Working Paper

Tree Diversity and Carbon Stock in Various Land Use Systems of Banyuasin and Musi Banyuasin Districts, South Sumatera

Sidiq Pambudi and Subekti Rahayu

World Agroforestry Centre

Tree diversity and carbon stock in various land use systems of Banyuasin and Musi Banyuasin Districts, South Sumatera

Sidiq Pambudi and Subekti Rahayu

Working paper no. 267

LIMITED CIRCULATION

Correct citation
Pambudi S and Rahayu S. 2017. *Tree diversity and carbon stock in various land use systems of Banyuasin and Musi Banyuasin Districts, South Sumatera.* Working Paper 267. Bogor, Indonesia: World Agroforestry Centre (ICRAF) Southeast Asia Regional Program. DOI: http://dx.doi.org/10.5716/WP17358.PDF

Titles in the Working Paper series aim to disseminate interim results on agroforestry research and practices, and stimulate feedback from the scientific community. Other publication series from the World Agroforestry Centre include Technical Manuals, Occasional Papers and the Trees for Change Series.

Published by the World Agroforestry Centre
Southeast Asia Regional Program
JL. CIFOR, Situ Gede, Sindang Barang, Bogor 16680
PO Box 161, Bogor 16001, Indonesia

Tel: +62 251 8625415
Fax: +62 251 8625416
Email: icraf-indonesia@cgiar.org
ICRAF Southeast Asia website: http://www.worldagroforestry.org/region/southeast-asia/

Working paper no. 267

Photos/illustrations: the authors

Disclaimer and copyright

About the authors

Sidiq Pambudi is research assistant in World Agroforestry Centre Indonesia. His areas of work generally on biodiversity assessment in various land use including analysis vegetation and above-ground carbon stock estimation. Aside from working on field work surveys, analyzing and interpreting data, he has also conducts trainings, and develops reports and briefs. Sidiq also passionate in wildlife study and experienced in conducting fauna inventory in various activity before joining World Agroforestry Centre. He received bachelor degree in Biology from Institut Teknologi Bandung in 2012, focusing on ecology and biosystematics research group. Contact: s.pambudi@cgiar.org

Subekti Rahayu is a biodiversity and carbon stock specialist at the World Agroforestry Centre. Her main areas of interest include biodiversity conservation, forest and landscape restoration, forest ecology, bioindicators and agroforestry ecology. She is a PhD candidate on restoration model in Samboja Research Forest, East Kalimantan. She has a master degree in Tropical Biodiversity Conservation from Bogor Agriculture University. She holds a bachelor degree from the same university, majoring in Plant Protection. She has had experience with carbon-stock measurement at plot level since 1998 and delivering training on the subject to various institutions in Indonesia and to local communities in Indonesia and Viet Nam since 2002. Contact: s.rahayu@cgiar.org.

Abstract

In an effort to mitigate climate change, landscape management planning aims to balance socio-economic needs with environmental sustainability. South Sumatra is one of the provinces in Indonesia committed to the restoration and creation of a green economy based on sustainable use of natural resources. Land-based development should be planned to achieve a balance between these aspects. Therefore, an assessment of current conditions and potential existing land use resources is needed to provide basic data for future development. Amount of 55 plots in 8 land use systems in Banyuasin, Musi Banyuasin and Musi Rawas were set up for the analysis of tree diversity and above-ground carbon stock estimation. Based on tree diversity composition, logged-over forest is considered as a sustainable ecosystem due to its high tree species richness, high diversity index and medium similarity among growth stages. The shrub on swampy area are land cover type that has potential in supporting biodiversity due to not been managed intensively. Compared with terrestrial ecosystem, mangrove has lower species richness, even though the typical characteristics of those ecosystem type is also good habitat for biodiversity, especially supports aquatic biodiversity and has other physical functions such as preventing coastal abrasion. In terms of carbon stock, natural land cover such as undisturbed forest, logged-over forest and mangrove forest has high to medium amount of carbon stock. Man-made land use systems such as rubber agroforest also potential to be developed as part of mitigation action as it contains relatively high carbon stock.

