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Original paper

Effects of forest use by local people in livelihoods and ecosystem: Exploring co-benefits in the Gunung Palung National Park, Indonesia

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Abstract

As an efforts to climate change, mechanism of reducing greenhouse gas emissions from deforestation and forest degradation with forest management (REDD+) has been discussed under the United Nations Framework Convention on Climate Change. However, there are concerns that activities prioritizing the amount of carbon stock available would have negative consequences for the people if appropriate environmental and social safeguards were not implemented. This study aimed to determine the practical implications of promoting REDD+ co-benefits and safeguard by exploring situations and impacts of forest use through a series of surveys in two villages, Sedahan Jaya and Sejahtera, around the Gunung Palung National Park, Indonesia. The forest in Sedahan Jaya is mostly used for collecting non-timber forest products by using traditional forest gardening practices, while in Sejahtera, the forest serves a relatively commercial purpose for producing income in rubber plantation. Carbon stock in Sedahan Jaya exhibited recovery from the extensive forest fire that took place in the past. However, it has been reduced in Sejahtera by expansion of land degradation due to frequent forest fires mainly in peat swamp forest. These practical results in both socio-economic and natural environmental aspects will have useful implications for co-benefit activities, which promote carbon stock and community livelihoods.

Key Words：REDD+, Gunung Palung National Park, co-benefits, forest garden, carbon stock

1. Introduction

Efforts to reduce greenhouse gas (GHG) emissions due to deforestation and forest degradation by using forest management techniques (referred to as REDD+) are expected to have a prominent role in forest conservation, especially in the tropics. Under the United Nations Framework Convention on Climate Change (UNFCCC), the basic concept and methodologies of REDD+ were discussed and agreed upon during the latest Conference of the Parties (COP) 21 (UNFCCC, 2015). As determined in COP 13, the parties (especially those in developing countries) would be encouraged to continue sustainably reducing emission caused by deforestation and forest degradation by using stable and predictably available resources (UNFCCC, 2007). REDD+ can not only reduce GHG emissions, which would be considered to be a “carbon benefit” but also lead to other “non-carbon

benefits" such as alleviating poverty, securing human rights, improving methods of governance, conserving biodiversity, and supporting other environmental services, termed "co-benefits" (Brown et al., 2008). However, there are concerns that activities prioritizing the amount of carbon stock available would have negative consequences for the people living in regions with low carbon stock, but an abundance of precious ecosystems, if the appropriate safeguards were not implemented (Putz and Redford, 2009). Therefore, parties have promoted and reported the implementation of seven social and environmental safeguards for REDD+ as determined by the Cancun Agreement at COP 16 (UNFCCC, 2010).

Each country is required to develop a Safeguard Information System (SIS) for REDD+ according to the UNFCCC COP 16 held in 2010 (UNFCCC, 2010). For this, appropriate understanding of the links between effects on carbon stock and other non-carbon related benefits (such as biodiversity conservation and forest use rights) are needed. Some studies conducted on linkages between carbon stocks and biodiversity conservation, revealed that forest management that sustains carbon stock in the long term could have a positive effect on various environmental aspects, such as biodiversity (Norris et al, 2010; Thompson, 2015). However, there is little data assessing social, cultural, and economic impacts of REDD+ implemented in protected areas due to lack of appropriate methods (Arhin, 2014). In particular, it is difficult to clarify the relationship between environmental services and forest use by locals, even though traditional rights related to access to forest resources, such as non-timber forest products (NTFPs), have been defined as a social safeguard (Sunderland et al., 2011). For instance, complex interrelations among various social and ecological factors, including policy and tenure, affect forest ecosystems and sustainability of NTFPs species (Ticktin and Shackleton, 2011). Most of the countries involved tend to lack the methodology and scientific data necessary to assess and promote co-benefits and REDD+ safeguards (McGregor et al., 2010).

