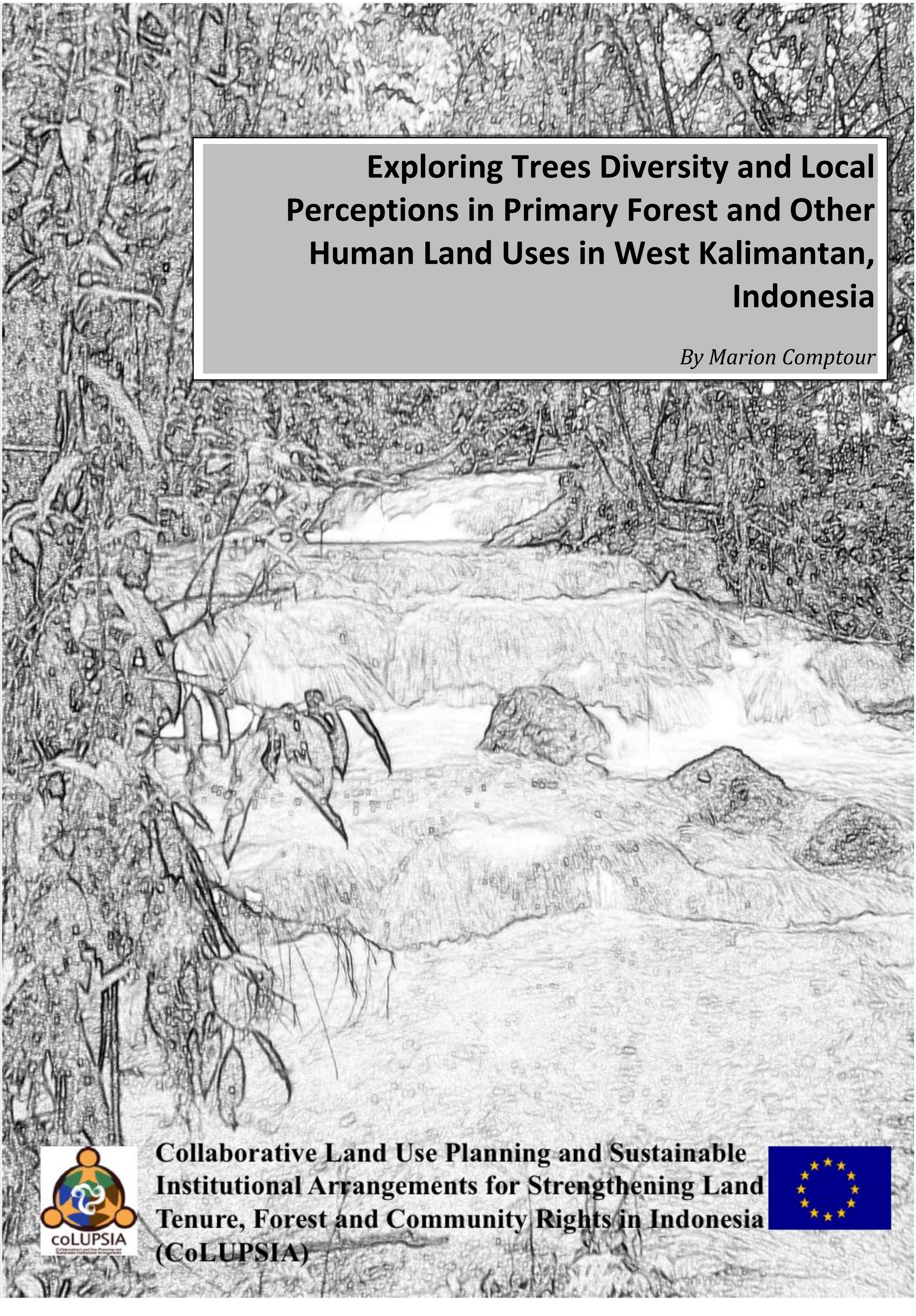

Exploring Trees Diversity and Local Perceptions in Primary Forest and Other Human Land Uses in West Kalimantan, Indonesia

By Marion Comptour

Collaborative Land Use Planning and Sustainable Institutional Arrangements for Strengthening Land Tenure, Forest and Community Rights in Indonesia (CoLUPSIA)

ABSTRACT

As Indonesia is facing a high rate of deforestation, an increasing attention is now being placed on other tree-based land uses that may play an important role in biodiversity conservation and sustaining local people livelihood.

In the framework of the COLUPSIA project, the vegetation structure (diameter, height) for trees over 5 cm dbh and the floristic composition of the four main land use types found in the area (Dipterocarp rainforest, logged-over forest, fallows and traditional rubber gardens) have been studied in the vicinity of an Iban village in Kapuas Hulu Regency, West Kalimantan. Comparisons of composition and structure have been made to estimate the conservation value of the land uses in term of biodiversity and habitat. At the same time, a study was also conducted to assess the perceptions of the villagers to these land uses using scoring exercises and free-lists.

As expected tree species richness and diversity decreased from primary forest to logged-over forest, fallows and rubber gardens. However the structure of old rubber gardens and even the floristic composition resemble the primary forest. For local people, rubber gardens are the most important land uses and are the first source of income.

In a context of globalization and fast changes, the land uses are likely to evolve. In the management of this landscape, local people should be more involved in decision making.

Keywords : Trees diversity. Conservation. Tropical forest. Human land uses. Local perceptions. Iban people. West Kalimantan.

RESUME

Le taux de déforestation élevé en Indonésie attire de plus en plus l'attention sur les autres types d'occupation des sols forestiers dans un but de conservation de la biodiversité. Ces terres boisées jouent également un rôle important pour les paysans locaux dépendants de leurs ressources. Dans le cadre du projet COLUPSIA, la diversité structurelle (diamètre et hauteur) et la composition floristique des arbres supérieurs ≥ 5 cms dbh dans les quatre principaux types d'occupation du sol forestiers présents à proximité d'un village Iban à Kalimantan Ouest (forêt primaire à Diptérocarpaceae, forêt après exploitation, jachères après agriculture sur brûlis et jardins d'hévéa) ont été étudiés et comparés. Une étude a également été conduite pour estimer les perceptions des villageois de ces terres en utilisant des exercices de notation et des listes libres.

La richesse spécifique et la diversité des arbres diminuent graduellement de la forêt primaire à la forêt après exploitation, les jachères et les jardins d'hévéa. Cependant la structure et la composition floristique des jardins d'hévéa sont les plus proches de la forêt primaire. Pour les villageois, les jardins d'hévéa sont les plus importants des terres boisées et constituent la principale source de revenus.

Dans un contexte de mondialisation et de changement rapides, ces types d'occupation du sol sont susceptibles d'évoluer. Les villageois devraient être plus impliqués dans les prises de décision de conservation de la biodiversité.

Mots clés : Biodiversité. Conservation. Forêts tropicales. Ecosystèmes anthropisés. Perceptions locales. Iban. Kalimantan ouest.

La question [...] n’est pas de savoir si la conservation de la biodiversité, y compris les aires protégées, doit être accrue. Elle doit l’être, et elle le sera. Il ne s’agit pas non plus de décider si les moyens de subsistance et les droits des personnes doivent être préservés et améliorés. Il faut qu’ils le soient. Encore moins faut-il se demander si ces deux considérations sont étroitement liées. Elles le sont. Les solutions aux dilemmes posés par la protection simultanée de la biodiversité et de la subsistance ne concernent pas les «si», mais les «comment». C’est l’efficacité des moyens qui est en question.

Michael M. Cernea et Kai Schmidt-Soltau. 2003.

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ACRONYMS

CIFOR: Centre international for forestry research

CIRAD : Centre international de recherche agronomique pour le développement

COLUPSIA: Collaborative Land Use Planning and Sustainable Institutional Arrangements

Dbh: Diameter at breast height

FAO: Food and Agriculture Organization of the United Nations

IUCN: International Union for Conservation of Nature and Natural Resources

Land use: component of landscape that is covered by natural coverage or used for human activities

MLA: Multidisciplinary landscape assessment

PDM: Pebbles distribution method

PES: Payment for ecosystem services

I. Introduction

A. Tropical forests in Indonesia

1. Generalities

It is of general agreement that tropical forests are important hotspots of biodiversity with high levels of endemism and offer habitats for many endangered species (Myers et al., 2000, Mittermeier et al., 1998). They supply ecosystem services[1] of numerous sorts (Myers, 2007, Cramer et al., 2004) and are particularly important to populations who rely on natural resources for their livelihood.

Indonesia is one of the most biodiversity-rich nations in the world and accounts for nearly 10% of the world's remaining tropical forest (Kinnaird et al., 2003). The rain forests of Indonesia are also known as the "mixed dipterocarps forests" due to the dominance of the Dipterocarpaceae family in the lowlands (Whitmore 1984), and this family of trees plays an important role in the ecological, economical and social aspects of the country (Bawa, 1998, Maury-Lechon et al., 1998). The lowland dipterocarp forests are one of the most species-rich in the world, with between 200 and 300 tree species.ha^{-1} (Ashton 1989, Laumonier, 1997, Okuda et al., 2003, Whitmore, 1984).

2. Deforestation and conversion in other land uses

Indonesia has been facing a very high rate of deforestation[2], losing 25% of forests area from 1990 to 2005 according to the FAO, 2005 (Table 1). In Kalimantan (Figure 1), where the study has been conducted, the annual deforestation rate between 1985 and 1997 was 2,1 % , so approximately three times greater than the rate reported for Southeast Asia as a whole (Fuller et al., 2004) (Figure 2).

This is mainly due to the conversion of large areas to agriculture, especially large scale estates for oil palm and rubber plantations (Ichikawa, 2007), to legal and illegal logging (the high commercial value of Kalimantan's lowland dipterocarps forests has attracted significant investment in capital-intensive logging (Fuller et al., 2004, Curran et al., 2004)), transmigration[3] (Fearnside, 1997), and major forest fires during El Nino episodes (Ihalainen, 2007).

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[1] The Millennium Ecosystem Assessment 2005 identifies 4 types of ecosystem services : provisioning services (food, water, timber, fiber); regulating services (regulation of climate, floods, disease, wastes and water quality); cultural services (recreation, aesthetic enjoyment, spiritual fulfillment), and supporting services (soil formation, photosynthesis…)

[2] The FAO (1998) defines deforestation as a change of land cover with depletion of tree crown cover to less than 10 percent.

[3] Transmigration is Indonesia's program of transporting millions of people from the overcrowded islands of Java, Madura, Bali, and Lombok to settlement areas in the outer islands of Sumatra, Kalimantan, or Sulawesi.

FRA 2005 categories	Area (1000 hectares)		
	1990	2000	2005
Forest	116,567	97,852	88,495
Other wooded land	-	-	-
Forest and other wooded land	**116,567**	**97,852**	**88,495**
Other land	64,590	83,305	92,662
...of which with tree cover	7,857	9,051	9,648
Total land area	**181,157**	**181,157**	**181,157**

Table 1. Extent of forest and other wooded land in Indonesia from 1990 to 2005.
Source: FAO, Global Forest Resources Assessment 2005

Figure 1. Kalimantan and Kapuas Hulu regency
Source : Luisiana et al., 2008

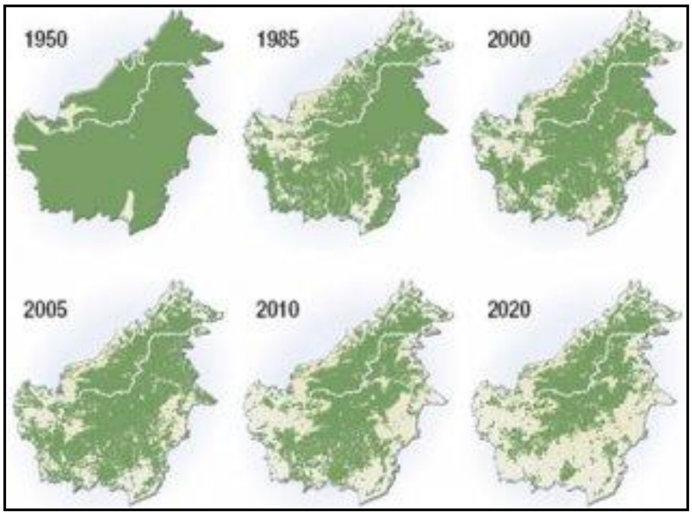

Figure 2. Forest cover in Borneo.
Source : krapooarboricole.wordpress.com

This high rate of deforestation and land use change could have many consequences: it could play a role in changing the global carbon cycle and, possibly, affect the global and regional climates (Foley et al., 2005). It also causes declines in biodiversity through the loss, modification, and fragmentation of habitats and the degradation of soil and water. In Kalimantan, these land use changes may result in a number of species extinctions, not only flagship species such as orang-utan (Pongo *pygmaeus*), gibbon (Hylobates *spp*), and leaf monkey (Presbytis *spp*.), which are on the IUCN red list, but also a myriad of other animals and plants. Deforestation and land degradation also threats the livelihoods of the smallholder farmers in Kalimantan (Ihalainen, 2007).

B. The COLUPSIA project

In this context, the CIRAD (Centre International de Recherche Agronomique pour le Developpement) is conducting an European Commission funded project called Collaborative Land Use Planning and Sustainable Institutional Arrangements (COLUPSIA) for strengthening land tenure, forest and community rights in Indonesia since April 2010. The overall objective of this project is to avoid deforestation and environmental degradation by supporting the development of sustainable institutional arrangements promoting land policies and instruments involving local communities. Payment for environmental services (PES) may be implemented later on. The project is conducted in partnership with the CIFOR (Centre International for Forestry Research) and other partners.

C. My study within the project

Facing deforestation and population growth, it seems imperative to know how development and biodiversity conservation may be reconciled. An increasing attention is now being placed on logged-over forests and other land uses such as traditional agroforestry systems to play an important role in biodiversity conservation (Gradstein et al., 2007, de Jong, 1997, Ichikawa, 2007, Foley et al., 2005, Brearley et al., 2004). They can serve as a habitat for forest plants and animals displaced from primary forest which has been destroyed (Beukema et al., 2007, Brearley et al., 2004, Lawrence, 1996) and contribute to local people livelihood.

1. Contribution of land uses in biodiversity conservation

Many studies have been conducted on the value of human land uses for biodiversity conservation, but the current knowledge is still limited and some results are contradictory. Some ongoing debates are presented in this paragraph.

Logged over forest

In all Southeast Asia, governments have promoted commercial logging (Ichikawa, 2007, de Jong, 1997) and selective logging[4] is the preferred approach for commercial timber production (Gustafsson et al., 2007, Bischoff et al., 2005, Okuda et al., 2003). In Indonesia, according to a report in 2006 of The Ministry of Forestry of Indonesia (Gustafsson et al., 2007), the area of production forest[5] covered 59.2 million ha and considering this large area these forests could play a great role in biodiversity conservation.

In order to reduce the impact of logging on biodiversity, many studies have been led and many organizations (FAO, International Tropical Timber Organization ITTO, Forest Stewardship Council FSC, Indonesia Ecolabelling Institute LEI…) have developed tools and proposed recommendations for a sustainable forest management in Indonesia (Gustafsson et al, 2007). However, the effects of commercial logging on the forest structure and on trees diversity are still insufficiently known. Structural damages after selective logging are recognized by Cannon (1998) while Bischoff et al. (2005) and Okuda et al. (2003) showed that the stems densities and basal area in primary forest and in logged forest are similar. Bischoff et al. (2005) found the same number of species in logged forest than in primary forest while Cannon et al. (1998) and Okuda et al. (2003) showed that species richness is affected by logging and that the trees composition differs greatly. They found more pioneer species in logged forest.

Fallows

Fallows are old swiddens that are either promised to be seeded again or that are abandoned. Swidden cultivation[6] is often considered as one of the main cause of deforestation,

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[4] In the Indonesian Selective Logging and Planting System (Tebang Pilih dan Tanam Indonesia, TPTI) established in 1993, all trees with a dbh greater than 50 cm (Production Forests) or 60 cm (Limited Production Forests) may be felled. The system is based on a fixed 35-year felling cycle (Gustafsson et al., 2007).

