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ABSTRACT

Forest area in North Sumatera has declined since many years ago and have changed to more intensive land use systems, e.g. oil palm plantation, rubber monoculture plantation and smallholder. The study of local perception on land use systems and biodiversity was conducted in six villages in Simalungun district, Asahan district, and Serdang Berdagai district, North Sumatera province, to understand local preferences for land-use systems, local perceptions on land-use functions, and values on biodiversity, using Multidisciplinary Landscape Analysis (MLA) approach. The study showed that smallholder rubber and oil palm were the main sources of livelihoods in almost every village, since the two land use systems were important as cash income source. All participants perceived that rubber agroforest was the most important land use, as it could provide sources of income, food and environment values. People's understanding on biodiversity was closely associated with livelihood patterns and social life, as biodiversity contributed to their daily needs, and related to specific knowledge. All rubber plots under mixed and monoculture systems were perceived as good value in preventing erosion, while oil palm plots were of relatively low value. Interestingly, people also understood that forest had the highest function as an erosion control as these area are prone to soil erosion due to topography. Local people classified flora and fauna diversity based on their functions, such as food, source of income, fuelwood, construction, medicine, fodder, handycraft and tools, and erosion control. They noticed different biodiversity occured in different land-use types. Rubber agroforests provide all needs, e.g. goods and services, for local communities.

Keywords: agroforestry, rubber agroforest, Multidisciplinary Landscape Analysis (MLA)

1. INTRODUCTION

Deforestation owing to over-exploitation, over-population and changing forests to more intensive land-use systems has caused habitat loss for animals and many other living organisms. Loss of biodiversity should be considered as the greatest economic problem (Helm and Heppburn 2012). Human is always regarded as the major threat to biodiversity, although natural disturbance can also be as main factor. Through knowledge, people can manage their environment to live together with the animals and plants.

It is important to take into account human and environmental aspects in biodiversity conservation. The value of land-use systems in a landscape is not only captured by its physical aspects but also the cultural and social aspects embedded in it. This also reflects on how to measure biodiversity, that is, it need not always be based on a natural science approach. The relative importance of biodiversity to humans can be assessed through understanding the socio-cultural aspects of local communities. Natural scientific methods define the 'level of biodiversity', making it possible to compare sites or to provide data that can be used for

comparisons (Sutherlands 2000, Jennings 2000). On the other hand, the socio-cultural approach reveals how local people measure biodiversity and the importance of maintaining it for the sustainability of their livelihoods. This is particularly important when biodiversity conservation is linked to poverty alleviation (Huq 2000, Solis-Rivera 2000) through rewards for environmental services' schemes. Judging the value of what is important for local communities helps them to capitalise on opportunities for biodiversity conservation.

Objective of the research aimed to study (i) local perceptions of land-use systems and their functions, and (ii) importance of biodiversity for their livelihoods, which reflected through the most valuable plants and animals in each land use.

2. METHODS

2.1 Location and Village Selection

The study was conducted in Dolok Merangir of Simalungun district, Serdang Berdagai district and Asahan district, North Sumatera province. The area encompassed of large area of rubber estate plantation, smallholder rubber and secondary forest (Figure 1). Some villages were selected purposively within some sub-districts that were statistically well known as producers of high quality and quantity of rubber latex. This is important since most of the villages in the three districts are main producer of rubber latex and oil palm as it could also help to minimize village selection.