Keywords

Above-ground carbon stock, South Sumatera, Sustainable development, Tree diversity

Content

List of Tables

List of Figures

1. Introduction

Greenhouse gases emission in Indonesia is mostly caused by forest conversion to another land use (Harris et al 2012). The loss of forest cover has led to a loss of biodiversity that in turn has reduced ecosystem services including carbon sequestration. Tree stands are the component most affected by land use changes due to land clearing activity.

In an effort to mitigate climate change, landscape management planning aims to balance social-economic needs with environmental sustainability. Land-based development should be planned to achieve a balance between these three aspects. Therefore, an assessment of the current condition and potential resources of existing land use is needed to provide basic data for future development.

South Sumatera has millions of hectares of forest. Some of the natural forest is in pristine condition and provides huge amounts of ecosystem services. Not only do such areas store significant amounts of carbon and, therefore, contribute to climate regulation but also they serve as habitat for the extremely rich biodiversity, many of the flora and fauna of which are endemic owing to the diversity of the ecosystems. In addition, South Sumatra has committed to develop a green economy to increase income while reducing emissions.

The main effort to reduce emissions of CO_2 is by increasing carbon sequestration. The level of carbon uptake by terrestrial ecosystems is dependent on three aspects: 1) vegetation (species composition, and structure), 2) conditions (variations in climate, soils, and natural disturbances such as forest fires) and 3) land management (Hairiah 2007). Therefore, the most appropriate efforts to reduce CO_2 in the atmosphere are through managing vegetation, and in particular, by keeping trees in the land use.

The value of the carbon stock of a land use is highly dependent on the presence of trees—both standing and fallen, live and dead—as a carbon pool. The tree size, density and characteristics of each species affect the carbon stock of the land. While the sustainability of environmental services is not only characterised by the presence of trees alone, the existence and composition of certain tree species can have specific roles, including supporting the sustainability of other biodiversity. The aims of this study were to assess the diversity of trees across land use systems and to estimate the tree-based carbon stock.

2. Methods

2.1 Study site

The study area covered three districts in South Sumatera: Banyuasin, Musi Banyuasin and Musi Rawas (Figure 1). However, the detailed analysis in this working paper focuses on Banyuasin and Musi Banyuasin. As additional data for above-ground carbon stock assessment, we use reports of Musi Rawas data collection conducted by the Bandung Technology Institute (ITB). The sample plots were set up in the major land use systems in the three districts (Figure 1).