Indonesia is a key REDD+ member since this region includes extensive forested areas and peatland, with the largest carbon stocks in the tropics, while it is also a global leader in land-based GHG emissions, mainly because it is characterized by the second-greatest rates of forest reduction found globally (FAO, 2015). In 2015, the Government of Indonesia submitted the Intended National Determined Contribution to the UNFCCC, which mentions the commitment to GHG emission reduction as well as REDD+ by 26%, compared to the current baseline, by 2020 (RoI, 2015). After the reorganization of ministries in 2015, which involved integrating the previous REDD+ Agency into the Ministry of Forestry, the newly organized Ministry of Environment and Forestry has undertaken initiatives to draft and enforce REDD+-related strategies and policies. Even though neither principles nor framework on social and environmental safeguards have been announced, they are expected to correspond to stipulations in the Cancun Agreements, as well as those related to national circumstances (UNORCID, 2015). To implement REDD+ and safeguards in Indonesia, encouraging participation of the community in forest governance and tenure arrangements will be a critical challenge since traditional forest use rights are not allowed as approximately 98% of forest area is owned by the governments (Agung et al, 2014). Even at our study site, the Gunung Palung National Park (GPNP) in West Kalimantan, local people living around GPNP have maintained a Forest Garden (FG), known as "Hutan Kebun" in Indonesian, as customary practices without legal rights by collecting and cultivating NTFPs such as durian and coffee for domestic and marketing purposes (Salafsky, 1994). Although farming and cultivation activities inside the national park are prohibited, some FG practices are being continued without sufficient information regarding regulations and zoning in the national park. Similar situations and issues have been associated with other national parks and conservation forests throughout Indonesia (Diaulhaq, 2015). Thus, examination of FG practices in GPNP can provide useful information regarding REDD+ safeguards through encouraging appropriate understanding and evaluation of FG practices, which is a type of forest use related to local people.

In instances where there is a lack of data concerning linkages among conservation, forest use, and carbon stocks, decisions tend to prioritize conservation rather than common practices or safeguards, which concerns stakeholders located around the GPNP. Thus, this study aimed to determine the practical implications of promoting REDD+ co-benefits and safeguards by exploring situations and impacts of forest use related to socio-economic circumstances as well as forest ecosystems.

2. Methods

2.1. Study Area

Our study site, illustrated in Figure 1, was the Gunung Palung National Park (GPNP) in West Kalimantan province, which covers 108,000 ha and harbors approximately 32.7 million tons of carbon stock in 2013, was proposed as a potential REDD+ area by the Ministry of Environment and Forestry (MoEF) in Indonesia (JICA, 2016). This park consists of diverse forest types, including peat swamp and montane forest, and includes precious ecosystems as well as habitats for the proboscis monkey (*Nasalis larvatus*) and orangutan (*Pongo pygmaeus*). The density of these two species could decrease due to logging and disruption of forests both within the park as well as in adjacent areas (BTNGP, 2015). Even though illegal logging was previously the main cause of deforestation, it has decreased since 2003, due to enhanced patrolling activities by the GPNP office (Zamzani, 2008). Currently, oil palm plantations around GPNP have expanded and converted large previously forested areas.

Therefore, the GPNP is a valuable study area for biodiversity conservation and REDD+ since it has regions, which have been subjected to illegal logging and the conversion of forest area to oil palm plantations (BTNGP, 2015). Currently, approximately 45,000 people live in 20 villages (Desa) that share boundaries with the GPNP. The majority of the villages are situated in the Sukadana sub-district (Kacamatan), Kayong Utara. In this sub-district, the annual population growth was approximately 2.6% from 2010 through 2014 (BPS, 2014). Traditionally, local people utilize forested regions for forest gardening of durian and other NTFPs, which are mainly located inside the current national park area. In a previous study (Salafsky, 2014), approximately 40% of households in Benawai Agung village, in the Sukadana sub-district, owned durian mixed forest gardens. Sedahan Jaya, separated from Benawai Agung in 2005 according to a revision of the administrative boundary, and the Sejahtera villages in the Sukadana sub-district were selected as a target for this study because the number of residents that utilize the forest for activities such as forest gardening and plantation (FG/PT) is relatively larger than that in other villages. Both villages consist mainly of Malay as the main ethnic group, along with a mixture of Balinese and Javanese in Sedahan Jaya and Bugis in Sejehtera while total residents are 1,805 and 1,994 respectively (BPS, 2014). In addition to illegal logging in the past, frequent forest fire, especially severe forest fire in 1997 to 1998, has been recognized as main deforestation and forest degradation around the area. Thus, the potential for REDD+ seems to be higher in these villages.