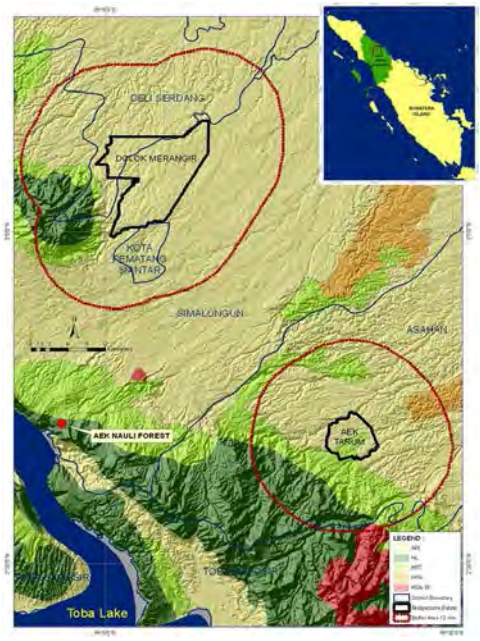

Figure 1: Study sites in the areas of the Bridgestone Sumatera Rubber Estate (BSRE) company and six villages in surroundings

Six villages surrounding the plantation were selected taking into consideration the village's position (inside or outside the plantation area), distance to the forest and rubber as one of the main livelihood sources.

The sample villages were grouped into three clusters based on the distance to the forest. Cluster 1, is the furthest distance to the forest villages and inside the area of the BSRE, represented by Batu Silangit. Cluster 2, the villages with moderate distance (5 – 10 km) to the forest, represented by Naga Raja and Aek Bamban,— and, Cluster 3, villages close to the

forest—Huta Rao, Silau Padang and Merjanji Aceh villages. Selected villages are presented in Table 1.

Table 1: Characteristics of selected villages

Cluster	Distance to forest	Distance to rubber plantation	Village	Administrative location	Main Livelihood Source
1	> 10 km	Enclave	Batu Silangit	Tapian Dolok sub-district, Simalungun district	Rubber
2	5 – 10 km	Bordering	Naga Raja	Sipispis sub-district, Serdang Berdagai district	Oil palm, rubber
		> 10 km	Aek Bamban	Aek Songsongan sub-district, Asahan district	Rubber
3	< 5 km	Bordering	Huta Rao	Bandar Pulau sub-district, Asahan district	Oil plam, rubber
		> 10 km	Merjanji Aceh	Aek Songsongan sub-district, Asahan district	Oil palm, rubber
		> 10 km	Silau Padang	Sipispis sub-district, Serdang Berdagai district	Rubber

2.2 Multidisciplinary Landscape Analysis (MLA)

Multidisciplinary Landscape Analysis is an approach used to understand local people's perspectives of their surrounding landscape. Information is collected through multidisciplinary and collaborative methods, primarily related to environmental impact and local people's perspectives (Sheil *et al.*, 2002).The MLA was adapted to highlight the values and preferences of local people in the context of biodiversity and its utilisation. Whilst MLA was designed to explore forest values as a core of assessment and other land uses as complementary, we treated landscape as a continuum and positioned community in the centre of the system.

Perception of the local community was assessed through focus group discussion (FGD). Two groups, differentiated by men and women with 3-11 people in each group. Every groups discussed on the value of land-use and function of flora and fauna diversity. Weight ranking or pebble distribution methods were employed as practical methods to assess the importance of biodiversity for the people in each village. While doing the ranking, discussions with participants were also captured, in particular, to obtain more information about valuable plants and animals.

3. RESULTS AND DISCUSSION

3.1. Classification and Value of Land-use Types

During discussions with farmers, questions about land-use values referred to the use and importance of the land in people's lives, while questions on biodiversity values referred to the importance of a high of variety species in each land-use system. Knowing the value or the

importance of land use and biodiversity was important for understanding people's preferences and priorities (Sheil *et al.,* 2002).

Land-use classification in this study was defined based on local people's perspectives. People were asked for the main land-use system in their village and surrounding areas. The classification and availability of each land use in each village are illustrated in Table 2. The majority mentioned the productive and economically important land uses, while fallow and shrubs land were not mentioned in the discussion, since the land was not high value and was considered unused.

Smallholder rubber and oil palm were the main sources of livelihoods in almost every village, since the two systems were important as cash income source. Smallholder rubber plots appeared as monoculture plantation as well as agroforestry systems with some important timber trees or fruit trees and shrubs.