[5] Production forest refers to state forestland designated for production purposes (FAO, 2010).

[6] Swidden cultivation, also known as “shifting” or “slash-and-burn” cultivation is referring to established, integral swiddening, were, following the definition of Conklin (1961) , the fields are reused cyclically and the cultivation period is shorter than the fallow period.

biodiversity loss and ecosystem degradation in tropical countries and governments all over South East Asia have tried to ban it (Ducourtieux, 2006, Lawrence, 1998, De Jong, 1997, De Koninck et al., 199, Dufumier, 1996).

Numerous studies have been conducted on the effects of this cultivation system and many have shown that shifting cultivation could be a sustainable method to preserve biodiversity within the fallows (Ichikawa, 2007, Ducourtieux, 2006). However the effects of swidden cultivation on structure and composition and the recovery of fallows are still on debate and are dependent on many factors such as the distance from the forest edges (Sovu et al., 2009), the prior cultivation intensity and the prior species cultivated (Fukushima et al., 2008) or the influence of animals as seed dispersers (Wangpakapattanawong et al., 2010).

Sovu et al. (2009) found that trees density and basal area are lower in fallows than in primary forest and that the basal area tends to increase while stem density tends to decrease with the age. Brearley et al. (2004) showed that the structure of a 55 years old secondary forest has a close resemblance with primary forest. Wangpakapattanawong et al. (2010) found that trees diversity in 6 years old fallow is higher than in adjacent primary forest but Brearley et al. (2004) found that trees diversity in a 55 years old fallow is lower with major floristic differences. Sovu et al. (2009) conclude that species richness and diversity remained insensitive with fallow age.

Rubber gardens

Besides large rubber estates, rubber tree (*Hevea brasiliensis*) is the most widespread smallholder tree crop in South-East Asia (de Jong, 2001, Dove, 1993). According to many studies, traditional rubber gardens could play an important role in biological diversity conservation (Beukema et al., 2007, Lawrence, 1996, Michon et al., 1999, de Jong, 2001). Marjokorpi et al. (2003) affirm that the structure and function of smallholder agroforests resemble those of mature natural forest. Rubber gardens can also provide multiple types of environmental services and ensure farmer livelihoods as rubber tapping, as well as the secondary products of rubber gardens, are important sources of income (Ekadinata et al., 2011, Lehébel-péron, 2011, de Jong, 2001, Dove, 1993). However other trees diversity may limit the productivity of rubber trees (Lawrence, 1996) and traditional rubber gardens tend to evolve to more intensive and permanent cropping systems (Feintrenie et al., 2010, Sodhi et al., 2010, Michon et al., 2007).

2. Indigeneous knowledge

Worldwide, local communities living in proximity of tropical forest have a deep knowledge on the forest resources for food, medicines (Caniago et al., 1998) and other uses (Sheil et al., 2006). In Borneo, local people actively manage their resources through forest sacred areas (Wadley et al., 2004) and enriched fallows and gardens (Mulyoutami, 2009).

There is already long recognition that indigenous knowledge are a key to sustainable development and that local environmental knowledge should be an important basis for a sustainable natural resource management in many developing countries (Mulyoutami et al., 2009, Boissiere et al., 2006, Wadley et al., 1997, CBD, 1992, Basuki et al., 2005).

Iban people knowledge in biodiversity conservation

The Iban have a deep knowledge of the forest and the natural resources and are explicitly aware that their actions and practices have consequences for their descendants (Wadley et al., 1997). Sacred areas (sites of human death or burial and sites claimed to be inhabited by nonhuman spirits) are preserved forest found in Iban landscape that play an important role in providing food resources and hosting some type of wildlife for local people. It can also enhance larger conservation goals (Wadley et al., 2004).

3. Aims of the study

The previous studies showed that the effects of human uses on the primary forest cannot be generalized. For possible implementation of payment for ecosystem services in the studied area later on, it is important for the project to assess the current condition of primary forest and to know how different land use types compare with primary forests in terms of species richness, species similarity, structure, and of the ecosystem services they provide for the local people. Improved knowledge of what is important to local people is mandatory to incorporate indigenous knowledge in decision making for a sustainable forest management.

To that purpose, the trees diversity in different human land uses will be measured and structure and composition will be compared with primary forest. Secondly, a study will be conducted on the perception of local communities of the land uses and their importance for their livelihood. Local knowledge of the environment and important species for people will be compiled.

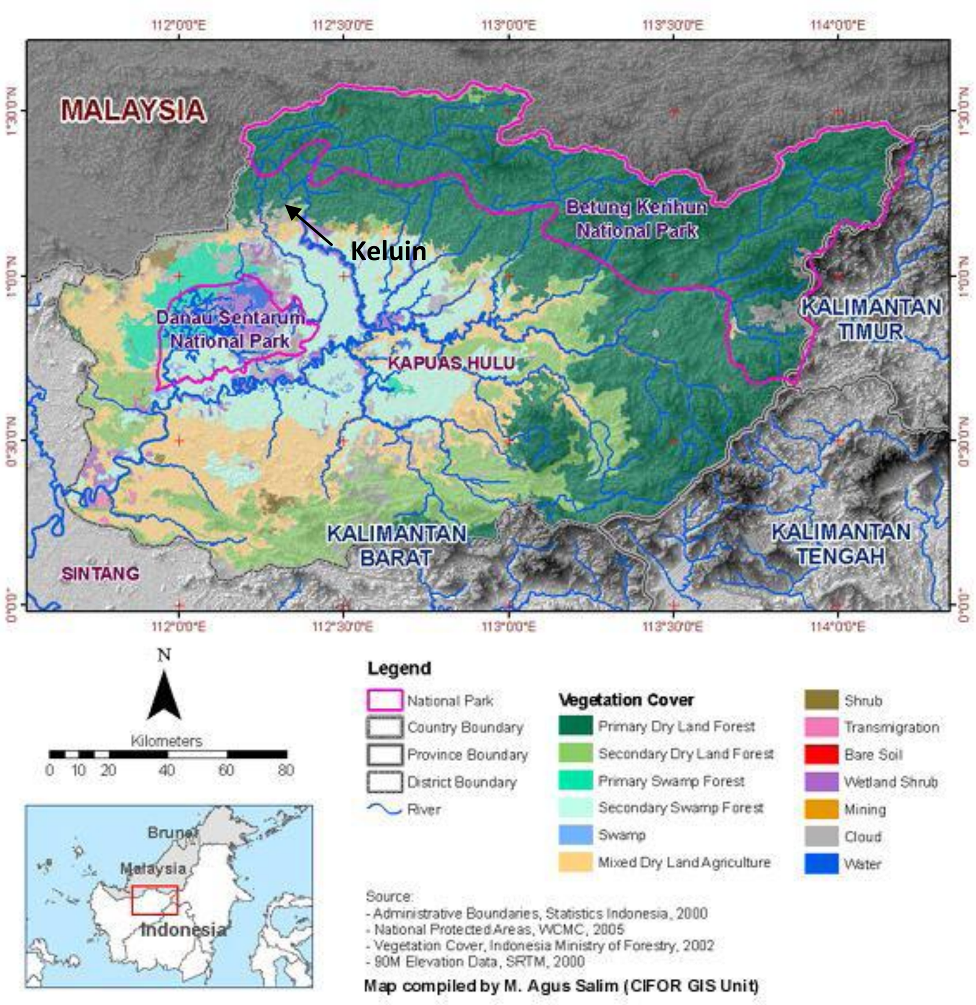


Figure 3. Location and bio-physical condition of Kapuas Hulu area.
Source: COLUPSIA project

Land uses	Indonesian name	Iban name	Explanation
Primary forest	Hutan primar / Hutan yang belum ditebang	Babas	Lowland dipterocarp forest with traditional uses only : selective collect of trees and plants, hunting
Logged over forest	Hutan logging/ Hutan yang sudah ditebang		Forest logged by a malaysian company from 1997 to 2005
Fallows	Belukar/Bekas ladang	Damon (young fallows)/Pengerang (fallows over 30 yrs old)	Secondary regrowth forest after shifting cultivation.
Rubber gardens	Kebun karet	Kebun geta	Smallholders rubber trees gardens

Table 2. Land uses studied.

II. Material and methods

The village where the study has been conducted is an Iban Dayak[7] village named Keluin, located in the regency of Kapuas Hulu, West Kalimantan (Figure 3). In Iban territories, there are two main ways in which primary forest is converted into secondary forest: commercial log production and swidden cultivation. Along with swidden agriculture, hunting and forest products gatherering, Iban people also practice traditional agroforestry as rubber agroforestry (Clerc, 2010, Ichikawa, 2007, Wadley et al., 1997, Lawrence, 1996).

Four land uses have been selected for my study in order to compare the tree diversity and the services they provide: primary forest, logged over forest, fallows and rubber gardens. (Table 2)

A. Location of the study area

1. Kapuas Hulu regency

Kapuas Hulu regency is situated in West Kalimantan (Kalimantan Barat), an Indonesian Province on the island of Borneo. The floodplain is mainly composed by seasonal lakes, freshwater swamp forests and peat swamp forests whereas upper areas are covered with lowland rainforest, dominated by species of the Dipterocarpaceae family (Wadley et al., 2004). The climate of the region is classified as moist tropical rainforest climate with a "wet" monsoon (November-April) and a "dry" monsoon (May-October). Daytime temperatures are consistently 26-30 degrees Celsius and the average annual precipitation is over 3000 mm/year (Fontanel and Chantefort, 1978). Kapuas Hulu regency covers 29 842 km^2 and has an average density of 7,5 persons/km^2 with a total of 222 893 inhabitants (http://regionalinvestment.com). It's the least populated regency in West Kalimantan, with 94% of the population living in rural areas. The poverty index is the highest of West Kalimantan province and very high in comparison with national level figure (Clerc, 2010). The main regency revenues are timber, agriculture, and fish. Kapuas Hulu is bordered by Sarawak, Malaysia in the north, which encouraged cross border illegal trade and illegal logging in the past (Wilkie et al., 2004). The regency is also peculiar in harboring two national park, Betung Kerihun National park in the hills and Danau Sentarum National Park in the wetlands.

[7] The Iban people are also called Iban Dayak, even if Dayak is a rather imprecise terms that covers many ethnic groups with their own distinctive language and cultures. This term is used to design christian people in opposition with the Malay that are muslim (Sellato B., 2002).

Photo 1. Keluin's long house
(M.Comptour)

Photo 2. Women group during the participatory mapping
(M.Comptour)

Photo 3. Map representing the different land uses, drawn by the men.
(M. Comptour)

Land type	Sampling area (ha)	Elevation (m)	Slope (°)
Primary forest	0,24	380- 400	26
Logged over forest	0, 24	350-380	35-45
Fallows/ secondary forest	0,24	90-120	20-50
Rubber gardens	0,24	80-130	5-35

Table 3. Characteristics of the plots

2. The village of Keluin and Iban people

The study has been conducted in the landscape surrounding the Iban Dayak village of Keluin (N 01°08.955’ E 112°15.612’). Keluin exists in its actual location since the 60’. The total registered population reaches 75 inhabitants, but the real population is much lower as most of the men work in Malaysia or in the nearest towns.

The Iban people are settled shifting cultivators living in communal longhouses in which many families of a clan live together (King, 1993) (Photo 1)

The soils near the village are mainly composed of Ultisols, Inceptisols and Entisols. The watershed directly affects the northern border of the swamps and the wetlands of Danau Santarum National Park.

B. Assessing trees diversity in the four land use types

1. Samples sites selection and sampling method

Participatory mapping

A participatory mapping has been conducted at the beginning of the survey in order to locate the different land uses around the village (Corbet, 2009, Mascarenhas, 1991). Two groups of discussion have been settled, men and women (Photo2). On transparent paper, base maps have been previously drawn representing the different villages around Keluin, the main rivers and the logging roads. It has then been asked to the villagers to draw on the map the streams, the swiddens, the fallows, the rubber gardens, the logged over forest and the primary forest. The age of fallows and rubber gardens have been added as well as the cemetery (Photo 3). These two maps have allowed to obtain basics information on the different land uses and to explain the main goal of my study. They have been a precious support when discussing of the selection of the sample sites with local informants (Appendix 1).

Field sampling

The pattern of plots of the four different land uses have been selected and adapted to represent as much as possible the range of variation in the local environment (Figure 4). Looking for homogeneity in the environmental conditions, plots have been selected as much as possible at similar elevation and when possible on similar slopes. A total of 0,24 ha have been sampled in every land uses (Table 3).

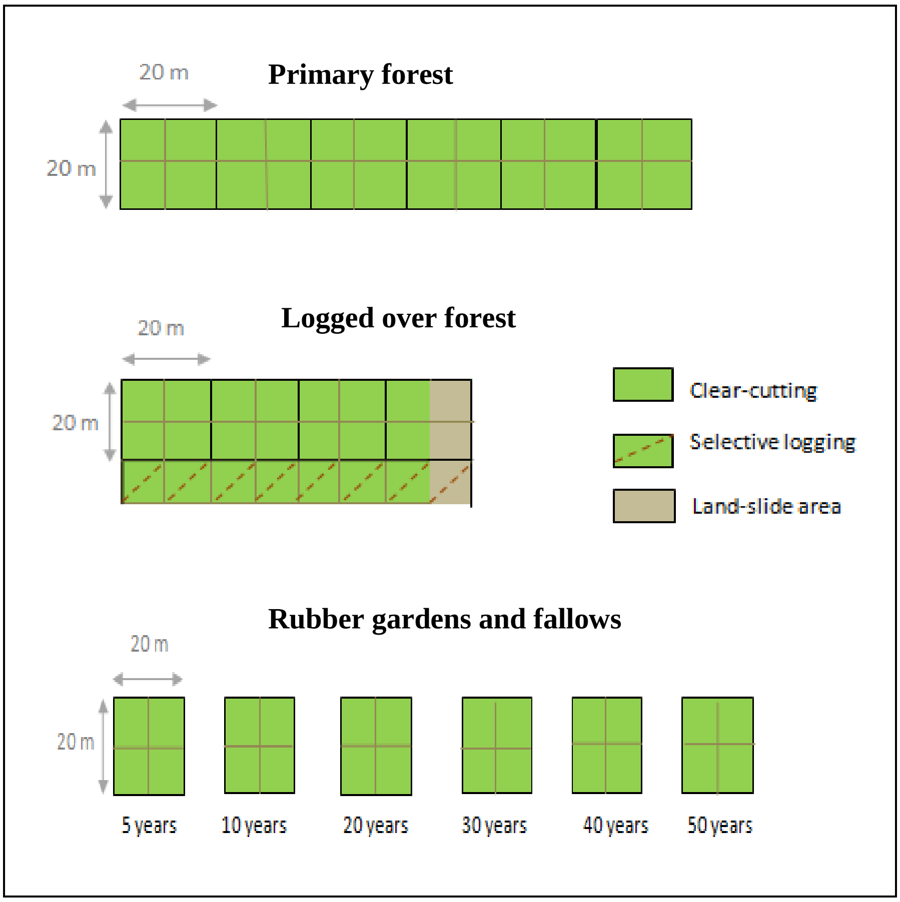


Figure 4. Design of sampling plots

Photo 4. Primary lowland dipterocarp forest.
M.Comptour

Photo 5. Logged over forest.
M. Comptour

Photo 6. Rubber gardens, 50 years old.
M. Comptour

Photo 7. Fallows, 40 years old
M. Comptour

The **primary forest** (Photo 4) where the plots have been settled is a lowland Dipterocarp Forest[8] situated near the border of Malaysia at 2 hours walk from the village of Keluin. This forest is affected by limited human disturbance such as hunting, extraction of rattan and occasional timber for local use. The elevation is 380- 400 m and the mean slope is of 26°. A plot of 120*20m has been settled following the contour line to avoid heterogeneity of soil composition.

The **logged over forest** (Photo 5) studied was further from the village and has been exploited by a Malaysian logging company from 1997 to 2005. The elevation is 350-380 and the slope is comprised between 35 and 45°. A plot of 80 m×30 m has been designed, the first 20m upper slope corresponding to clear cutting and in the 10 last meters down slope only selective logging occurred.