Figure 1. Location of the study site: the Gunung Palung National Park in West Kalimantan (left) and targeted villages, Sedahan Jaya and Sejahtera.

2.2. Satellite Imagery Analysis

In order to clarify the land cover in relation to the forest area in the two villages located near the GPNP, shifts in land cover in accessible areas with 10 × 10 km^2, 10,000 ha, in size, were analyzed using remote sensing data. For the analysis, satellite imagery from a middle-range resolution LANDSAT sensor, in 2005 and 2015 was analyzed to compare land cover changes within each area accessed by the two villages. An additional assessment was completed using a high-resolution sensor, SPOT 6, in 2005 and 2015 to verify the results from the LANDSAT TM data. In addition to comparing land cover and forest type situations in the two villages, changes in forest area according to type during the 10 years between 2005 and 2015, were summarized using a matrix. The forest types were classified as forest garden (FG), plantation (PT) mainly with rubber trees, degraded forest (DF), montane forest (MF) situated in mountains, peat swamp forest (PSF), and mangrove and shrubs (MS). In this study, FG was defined as a durian mixed FG inside the national park in the Sedahan Jaya village region, separate from the plantation mainly with rubber and durian trees outside the national park in the Sejahtera area.

2.3. Socio-economic Survey and Analysis

Necessary data for identifying the socio-economic conditions in the two target villages were collected through questionnaire based surveys as well as semi-structured interviews as a part of the Indonesia–Japan Project for the Development of the REDD+ Implementation Mechanism (IJ-REDD+). This project is a technical cooperation venture between Japan International Cooperation Agency (JICA) and the Ministry of Environment and Forestry (MoEF) in Indonesia. The surveys and semi-structured interviews were conducted by experienced local surveyors after confirming their survey skills and ethics. The semi-structured interview was undertaken by Indonesian staff in the IJ-REDD+ project. The questionnaire survey was conducted by attempting to elicit quantitative information within the following five main survey sections: basic information, assets such as land and livestock, faming practice, collection of non-timber forest products (NTFPs), and income structure. Data from the interview obtained from questions regarding the area used for farming and forest gardening was not based on any actual measurements in the field. A sampling method that assessed the stratified number of ethnic groups, farming types, and livelihood types in each village, along with guidance from village leaders, were used to ultimately select sample households. A total of 120 (20.0%) sample households were located in Sedahan Jaya and 70 (12.3%) in Sejahtera (BPS, 2014). After the questionnaire survey was administered, semi-structured interviews, which aimed to obtain supplemental background information about forest gardening practices, were conducted in 10 randomly selected households in each village that engaged in farming or forest gardening. These surveys and interviews were conducted from October 2014 to March 2015.

2.4. Forest Plot Survey

In the two villages, forest plot surveys were conducted in each forest type, except in the MF in the Sejahtera, which is difficult to access. In a 100-m^2 plot randomly selected for each forest type, tree genus, tree height, and diameter at breast height (DBH) were measured for every tree with a DBH greater than 5 cm. For tree identification, knowledgeable villagers accompanied the researchers and assisted during the survey.

With the data obtained, mainly the DBH, from the forest plot survey, the volume of sampled trees above ground was calculated using allometric equations. By referring to official guidance on tree biomass estimation in Indonesia (Krisnawati et al., 2012), the equation from Hashimoto et al. (2004) was applied to the survey results in Sedahan Jaya, of which forest was dominated by the Macaranga spp. For the data in the Sejahtera village, the equation from Ketterings et al. (2001) was selected since a large part of the forest is dominated by secondary or degraded forests created after fire or logging. Using the calculated tree biomass as well as changes in forest area determined using the satellite imagery, forest biomass

changes in 2005 to 2015 were identified according to forest type.