Smallholder rubber agroforests and home gardens existed in each village. Home gardens were perceived as the plot surrounding the house, used for basic needs. The gardens consisted of some fruit trees, light timber trees, flowers and sometimes rubber trees. Smallholder rubber agroforests were usually somewhat further from the house and consisted of some economically important trees such as rubber combined with fruit trees. Rubber monoculture plots were also common within the surveyed villages; they occurred surrounding houses and also far from settlements. Forest was defined as dense vegetation that grow naturally, multi-strata, of different ages with a multilayer canopy. It may occur beside rivers, called riparian forest. All farmers perceived that rubber agroforest was the most important land use, as it could provide sources of income, food and environment values (Figure 2). The second important land use was smallholder oil palm, followed by smallholder rubber monoculture, as the main cash income for the household.

Table 2: Land use and its availability in each cluster

Land use type	Cluster 1	Cluster 2	Cluster 3
Rice field		√	
Dry rice field	√	√	√
Home garden	√	√	√
Smallholder oil palm		√	√
Oil palm estate		√	
Smallholder rubber monoculture		√	√
Rubber monoculture estate	√	√	√
Rubber agroforest	√	√	√
Forest			√

Each cluster, however, showed different description of land-use value, as shown in Figure 3. Rubber agroforest was most prioritized in Cluster 1, on the other hand, it was less prioritized in Cluster 2. The value of rubber agroforest in Batu Silangit village (Cluster 1) was very high, since they cultivated rubber within their systems. Batu Silangit was an enclave village and most

people who lived there had a close relationship with the rubber plantation, however, interestingly, they preferred to cultivate rubber trees in mixed systems. The main reason for this was limited land ownership: on average, farmers had 0.5–2 ha. Therefore, they had to optimise the use of their plots, not only for income but also for subsistence needs, by planting food and fruit trees and other useful trees.

In Cluster 2, which consisted of Naga Raja and Aek Bamban villages, the highest value land use was smallholder oil palm followed by irrigated paddy field. Previously, in Aek Bamban village, cultivation of irrigated paddy rice and rubber played a leading role in the village's livelihood. Currently, paddy rice farming is slowly vanishing owing to erratic water supply for irrigation. Most of the irrigated paddy lands have been converted to oil palm plantations, such as the two big private company oil palm plantations close to Aek Bamban village. Naga Raja village is located close to the BSRE, but river water flow in the area is influenced by a private oil palm plantation in Sipispis sub-district.