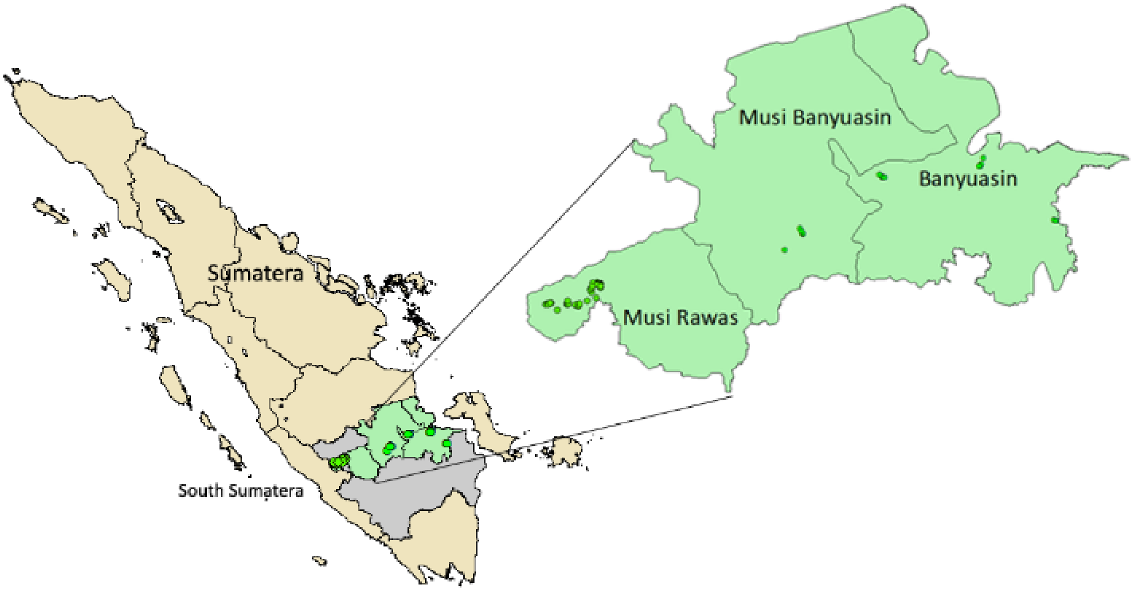

Figure 1. Study site

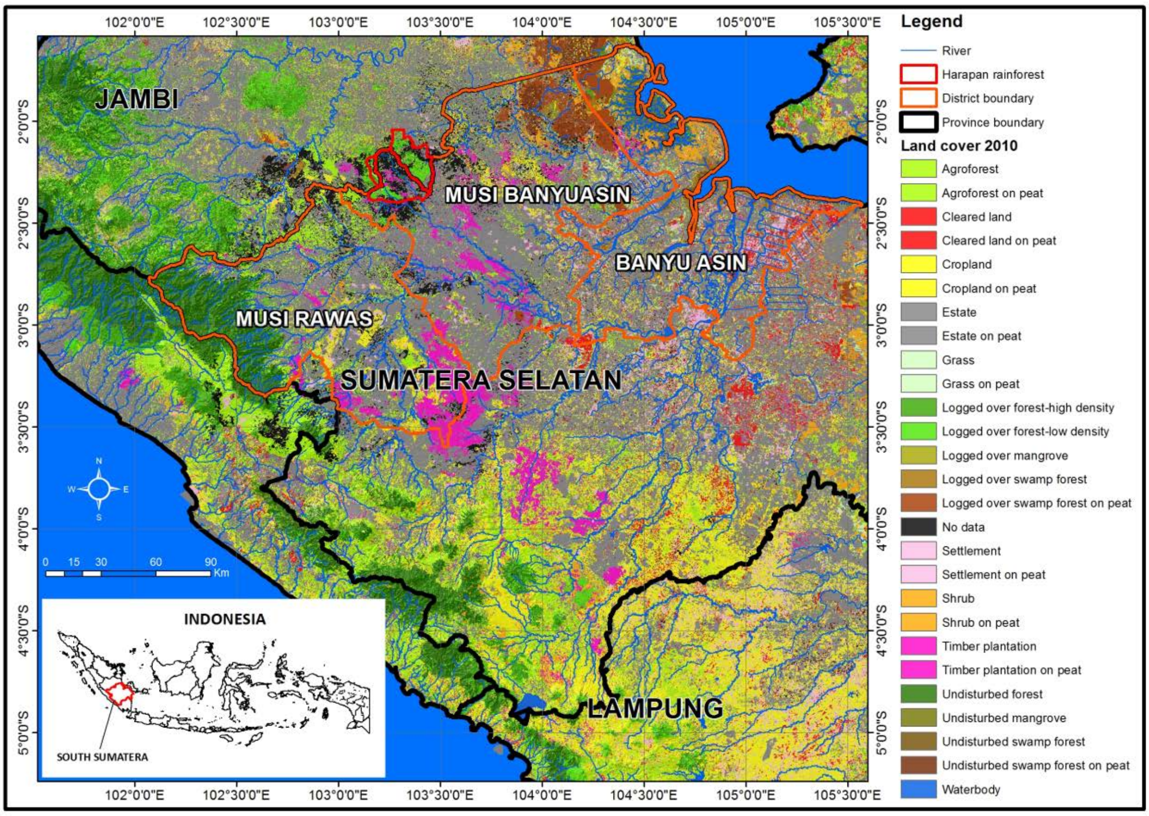

Figure 2. Land use systems in Banyuasin, Musi Banyuasin and Musi Rawas

2.2 Sampling method

Carbon stock assessment was undertaken using the widespread method developed by Hairiah et al (2011), while tree diversity assessment occurred in the same plot as the carbon stock assessment.