3. Results

3.1. Overview of Land Use and Forest Type

The results of the satellite imagery analysis in 2015 include an overview of land cover and forest type in Sedahan Jaya and Sejahtera (Figure 2). In Sedahan Jaya, total residential and farm area expanded north to south between MF in the west, and PSF in the east. We found that FG exists in the edge of MF, close to a residential area. The open and grass area on the edge of PSF was likely caused by a forest fire. In Sejahtera, residential and farm areas were located along the sea and mangrove forest in the west. In the east region, vast PSF surrounded the village. However, DF, which might have been caused by fires or logging, is visible up to the MF. The PT surrounded by grass implies that the area utilized could have previously been a fired area in the PSF. When comparing the two villages with percentage of area inside the 10,000 ha plot excluding water body, PSF occupied the largest area utilized in Sedahan Jaya, 58.4 %, and in Sejahtera, 40.2 % (Figure 3). Clear differences between the villages are apparent in the DF and MF. While the MF is larger in Sedahan Jaya, 21.2 %, a greater DF was found in Sejahtera, 16.5 %. In the villages, FG

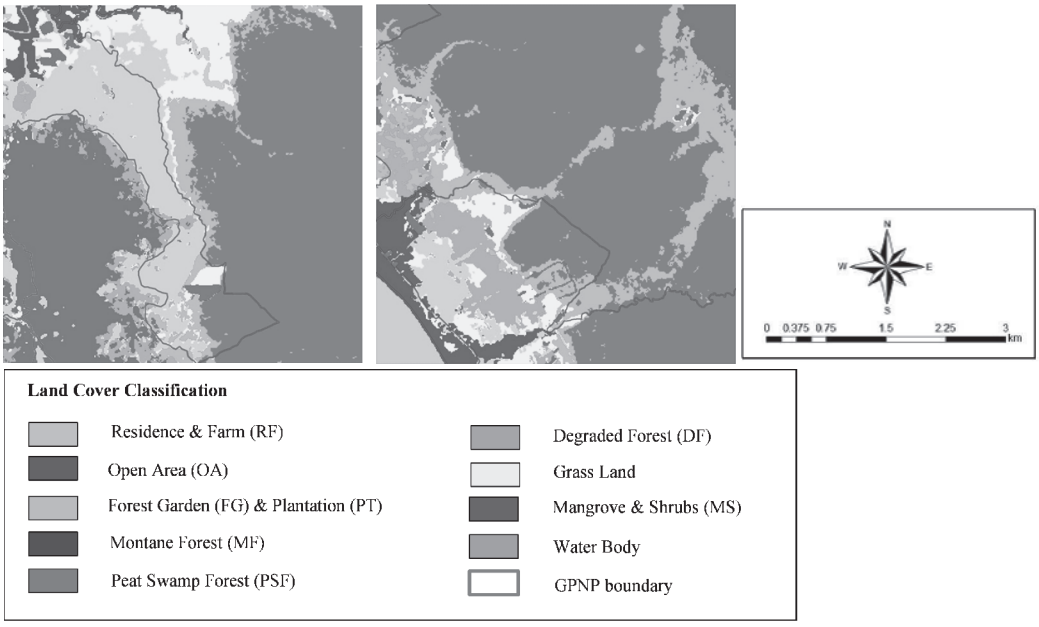

Figure 2. Locations of land use and forest types in Sedahan Jaya (left) and Sejahtera (right) based on LANDSAT imagery in 2015.

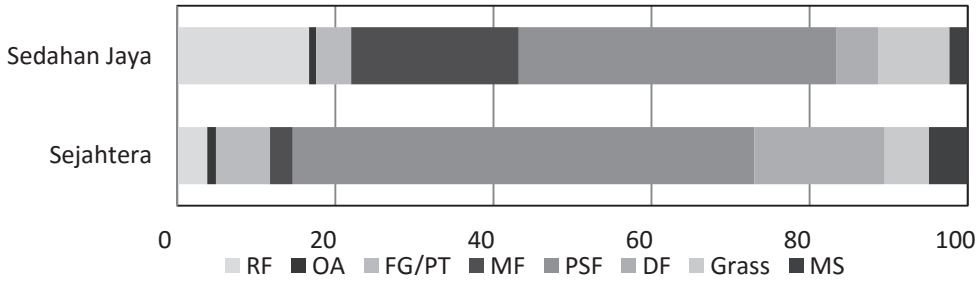

Figure 3. Percentage (%) of land cover classification in Sedahan Jaya and Sejahtera.
RF: Residence and Farm, OA: Open Area, FG: Forest Garden, PT: Plantation, DF: Degraded Forest, MF: Montane Forest, PSF: Peat Swamp Forest, MS: Mangrove and Shrubs