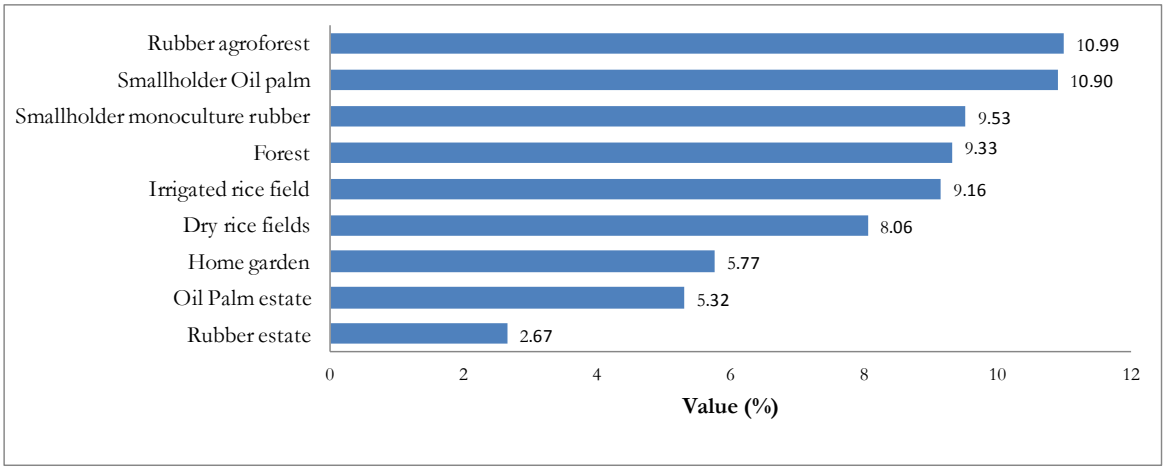

Figure 2: Farmers' descriptions of land-use value

Rubber and oil palm plots in Cluster 3 had the highest value, followed by smallholder oil palm plots and rubber agroforestry systems. Rubber had higher value than oil palm, but the difference was not significant.

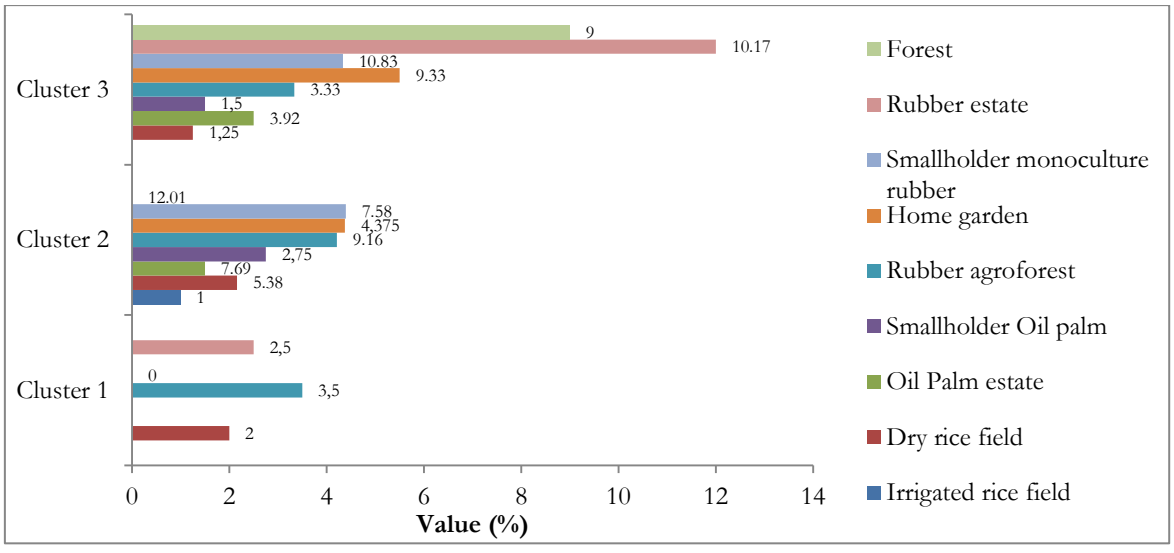

Figure 3: Farmers' descriptions of land-use value per cluster

3.2. Biodiversity Functions

Biodiversity provides ecosystem services, such as provisioning, regulating, cultural and supporting services (Pagiola *et al.*, 2004). Our study showed rural communities who have direct dependence on diverse local natural resources have various perceptions on the value of biodiversity. People's understanding of biodiversity was closely associated with livelihood patterns and social life, as biodiversity contributed to their daily needs, and related to their knowledge. Perceptions of different user groups (for example, farmers, hunters) varied and there was a noted difference depending on distance to natural resources, access to markets, etc.