2.2.1 Tree diversity

Tree diversity sampling was done in four stages of tree growth: seedling (woody plant less than 2 m height), sapling (woody plant less than 5 cm diameter at breast height (DBH), above 2 m height), pole (woody plant 5–10 cm DBH) and tree (woody plant above 10 cm DBH). Nested plots were set up on a 20 x 100 m grid to observe the different stages of vegetation growth (Figure 3), using subplots (2 m x 2 m for seedlings, 5 m x 5 m for saplings, 10 m x 10 m for poles and 20 m x 20 m for trees). All seedlings and saplings inside subplots were identified through collecting leaf specimens and by counting the individual number of each species. All poles and trees inside subplots were measured for DBH; at 1.3 m above ground) and identified using the leaves and also flower and seed specimens if available.

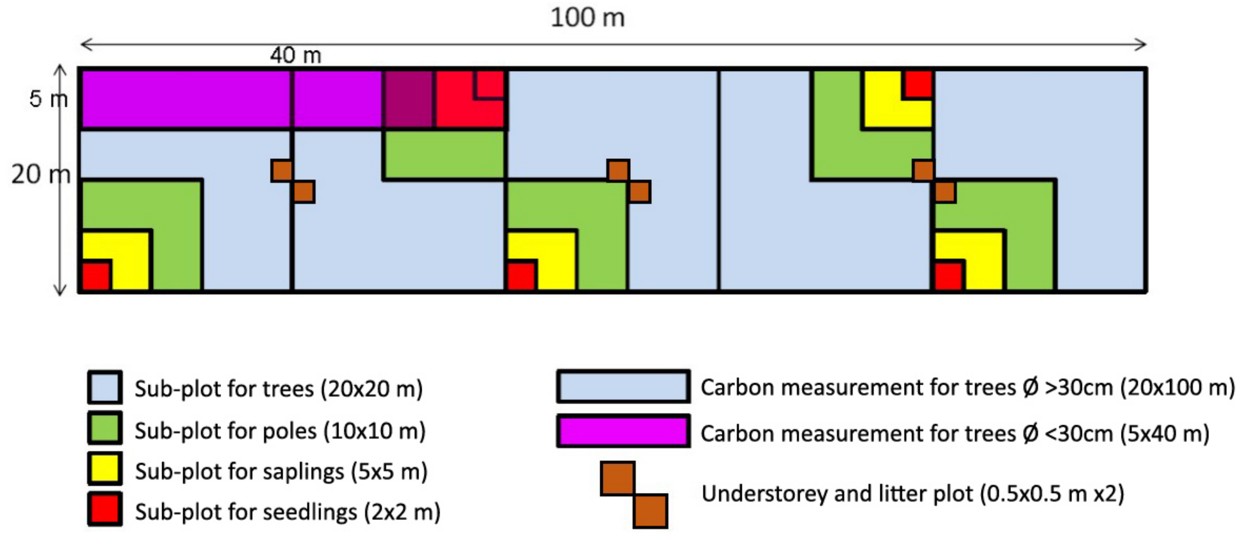

Figure 3. Plot design for tree diversity analysis

2.2.2 Above-ground carbon stock

Carbon stock assessment focused on four carbon pools: tree biomass, understorey, tree necromass and litter. Non-destructive methods were applied to estimate tree biomass using allometric equations, while understorey and litter sampling used destructive methods in taking samples. Biomass estimations for large living and dead trees above 30 cm DBH were analysed within a 2,000 m^2 plot, while the smaller living and dead trees (5–30 cm DBH) were analysed in a 200 m^2 (5 m x 40 m) plot as shown I (Figure 3). Understorey and litter sampling were conducted in a quadrant (2 x 50 cm x 50 cm) placed randomly inside the 5 m x 40 m plot. At least 3 replications were carried out during sampling. All understorey and litter within the quadrant were collected and their fresh weight and oxen dry weight were recorded.

A set plot (5 m v 5 m) was established for sampling Nypa. Measurement of Nypa biomass was conducted using destructive sampling. All Nypa clumps inside the plot were counted. The number of fronds in each stand was counted. On a 5% sample, the number of fronds in each Nypa clump was recorded. All frond parts—leaves, rachis and frond base—were weighed. A 300 g fresh weight sub-sample of each of the leaves, rachis and frond base was taken and processed to determine the oxen dry weight.