Table 1. Matrix of land cover and forest area changes between 2005 and 2015 in a) Sedahan Jaya and b) Sejahtera (unit: ha)

a)

Land cover type		2015						
		RF	OA	FG	DF	MF	PSF	**Total**
2005	RF	628	2	38	19	23	-	**711**
	OA	518	1	22	4	9	-	**556**
	FG	80	1	214	19	193	-	**507**
	DF	45	12	3	341	6	194	**602**
	MF	78	3	150	12	1,838	0	**2,082**
	PSF	1	15	1	53	5	3,787	**3,863**
	Total	**1,352**	**34**	**429**	**449**	**2,075**	**3,982**	

b)

Land cover type		2015						
		RF	OA	PT	DF	MF	PSF	**Total**
2005	RF	240	13	76	14	-	-	**343**
	OA	79	17	43	10	-	-	**148**
	PT	13	5	424	59	-	-	**502**
	DF	6	18	92	808	4	314	**1,243**
	MF	-	-	-	34	263	3	**299**
	PSF	4	26	14	640	13	5,369	**6,066**
	Total	**341**	**78**	**649**	**1,566**	**280**	**5,686**	

RF: Residential and Farm area, OA: Open Area, FG: Forest Garden, PT: Plantation, DF: Degraded Forest, MF: Montane Forest, PSF: Peat Swamp Forest

in Sedahan Jaya and PT in Sejahtera were located near residences and function as a buffer of MF and PSF.

Using the results of satellite imagery analysis in 2005 and 2015, changes in forest area were summarized and compared in a matrix (Table 1). In Sedahan Jaya, larger forest recovery was observed after a severe forest fire, that lasted from 1997 to 1998, in PSF from DF (194 ha) as well as MF from FG (193 ha). However, there was also a clear increase in residential and farm areas from 711 ha to 1,352 ha. Since a decrease was observed in the OA, from 556 ha to 34 ha, and DF, 602 ha to 449 ha, these areas were converted to residences and farms after being previously devastated. A slight decrease was also observed in FG, which might be due to the reduction of households engaging in FG.

In Sejahtera, it is remarkable that 640 ha of PSF degraded due to frequent forest fires even after severe forest fires in 1997, according to the interviewee. Even though the OA decreased from 148 ha to 78 ha, there was an increase in PT, 502 ha to 649 ha. We observed a difference in FG in Sedahan Jaya, which decreased slightly in area. The DF and OA tended to be used for farming rather than for forest gardening in Sedahan Jaya, which was converted to PT in Sejahtera.

3.2. Forest Uses by Local People

According to the socio-economic survey, Malay is the main ethnic group in both villages, in addition to a mixture of Balinese and Javanese in Sedahan Jaya and Bugis in Sejahtera. Although paddy cropping is the main farming activity in both villages, some households use forest area mainly for forest gardening or plantation. In Sedahan Jaya, 30.0% of households engage in forest use mainly as forest gardening, which is mostly located along a slope on the lower side of the MF in the west of the residential area (Figure 2). A type of agroforestry mainly exists inside the national park, in which 20.8% of sample households participate. Activities include collecting NTFPs, such as durian, sugar palm, and bamboo shoot. On the other hand, outside of the park, the forest use is mainly for PT, and 31.4% of sample households participate in this type of farming, generally located in the degraded area, which is present after forest fires. However, some households collect NTFPs inside the national park.

When the income structure between FG users and all sample households in both villages (Figure 4) was compared, on-farm activities are the primary source of income in Sedahan Jaya while it is mostly derived from off-farm activities in Sejahtera. In Sedahan Jaya, FG users rely on on-farm activities including the selling of NTFPs (7.5%) for over 80% of income, higher than the average of all sample households in Sedahan Jaya (61.1%). Similar trends, including a high rate of on-farm income obtained by FG users is observed in the Sejahtera village as well. However, income in Sejahtera is obtained primarily by PT (22.8%), which is higher than that obtained from paddy farming (10.0%). Because of low paddy production, PT is a key income source in addition to off-farm activities in Sejahtera.