Sampling in **rubber gardens** (Photo 6) is complicated by the internal variability of this land use: rubber gardens landscape is a mosaic of small gardens of different ages, rubber tree densities and management intensities (Beukema et al., 2007, Lawrence, 1996). Because of this, the sampling strategy in the rubber gardens can not been the same than in the primary and secondary forests: a larger number of gardens plots has to be settled but each plot doesn't have to be as large as in primary and secondary forest. The selection of the studied gardens has been made on the age criteria: six plots of 20m*20m have been designed in gardens of 5, 10, 20, 30, 40 and 50 years old. The ages of the gardens have been given by the villagers and it has to be understood that they are approximate, with a difference of less or more 5 years.

The elevation was between 80m and 130 m and the slope ranges from 5° to 35°.

For **fallows and secondary forest** (Photo 7**)**, the plot design is similar with the rubber gardens. Plots of 20m*20m have been settled in fellows of 5, 10, 20, 30, 40 and 50 years old at the same distance from the forest edge to avoid the effect of the forest on the regeneration. The slope ranges from 20° to 50°and the elevation was comprised between 90 m and 120 m.

2. Collection of data

In each plot, the diameter at breast height (dbh) (measure at 1.3 m) of all trees over 5 cm diameter has been recorded. If presence of buttresses, the dbh were measured 30 cm above the top of the buttresses. The height of each tree has been estimated, vernacular name (Iban name)

[8] lowland forest refers to areas below 800 m above sea level, and does not include specific habitats like kerangas forest, swamp forest, coastal and mangrove forest .

Diversity index	Formula	Explanation
Species richness S		Number of species
Simpson diversity index 1- D	$D = \Sigma Ni(Ni-1)/N(N-1)$	Probability that two randomly selected individuals in the habitat will not belong to the same species. It ranges from 0 to 1 and the diversity is maximal when 1- D=1
Shannon Wiener index (H')	$H' = - \Sigma ((Ni / N) * \ln (Ni / N))$	Takes into account species richness and proportion of each species. It ranges from 0 to lnS and the species richness and evenness are maximal for H'=lnS.
Pielou Evenness index (J')	$J' = H'/ \ln S$	Quantifies how equal the community is numerically. The abundance of species are equal when J'=1

Table 4. Biodiversitv index

Ni : number of individuals of one species; N : total number of individuals; S : number of species per unit area

Relative density	(number of individuals of a taxon / total number of individuals)* 100
Relative dominance	(basal area of a taxon/ total basal area of the plot)*100
Important value index	(Relative density + Relative dominance) /2

Table 5. Relative density and relative dominance

has been recorded and voucher materials (leaves, flowers and fruits when possible) have been collected in 5 duplicates. All specimens have been conserved in alcohol before drying and brought to Bogor for identification.

3. Data analysis

The **compositional** diversity of the trees has first been evaluated by calculating and identifying the number of species (species richness), genus and family in the four land uses.

Tree species diversity in each plot has been quantified using the 3 indexes communally used in biodiversity assessment (Favrichon et al., 1998): Simpson dievsrity index (1- D), Shannon-Wiener index (H') and Pielou evenness index (J') (Table 4). The ten most abundant families in the four land uses have been identified and their relative density, relative dominance and their importance value index have been calculated (Sidiyasa, 2001) (Table 5). The most abundant species in the herbs and shrubs layers have also been recorded.

Euclidean distance (Kindt et al., 2005) has been calculated to assess the ecological distance between the land uses. It looks at the difference in species abundance and composition among the land uses and allows assessing which land use resemble the most with primary forest in term of composition. The distances have been calculated on the basis of the species and on genus.

In order to assess the effect of two types of logging and to assess the evolution of the trees composition in rubber gardens and fallows with the age, distinctions have been made:

- in logged over forest, between the 20 first meters upper slope where the forest has been cleared cut (total of 0,16 ha) and the last 10 meters where the logging company has proceed to selective logging (total of 0,08 ha). For comparisons the results have been converted and given for 0,12 ha.

- in fallows and rubber gardens, between the "young" plots aged from 5 to 20 years (total of 0,12ha) and the "old" plots from 30 to 50 years old (total of 0,12ha).

The **structural diversity** has been analyzed by comparing first the trees density (number of trees over 5cms dbh/ 0,24 ha) and the density of regenerating trees (trees between 5 and 10 cms dbh) in the land uses. However, the density alone is not a good indicator to assess the composition of a land use. Indeed, one land use can have many small trees and another one few bigger trees. The total basal area G (Favrichon et al., 1998) has thus been calculated in each land use using the following formula: Individual basal area $g = \pi(\frac{D}{2})^2$ with D the diameter of the tree and G= $\sum_{i=1}^{N} gi$ with N= number of individuals

<u>Photo 8</u>. Men and women groups during a scoring exercice
(M. Comptour)

<u>Photo 9</u>. Exemple of cards used for the PDM (M. Comptour)

The distribution of trees diameter and height in the land uses is represented by box plots and histograms constructed with the statistical software R.2.12.1. Comparisons of mean diameter and height between the land uses have been made using the kruskal wallis test and wilcoxon mann-whitney test with $\alpha = 5\%$. The H0 hypothesis considers the diameter and height of trees of the different land uses as homogeneous. All the calculations have been made with R.2.12.1 and Excel 2009.

Distinctions have also been made between clear cut forest and selectively logged forest and between young and old rubber gardens and fallows and the results are given for 0,12 ha.

C. Perception of the different land uses by the villagers

Two methods have been chosen to assess the local perceptions and the importance of the different land uses.

1. The Pebble Distribution Method

The Pebble Distribution Method (PDM) is a scoring exercise that allows getting quantitative results on preferences. It has been used in particular in the Multidisciplinary Landscape Assessment method (MLA) developed by CIFOR scientists to assess what is important to local communities in terms of landscape, environmental services, and resources (Colfer et al., 1999, Sheil et al., 2002, Boissière et al., 2006). People have to distribute pebbles among cards representing a landscape or a resource according to the importance they give to the card. The more a card gets pebbles the more this land use is important for the villagers. The quantitative data don't have to be taken as absolute; it only indicates the relative importance of a land use. As different villager's categories (sex, age) may have different points of view concerning the importance of the forest types, two groups of discussion separating men and women have been hold.

Overall and specific importance of the land uses

It has first been asked to the villagers to distribute 50 pebbles among cards representing five land uses (primary forest, logged over forest, old fellows, rubber gardens and swidden) given their importance[9] (Photos 8 and 9). Cards of different categories of use (basketry, food, marketable items, construction, medicine…) have then been showed and for each categories

[9] Importance is a relative judgment which should not be expressed as a list of prices and quantities. Thus, I avoided using words associated with prices like 'price' (*harga*), 'money' (*uang*), 'expensive' (*mahal*), 'cheap' (*murah*) but used words such as 'usefulness' (*manfaat*) and 'importance' (*penting*).

<u>Instruction 1.</u> Among the following land uses on these cards, which one do you think is the most important? Please distribute 50 pebbles among the cards to express the importance. ***Di antara tipe-tipe tata guna lahan mana yang paling penting menurut Bapak/ Ibu ?Silahkan bagikan 50 kerikil ke dalam kartu-kartu yang telah disediakan berdasarkan tingkat kepentingannya.***
<u>Instruction 2</u>. For each of the use categories (food, medicine…) on the cards, which type of forest is the most important? Please distribute 100 pebbles among the cards based on importance of this category of use. ***Untuk setiap kategori guna berikut (makanan, obat-obatan…), tipe hutan mana yang paling penting menurut Bapak/ Ibu? Silahkan bagikan 100 kerikil ke dalam kartu-kartu berdasarkan nilai kepentingan dari kategori guna ini.***
<u>Instruction 3</u>. Where does your income come from? Please name the products and their price. ***Dari mana saja sumber penghasilan Bapak-bapak/ Ibu-ibu? Tolong bilang barang yang bisa dijual dan berapa harga barangnya?***
<u>Instruction 4</u>. What is the area of primary forest, logged forest, fallows, rubber gardens and swidden at present, in the past (30 years ago) and in the future (In 30 years). Please order the cards according to the area. ***Berapa luas hutan primar, hutan logging, bekas ladang, kebun karet dan ladang sekarang, 30 tahun yang lalu, dan 30 tahun yang akan datang ? Tolong rangka kartu-kartu dari yang paling besar ke yang paling kecil.***
<u>Instruction 5</u>. How important were/are/will be land uses 30 years ago, at present, and in 20 years from now? Please distribute 50 pebbles among the cards to express the importance. ***Di antara tipe-tipe tata guna lahan mana yang paling penting 30 tahun yang lalu, sekarang, dan 20 tahun yang akan datang menurut Bapak/ Ibu ?Silahkan bagikan 50 kerikil ke dalam kartu-kartu yang tersedia berdasarkan kegunaan hutan pada waktu tertentu..***

Table 6. Instructions for the PDM

INDEX OF CULTURAL IMPORTANCE

The **<u>Smith index</u>** is calculated as followed: $S_a = \frac{\sum_{i=1}^{N} \frac{L_i - R_a + 1}{L_i}}{N}$

With: S_a: Cultural importance of item « a » according to Smith index
N: Number of lists (number of informants)
L_i: Length of the list « i »
R_a: Citation rank of landrace « a »

The **<u>Sutrop index</u>** is calculated as followed: $S_a = \frac{F}{N\ mP_a}$

With: S_a: Cultural importance of item « a » according to Sutrop index
N: Number of lists (number of informants)
F: Citation frequency of the item in all lists
mPa: average citation rank, which is: $\frac{\sum_{i=1}^{N} r_{ai}}{F}$ with r_{ai} citation rank of item « a » in list « i »

<u>Figure 5</u>. Calcul of index of cultural importance

the villagers have also distribute 50 pebbles among the different land uses. The more a land use get pebbles the more it is important for this category of use (Table 6- Instructions 1&2).

The results have been analyzed using the free software Netdraw. On the base of the matrix, Netdraw draws a graph linking the land uses and the category of use they provide. The relations between the nodes are multiple and valued, the value here being the number of pebbles distributed.

A list of the main species for each category of use and the place where they can be collected has also been recorded during that time, completing what I already knew by discussing with villagers in informal times.

Income

If the previous questions were assessing the general importance of every land use, the villagers have also been asked on the important land uses and important species for their income, and how much they get from these species. (Table 6- Instruction 3)

Evolution of the land uses

In a context of global and fast changes of land use and land cover, it seems also important to record the perception of the villagers about the evolution of the different land uses in the time.

The villager have first classified the different land uses according to their area for the present time: the cards representing the land uses have been ordered from the widest land use to the smallest one. No quantitative data have been given.

In a second time, they to re-ordered the cards according to the area of the land uses in the past time (20 years ago) and the area they predict to be in the future (in 30 years) . The PDM method has then been used to evaluate the relative importance given by the villagers of the different land uses in the past, the present and the future (Table 6- Instructions 4&5). The results have been analyzed using Excel 2007.

A calendar of the main activities and the cycle of rice cultivation have also been established.

As the villagers work all the day, and are then busy with the children and other occupations at the evening, it has been hard to find time to hold the groups discussions. The villagers were informed in the morning at informal times that a discussion would take place in the evening and were welcome if willing to participate. All the discussions have been made in Indonesian language.

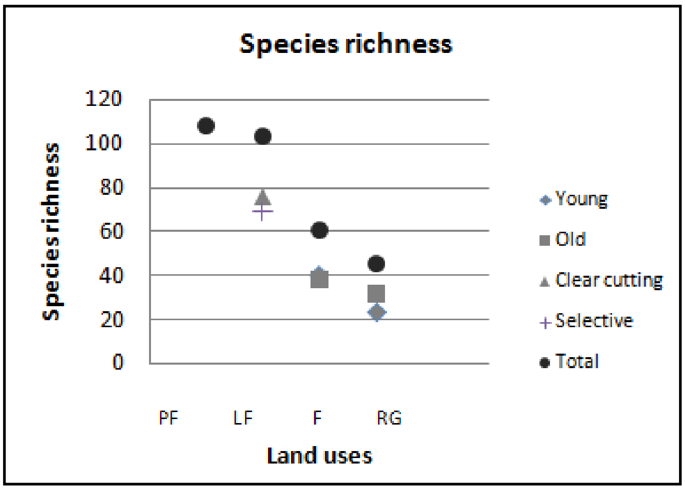


Figure 6. Species richness in the land uses

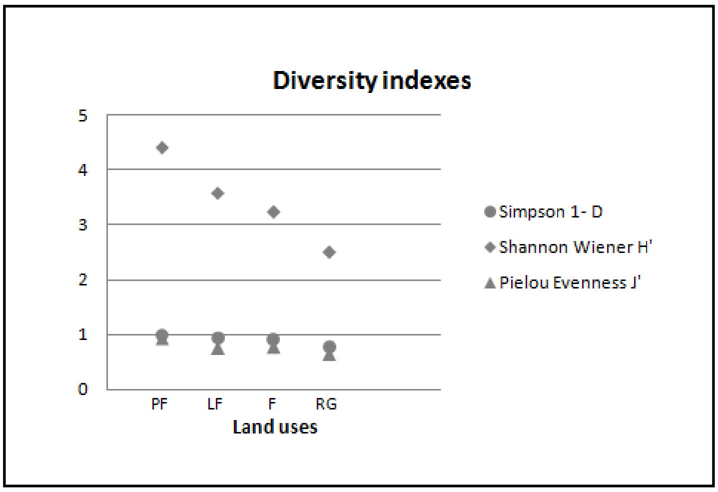


Figure 7. Diversity indexes in the land uses

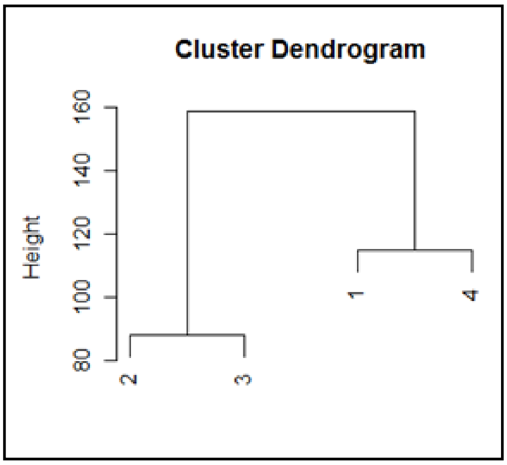


Figure 8. Euclidean distance among the land uses.
1 : Primary forest; 2: Logged forest; 3 : Fallows; 4 : Rubber gardens

	Primary forest	Logged over forest		Fallows		Rubber gardens	
		Clear cutting	Selective logging	Young	Old	Young	Old
Species richness S	**108**	**103**		**60**		**45**	
		76	69	40	38	23	32
Simpson diversity index 1- D	**0,98**	**0,93**		**0,90**		**0,78**	
		0,91	0,97	0,89	0,92	0,68	0,87
Shannon Wiener index H'	**4,40**	**3,57**		**3,23**		**2,5**	
		3,26	3,75	2,90	3,06	1,85	2,71
Eveness index J'	**0,94**	**0,77**		**0,79**		**0,657**	
		0,75	0,89	0,78	0,84	0,59	0,78

Table 7. Species richness and trees diversity in the land uses

2. Free list of trees

The villagers have been asked to list 15 species of trees they know, where you could find these species and for which use. The person interviewed could say different uses and different locations for one tree. For this exercise, I avoided to say the word "important" (*penting*). The free list analyze is based on the hypothesis that the persons interviewed tend to name first the trees the most important culturally and that the most well known trees are more frequently cited.

The free lists have been analyzed using the software FLAME_v1.0 [10] which calculates index of cultural importance by assessing the frequency of the item cited, the position of the item in the free lists and other factors such as the length and the number of the lists (Figure 5).