Table 3: Functions of each land-use type relative to function of biodiversity

Row Labels	Forest	Home garden	Rubber agroforest	Rubber estate	Smallholder monoculture rubber	Oil palm estate	Smallholder oil palm	Irrigated rice field	Dry rice field
A. Direct functions:									
Source of income	High	High	High	Medium	High	Medium	High	High	High
Source of food	Medium	High	Low	No	Low	No	Low	High	High
Source of fuel wood	Low	Low	Low	High	Medium	Low	Low	No	Low
Raw material for house building	High	Low	Low	No	Low	Low	Low	No	Low
Material for handicraft	Medium	Low	Low	No	Low	Medium	Low	Low	Low
Medicinal plants	Medium	High	Low	No	Low	No	Low	Low	Medium
Raw material for tools	Low	No	Low	No	Low	No	Low	No	Low
B. Indirect functions:									
Grazing land or source of fodder	Low	Low	Low	High	Low	High	Low	Medium	Low
Animal habitat	High	No	Low	No	Low	No	Low	No	No
Erosion prevention	High	Low	Low	Low	Low	Low	Low	Low	Low

Note: High, Medium and Low indicated the diversity of plants and animals within each land-use systems

Table 3 shows the relational function of biodiversity in the different land-use systems. Forests were perceived as an important habitat for wild animals, such as monkey, snake, wild boar, bat, squirrel, civet cat, *trenggiling* (scaly anteater), reptiles, bear, peacock, deer, *kancil* (mouse deer), tiger, gibbon, hornbill, crow, magpie and parrot. Rubber agroforestry systems have medium-to-low value in terms of wild animal habitat, even though the systems are not significantly different from smallholder monoculture rubber and smallholder oil palm. The participants mentioned that wild boar, snake and bat were often found in the systems. Although local people during the scoring exercise consistently said other land uses were not important as animal habitat. They mentioned that they still found some bird species, bat, rat, snake, etc. Forests and rubber agroforestry performed the highest biodiversity value, followed by homegarden, dry rice field and smallholder monoculture rubber and irrigated paddy systems.

People also understood that forest had the highest function as erosion control, as these area are prone to soil erosion due to topography. Most villagers in each area mentioned this. All rubber plots under mixed and monoculture systems were perceived as good value in

preventing erosion, while oil palm plots were of relatively low value. Interestingly, in Cluster 3, in particular in Huta Rao village, farmers agreed that the use of the rubber estate for erosion control was good, as the village was in a mountainous area. They mentioned that rubber monoculture functioned as erosion control better than that of oil palm plantation. Oil palm expansion in this area was relatively high. The villagers mentioned some species as erosion control, such as bamboo, rattan, betel nut, mahogany, *Erythrina*, lemon grass, *Hibiscus* tree ('waru'), 'glagah' (a family of Cyperaceae) and 'jati putih' (*Gmelina). Hibiscus tiliaceus*, bamboo and *Gmelina* were good in preventing landslides and erosion in riparian areas.