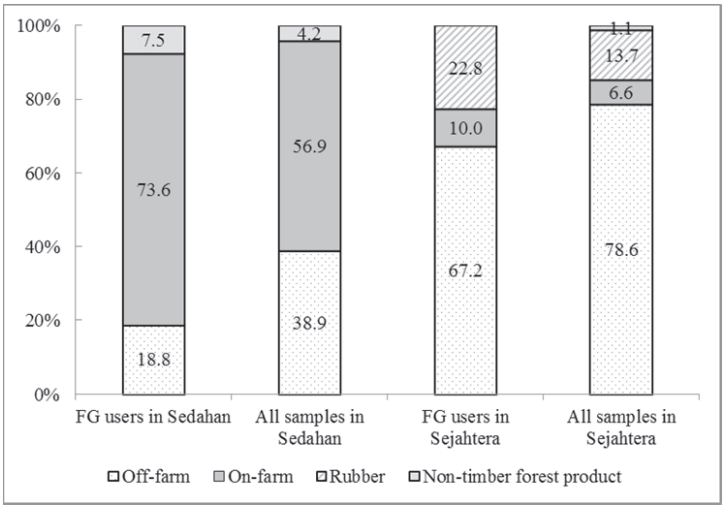

Figure 4. Income structure of Forest Garden (FG) users and all sample households in the Sedahan Jaya and Sejahtera villages.

3.3. Estimation of Forest Biomass Changes

In the forest plot survey, 699 trees in 48 plots were measured. For each forest type in the two villages, tree density, average DBH, estimated biomass, and main tree genus were summarized (Table 2). The biomass was the greatest in PSF while the least is in the DF in both villages. The tree biomass of FG in Sedahan Jaya is relatively small (309.4 ton per hector), but larger than that of DF. The tree density in FG (1,125 trees per hector), was higher than that in MF, 933 trees per hector. Even though the main tree genera include fruit trees such as durian, they occupy 33.3% of total sampled trees in FG. From these results, it is apparent that the FG maintains diversity and biomass to some extent. In the case of Sejahtera, the extremely higher rate of *Hevea* involved in PT and *Durio* in durian forest explains why utilization and management are significantly intensive compared with the FG in Sedahan Jaya.

By assessing forest area according to different types during 2005 and 2015 (Table 1) as well as including results from forest plot survey (Table 2), changes in biomass were calculated and compared (Table 3). We found that forest biomass in Sedahan Jaya is in the process of slightly recovering at a rate of 4.4 tons per

Table 2. Overview of forest plot survey by forest type in Sedahan Jaya and Sejahtera.

Village/ Forest Type	No. of plot	No. of trees/ha	Mean DBH (cm)	Tree Biomass (ton/ha)	Dominated trees	
					Genus name	% in total
Sedahan Jaya						
Peat Swamp Forest	11	1,773	21.6	483.6	*Palaquium, Macaranga, Shorea*	40.5
Degradation Forest	3	1,433	18.5	157.6	*Macaranga, Pternandra, Syzygim*	88.4
Montane Forest	6	933	29.0	635.2	*Baccaurea, Strombosia, Syzygium*	39.3
Forest Garden	8	1,125	28.8	309.4	*Durio, Lansium, Dimocarpus*	33.3
Sejahtera						
Peat Swamp Forest	10	1,680	22.2	420.7	*Syzygium, Dipterocarpus, Blucia*	39.9
Degradation Forest	4	1,725	14.7	182.9	*Paraquim, Diospyros, Litsea*	33.3
Rubber Plantation	2	2,100	15.8	203.8	*Hevea, Artocarpus*	88.1
Durian Plantation	4	850	63.6	787.1	*Durio, Lansium*	85.3

Table 3. Changes of forest biomass between 2005 and 2015 according to forest type in the Sedahan Jaya and Sejahtera villages.