III. Results

A. Trees diversity in the four land uses

1. Species richness, trees diversity and composition

Trees species richness declines from primary forest to logged over forest, fallows and rubber gardens (Figure 6). In primary forest, 108 species belonging to 63 genus and 34 families have been identified. Three individuals have been ascribed to the family level only and a total of 26 individuals have not yet been identified. In logged over forest we have recorded a total of 103 species belonging to 68 genera and 37 families. We found 60 species in the fallows, belonging to 46 genera and 24 families. In the rubber gardens, 45 species have been recorded, belonging to 37 genera and 23 families.

This decline is parallel with the decline of trees diversity. The plot in primary forest has the highest diversity and evenness, followed by logged over forest, fallows and rubber gardens. (Figure 7 and Table 7)

For our sampling intensity and minimal diameter of 5 cms dbh recorded, the calcul of Euclidean distance based on the species shows that rubber gardens is the land use the most similar with primary forest in term of composition (distance = 115) while logged forest is the furthest (distance = 142). Fallows and logged forest have the closest composition (distance = 88) (Figure 8). The Euclidean distance calculated on the basis of genus gave the same results.

[10] The software Flame is not yet published. It has been created by Pennec, F., Wencélius, J., Garine, E., Raimond, C. and Bohbot, H. CNRS UMR 8586, CNRS UMR 5140, CNRS Laboratoire d'ethnologie Université de Nanterre

Family	NI	NG	NS	BA	RD (%)	RDo (%)	IV
Primary forest							
Lauraceae	49	8	10	1,46	13,3	16,9	15,1
Myrtaceae	47	3	8	0,67	12,8	7,7	10,2
Guttiferae	41	4	13	0,63	11,1	7,3	9,2
Euphorbiaceae	26	5	9	0,55	7,1	6,4	6,7
Burseraceae	21	2	5	0,87	5,7	10,1	7,9
Hypericaceae	18	1	1	0,67	4,9	7,7	6,3
Dipterocarpaceae	17	1	6	1,73	4,6	20,0	12,3
Bombaceae	14	1	2	0,24	3,8	2,8	3,3
Melastomataceae	11	2	4	0,17	3,0	1,9	2,4
Annonaceae	10	2	4	0,058	2,7	0,7	1,7
Remaining families (24)							
Logged over forest							
Euphorbiaceae	135	5	9	0,90	25,7	18,3	22,0
Melastomataceae	110	1	1	0,64	20,9	13,0	16,9
Dipterocarpaceae	69	3	13	0,98	13,1	19,9	16,5
Lauraceae	17	7	8	0,091	3,2	1,8	2,5
Moraceae	17	2	4	0,12	3,2	2,4	3,8
Actinidiaceae	16	1	1	0,078	3,0	1,6	2,3
Flacourtiaceae	13	1	1	0,078	2,5	1,6	2,0
Elaeocarpaceae	12	1	4	0,11	2,3	2,2	2,7
Guttiferae	12	3	5	0,052	2,3	1,0	1,6
Sapotaceae	12	1	2	0,083	2,3	1,7	2,0
Remaining families (27							
Fallows							
Melastomataceae	94	1	1	0,61	28,3	13,7	21,0
Euphorbiaceae	63	7	13	0,43	18,9	9,6	14,2
Rubiaceae	40	5	6	1,09	10,5	24,4	17,4
Moraceae	19	4	8	0,65	5,7	14,6	10,1
Myrtaceae	17	2	4	0,096	5,1	2,1	3,6
Verbanaceae	17	1	1	0,25	5,1	5,6	5,3
Crypteroniaceae	12	1	1	0,15	3,6	3,4	3,5
Dillenaceae	9	1	1	0,057	2,7	1,3	2,0
Guttiferae	9	2	3	0,036	2,7	0,8	1,7
Rosaceae	8	2	2	0,62	2,4	13,9	8,1
Remaining families (14)							
Rubber gardens							
Euphorbiaceae	112	6	9	2,76	51,4	55,3	53,3
Melastomataceae	19	1	1	0,23	8,7	4,6	6,6
Moraceae	13	2	4	0,14	5,9	2,8	4,3
Myrtaceae	10	2	2	0,53	4,6	10,6	7,6
Verbenaceae	8	1	1	0,10	3,7	2,0	2,8
Dilleniaceae	7	1	1	0,046	3,2	0,9	2,0
Lauraceae	7	2	2	0,21	3,2	4,2	3,7
Sapindaceae	6	1	3	0,13	2,7	2,6	2,6
Anacardiaceae	5	4	4	0,025	2,3	0,5	1,4
Guttiferae	4	2	2	0,087	1,8	1,7	1,7
Remaining families (13)							

Table 8. Taxonomic composition in the four land uses. Only the 10 most abundant families are represented.

NG: number of genera

NS : number of species

NI : number of individuals/ 0,24 ha

BA : basal area en m^2/ 0,24 ha

RD : relative density

RDo : Relative dominance

IV: Importance value index

At the family level, taxonomic composition in the four land uses show some differences (Table 8). Most often, the relative density of one family is not related with the relative dominance of this family.

In **primary forest** Lauraceae, Myrtaceae and Guttiferae are the three families with the highest density but Dipterocarpaceae is the dominant family in term of basal area (1,73 m^2/ 0,24 ha).

In the other land uses we observe a shift of these families toward Melastomataceae and Euphorbiaceae which are the two most abundant families in term of number of individuals.

In logged forest and fallows Euphorbiaceae is mostly represented by *Macaranga spp* and the family of Melastomataceae is only represented by one species, *Astronia macrophylla*. This two species are fast growing species commonly found in the early successional stages in the tropics (Whitmore, 1984, Slik, 2005).

As expected, in rubber gardens the family of Euphorbiaceae, most represented by *Hevea brasiliensis,* is from far dominant related to the number of individuals and the basal area.

The eveness of the families in logged over forest, in fallows and in rubber gardens is low as the three most important families totalize respectively 55,4%, 52,6% and 67,5% of importance value index comparing to 37,6% in primary forest.

A closer look to the composition within the land uses show interesting results (Table 9).

In **logged forest** the relative density of Dipterocarpaceae has increased but the relative dominance is similar with primary forest. Big trunks of dipterocarps have been removed for their high timber value and the canopy gaps have allowed many dipterocarps trees belonging to various species to grow. The number of individuals belonging to the Myrtaceae family, commonly found in the primary forest, has considerably decreased and is only represented by one genus. In the selective logging area, species richness is lower but the diversity is higher than in clear cut area, and the abundance and dominance of fast growing species has decreased but remains high whereas the basal area of Dipterocarpaceae increased. The shrub and herbaceous vegetation is not abundant

In **fallows**, the family of Rubiaceae, mostly represented by *Timonius borneensis*, is the third family in number of individuals but the first in basal area. This family is well installed in the old plots. The trees diversity increased in the old fallows and the abundance of regenerating trees decreased. However the family of Melastomataceae remains abundant: *Astronia macrophylla* still represents 24% of total trees. Except in the 40 years olds plot, the secondary vegetation is quite low with no dominant species. Some bamboos are present in the young plots and we found many Polypodaceae in the herbs layer.

		Ni	BA (m2/surface echantillonée)		Ni	BA (m2/surface echantillonée)
Logged over forest	**Clear-cutting**			**Selective logging**		
	Euphorbiaceae	98	0,71	Euphorbiaceae	37	0,19
	Melastomataceae	91	0,56	Dipterocarpaceae	27	0,58
	Dipterocarpaceae	42	0,40	Melastomataceae	19	0,080
Fallows	**Young**			**Old**		
	Melastomataceae	62	0,40	Melastomataceae	32	0,21
	Euphorbiaceae	48	0,22	Rubiaceae	24	1,02
	Rubiaceae	16	0,086	Euphorbiaceae	15	0,20
Rubber gardens	**Young**			**Old**		
	Euphorbiaceae	69	1,12	Euphorbiaceae	44	1,64
	Melastomataceae	14	0,18	Myrtaceae	10	0,53
	Verbenaceae	8	0,10	Moraceae	8	0,11

Table 9. Family composition within the land uses. Only the 3 most abundant families are represented

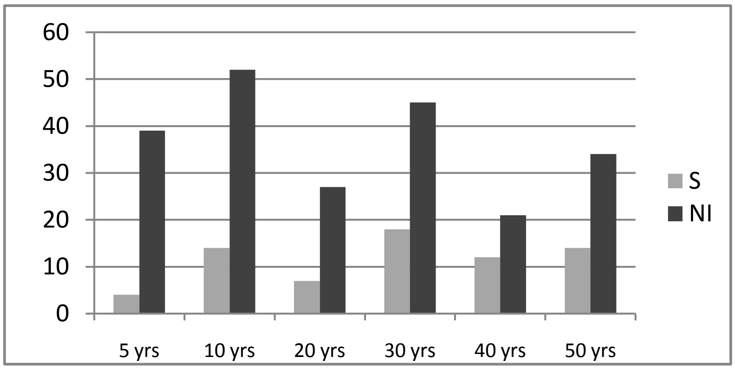


Figure 9. Species richness (S) and number of individuals (NI) in rubber gardens

	Primary forest	Logged over forest	Fallows	Rubber gardens
Tree density *(number of individuals ≥ 5cms dbh /0,24ha)*	**368**	**525**	**332**	**218**
Density of regenerating trees *(number of individuals between 5 and 10 cms dbh / 0,24 ha)*	**179 =48,6%**	**369 =70,3%**	**220 =66,3%**	**108 =49,5%**
Total Basal area G *(m2/0,24ha)*	**8,63**	**4,92**	**4,46**	**4,99**
Diameter (cm)				
Mean	**13,7**	**9,1**	**9,9**	**13,3**
Min	**5,0**	**5,0**	**5,0**	**5,0**
Max	**66,5**	**66,0**	**57,1**	**54,8**
Standard deviation σ	**10,69**	**5,73**	**7,49**	**7,49**
Height (m)				
Mean	**14,5**	**8,3**	**9,7**	**10,7**
Min	**2**	**3**	**3**	**3**
Max	**48**	**29**	**31**	**23**
Standard deviation σ	**7,16**	**3,22**	**4,91**	**4,15**

Table 10. Structure in the land uses

In **rubber gardens** more individuals of *Hevea brasiliensis* are found in the young plots than in the old one but Euphorbiaceae family remains dominant. We observe a shift from Melastomataceae and Verbenaceae families in the young plot toward Myrtaceae and Moraceae families in the old plots. Few fast growing species remained in the old rubber gardens. Species richness and diversity increased with the age but is also highly dependent of the owner's management (Figure 9). We found an abundant herbs and shrub layer. The secondary vegetation is dominated by bamboos (*Bambusa sp*.) but we can find many other species belonging to various families e.g. Rosaceae, Anacardiaceae, Burseraceae, Elaeocarpaceae or Gnetaceae. We also find a lot of rattan species. The herbs layer is dominated by Polypodaceae (*Nephrolepsis bisserrata*, *Coniograma intermedia*…).

2. Structure

The density of trees (number of stems over 5cms dbh/ 0,24ha) and of regenerating trees (number of stems between 5 and 10 cms dbh/0,24 ha), the basal area G, the mean of diameter and height and the minimum and maximum of diameter and height in every land uses are resumed in the table 10. The distribution of dbh and height of trees in each land use are given in Appendix 2.

The highest trees density is found in the logged over forest with 525 individuals in 0,24 ha, followed by primary forest (368), fallows (332) and rubber gardens (218). However, the total basal area G is the highest in primary forest (8,63 m^2/0,24 ha), almost twice bigger than in rubber gardens (4,99 m^2/0,24 ha), logged forest (4,92 m^2/0,24 ha) and fallows (4,46 m^2/0,24 ha). We found many regenerating trees in the fallows and in logged over forest, representing respectively 66,3% and 70,3% of the total density. In primary forest and in rubber gardens, they represent a bit less than 50%.

The lilliefors test conducted with R.1.12.1 reveals that the diameter and the height of the trees in each land use is not normally distributed (pvalue $< \alpha$, hypothesis H0 can not be accepted with H0 : the population are normaly distributed). Trees diameter in primary forest and in rubber gardens are significantly (Kruskal Wallis test, pvalue < 0, 05) bigger than the in fallows and logged over forest. However, the trees diameter between primary forest and rubber garden and between logged over forest and fallows are homogeneous (pvalue > 0,05) (Figure 10).

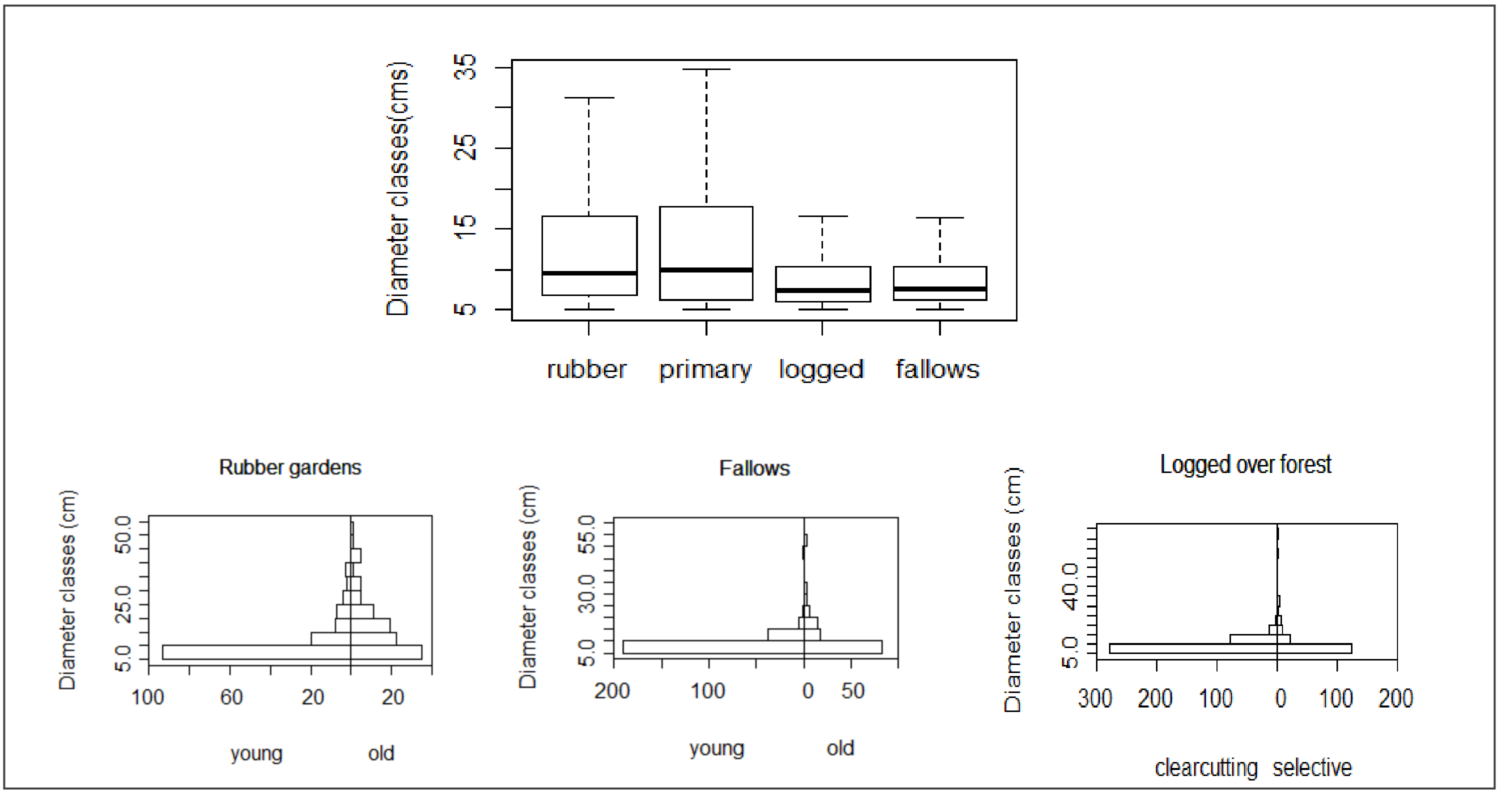


Figure 10. **Trees diameter distribution in the four land uses.**
In the three graphs in the bottom, the Y axis represents the diameter class and the X axis represents the number of individuals. "Young" refers to the plots of 5,10 and 20 years old and "old" to the plots of 30, 40 and 50 years old."Clearcutting" corresponds to the 20 first meters upper slope in the logged over forest of the plot and "selective" to the last 10 meters.