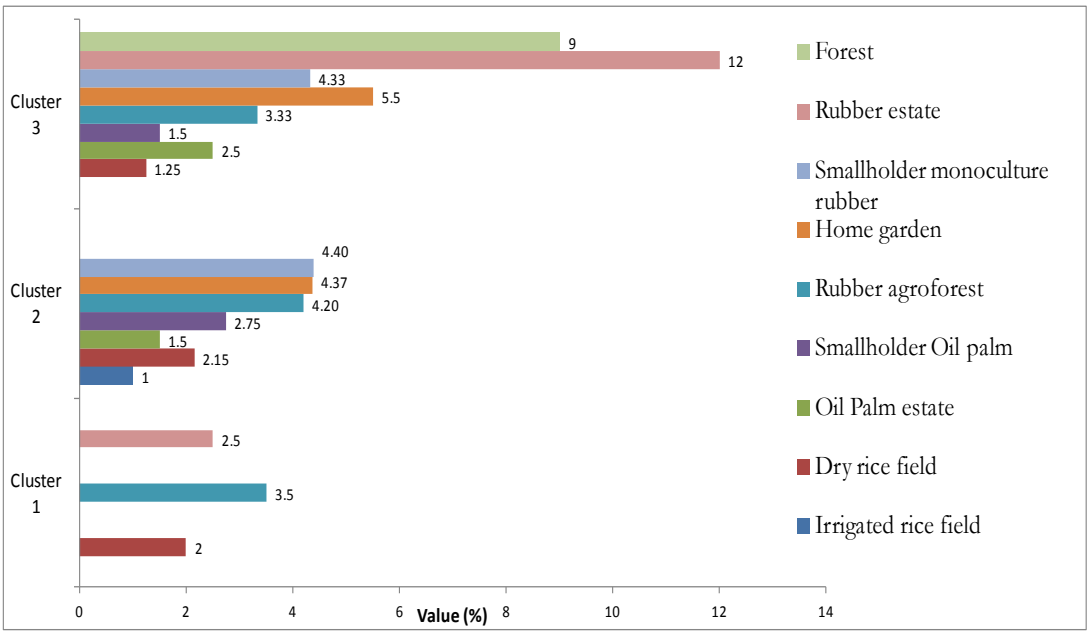

Figure 4: People perception on erosion function of each land use type

People usually used the rubber or oil palm plantations for grazing. 'Rumput paitan' (*Paspalum conjugatum*), 'rumput babi' (*Leptaspis urceolata*) and 'rumput putihan' (*Clibadium surinamense)*, that grew wild in the plots, were used as fodder, in particular, for cows and goats. Villagers also mentioned 'rumput gajah' (*Panicum maximum*). Actually, grazing was not allowed inside the plantation but because people didn't have other alternatives they still used the area since animal husbandry had become an important livelihood source. There was no alternative pasture nearby.

Rubber agroforests provided sources of raw materials for handicrafts and farming equipment for three groups of villages. Oil palm plots remained important for handicrafts as they could provide palm midribs for brooms, in particular, in Aek Bamban village. Old trunks oil palm can be used as handles for machete and plaited leaves can be used as house walls. Irrigated and dry paddy areas were important for grass that could be used for floor mats. Villagers also used leaves of palm sugar (*Arenga pinnata*) for brooms and raw material for roofs.

Connection of biodiversity and health is multifaceted, intrinsic and dynamics. Agroforest system provide biodiversity with some of the diversity is valuable for medicine and nutrition (Heywood 2013). Our study showed, home gardens, dry rice fields and rubber agroforests were three important land-use systems for medicinal plants. Naga Raja village was one step ahead of other villages as there was a demonstration plot at the village office for many kinds of medicinal plants. The main species that were used as medicine were ginger (*Zingiber officinale* Rosc.), turmeric ('kunyit'; *Curcuma domestica* Val.), java turmeric ('temulawak'; *Curcuma*

xanthorriza Roxb.), 'lempuyang' (*Zingiber* spp.), 'laos' (galangal; *Alpinia galangal*), 'bengle' (*Zingiber cassumunar*), sand ginger ('kencur'; *Kaemferia galangal*), 'jeringo', 'payang' (*Mangifera* ***payang),*** betel nut ('pinang'; *Areca catechu*), 'andi lotung', sugar palm ('aren'; *Arenga pinnata*), 'pasak bumi' (*Eurycoma longifolia*), bark of 'maibung' (*Millettia atropurpurea*), leaves of 'jarak' (*Ricinus communis* Linn.), 'bunga raya' (*Hibiscus rosa sinensis*), 'setawar' leaves (*Costus speciosus)*, 'kelundang' root, 'kulit manis' (*Cinnamomum* sp.) and 'sambiloto' (*Andrographis paniculata*).

Raw materials for housing and construction, such as timber, mainly came from the forest. However, poor families used palm midribs and leaves as house walls. Therefore, oil palm plots have become an important source of building materials. Home gardens and rubber agroforests were also important land uses as source of raw materials for building in every cluster of villages. The main species for constructions were meranti (*Shorea* sp.), durian (*Durio zibbetinus*), coconut tree (*Cocos nucifera*), white teak (*Gmelina arborea*), 'rambai' (*Baccaurea motleyana*), mangosteen (*Garcinia mangostana* L.), stinky bean (*Archidendron jiringa*), Indian devil tree (*Alstonia scholaris*), paraserianthes (***Paraserienthes*** *falcataria*), candle nut (*Aleuritus moluccana*), jackfruit (*Artocarpus integra*), 'kayu losa', mahogany (*Swietenia macrophylla*), 'dadap' (*Erythrina variegate*), 'kayu raja' (*Endospermum* sp.), 'kayu laban' (*Vitex* sp.), 'kayu johar' (*Senna* sp.), and 'cempedak' (*Artocarpus champedan*).