2.3 Data analysis

2.3.1 Tree diversity analysis

Species richness, Important Value Index (IVI), Bray-Curtis dissimilarity and Shannon's diversity index were used to analyse tree diversity. Species richness is the number of different species represented in an ecological community, landscape or region (Cowell 2009). In this study, species richness represented the number of different species found in certain land use systems.

The IVI expresses the dominance of species in the unit area and is calculated based on the relative frequency, relative density and dominance (Curtis & McIntosh 1950):

$$IVI = Relative\ Frequency + Relative\ Density + Relative\ Dominance$$

a. Relative frequency

Relative frequency is the proportion of quadrants sampled in which the species is represented:

$$Frequency\ of\ species\ i = \frac{Number\ of\ quadrats\ with\ species\ i}{Total\ number\ of\ quadrat\ sampled}$$

$$Relative\ Frequency = \frac{Frequency\ of\ species\ i}{Total\ frequency}$$

b. Relative density

Relative density is the proportion of a species in relation to the total number of individuals of all species, and is estimated by quantifying the number of individuals of a species per unit area:

$$Density\ of\ species\ i = \frac{Number\ of\ individual\ species\ i}{Area\ of\ quadrat\ sampled}$$

$$Relative\ Density = \frac{Density\ of\ species\ i}{Total\ density}$$

c. Relative dominance

Dominance of a species is determined by the value of the basal cover. Relative dominance is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area:

$$Dominance\ (Basal\ area\ of\ species\ i) = \frac{\pi\ *(Diameter\ of\ species\ i)^2}{4}$$

$$Relative\ Dominance\ = \frac{Basal\ area\ of\ species\ i}{Total\ basal\ area}$$

The similarity index is a comparison of the current vegetation component on an ecological site. A similarity index determines how closely the current plant community resembles either the potential natural community or some other reference community. The similarity index is expressed as the percentage of the reference community that is currently on an ecological site. The similarity index value varies between 0 and 1, where 0 means very dissimilar and 1 means very similar.

Bray-Curtis dissimilarity (B) is used to quantify the compositional dissimilarity between two different sites, based on counts at each site. Bray-Curtis dissimilarity uses individual numbers as parameters in the calculation, so that both species and individual parameters can affect the degree of similarity for two compared sites:

$$Bray\text{–}Curtis\ similarity\ (1 - B) = 1 - \frac{\sum_{i=1}^{S} |(n_{1i} - n_{2i}|)}{\sum_{i=1}^{S} (n_{1i} + n_{2i})}$$

where:

B = Bray-Curtis dissimilarity; S = total species number in land use 1 and land use 2; n_1 = number of individual of species i in land use 1; n_2 = number of individual species i in land use 2.

The diversity index is a quantitative measurement that reflects how many different species there are in a site. The Shannon-Wiener diversity index (H') is one of the popular indices that is used in ecological studies. It represents how the species heterogeneity of a site incorporates species richness and evenness. The value of H' commonly varies between 0 and 3.5, and rarely surpasses 4.5:

$$H' = -\sum pi\ (ln\ pi)$$

where:

pi = proportion of the individual number of each species to the total species i

The value of H' represents species heterogeneity and can be classified into low (H' < 1.5), medium (1.5–3.5) and high (H' > 3.5).

2.3.2 Tree biomass carbon stock analysis

Tree biomass carbon stock is generated from individual tree diameter (D) and wood density (ρ) using an allometric equation developed by Chave et al. (2005) for humid/moist topical forest with precipitation between 1,500 and 4,000 mm/year:

$$Aboveground\ Biomass_{.est}(kg) = \rho * esp(-1.499 + 2.148\ ln(D) + 0.207(ln(D))^2 - 0.0281(ln(D))^3)$$

For certain species such as coffee, cacao, oil palm, palm, banana and bamboo, we applied specific allometric equations developed by researchers previously (Table 1).