Forest Type	Sedahan Jaya		Sejahtera	
	Area (ha)	Biomass (ton)	Area (ha)	Biomass (ton)
Peat Swamp Forest	118.1	57,105	-3.8	-159,519
Degradation Forest	-152.6	-24,054	3.2	59,120
Montane Forest	-7.1	-4,517	-0.2	-12,178
Forest Garden/Rubber Plantation	-77.8	-24,088	1.5	29,966
Change in total biomass (ton)		4,446		-82,610
Total (t/ha/year)		4.4		-82.6

hector per year. Since greater increases were observed in PSF compared to the other forest types, this could be due to efficient recovery after severe forest fire that lasted from 1997 to 1998. On the other hand, tree biomass greatly diminished after 2005 in Sejahtera, at a rate of 82.6 ton per hector per year. The slight increase observed in the DF and PT, compared to the dramatic decrease in the PSF, could have been caused by frequent forest fires that took place after the severe forest fire.

4. Discussion

4.1. Differences in Forest Use Observed according to Community

In this study, land use and forest ecosystem between two villages were compared by assessing socio-economic characteristics and forest structure. Especially with respect to forest gardening, differences were observed in relation to management and farming practices, even though more than 30% of sample households engage in farming in both villages. The forest in Sedahan Jaya is mostly used for collecting NTFPs, such as durian and sugar palm, by using traditional FG practices, while in Sejahtera, the forest serves a relatively commercial purpose for producing income in a PT. This difference is remarkable when the income structure is accounted for (Figure 4). In Sedahan Jaya, on-farm activities account for the majority of their income, and NTFPs complements 7.5% of the income especially for households that use FG. On the other hand, PT accounts for 22.8% of total income obtained by FG users when off-farm activities are the main source of income. This suggests that NTFPs obtained from FG in Sedahan Jaya functions as a safety net to make up for shortages in domestic commodities and on-farm income, as is apparent in other areas that are also distantly located from markets (Shackleton et al., 2011). However, forest use in Sejahtera was mainly designated for PT and functioned as a means of cash income as well as off-farm activities.

The role and function of FG differed in villages depending on traditional practices, income structure, and available land and forest areas. Furthermore, land use changed over the years according to market needs and natural phenomena such as forest fires. As an overall current trend, farming practices has become more intensive and commercially driven, leading to the expansion of land for use for specific tree crops such as rubber in Sejahtera.

4.2. Influence on Forest Biomass and Structure

Using satellite imagery and forest plot surveys, impact on forest ecosystem by village use and management could be deduced. While forest biomass in Sedahan Jaya tended to recover from severe forest, it has been reduced in Sejahtera by expansion of land degradation due to frequent forest fires mainly in PSF. A part of the area in the degraded forest was often converted to PT (Table 1). Regular use and maintenance of the rubber trees would be expected to prevent forest fires. However, the recent slump in rubber market piece discourages the majority of villagers to continue rubber tapping, leading to a decrease in PT. These situations can cause further risk of forest fires and reduction in forest biomass as well

as carbon stocks. Although it is difficult to identify the precise cause of forest fires, the forest area and biomass in Sedahan Jaya often recovered even after severe forest fire. Thus, it can be inferred that a type of forest management awareness based on traditional practices and daily use would affect differences in fire prevention and forest recovery compared with those implemented in Sejahtera, where the main forest use is commercially driven and involves more intensive plantation.

The results of forest plot survey provide a clearer understanding of forest use and its influence on forest biomass according to various types of use. In both villages, PSF have a higher tree density with larger trees that can be used as timber. Therefore, PSF would be expected to maintain a higher biomass by forest fire prevention and logging. On the other hand, DF is composed of smaller sized trees such as *Macaranga* spp, a pioneer species that is present after fires. Since these forests are located in buffer areas between residential areas and forests with large biomass such as PSF and MF, rehabilitation of these deteriorated areas is a key for future park management. While forest use in Sejahtera is biased depending on forest structure with management focused on durian and rubber trees, FG in Sedahan Jaya is relatively similar in diversity and biomass in both PSF and MF. This suggests that appropriate practices such as forest gardening in Sedahan Jaya can contribute not only to the maintenance of biomass but also prevent forest fires.

4.3. Implications for Co-benefits

By exploring both socio-economic and ecological impacts of forest utilization in this study, we identified changes in forest gardening purposes that could be related to forest biomass and structure. These findings are important to consider when determining the co-benefit to the carbon pool and community livelihoods, as well as enhance awareness of forest management among stakeholders. At the same time, further studies and preparations related to social and environmental safeguards are needed to promote appropriate decision making.