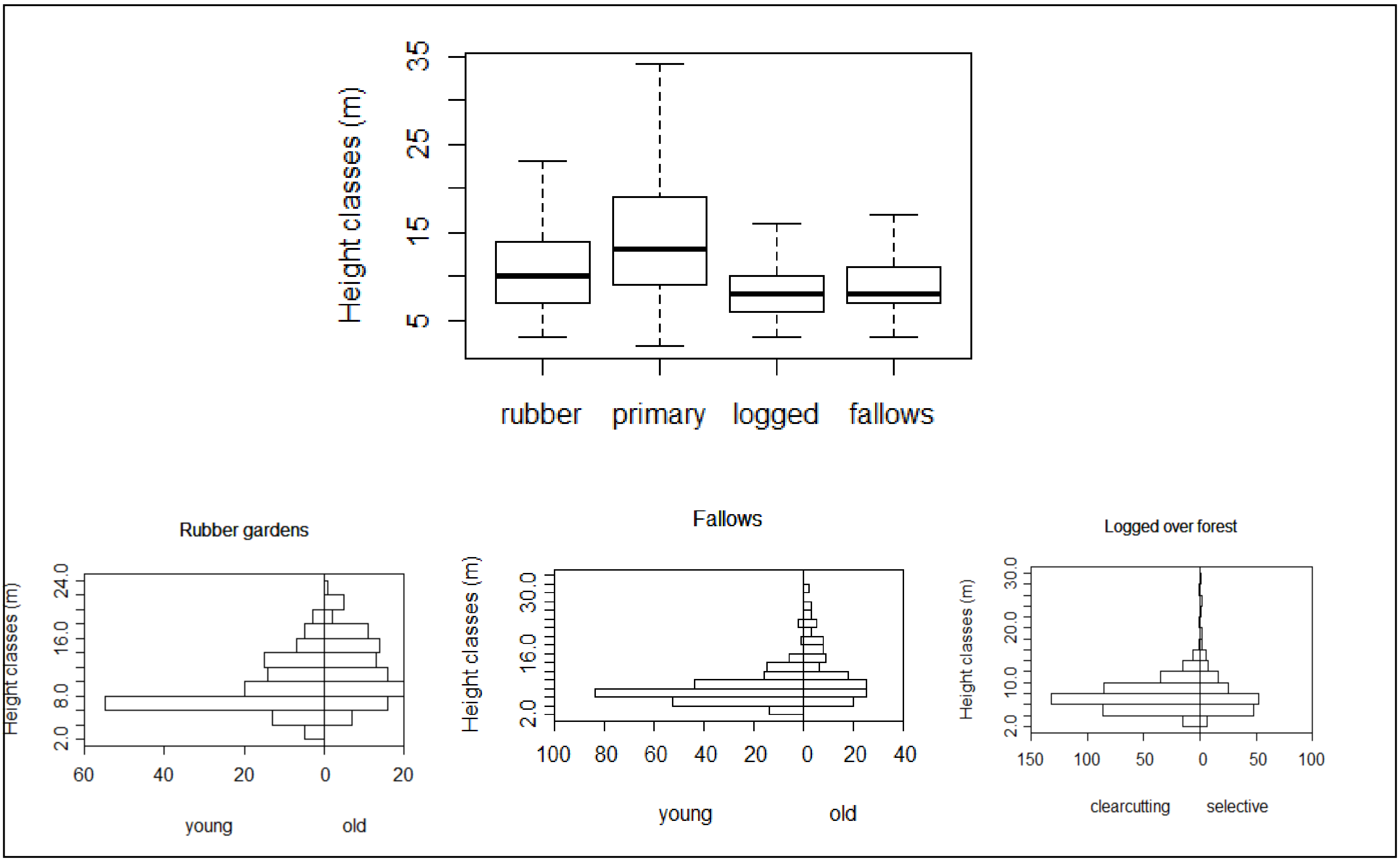


Figure 11. **Trees height distribution in the four land uses.**
In the three graphs on the bottom, the Y axis represents the height class and the X axis represents the number of individuals within one class. "Young" refers to the plots of 5,10 and 20 years old and "old" to the plots of 30, 40 and 50 years old.."Clearcutting" corresponds to the 20 first meters upper slope in the logged over forest of the plot and "selective" to the last 10 meters

The mean canopy height in the primary forest is 14,5, and this value is significantly (Kruskal wallis test, pvalue < 0,05) higher than the mean of 10,7 m ; 9,7 m and 8,3 m in respectively rubber gardens, fallows and logged over forest.(Figure 11)

The values of standard deviations show that the variability of diameter and height of trees is the highest in primary forest and the lowest in logged forest.

No big differences on tree density and on percentage of regenerating trees (respectively 69,4% and 72,3%) are found between selective logging and clear cutting. The total basal area is however significantly higher in selective logging area.

With the age, the structure of rubber gardens and fallows evolved (Table 11). As expected, overall trees density and regenerating trees density decreased and basal area increased in the old plots.

Some interesting results are found when comparing the structure with primary forest. The mean diameter and height are significantly (Wilcoxon Mann Whitney, pvalue<0,05) higher in primary forest than in selective logging area but no significant differences of diameter (pvalue >0,05) are found between primary forest and the old fallows. In old rubber gardens, the dbh (16,6 cms) is significantly higher than in primary forest (13,7 cms).

B. Iban perceptions

1. Overall and specific importance of the land uses

For each scoring exercises groups of 5-6 persons of each sex have participate. If the distribution of pebbles differs between men and women, for more clarity purpose the analyze of the results is made without separating men and women: for each category of use, the number of pebbles distributed by the men and the one by the women have been added. The complete results are presented in Appendix 3

According to the pebbles distribution, rubber gardens and swiddens are the most important land uses, representing both more than 30%. This distribution is not correlated with the area of the land uses. Indeed, according to the villagers, the logged over forest has the widest area around the village, followed by primary forest, fallows, swiddens and rubber gardens. The figure 12 is a valued graph that represents the importance of the land uses in providing different products and services. For each category of use only the two most important land uses are represented.

Swiddens provide a lot of services and are particularly important for food and fodder : among with rice, many other fruits and vegetables such as cassava, sweat potatoes or bananas, and food for the domestics animals (pigs and chicken) grow within the swiddens.

	Primary forest	Logged over forest		Fallows		Rubber gardens	
		Clear cutting	Selective logging	Young	Old	Young	Old
Tree density *(number of individuals ≥ 5cms dbh/0,12ha)*	**184**	**269**	**249**	**205**	**127**	**118**	**100**
Density of regenerating trees *(number of individuals between 5 and 10 cms dbh / 0,12 ha)*	**89,5 =48,6%**	**187 =69,4%**	**180 =72,3%**	**147 =71,7%**	**73 =57,5%**	**74 =62,7%**	**34 =34%**
Total Basal area G (m2/0,12ha)	**4,31**	**1,97**	**3,43**	**1,47**	**2,99**	**1,79**	**3,20**
Diameter (cm)							
Mean	**13,7**	**8,6**	**10,1**	**8,1**	**12,9**	**10,8**	**16,6**
Standard deviation σ	**10,69**	**3,80**	**8,56**	**3,67**	**10,78**	**7,10**	**10,65**
Height (m)							
Mean	**14,5**	**8,2**	**8,7**	**8,3**	**12,4**	**9,5**	**12,2**
Standard deviation σ	**7,16**	**2,74**	**4,09**	**3,08**	**6,26**	**3,57**	**4,36**

Table 12. Variations of structure within the land uses

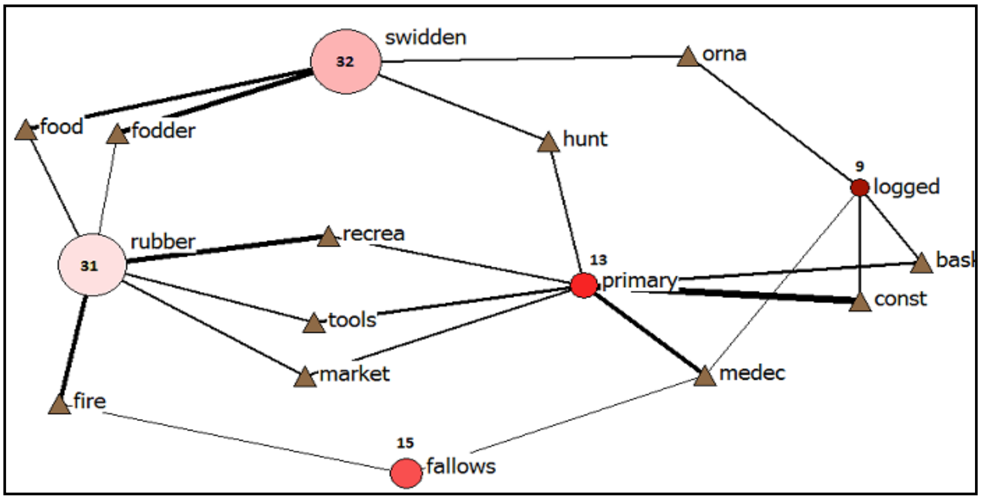


Figure 12. Importance of the land use types for the category of use. The overall importance of the land uses is represented by the size of the circles and the numbers associated. The land uses have been classified according to their relative estimated area, and this qualitative data is represented by the color gradient, dark red being the widest area and light pink the smallest. The wide of the lines represent the intensity of the link : the more a land use gets pebbles the wider the link between the category and the land use which provides the service is.

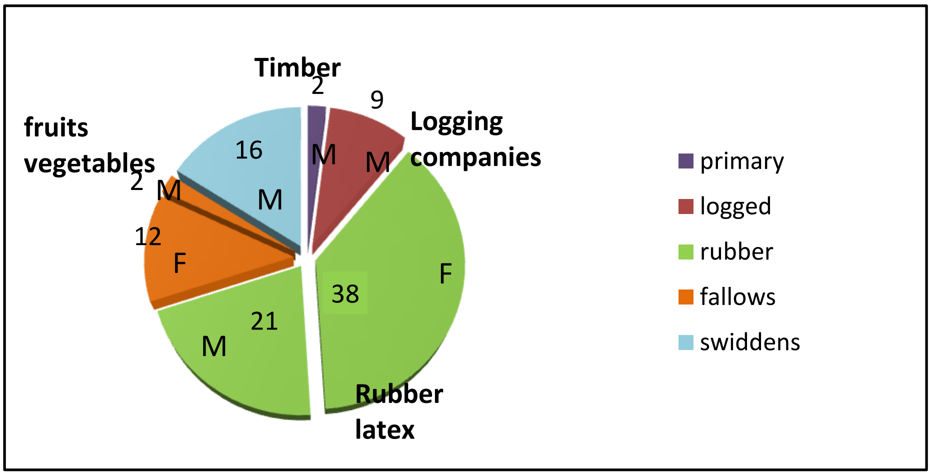


Figure 13. Sources of income. The numbers reprsent the value given by the men and the women at one land use for providing income. The “F”represents the pebbles distributed by the women and the “M” those distributed by the men

Rubber gardens are important sources of income and they are also essential for recreation and to collect firewood.

If primary forest is not cited as a very important land use, representing only 13% of the total importance, it is however recognized as providing numerous services such as construction material, medicines[11] or basketry.

Logged over forest and fallows don't provide a lot of services. For these two land uses, there are big differences between men and women about the role these types can play.

A list of the main species for each category of use and where to find them has been recorded and is synthesized in Appendix 4.

2. Income

Rubber gardens constitute the main source of cash (Figure 13). Tapping can only be done when it is not raining and with one day of work the villagers can collect 5 kgs of latex, which can be sold 15000 Rp/kg (villagers of Keluin, pers comm).

Young fallows and swiddens also provide income as small amounts of agricultural and non-timber products (fruits and vegetables as bananas, cassava, sweet potatoes, corn, chili…) can be sold at the market of Lanjak, the closest city.

Timber products from the primary forest are rarely sold and the only income from logged forest is when logging companies work in the area and provide work for the villagers.

More details about the products and the prices are given in Appendix 5.

3. Evolution of the land uses

The area of the land uses around the village has and will evolve. The villagers are aware that the area of primary forest has decreased in the last 30 years and think it will keep on decreasing by the expansion of rubber gardens, swiddens and fallows (Table 12).

The importance given to the land uses also changes and is not correlated with the evolution of their area. Primary forest and logged over forest are becoming more important while the importance given to swiddens and fallows is decreasing and the importance given to rubber gardens is quite stable. However these changes are little as rubber gardens and swiddens remain the most important land uses and logged forest the less important (Figure 14).

[11] Medicine here refers to traditional medicine. However, when asked for the land use important for medicines, the villagers first distributed all the pebbles on the rubber gardens. Indeed, it's from where they get money to buy medicines. We thus have to be aware that the villagers don't really collect medicine in the environment any more.

area	30 years ago	present	20 years from now
+	Primary forest	Logged over forest	Rubber gardens
	Fallows	Primary forest	Fallows
	Swiddens	Fallows	Swiddens
	Rubber gardens	Swiddens	Logged over forest
-	Logged over forest	Rubber gardens	Primary forest

Table 12. Evolution of the land uses' area. The land use are ordered from the largest to the smallest

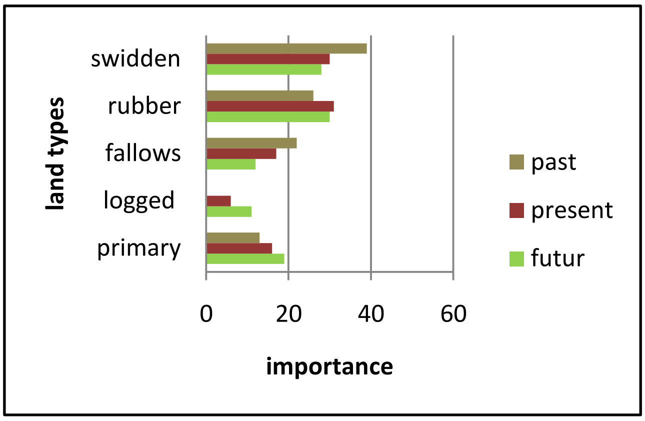


Figure 14. Evolution of the land uses' importance. The X axis represent the number of peebles distributed according to the importance of the land uses.

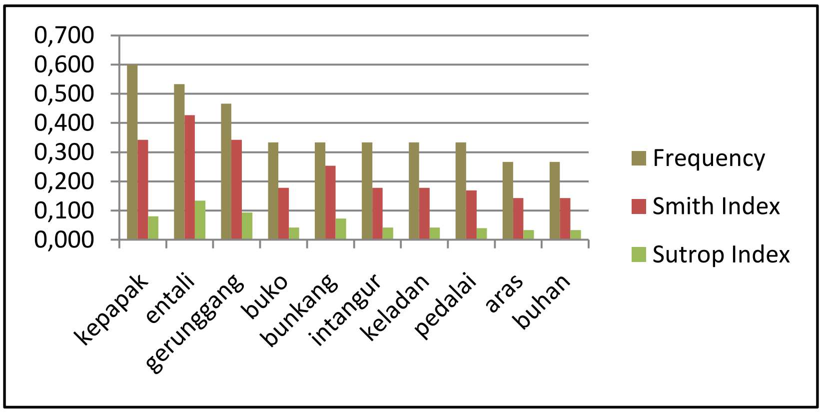


Figure 15. Cultural importance of species. Only the 10 most important species are represented on the graph.