Table 1. Allometric equations for biomass estimation of specific species

Tree species	Allometric equation	Source
Coffee regularly pruned	(AGB)est = 0.281 $D^{2.06}$	Arifin 2001
Cacao	(AGB)est = 0.1208 $D^{1.98}$	Yuliasmara 2008
Oil palm	(AGB)est = 0.0976 H + 0.0706	ICRAF 2009
Palm	(AGB)est = exp{-2.134 + 2.530 v ln(D)}	Brown 1997
Palm	(AGB)est = 4.5 + 7.7 v H	Frangi & Lugo 1985
Bamboo	(AGB)est = 0.131 $D^{2.28}$	Priyadarsini 2000
Banana	(AGB)est = 0.030 $D^{2.13}$	Arifin 2001

Note:
(AGB)est = estimation aboveground tree biomass, kg $tree^{-1}$; D = DBH, diameter at breast height, cm; H = tree height, m;
ρ = wood density, g cm^{-3} (available from: http://db.worldagroforestry.org/wd).
A default value was used for the carbon content to estimate the carbon fraction in the aboveground biomass (47% of biomass value) based on IPCC (2006).

3. Results

3.1 Land use descriptions

3.1.1 Undisturbed mangrove

Undisturbed mangrove remains in certain areas along the coast of Banyuasin and Musi Banyuasin. There are several types of mangrove in Banyuasin ranging from mono species to more diverse mixed species. Plot samples of mangrove were set up in Telang, Sungsang and Tanjung Lago (Banyuasin). Mangrove formation in the Telang area is dominated by perepat (*Sonneratia caseolaris*) with diameters up to 60 cm. The tree-stage population in this area reaches about 40 individuals per 2,000 m^2 or about 200 trees per hectare, but there are fewer in the sapling and seedling stages (Figure 4). Other species in the mangrove include the herb jeruju (*Acanthus* sp.), but at very low density. The local community mentioned that they benefit from this mangrove through extracting roots for bottle cap (Rp. 100 per cone root).

Figure 4. *Sonneratia caseolaris* as dominant species in small delta of Telang area

Mangrove types in Sungsang are closer to the sea and consist of more species such as *Avicennia alba* and *Bruguiera cylindica* as dominants mixed with *Sonneratia caseolaris* and *Nypa fruticans* (Figure 5). The tree stage (> 10 cm diameter) is dominated by *Avicennia alba* that reaches up to 60 cm diameter and the pole stage (5–10 cm diameter) is dominated by *Bruguiera cylindrica*, but both species have balanced populations in the seedling and sapling stages.

Figure 5. Mixed mangrove, dominated by *Sonneratia caseolaris* and *Avicennia alba*

Other undisturbed mangrove types in Tanjung Lago are dominated by *Rhizophora apiculata* and *Rhizophora mucronata* in the tree stage with a range of 20–60 cm diameter, with *Avicennia alba* in the pole stage and the three species occur as seedlings, saplings and poles with *Nypa fruticans* distributed across the plots (Figure 6).

Figure 6. Mangrove type dominated by *R. apiculata* and *R. mucronata*

3.1.2 Shrub on swamp

Shrub on swamp is spread out in Banyuasin and Musi Banyuasin. There are different types of shrub vegetation in the area. Two plot samples of shrub on swamp were set up in Jalur 21, Tirto Raharjo, Muara Padang (Banyuasin) at -2.726431^{o}, 105.186193^{o} and -2.729844^{o}, 105.196555^{o} at 10–20 meters above sea level. Four plots sample were set up in Puyuh, Teluk Tenggulang, Tungkal Ilir (Musi Banyuasin) at -2.509485^{o}, 104.318938^{o}; -2.506788^{o}, 104.307905^{o}; -2.511469^{o}, 104.309577^{o}; and -2.495172^{o}, 104.295696^{o}.

The area in Muara Padang was cleared several years ago for oil palm plantation, oil mining, and settlement. Some abandoned land has become occupied by Imperata grassland and the expansion of gelam (*Melaleuca* sp.) in an early growth stage, as well as *Acacia mangium* and *Melastoma malabathricum* (Figure 7). Shrub on swamp is mostly located alongside the canal and is inundated during the rainy season. During the dry season, the area may be affected by fire.

Figure 7. Shrub on swamp dominated by Imperata grassland with remaining standing dead and live trees spread out the area

Logged-over forest has a very low density which is described as shrub on swamp can be found in Tungkal Ilir. Various species and different tree densities—from early succession (Figure 8) to more dense and diverse species—can be found in this area with minimum management applied by the local community.