Regarding social aspects, the ambiguous tenure situations for customary FG practices such as those in Sedahan Jaya, which are not clearly currently permitted in the national park, need to be considered. While approximately 30% of households engage in FG maintenance and make a living through on-farm activities, which include selling NTFPs, loss of forest access could force villagers into difficult situations or poverty. These restrictive measures could inhibit sustainable park management by worsening trust between the national park staff and villagers and promoting intense illegal activities inside forest area. Similar attention should also be paid to Sejahtera since PT tends to be expanded in areas of degraded forests, which occur after fires. If no rehabilitation or monitoring were conducted, it would be quite difficult to expect any enhancement in forest biomass or carbon stock in these areas. Since similar issues have been observed in other forest areas in Indonesia, appropriate measures and decision making are needed and should involve both community and local stakeholders (Sunderlin et al., 2014).

Regarding the conservation of the GPNP, further studies are needed to determine the impact of forest use on ecosystems and biodiversity, even though here, we have attempted to quantify differences in forest biomass. The quantitative methods we have used are effective for use in participatory monitoring programs as well as raising awareness for forest conservation.

5. Conclusion

In this study, questionnaire surveys with semi-structured interviews, satellite imagery analyses, and forest plot surveys were conducted in two villages near GPNP in order to assess the practical effect of appropriate decision making on the promotion of co-benefits while also considering essential safeguards. Using socio-economic interviews, differences in forest use were identified by assessing engagement and income structures among sample households. Further comparison of changes in forest area and biomass revealed that frequent forest fires in the Sejahtera region affected

the recovery of biomass while the biomass in Sedahan Jaya tended to recover after 2005, even following the severe forest fire that took place from 1997 to 1998. These differences in forest biomass are affected by socio-economic factors such as traditional practices and the role of the forest in the community. Results from the forest plot survey identified clear differences in diversity and biomass according to forest type. The most prominent findings were that a part of forest gardening practices in Sedahan Jaya were characterized by utilizing plants, which spanned a relatively large genus diversity and biomass. We found that appropriate actions could minimize impacts on forest ecosystems. These practical results could lead to better decisions by the national park office in respect to management activities, such as zoning revisions. Furthermore, both socio-economic and natural environmental aspects of this study will have useful implications for co-benefit activities, which promote forest biomass and community livelihoods. However, additional studies are required to clarify the effect on other aspects of the ecosystem such as biodiversity, water conservation, as well as climate change mitigation.

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地域住民による森林利用の生計および生態系への効果：インドネシア共和国グヌンパルン国立公園におけるコベネフィットの検討

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要　旨

気候変動対策の１つとして、「発展途上国の森林減少・劣化に由来する排出削減と森林保全（REDD+）」の制度構築に向けた協議が、気候変動枠組条約で進められている。そうした中、炭素蓄積に焦点を置いた取り組みによる負の影響が懸念され、環境・社会面でのセーフガードの実施が要件として組み込まれた。本研究は、インドネシア共和国グヌンパルン国立公園周辺の２村（スダハンジャヤ村およびスジャトラ村）を対象とした衛星画像解析による土地被覆変化、社会経済調査、森林プロット調査を通じ、地域住民の森林利用による森林面積や炭素蓄積への影響を把握し、炭素蓄積の維持と住民の生計向上等に資する「コベネフィット」の達成に向けた検討を目的とした。スダハンジャヤ村では自給用として国立公園内での非木材林産物の採集が主な森林利用である一方、スジャトラ村では国立公園外での火災跡地における商業用のゴム栽培が行われていた。炭素蓄積の変化を比較したところ、スダハンジャヤ村では過去に火災があった山岳林で回復傾向を示したが、スジャトラ村では泥炭湿地林で火災が頻発したことによって劣化やゴム林への転換が進み、全体として減少していた。こうした社会経済および自然環境の両面から森林利用を分析することで、コベネフィットの促進に向けた実用的な判断材料となり得る。

Key Words： REDD+、グヌンパルン国立公園、コベネフィット、フォレストガーデン、炭素蓄積

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