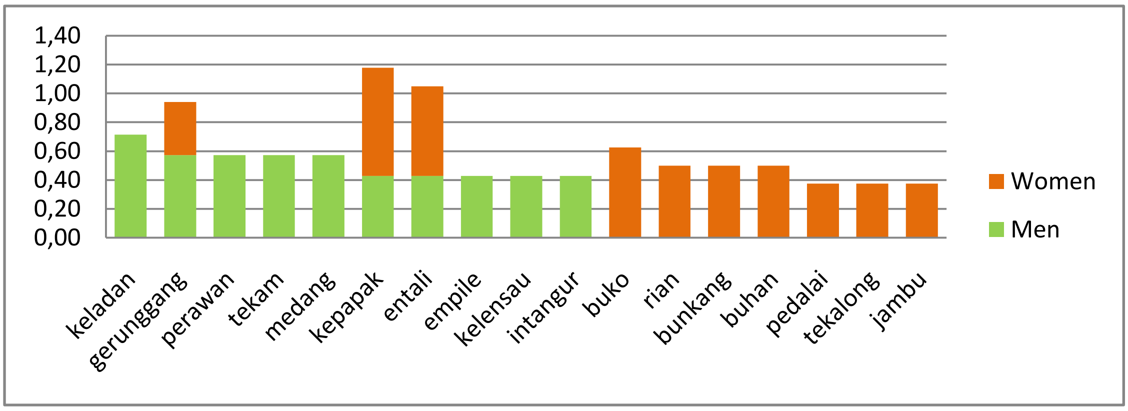


Figure 16. Important species for men and women. Only the 10 most important species for each sex are represented on the graph.

4. Important species

15 villagers, 7 men and 8 women have been interviewed and asked to list 15 species of trees they know, for what purpose and where to find them. The lists are given in Appendix 6

A total of 102 species have been cited and kepapak, (*Vitex pubescens*), entali (refers to two species, *Prunus arborea* or *Pygeum parviflorum*) and gerunggang (*Cratoxylum spp*.) are the three species the most recurrent and culturally important according to the Smith index and the Sutrop index (Figure 15).

If men and women have cited the same number of species (65 species for the men and 66 species for the women), they don't quote the same species and at different frequencies. For exemple, two of the most important species for men are keladan (*Hopea dryobalanoides*) and perawan (*Shorea sp*.), both belonging to the Dipterocarpaceae family. They are respectively cited by 71, 43% and 57, 14% of the men but are not quoted by women. On contrary, 62, 5% and 50% of the women have cited buko (no identified) and rian (*Durio zibethinus*) but the men didn't mention any of these two species (Figure 16).

The ethno ecology of the three most important species for men and women is described in the Appendix 7.

Fourteen categories of use and 8 locations have been identified in the free lists. If considering men and women together, food, firewood and heavy construction are the three categories of use the most recurrent (Figure 17) and fallows, primary forest and the close area around the longhouse are the locations the most often associated to the trees (Figure 18). We observe high differences between the two sexes in the frequency of the categories and of the locations named. Women mostly cited trees associated to food and firewood which can be found in swiddens, fallows and in close areas around the village, while men cited trees found in primary forest and fallows and that provide timber for heavy construction and firewood.

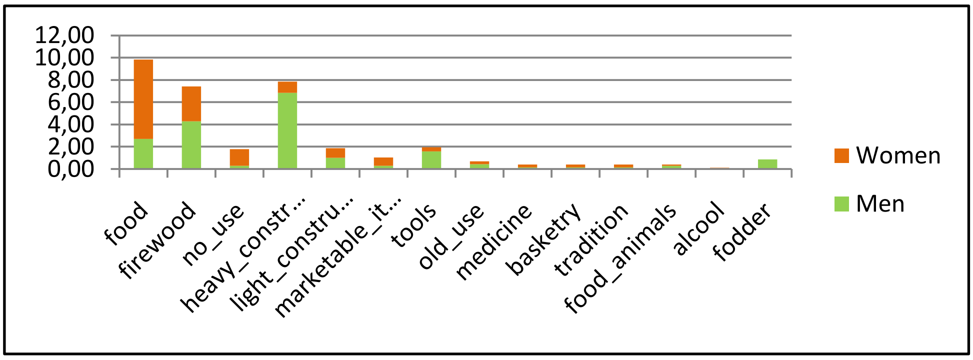


Figure 17. Categories of uses the most often associated with trees.

Legend: Heavy_construction : construction of the house or the canoe
Light_construction : construction of non permanent camps in the swidden
No_use : no specific use is recognized for the tree
Old_use : used in the past (leaves for soap, resine for the lamps…)but not used anymore
Food_animals : fruits, leaves are recognized to be eaten by the wild animals
Fodder: to feed the domestics animals (chicken, pigs)
Alcool: refers to a specific tree, hijuk, which provides seguir, a fermented liquid

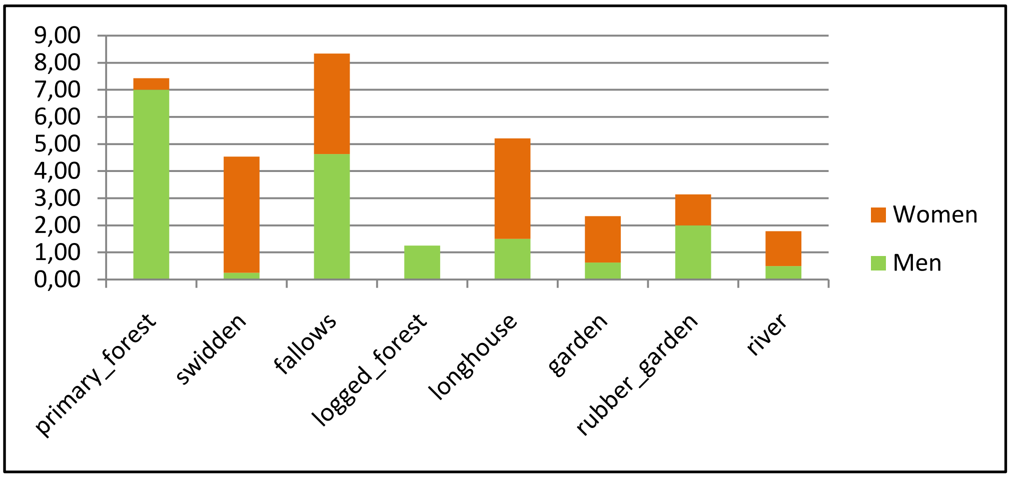


Figure 18. Locations the most often associated with the trees

Legend : Longhouse: close area around the longhouse, such as the backyard, the front yard or the path arriving to the village.
Garden : fruit and vegetables garden which can be close to the house or in the river banks
River : river banks

IV. Discussion

A. Trees diversity conservation and local perceptions

1. Primary forest

Considering only the trees over 10 cms dbh, we found a total basal area of 34,36 $m^2.ha^{-1}$, value which fits the average of 32 $m^2.ha^{-1}$ in the tropical forests (Kessler et al., 2005). The density of trees ≥10 cms dbh reaches 787 trees ha^{-1} which is a high value compared to other studies conducting in primary forests in Borneo and Peninsular Malaysia where the tree density ranged from 431 to 778 trees. ha^{-1} (Sidiyasa, 2001). In mixed dipterocarp lowland rain forest, species richness usually ranges from 200 to 300 species/ha and we found a value of 108 species + 26 species not yet identified for trees ≥ 5cm in 0,24 ha. For trees ≥ 10 cms dbh only a total of 44 species + 12 non identified species only have been recorded. A larger area of 4 ha is under completion by the COLUPSIA project to allow proper comparison with other lowland mixed dipterocarps forests.

According to the villagers, primary forest used to be the largest land use around the village 30 years ago. It provides the most diversified services for Iban people and is particularly important for the men. They consider it as the third most important land use after swidden and rubber garden, which can be explained by the presence of trees belonging to the Dipterocarpaceae family that provide timber for heavy construction. The villagers agree that the overall importance of this land use will increase in the future

Trees richness and diversity indexes show that primary forest is the richest land use. It has decreased by the effect of logging companies and will keep decreasing by its conversion in other land uses such as rubber gardens and swiddens. If those land use can not replace primary forest, they can help to maintain a certain portion of species diversity and provide services to people relying on their resources. This will be presented for each land use separately.

2. Logged forest

More than 10 years after logging, the effects on structure and tree species composition were still visible. Species richness in logged forest is similar with species richness in primary forest and the species diversity is quite high. However, this high tree diversity does not equate to high conservation value. Logged forest is dominated by fast-growing pioneer species belonging to the Euphorbiaceae and Melastomataceae families with few economic value. The floristic composition and the structure in logged forest differ the most with primary forest.

The increase in tree density and the high proportion of regenerating trees can be explained by the canopy gaps created by the tree felling that leave place for a large number of trees to grow. This tree density is particularly important considering that within the plot of 0,24 ha, 0,03 ha were in a landslide area were almost no trees grow.

In the last 30 years logged over forest has quickly extended to occupy the first place in term of area, but this land use is classified as the last important one according to the villagers. If the logging companies opened roads, thus facilitating the mobility of the villagers, the logged forest doesn't provide as much services to the villagers except for construction and basketry in complement of the primary forest.

3. Fallows

We observe a decline in species richness and diversity within the fallows. The composition is close to the logged forest composition but also to the primary forest composition.

The structure resembles the structure in the logged forest with many small regenerating trees belonging to the Melastomataceae and Euphorbiaceae families. Fallows develop on previously almost totally clear-felled area for rice cultivation, thus few large trees are remaining in the young fallows.

In the old plots, species richness remained stable but diversity increased. As found in Okimori et al. (2000), the basal area increased, the distribution is more spread and the abundance of regenerating trees has decreased. Shifting cultivation is thus an agricultural system allowing to maintain a reasonable level of diversity and conserving a certain amount of species, especially in the old fallows.

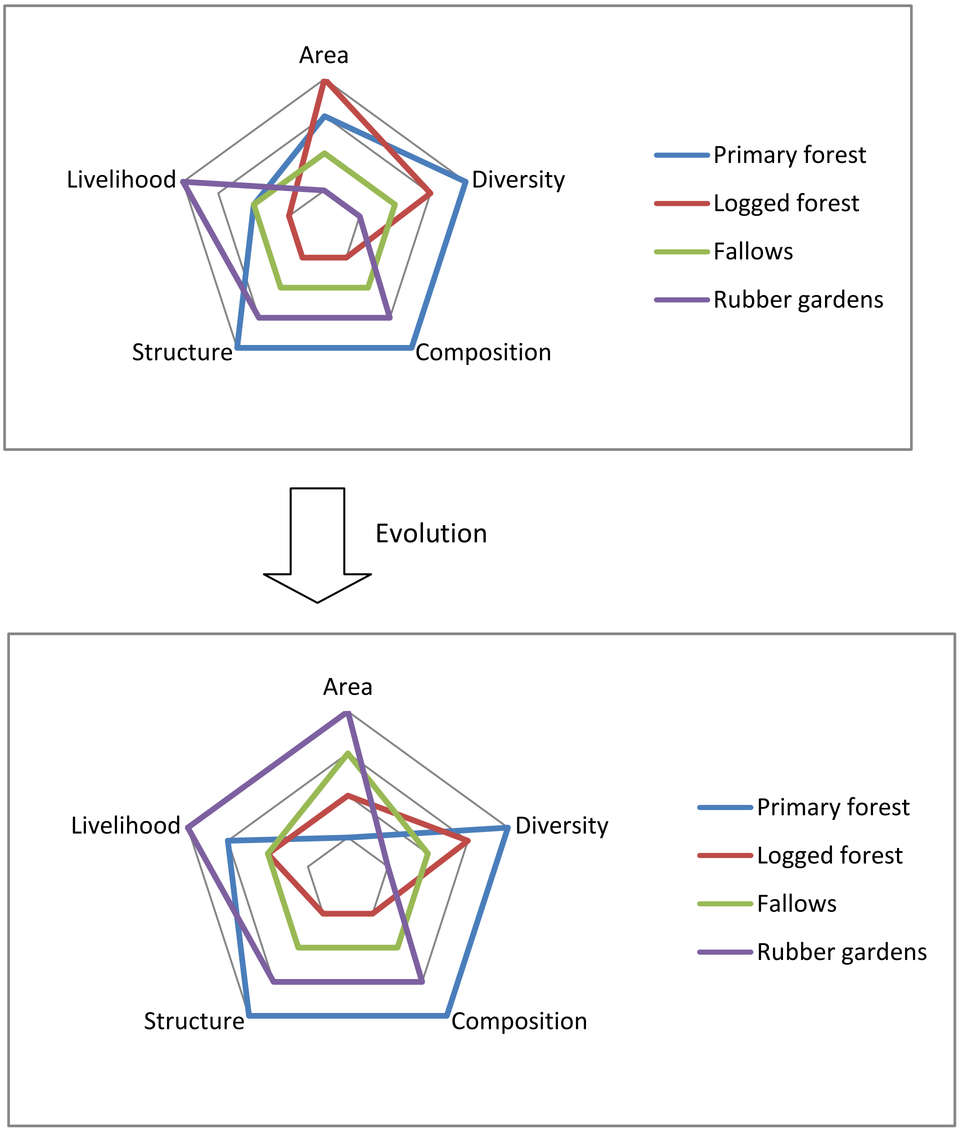
According to the pebbles score, fallows don't provide many products except firewood. It has however a great overall importance especially for women and many important trees used for firewood, light construction or food can be found in the fallows. The fallows can also be enriched with fruit (*Durio zibethinus*) or rubber trees. Moreover, this land use is important as an integral and essential part of the swidden cultivation rotational system. Swidden, by providing food and playing an important role in the cultural life of Iban people, is the most overall important land use for the villagers. The labor calendar of shifting cultivation dictates the life of Iban people.

4. Rubber gardens

Species richness and diversity in rubber gardens are lower than in the other land uses, this obvisously due to the dominance of *Hevea brasiliensis*. However, for our sampling, this land use is the most similar with the primary forest in term of composition and structure and on contrary to fallows and logged forest, rubber gardens have few pioneer species and regenerating trees. The abundance of the herbs and shrub layers in the gardens may also play a role in biodiversity conservation. The close botanical composition of rubber gardens with primary forest is exceptional in a production system that has to be profitable for the owner. The removing of trees without economic or nutritious importance can explain the low tree density but these management practices are particularly low. In old gardens, management is limited to maintain paths between rubber trees to allow for tapping (Beukema et al., 2007). As showed in other studies (Michon et al., 2007, Lehébel-péron et al., 2011), the rubber gardens are often enriched by other plantations providing food such as Rambutan (*Nephelium lappaceum*), Durian (*Durio zibethinus)*, Cempedak (Artocarpus *integer)*, or timber used for firewood: *Syzygium glomerata*, *Horsfieldia sp*. The long tapping life of rubber trees[12] can also explain the presence of other species as gardens are more or less carefully maintained during this time. When the trees can not be taped anymore the trunks are used as firewood (villagers, pers. comn and obs.) and the gardens gradually revert to typical successional secondary forests (Michon et al., 2007)

Introduced in the last century in Borneo, rubber plays an important role for Iban people. As other studies showed in many swidden cultivation systems (Ekadinata et al., 2011, de Jong, 2001), rubber is the first source of income. It also provides other resources such as food, fodder and firewood. Both men and women also accord a great importance to rubber gardens in recreation services. Rubber cultivation fits perfectly the traditional Iban shifting cultivation system (De Jong, 2001, Dove, 1993) as rubber trees are often planted in the fallows and are thus included in the swidden fallow cycle, only making it more productive. Rubber is adapted to intermittent exploitation, can be stored for long periods (De Jong, 2001) and as rubber trees can only be tapped during dry days it provides work and income mainly during the dry season when the swidden labor demand is low (Appendix 8). Indeed, a characteristic of swidden cultivation is the variable and seasonal nature of its labor demands. Labor is in great demand during some stages of the swidden cycle (planting, weeding, harvesting), in less demand during other stages and not in demand at all during the periods between stages (Ducourtieux, 2006, Dove, 1993), allowing then to collect rubber

[12] Rubber trees can be tapped aproximatively from 15 to 40 years old and some can live until 60 years old (villagers, pers.com)



<u>Figure 20</u>. Role of land uses in tree diversity conservation value and in sustaining local people livelihood.

According to the villagers, this land use is likely to expend. Beukema et al. (2007) also agree that rubber gardens may become the most extensive forest-like vegetation in the lowland of Indonesia. They can thus play an important role in trees diversity conservation and in local people livelihood.