Figure 8. Shrub on swamp—early succession

Figure 9. Shrub on swamp with heterogenic species

3.1.3 Nypa clumps

Large areas of *Nypa fruticans* can be found in Tanjung Lago—with some *Avicennia* growing along the edges of streams (Figure 10)—and in Rimau Sungsang, Banyuasin II (Banyuasin). Three plots of Nypa were established at -2.369678º, 104.814695º; -2.368632º, 104.816958º; and -2.372349º, 104.816458º. Large areas of Nypa, located about 1 km from the coastline were cleared as part of the port development process.


Figure 10. Nypa mixed with other mangrove vegetation

3.1.4 Coconut monoculture

Coconut monoculture can be found in large areas of Marga Sungsang and Teluk Payo, Banyuasin II (Banyuasin). Three plots of coconut monoculture at different ages were established at -2.410208 º, 104.828633º; -2.452551º, 104.807313º; and -2.45442º, 104.804828º in young, middle-aged and older than 20 years, respectively. Commonly, coconut trees are planted 10 meters apart. Semi intensive management is applied with weeding, which may be irregular. Some species such as areca nut (*Areca catechu*) or taro (*Colocasia esculenta*) are integrated in the system (Figure 11).


Figure 11. Coconut monoculture

3.1.5 Logged-over forest

Natural land uses such as logged-over forest, undisturbed forest and shrub are still present but are difficult to access. Remnant forest remains in the area mostly because such sites are unsuitable for conversion (because of inundation in certain periods) or because they are protected by some regulations, such as being in a national park and other protected forest area. Five plots of logged-over forest were set up at Muara Teladan and Sekayu, Sekayu (Musi Banyuasin) at -2.799205º, 103.903882º; -2.881691º, 103.810277º; -2.794727º, 103.902356º; -2.786549º, 103.898087º; and -2.771383º, 103.889759º. Logging activity and other forest product harvesting activity still occur in this area. In addition, the forest is also used as access to garden agricultural fields and plantation areas. The canopy cover is quite high with medium density tree stands of *Eugenia* sp. and *Garcinia* sp

(Figure 12). No land management is applied in this land use system due to inundation during the rainy season. The forest is located near the Batanghari Leko River.

Figure 12. Logged-over forest

3.2 Tree diversity and composition

The tree diversity analysis of this research focused on land use samples in Banyuasin and Musi Banyuasin, since land use samples data of Musi Rawas had already been collected and reported on by SITH-ITB.

3.2.1 Species richness

Tree-based natural ecosystems of logged-over forest of low density in Musi Banyuasin and shrub on swampy areas in Banyuasin have high species richness, with 96 and 38 species in total on 5 and 6 plots, respectively. High tree species richness is found in the logged-over forest,with 65 of 96 species (almost 70% of total species). A similar trend is found in the shrub on swamp land use type, although with lower species richness. Undisturbed mangrove in Banyuasin has 7 species, but Nypa, as part of the mangrove formation has only the single species. Coconut monoculture represented by smallholder plantations consist of only the single species of saplings and poles, but a few species have managed to grow inside the systems (Table 2).

Table 2. Tree species richness in each land uses systems and each growth stage

District	Land use	No. of plots	Seedling	Sapling	Pole	Tree	All
Bayuasin	Undisturbed mangrove	3	5	6	5	6	7
	Nypa	3	-	-	-	1	1
	Swamp on shrub	6	10	16	17	23	38
	Coconut monoculture	3	0	1	1	3	4
Musi Banyuasin	Logged-over forest low density	5	37	55	37	65	96

3.2.2 Tree species diversity

The high species richness in the tree-based natural ecosystems of logged-over forest and shrub is in line with the species diversity index (Table 3). High diversity index found in logged-over forest for saplings, poles and trees (> 3 for the Shannon-Wiener Index), however the diversity index of seedlings are the lowest among other growth stage. The diversity index in the shrub and undisturbed mangrove for all growth stage are medium.

