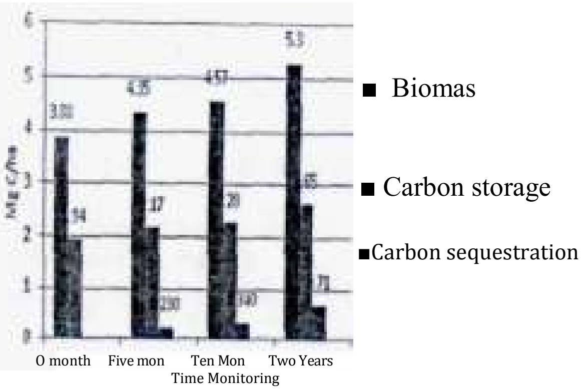
3.3 Biomass, Carbon and Their Sequestration

Total amount of above biomass and carbon content were increasing during two years rehabilitation (Figure 6). Biomass increased from 2.94 Kg ha^{-1} to 32.51 Kg ha^{-1}, and carbon storage increased from 1.55 kg C ha^{-1} to 16.28 kg C ha^{-1} in experimental sites. Carbon sequestered by vegetation rehabilitation increased from 3.77 Kg C ha^{-1} to 14.07 Kg C ha^{-1}.

Increasing in biomass, carbon storage and carbon sequestration in forested areas by natural regeneration processes are shown in figure 7. The forest recovery through natural processes contributed in sequestrating carbon of 0.71 Mg C ha* within two year of monitoring. In the say direction, there was an increasing in biomass from 3.88 Mg ha^{-1} to 5.3 Mg ha^{-1} and

Fig 5. Growth performance of mixed tree species in Gap Planting Method.





f Fig 6. Carbon sequestration in rehabilitation plots   Fig 7. Carbon sequestration in forested areas.

carbon storage of 1.94 Mg C ha^{-1} to 2.65 Mg ha^{-1}.

In this research, the effect of vegetation rehabilitation and natural regeneration processes on the total accumulation of carbon storage was counted. Our results showed that total amount of carbon sequestration was 0.72 C Mg ha^{-1} in both experimental sites and forested areas which indicates that the combination of forest recovery by vegetation rehabilitation and natural regeneration processes have potential to enhance carbon storage among forest rehabilitation efforts. Furthermore needed to clarify estimation of carbon sequestration accounted by using another appropriate equation. Katterings *et al* (2001) revealed there is a protocol for forest biomass assessment based on the use allometric. It will involve four steps; (1) choosing a suitable functional form for allometric equation, (2) choosing suitable values for any adjustable parameters in the equation, (3) field measurements of the input variables such as tree diameter, and (4) using the allometric equation to give the above-ground biomass of individual trees and summation to get area estimates.

3.4 Involving local community in achieving sustainable rehabilitation

We considered a role of the villagers and the importance of addressing their livelihoods concern in achieving sustainable rehabilitation activities. We planted tree species which have both economic values (i.e. timber and non-timber forest products) and conservation values such as *Dyera lowii, Tetramerista glabra, Palaquium sumatranum, Palaquium burckii. and Cratoxylon arborescens.* Moreover, various non-timber forest products are provided by these different species such as seeds *of Palaquium sumatranum* to produce oil for cooking, and white latex from *Dyera lowii.*

It would be ideal if the above economically important but endemic tree species could be planted by the villagers themselves. 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 strategics, or a combination of these. Financial

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Tabic 1. Local community participation in rehabilitation activities

No	Program	Activities
1.	Collecting seeds	Local people collected seed of typical trees species of peat swamp forest, as seeds of Bintangur *(Callophyllum lowii)* dan Halam *(Palaquium sumatranum)*. These trees produce many seeds and easily collected from forest floor.
2.	Collecting wildings	Some trees of peat swamp forest don't produce many seeds. *Tetramerista glabra, Palaquium burckii and Cratoxylon arborescens* arc those species taken by wildings methods from forest floor.
3.	Land Preparation	Selection of suitable place for planting may need to assisted by local people. There are location in conservation areas that we can't use for plot experiment. However in their own land, they can prepare it.
4.	Planting	Planting trees was started in suitable season, such as in rainy season. Before planting, we should give information how to planting trees. This purpose to increase survival rate or decrease strecs of trees.
5.	Monitoring	Teaching local people to use some method for monitoring survival and growth performance of trees planted. Their skill and knowledge will increase.

incentives are especially important to induce peoples' participation in sustainable rehabilitation efforts. From the initial, local community participation in rehabilitation activities explained in Table 1.

An interactive participation by the local community is vital for the success of rehabilitation. In our rehabilitation activities, we try to promote such level of participation by the local community in forest rehabilitation activities. First, we identified the different stakeholders as participation of stakeholder at all levels should be arranged from a start of rehabilitation project. We identified three important institutions which have different functions for supporting further rehabilitation project in Bukit Batu conservation areas. Inside the village, they had forest conservation community group (KM PI I), rubber fanners, and fisherman. Outside the village, we identified the Central Government of Forestry Department through Riau's Natural Conservation Agency, and some institutions that could potentially provide financial support through various funding mechanisms such as various Payments for Ecosystem Services (PES). PES is basically a blanket term that includes monetary "payments" (P) to a certain group of people in exchange for their efforts for keeping the natural resources continue providing valuable environmental services (ES). While there are various ES that peat swamp forests provide, we have considered here the newly proposed, although still being negotiated, the Reducing Emission from Forest Degradation and Deforestation (REDD) mechanism.

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

3.5 Promotion Camping Program

Integrated activities in order to promote sustainable conservation and rehabilitation in Bukit Batu Wild Reserve between Conservation Agency of Riau, Forestry Department through Village Conservation Model and Indonesian Institute of Science (LIPI) established Biovillage Program, and other stakeholders had initiated Ecotourism. From the initiation of this ecotourism activity, arose an idea to introduce CAMPING (Came and Planting) PROGRAM, where more participants are expected to come to Tcmiang Village in the future and will plant the saplings seeded by the local community. The advantage for the village women is when they are expected to develop woven handy craft as their expertise as well as provide Malay cuisine for visitors.

The implementation of ecotourism accompanied by planting saplings of endangered species of wood where participants are expected to purchase as many saplings as they want which have been seeded by forest care community group (KMPII) of Temiang Village for Rp 30,000/sapling and then plant it at the provided area. The polybag usually used in plant seeding is replaced by pandanus woven basket created by the housewives of the village.

To make Biosphere Reserve, particularly Bukit Bam block at Temiang Village as the location for the improvement of Camping Program and unique ecotourism development, support from various parties is still needed. Therefore, it is necessary to increase the role of stakeholder in the empowerment programs that have been done, is ongoing and will be done as part of CSR (Corporate Social Responsibility) and funding support from other institutions/agencies is also needed, including potential funding from abroad.

4. Conclusion

There are some directions to achieve sustainable rehabilitation of tropical peat swamp forest in Giam Siak Biosphere Reserve. Selection of useful species arc producing Non-Timber Forest Products (NTFPs) and multi-purpose trees (timber plus NTFPs) should be integrated by goals of sustainable rehabilitation including to local community incentives, carbon storage and biodiversity conservation. While encouraging institution in village level, such as KMPII Tcmiang Village and involving wider community or stakeholders will be the key processes in achieving sustainable rehabilitation.

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