However the expansion of rubber gardens may first lead to more pressure on the fallows and the reduction of the fallow period as rubber gardens usually replace swidden fallows. If villagers usually prefer to keep the gardens close to the village (De Jong, 2001, Dove, 1993), their expansion may also lead to the reduction on primary forest area.

The Figure 20 synthesizes the area, diversity, composition, structure, and provisioning and cultural services in the land uses and their predicted evolution according to the villagers.

B. Limits of the study and proposition for further studies

1. Tree diversity evaluation

Only 0,24 ha in each land use have been sampled. It would be interesting to enlarge the plots and to make more replicates in other villages to first know at which sample effort the number of species reaches its maximum number (by creating species accumulation curves based on individuals and on area) and secondly because vegetation type and diversity can be influenced by the elevation, the distance of the river, the type of soil and human activities and management.

In primary forest, for logistical reasons and to avoid heterogeneity of soil composition, one plot of 120m*20 m has been sampled. However in this plot the composition and distribution of species is believed to be influenced by spatial auto-correlation. Plots should thus have been randomly settled.

In the analyze of the results, we had to face the problem of how to consider the coppicing trees. The pattern of height and diameter distribution may have been slightly different if we would have considered only one trunk instead of every coppice.

For coming studies and especially in a purpose to implement PES later on, the effect of soil and abiotic factors should be assessed and data about biodiversity in every taxonomic groups should be sampled. The dynamic of the land uses could also be studied in a long term program.

We saw in this study that species richness and diversity are not sufficient criteria to assess the conservation value of an ecosystem. One ecosystem can host a high diversity but with few common useful species of the primary forest. Studies on biodiversity conservation should thus incorporate the Euclidean distance in the analyzes.

2. Assessing the provisioning and cultural services

The PDM had the great advantage to allow having quantitative data in a quite fast, easy and entertaining way and to encourage the discussion and debates among the villagers. However, the debates could be hard to follow as the villagers were arguing in Iban language, and important qualitative information may have been lost at that time. We also have to be careful during the exercise that everyone participates and we have to face the problem of influence between the villagers. Mobilizing enough villagers at the same time to participate at the group discussions may be quite difficult, especially when conducted in a very small village as Keluin. But most of all, this method can be considered having bias and do not really give results on the representations and perceptions of the villagers on their environment. The land uses and category of use had been listed previously to the study and may differ from the one people would have say on their own. We can for instance see that in the free-lists new categories of use and new locations appear. Moreover, it implies that the perceptions and representations of the environment can be represented by quantitative data and that Iban people have the same logical way of thinking than occidental people. If the method is easy to understand and to conduct, it is actually not that simple to give a quantitative value of the importance of a land use.

The free listing is also a highly cost effective method which can be easier to conduct than the groups discussion. This method is used in anthropology to understand a particular aspect of the culture and is more representative of the perceptions of the villagers than the PDM method. However, it assumes that the most cited items are the most culturally important, which can be simplistic. The Iban classification being different from the occidental classification, one name of tree in Iban language can often refers to two or more species in the occidental classification. Thus, this method allows knowing more about the classification but not really about which species (scientific name) is important for people. For instance, gerunggang, which is one of the most important trees, refers actually, after identification, to three different species of the genus *Cratoxylum*. One name can also refer to different genus and even family.

It seems difficult to really draw conclusion on which ecosystem is the most “important” as they all provide different services, and men and women don’t accord the same importance and the same services to the land uses.

3. Other services

In addition to provisioning and cultural services, the land uses provide regulating and supporting services. In the last decade, in response of the global loss of biodiversity many experimental and theoretical studies have tried to assess how biodiversity can affect ecosystem services (Duffy et al., 2007, Cardinale et al., 2006, Hooper et al., 2005).

If some studies show a positive correlation between species richness and ecosystem functions as above ground and root biomass, field water capacity, nitrogen retention, respiration, decomposition rates or CO_2 flux (Schwartz et al., 2000, Cardinale et al., 2006), the conclusions are often that the consequences of the loss of biodiversity on the functions of ecosystem are heavily complex to assess and to predict. According to Schwartz et al. (2000), several researchers found that the relationship between diversity and function is variable through time and space, negative or nonexistent.

In these studies, we can first question the complex and broad-scale term of biodiversity that can refers to the genetic, species or ecosystem scale and can be described in many ways such as the number of entities, the evenness of their distribution or their interactions.

Moreover, the properties and functions of an ecosystem depend greatly on dominant species, keystones species, ecological engineers and interactions among species (Duffy et al., 2007, Cardinale et al., 2006, Hooper et al., 2005) in every taxonomic groups: microorganisms, vegetals, animals… Ecosystem properties may also be primarily controlled by abiotic environmental conditions (Hooper et al., 2005).

Ecosystem functions such as climate regulation, water cycling or purification also appear to be extremely difficult to study experimentally.

In our study it seems hard to conclude how biodiversity influence ecosystem services. We saw that provisioning and cultural services are not linked with trees diversity as logged forest has higher tree diversity than fallows and rubber gardens but is the less important land use for the villagers. For other services we can make the hypothesis that primary forest provides more regulating and supporting services than the other land uses. For Myers (1997), an undisturbed dipterocarp forest in South east Asia intercepts an average of at least 35 percent of rainfall, whereas a logged forest intercepts less than 20% and a plantation of rubber or oilpalmtrees only 12%. From personal observations rubber gardens and fallows allows some environmental services as soil protection and regulation of water flows to be sustained whereas in logged forest many land slide areas occurred and erosion is higher. Other members of the team work on soil erosion and types of land uses.

V. Conclusion

As primary forest are decreasing, other land uses in the Iban mosaic landscape can play an important role in the conservation of biodiversity and provision of services.

This study shows that production forests can host a high tree diversity especially when selective logging is respected, but with a low conservation value. They also provide few services for local people. In fallows and rubber gardens, trees richness and diversity are lower but they allow protecting a certain amount of species found in primary forest. These two land uses are essential for Iban people livelihood and rubber is the first source of income.

In a globalizing world and with fast changing socio-economic conditions in Indonesia, the land uses are likely to change. Roads have been opened by the logging companies and even remote villages have now access to the market. Food habits are changing, most of the villages have now access to electricity and there is a developing need for cash resources (villagers, pers.comm). Land uses are not independent of each other and the expansion of one land use for some services as food production or income may lead to the decrease of other land use providing other services. In our case, the expansion of rubber gardens for income needs may first lead to the decrease of fallows and the reduction of fallow periods but also to the decrease of primary forest in a more distant future. Moreover, there are already signs that smallholders tend to replace rubber gardens by monocrop rubber plantations. (pers. Obs., Feintrenie et al., 2010, Sodhi et al., 2010, Michon et al., 2007). Indeed, if biodiversity conservation is an international concern, the main goal of Iban people forest management, however, is to produce food and useful materials for their families, and to increase their income, not to promote biodiversity as defined by Western conservationists (Feintrenie et al., 2010, Wadley et al., 2004).

In this context, management of tropical forest landscape is a complicated challenge. The future of the Iban landscape is unclear and will depend on international, national and local politics and choices. The maintenance of long fallows period and traditional rubber gardens instead of monocrop plantations should be promoted. Some tracks for a sustainable management in this area could be to (i) first, giving advises on better tapping system and grafting techniques for a better rubber production, (iii) secondly a better access to the market for non timber products could also allowed people to increase their income and (iv) third developing ecotourism could also be considered. A better understanding of the ecological and socio-economic determinants of land use change in the Iban territory is mandatory and Iban people should have more weight in decisions making.

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Appendix 1. Location of the plots

★ Village of Keluin

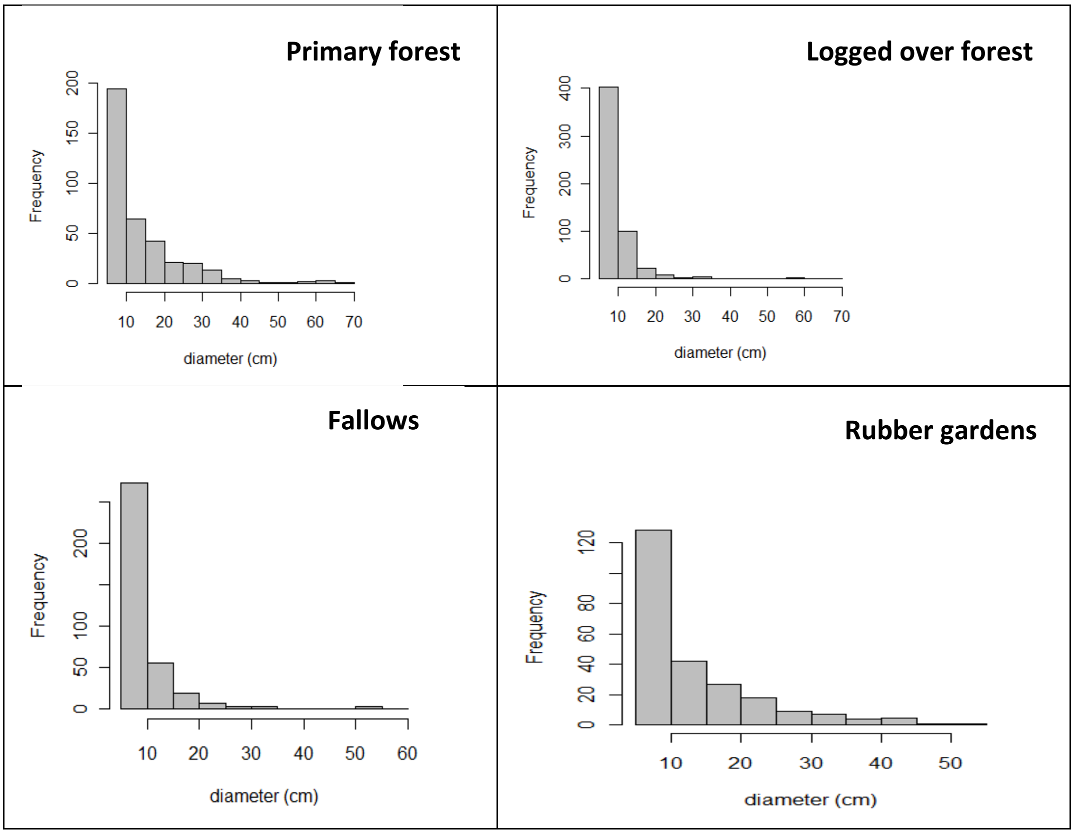
O Plot in primary forest

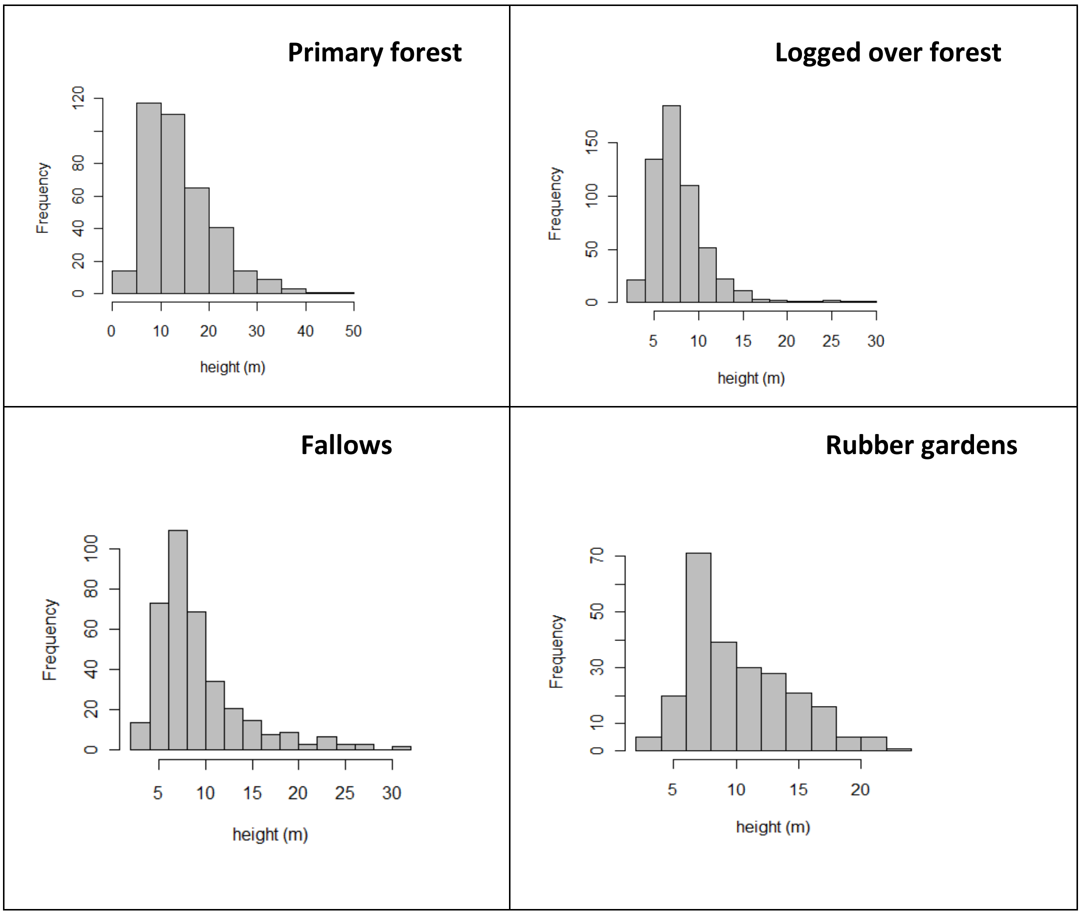
O Plot in logged over forest

O Plots in old fallows

O Plots in rubber gardens

Appendix 2. Diameter and height classes distribution in the four land uses





Appendix 3. Importance of the land use types

Participants : **WOMEN**

	Overall seluruh	**Basketry** Anyaman	**Firewood** Kayu bakar	**Fodder** Makanan ternak	**Food** Makanan	**Construction** Konstruksi	**Hunting** Berburu	**Marketable items** Produk untuk dijual	**Medecines** Obat-obatan	**Ornaments** Hhiasan, adat	**Recreation** Rekreasi	**Tools** Perkakas
Primary forest Hutan primar	**5**	**16**	**11**	**3**	**3**	**31**	**13**	**16**	**21**	**5**	**13**	**19**
Secondary forest Hutan logging	**4**	**14**	**10**	**9**	**4**	**6**	**9**	**5**	**6**	**10**	**0**	**0**
Old fallows Belukar	**10**	**13**	**12**	**6**	**13**	**10**	**8**	**8**	**14**	**15**	**5**	**11**
Rubber gardens Kebun karet	**15**	**7**	**12**	**9**	**8**	**3**	**8**	**11**	**5**	**5**	**25**	**12**
Swidden Ladang	**16**	**0**	**5**	**23**	**22**	**0**	**12**	**10**	**4**	**15**	**7**	**8**
Total use per category =50	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**

Participants: **MEN**

	Overall seluruh	**Basketry** Anyaman	**Firewood** Kayu bakar	**Fodder** Makanan ternak	**Food** Makanan	**Construction** Konstruksi	**Hunting** Berburu	**Marketable items** Produk untuk dijual	**Medecines** Obat-obatan	**Ornaments** Hhiasan, adat	**Recreation** Rekreasi	**Tools** Perkakas
Primary forest Hutan primar	**8**	**16**	**4**	**9**	**11**	**30**	**9**	**11**	**19**	**17**	**11**	**15**
Secondary forest Hutan logging	**5**	**11**	**4**	**3**	**4**	**17**	**8**	**9**	**14**	**15**	**10**	**11**
Old fallows Belukar	**5**	**11**	**6**	**3**	**3**	**0**	**9**	**3**	**6**	**0**	**0**	**0**
Rubber gardens Kebun karet	**16**	**6**	**24**	**10**	**14**	**3**	**8**	**14**	**6**	**8**	**20**	**14**
Swidden Ladang	**16**	**6**	**12**	**25**	**17**	**0**	**16**	**13**	**5**	**10**	**9**	**10**
Total use per category =50	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**