Traditional agricultural landscape that leads to maintenance diversity crops in a landscape can provide 20% of world medicinal and food crops (Heywood 2013). In the study sites of North Sumatera, irrigated paddy and croplands were very important land uses for food production. Home gardens, followed by rubber agroforests, were tree-based land-use systems that were also important for food production. In some villages, smallholder oil palm was important as a food source, because some villagers occasionally consumed oil palm tubers and shoots (edible topmost frond). The main species known as important food sources were durian (*D. zibbetinus*), champedan (*Artocarpus integer*), 'bedaro' (*Canarium littorale*), 'duku' (*Lansium domesticum*), *Parkia speciosa*, stinky bean (*A. jiringa*), 'kabau' (*Pithecelobium lobatum*), rambutan (*Nephelium lappaceum*), *B. motleyana*, 'langsat' (*Lansium* sp.). Most of the plants were not deliberately planted, but they mostly naturally grow. The trees were not maintained with fertiliser or insecticide applications.

People in the surveyed villages mostly used fuel wood for cooking (70–80% of participants). Rubber wood was the main source of fuel wood since it can be easily found in local rubber plots as well as in rubber plantations nearby. The villagers collected fallen branches or dead trees. In the villages near to rubber plantations, residents preferred to collect fuel wood from the plantations. Rubber agroforests were also important as sources of fuel wood because they contained some important fuel wood species such as *P. speciosa*, *A. jiringa*, candle nut (*A. moluccana)*, rambutan *(N. lappaceum)*, cocoa *(Theobroma cacao)* and *Syzigium* sp.

Most of the land uses functioned as sources of income; some tree species grown in the plots produced marketable products, which could be sold for cash. Table 3 shows that the estate plantation plots provided little value as income sources because villagers had no access for profit-making ventures. The most important source of income was from smallholder oil palm plots followed by smallholder rubber monoculture plots. Smallholder oil palm and monoculture rubber provided the highest values as sources of income, contributing the highest proportion of household income. Other important saleable products came from dry rice fields, rubber agroforests and home gardens, derived from durian, 'jengkol', 'petai', banana and cocoa. Forest also considered high in terms of income source, as it could provide timber. Mahogany and teak are the main timber products from the forest area. Eventhough extraction of timber from the forest area is not formally allowed, some of them were still produce. A list of useful plants and animals in each land use type is shown in Table 4.

4. CONCLUSIONS

This study revealed some local knowledge of biodiversity issues. People's perceptions on biodiversity were mostly based on direct use values which related to their daily life. People usually only focussed on phenotype characteristics or observable qualities, such as source of food and income. Rubber and oil palm were the most important species as source of income for the local communities. Fruit trees, such as petai (*P. speciosa*), jengkol *(A. pauciflorum),* and durian (*D. zibethinus*) were the most important species as source of food.

Home gardens and rubber agroforests remained important as sources of particular livelihoods for people in the three groups of villages. The two land uses had high values for subsistence and marketing purposes, which was expressed in every discussion.