Appendix 4. Important species for each category of use

Participants : WOMEN

	Important species			Important species	
	Local name	**Where to find them**		**Local name**	**Where to find them**
Basketry *anyaman*	Bemban	fallows	**Construction**	Gerunggang	
	Kulan	fallows	*Konstruksi*	Bintangur	
	Senggang	fallows		Perawan	
	Kerupuk	fallows		Tebelian	
	Rotan	Forest, rubber gardens, fallows		Tekam	Forest
	Daun lemak	Swidden, fallows		Keladan	
	Kulit Tekalong	Swidden		Langsau	
				Resak	
Firewood	Kayu karet	-rubber gardens	**Hunting**	Babi	
Kayu bakar	Entali		*Berburu*	Kijang	
	Kepapak			Pelandok	Forest
	Kedemak			Musang	
	Belete			Busao	Swidden
	Empaling			Kra	
	Kerupuk	fallows		Nyumbo	fallows
	Gungkang			Mayas	
	Empilé			Rusa	
	Bangas				
Fodder	Padi		**Medecines**	Kulit kayu selukai	
Makanan ternak	Jagung		*Obat-obatan*	Kulit kayu raru	
	Buah ubi	Swidden		Kayu bahu	Forest
	Linkolucit			Kayu buru	
				Ginseng	
Food	Nasi		**Marketable items**	Durian	
Makanan	Daun ubi		*Produk untuk dijual*	Sibao	
	Timun			Buah merenti	
	Buah terung			Linsat	
	Paniang			Rami	Swidden, gardens, rubber gardens
	Sayur	Swidden		Karet	
	Buah pisang			Buah piseng	
	Keladi			Buah ubi	
	Buah entekai			Buah abuk	
Ornaments, ritual	Lemak		**Tools**	kayu pedalai	
Hiasan, adat, ritual	Engkebai		*Perkakas*	kayu lihan	Forest, fallows
	Munkudu	Forest		kayu balai	
	Rengat				
	Kelempait				

Participants : MEN

	Important species			Important species	
	Local name	**Where to find them?**		**Local name**	**Where to find them?**
Basketry *anyaman*	Bemban	Swamps	**Construction** *Konstruksi*	Gerunggang	
	Kerupuk	Swamps		Perawan	
	Rotan	Forest		Keladan	
	Kulan	Forest, swamps		Tekam	
	Senggang	Swidden		Medang	
	Kayak	Swidden		Resak	Forest
	Kulit tekalong	Fallows		Langsau	
	Daun lemak	Swidden		Eutenggor	
	Damam	Fallows		Senaga	
	Tanduk	Forest		Tebelian	
Firewood	Kayu karet	Rubber gardens	**Hunting**	Babi	Forest
Kayu bakar	Entali	Old fallows	*Berburu*	Kijang	Fallows
	Kepapak	Old fallows		Rusa	Swidden
	Empile	Old fallows		Musang	Gardens
	Gungkang	Swidden, river banks		Nyumbo	Rubber gardens
	Rambutan	Gardens		Beruang	Logged over forest
	Mujau	Rubber gardens		Ikan	River
	Sibau	Yard			
	Belete	River banks			
	Empaling	River banks			
	Kerupuk	River banks			
Fodder	Ubi		**Marketable items**	Karet	
Makanan ternak	Keladi		*Produk*	Padi	
	Padi		*untuk dijual*	Ayam	
	Jagung			Sayur	
	Kerta			Babi	
	Entekai	Swidden		Ikan	
	Empusut			Tikar	
	Rampo			Tenun	
	Terong			Jala	
	Cabe			Dukat	
Food	Padi	Swidden	**Ornaments, ritual**	Benang	Market
Makanan	Singkong	Swidden	*Hiasan, adat, ritual*	Tanggau	Forest
	Genuk	Swidden		Pandung	Forest
	Ikan	River		Sungkit	Market
	Babi	Forest/ livestock		Kwa kumbo	Market
	Ayam	Livestock		Tongkat timang	Forest
	Pelanduk	Forest		Bidai	House
	Musang	Forest		Bulupapan	Forest
	Kijang	Forest		Rante panggau	Forest
	Mulung, sagu	River banks			
	Umbut	Fallows			
Tools	kayu	Forest	**Medecines**	Kulit kayu	
Perkakas	besi	Market	*Obat-obatan*	Daun-daunan	
	benan	Market		Akar-akaran	
	tumbuhan	Forest		Getah	Forest
	rotan	Forest		Pasak bumi	
	bemban	River barks		Ginseng	
	Krupuk	River barks			
	Kayu perahu	Forest			
	Lesung	Forest			
	Kisar	Forest			

Appendix 5. Sources of income

	Total (PDM)			Important species		F	Price		Unit
	MEN	WOMEN	TOTAL	Latin name	Local name		Rp	Eur	
Primary forest	2	0	2	Shorea *sp.* Shorea *sp.* Hopea *dryobalanoides*	tekam tebelian perawan keladan	Wood Wood Wood Wood	25000 65 000 18000 25000	2,06 5,35 1,48 2,06	3 m 1 m 3m 3m
Logged over forest	9	0	9	Salary when the logging companies provide work.					
Fallows	2	12	14	Musa *spp* Dioscorea *spp* Manihot *esculenta*	Pisang Ubi Cinkong	Fruit Vegetable Vegetable	2500 2000 1000	0,21 0,16 0,08	1 Kg 1Kg 1 ikat (bunch)
Rubber gardens	21	38	59	Hevea *brasiliensis*	Geta	Rubber	15000	1,23	1 Kg (around 5 kgs /day)
Swiddens	16	0	16	*Zea mais spp.* *Capsicum spp.*	Jagung Sawi Telong asam Cabe Timun	Vegetable Vegetable Vegetable 1000 6000	3000 2000 7000 0,08 0,50		1 Kg 1 ikat 1 Kg 4 biji (seeds) 1 Kg

Appendix 6 . Free list of trees

PF=primary forest ; LF=logged forest ; S=swidden; F=fallows; LH= longhouse; G= garden;

RG= rubber garden: H construction= heavy construction: L construction= light construction

Men : 35-45 years old			Men : 45-55 years old			Women : 15-25 years old		
Species listed	**Use**	**Location**	**Species listed**	**Use**	**Location**	**Species listed**	**Use**	**Location**
ubah	H_construction	PF	perawan	H_construction old_use	PF	pisang	food	LH
kumpang	firewood	PF	medang	H_construction	PF	pedalai	food	LH
lulai	tools	PF	resak	H_construction	PF	enkudu	medicine	LH
perawan	H_construction	PF	empile	firewood fodder	PF	rembai	food	LH
empile	firewood	PF	kedabang	food fodder firewood	PF LF	nkala	food	LH
tor	tools H_construction	PF	kelensau	H_construction fodder food	PF	hijuk	alcool	LH
gerunggang	H_construction	PF/ S	keladan	H_construction fodder	PF	buko	food	LH
berangan	food_animals	PF	tekam	H_construction	PF	merenti	food	LH
betikal	food_animals	PF	mujau	food fodder	PF LF	iniak	food	LH
mujau	fodder firewood	F/ PF	entali	firewood	F	limao	food	LH
ungit	food	PF	kepapak	firewood	F LF	rian	food	LH
kemayao	food	PF	intangur	H_construction	PF	lensat	food	LH
lepang	medicine	PF	senaga	H_construction	PF	tekalong	food	LH
tekam	H_construction	PF	aras	old_use firewood	F	jambu	food	LH
keladan	H_construction	PF	sepit_unai	H_construction old_use	PF	sibao	food	LH

Women : 25-35 years old			Men : 45-55 years old			Men : 25-35 years old		
Species listed	**Use**	**Location**	**Species listed**	**Use**	**Location**	**Species listed**	**Use**	**Location**
rian	food	G	sawi	tools	F	entali	firewood	F
aras	old_use	LF F	kedemak	firewood	F	kepapak	firewood	F
melidan	firewood	LF F RG	legai	L_construction	F LF	mpaling	tools firewood	F
bunkang	food	F RG	merempak	L_construction	RG	berangan	firewood food	F PF
gerunggang	tools	F RG	medang	tradition	RG	ngranie	food	RG F
nanka	food marketable_items	G	gerunggang	tools H_construction	RG	keladan	H_construction	PF
kepapak	firewood	LF F	intangur	H_construction	RG	babai	food tools	river
maniam	L_construction	F	senaga	H_construction	PF	pito	firewood food	river
buhan	L_construction	F	empile	firewood	F	kelensau	H_construction	PF
nkabang	H_construction marketable_items	G	bunkang	food firewood	RG	berangan_pipit	firewood food	F PF
babai	food tools	river	kande	food firewood	RG	berangan_entalo	firewood food	F PF
ntimao	food	F	menuang	H_construction	river	pingan	food L_construction	F RG
karet	firewood marketable_items	RG	nkabang	H_construction marketable_items	F PF	tekalong	food basketry	F
purang	L_construction	F	purang	L_construction	F LF	pedalai	food tools	G

tekalong	basketry	F
Women : 15-25 years old		
Species listed	**Use**	**Location**
purang	firewood	S
entali	firewood	S
kepapak	firewood	S
bunkang	firewood food	S river
pandung	tradition	F
regang	tradition	F
maniam	firewood	G
empile	firewood	F
ingur	food	S
rengas	no_use	RG
buhan	no_use	S
jambu	firewood	LH S
sibao	firewood	G
ara	food	G river
ntepung	firewood	F

nkerubung	L_construction	LF
Men : 45-55 years old		
Species listed	**Use**	**Location**
perawan	H_construction	PF
gerunggang	H_construction tools	PF
keladan	H_construction	PF
kelensau	H_construction	PF
mangris	H_construction	PF
tekam	H_construction	PF
kraulit	H_construction	PF
lelangai	H_construction	PF
peniao	H_construction	PF
terentang	tools	F
legai	H_construction	F
kempas	H_construction tools	PF
selanking	H_construction	PF
temeso	H_construction	PF
tebelian	H_construction	PF

bangas	H_construction	PF RG
Men : 45-55 years old		
Species listed	**Use**	**Location**
merempak	firewood	PF LH
legai	H_construction	LH
ntepung	no_use	G
mpaling	firewood	F
jambu_tuan	firewood	LH
maniam	L_construction	F
pulo	tools	LH
medang	H_construction	PF
medang_kala	H_construction	F
mangris	no_use	LH
perawan_bankit	H_construction	PF
kumpang	firewood	LH
malam	firewood	PF
tapang	H_construction	LH
aras	firewood	LH

Women : 35-45 years old			Women : 55-65 years old			Women : 25-35 years old		
Species listed	**Use**	**Location**	**Species listed**	**Use**	**Location**	**Species listed**	**Use**	**Location**
ara	food	river	aras	old_use	S	buhan	no_use	S F
kepapak	firewood	F	nkerubung	L_construction	S	bunkang	firewood food	river
gerunggang	L_construction	F	purang	L_construction	S	entali	firewood	F
intangur	L_construction	F	jambu_tuan	no_use	S	mujau	food	RG
merejemu	firewood	S	kenaran	no_use	S	buko	food	PF LH
nkabang	marketable_items	F	legai	H_construction	S	nanka	food	LH
rian	marketable_items	F	terentangcet	no_use	S	melidan	firewood	LH
pedalai	food	F	ubah	no_use	S	kemunting	food	LH
nanka	food	F	entali	no_use	S	ara	food	river
buko	food	F	gerunggang	H_construction	S	pulo	tools	LH
jambu	food	F	buhan	no_use	S	merejemu	no_use	S
sibao	food	F	ingur	food	S	kepapak	firewood	S
pisang	food	F S	perdok_jugam	no_use	S	merempak	no_use	S
merenti	food	G	kepapak	firewood	S	intangur	H_construction	PF
tebelian	H_construction	F	tekalong	basketry	S	tebelian	H_construction	PF

Women : 25-35 years old			Women : 55-65 years old			Men : 25-35 years old		
Species listed	**Use**	**Location**	**Species listed**	**Use**	**Location**	**Species listed**	**Use**	**Location**
entali	firewood	F	entali	firewood	S	karet	marketable_items firewood	RG
ntupak	firewood	F	kepapak	firewood	S	gerunggang	H_construction	RG
nkuang	medicine food	river	bunkang	food	river F	intangur	H_construction	PF
pito	food_animals	river	melidan	firewood	LH	medang	H_construction	RG
kedemak	firewood	F	puak	food	F	entali	firewood	F
rembai	food	G	nkegira	food	F	pedalai	food	LH
buko	food	G LH	kemayao	food	G	sibao	food	LH
rian	food H_construction	G	karet	marketable_items	RG	jambu_tuan	firewood	LH
mujau	food	RG	lelekat	food	G	keladan	H_construction	LG
menuang	H_construction	F	nyeka	food	G	perawan	H_construction	PF
kranie	food	RG	buko	food	G	bangas	H_construction	PF
babai	food	river	pedalai	food	LH	nanka	food	LH
petai	food	RG	nkala	food	LH G	tekam	H_construction	PF
mpelam	food	LH	kunong	food	RG	kepapak	L_construction firewood	F
jelentek	food	F	priha	food	RG	ubah	firewood	S F

Appendix 7. Ethnoecology of important species

Iban name	Latin name	Ecology	Occurrence in the plots	Local Use
Keladan	Dipterocarapaceae *Hopea dryobalanoides*	Locally abundant in mixed dipetocarp forest, at altitudes to 600 m*[1]	Primary forest, logged forest	Construction of longhouse, canoe. The fruits are eaten by wild pigs.
Perawan	Dipterocarpaceae *Shorea spp.*	Most frequently dominant genus in the emergent stratum of the zonal mixed and upper dipterocarp forests	Primary forest, logged forest	Construction of longhouse and canoe.
Gerunggang	Hypericaceae. *Cratoxylum spp*	Mainly present in the lowlands but can also be found in lower montane areas. In general *Cratoxylum* are all fast-growing trees commonly found in forest fringes, gaps and disturbed habitats. *[5]	Primary forest, logged forest, fallows and rubber gardens	Construction of longhouse, canoe and camp in the swidden. Wood is also used to make machete holster. Light hardwood timber

Ethnoecology of the 3 most important species for the men

Iban name	Latin name	Ecology	Occurrence in the plots	Local Use
Kepapak	Verbenaceae *Vitex pubescens*	Common in lowland forest, especially in more open habitats, secondary forests and river banks. It occurs gregariously in secondary forest and is a pioneer species in Imperata cylindrica vegetation and recently burnt grasslands. *[2]	Fallows, rubber gardens,	High quality as firewood and as timber to build the camps in the swidden. Timber is not commercially important*[3].
Buko			Close to the longhouse, fallows	The fruits can be eaten
Entali	Rosaceae - *Prunus arborea* - *Pygeum parviflorum*	-Common, found mostly in lowland but also in mountains up to 1300 m*[4]	Fallows, rubber gardens, logged forest	Used as firewood

. Ethnoecology of the 3 most important species for the women

Sources:

*[1]Ashton P.S. Tree flora of Sabah and Sarawak, Vol. 5. Edited by Soepadmo E. and Wong K.K..

*[2] http://www.worldagroforestrycentre.org/sea/Products/AFDbases/AF/asp/SpeciesInfo.asp?SpID=17970#Uses

*[3] Forest Department, Ministry of Primary Industries Malaysia. 1978. Tree flora of Malaya, vol. 3. Edited by F.S.P.Ng.C.Phil. (Oxon), F.L.S

*[4] Forest Department, Ministry of Primary Industries Malaysia. 1978. Tree flora of Malaya, vol. 2. Edited by F.S.P.Ng.C.Phil. (Oxon), F.L.S

*[5] Wong K.M. 1995. Tree flora of Sabah and Sarawak. Vol. 1. Edited by Soepadmo E. and Wong K.K.

Appendix 8. Calendar of activities

		January	February	Mars	April	Mai	June	July	August	September	October	November	December
Swidden cultivation calendar	Rice harvesting												
	new swidden site selection												
	Clearing and cutting												
	Burning												
	Rice planting												
	Cassava and corn planting												
	Weed control												
Other activities	Cut trees for firewood												
	Rubber trees taping		**Dry days only**									**Dry days only**	
	Gawai dayak						**1 week**						
	Weaving												
	Hunting												