Table 4: List of valuable plants and animals in each land use type

Functions	Smallholder oil palm	Rubber agroforest	Irrigated paddy field	Dry rice field	Homegarden	Rubber monoculture
Animal	Bat, snake perkutut/ turtledove *(Geopelia* sp.*)* *quail (*puyuh/ gemek*), squirrel*	*Bat,* perkutut/ *turtledove (Geopelia* sp.*),* squirrel monkey, wild boar, snake	Keong *(Pomacea canaliculata Lamarck),* rat *(Rattus argentiventer),* jangkrik *(*cricket*; Gryllus* sp.*),* wereng *(Nilaparvata lugens),* kepinding *(Scotinophora coarctata),* walang sangit *(Leptocorisa acuta)*	Wild pig (*Sus scrofa),* monkey snake, squirrel	Rat, jangkrik (cricket; Gryllus sp) centipede (kelabang) scorpion, chicken duck,	Bat, wild boar, snake squirrel
Food		Petai (*Parkia speciosa*) jengkol (*Archidendron pauciflorum*), durian (*Durio zibhetinus*) Candle nut (*Aleuritus moluccana*)	Paddy, soy bean	Maize, eggplant, cassava, banana, long bean, petai, jengkol (*Archidendron pauciflorum*), chilli, candle nut (*Aleuritus moluccana*), sweet potato, taro (caladium)	Banana, rubber, rambutan (*Nephelium* sp.) jambu air (*Eugenia aquea* Burm), jambu klutuk *(Syzigium* sp.), papaya	
Fuel wood	Oil palm fruit	Rubber, jengkol, petai	-	Petai, jengkol, candle nut *(Aleuritus moluccana)*	Rambutan (*Nephelium lappaceum),*Cocoa (*Theobroma cacao),*Jambu *(Syzigium* sp.)	Rubber
Source of income		Rubber (sap and wood), durian (fruit and wood), jengkol (fruit and wood), petai, candle nut	Paddy, soy bean	Durian, jengkol, petai	Cocoa, jambu air, rambutan, jambu klutuk	Rubber: latex, wood and fruit for seed
Construction	*Palm midrib for traditional house walls*	Durian, petai (Parkia speciosa), jengkol (Archidendron pauciflorum) mahogany, teak	-	Jengkol,Candle nut, *Durian*	Rumput paitan	Rumput paitan, rumput gajah
Medicinal plants	-	Sirih, candle nut, Rumput artisan , Suwawa *(*rumput tai babi)	Daun ekor anjung (scientific name unknown), Tapu arang (scientific name unknown)	Andi lotung (white flower) (scientific name not known) jeruk purut *(*Citrus aurantifolia*)*	Ginger, kencur, kunyit, lengkuas, bengle, jeringo sirih *(*Piper betle*),* sereh *(Cymbopogon winterianus*), kembang sepatu/daun bunga raya *(Hibiscus rosa-sinensis*),pinang *(Areca catechu)*	Sirih, sambiloto *(Andrographis paniculata),* ciplukan *(Physallisa angulata*)
Fodder	Gelagah *(Sacharum spontaneum)*	Gelagah *(Sacharum spontaneum)*	Gelagah *(Sacharum spontaneum)*	Gelagah *(Sacharum spontaneum)*	-	Rumput Markani Korok korok
Handicraft and tools		*Arenga pinnata Durian,* jengkol, Rubber wood	Pandanus	Banana leaves *(Musa* sp.*),* Jengkol wood, candle nut, durian wood		-
Erosion prevention		Pinang *(Areca catechu),* bamboo, rumbia *(Metroxylon* sp.*),* waru *(Hibiscus tiliaceus)*		Rattan, bamboo Pinang	Waru *(Hibiscus tiliaceus)* Rambutan, jambu Legumes	Bamboo, pinang

Oil palm and rubber plantations where grasses were abundant for fodder played a role as grazing areas. These areas held potential for greater production of livestock but, on the other hand, could cause some problems for the main commodity production of the estate companies. Extension services and community development are necessary to improve the awareness of villagers in livestock management, for example, building a cattle pen and introducing compost processing of cattle dung for manure, and bio-gas. These approaches could create a win-win solution beneficial for both the company and local people.

5. ACKNOWLEDGEMENTS

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