Table 3. Shannon-Wiener diversity index in various land use systems and growth stages

District	Land use	No. of plot	Seedling	Sapling	Pole	Tree
Bayuasin	Undisturbed mangrove	3	1.18	1.43	1.46	1.31
	Nypa	3	-	0	-	-
	Shrub on swamp	6	1.68	1.46	1.16	2.16
	Coconut monoculture	3	0	0	0.32	0.23
Musi Banyuasin	Logged-over forest low density	5	2.93	3.51	3.18	3.57

3.2.3 Dominant species

The dominant species in each land cover are presented in the list of three species with the highest IVI. *Sonneratia caseolaris* and *Avicennia alba* are the most two dominant species in the three mangrove plots sampled in Banyuasin for all growth stages. *Melaleuca leucadendra* is a very common species in the shrub on swampy area. *Pternandra caerulescens*, a sub-climax species that commonly grows under forest canopy is found as the most dominant species in logged-over forest for all growth stages (Table 4).

Table 4. Three highest IVI tree species for various land use systems and growth stage

Land use	Seedling	Sapling	Pole	Tree
Banyuasin, South Sumatra				
Undisturbed mangrove	*Avicennia alba* *Sonneratia caseolaris* *Bruguiera cylindrical*	*Avicennia alba* *Nypa fruticans* *Sonneratia caseolaris*	*Avicennia alba* *Sonneratia caseolaris* *Rhizophora mucronata*	*Sonneratia caseolaris* *Avicennia alba* *Rhizophora apiculata*
Nypa clump	-	-	-	*Nypa fruticans*
Shrub on swamp	*Melaleuca leucadendra* *Ploiarium alternifolium*	*Melaleuca leucadendra* *Ploiarium alternifolium* *Melastoma malabathricum*	*Melaleuca leucadendra* *Macaranga hypoleuca* *Alstonia scholaris*	*Melaleuca leucadendra* *Acacia mangium* *Macaranga hypoleuca*
Coconut monoculture	-	*Macaranga pruinosa*	*Fagraea crenulata*	*Cocos nucifera* *Macaranga pruinosa* *Areca catechu*
Musi Banyuasin, South Sumatra				
Logged-over forest low density	*Pternandra caerulescens* *Cleistanthus myrianthus* *Garcinia parxifolia*	*Pternandra caerulescens* *Dillenia excelsa* *Gardenia tubifera*	*Pternandra caerulescens* *Elaeagnus sp.* *Eugenia aquea*	*Pternandra caerulescens* *Garcinia parxifolia* *Eugenia aquea*

3.2.3 Similar species among land use and growth stage

Based on result, there is no similarity among the sampled land use in both Banyuasin and Musi Banyuasin Districts. Very low similarity occurs between logged-over forest and shrub (Table 5). The similarity of species among man-made and natural land use systems can show the capability of man-made land use systems to support natural species to grow.

Table 5. Matrix similarity species among land uses systems in Banyuasin and Musi Banyuasin

	UM	Nypa	ShS	CoM	LoF-L
Seedling					
Undisturbed mangrove (UM)	1	0	0	0	0
Nypa		1	0	0	0
Shrub on swamp (ShS)			1	0	0.05
Coconut monoculture (CoM)				1	0
Logged-over forest low (LoF-L)					1
Sapling					
Undisturbed mangrove (UM)	1	0.24	0	0	0
Nypa		1	0	0	0
Shrub on swamp (ShS)			1	0	0.01
Coconut monoculture (CoM)				1	0
Logged-over forest low (LoF-L)					1
Pole					
Undisturbed mangrove (UM)	1	0	0	0	0
Nypa		1	0	0	0
Shrub on swamp (ShS)			1	0	0.04
Coconut monoculture (CoM)				1	0
Logged-over forest low (LoF-L)					1
Tree					
Undisturbed mangrove (UM)	1	0	0	0	0
Nypa		1	0	0	0
Shrub on swamp (ShS)			1	0	0.02
Coconut monoculture (CoM)				1	0
Logged-over forest low (LoF-L)					1

Beside similarity in species among land use systems, we investigated more detail on the similarity of species among the growth stages in each land use system to understand the sustainability of species in the ecosystem. In the natural ecosystems, such as logged-over forest, shrub and undisturbed mangrove, some species have had a chance to develop from seedlings to the tree stage due to low disturbance. The intensity of disturbance may affect the level of sustainability of species in certain ecosystems and is expressed by the level of similarity among growth stages (Table 6). Low disturbance results in high similarity among growth stages. An exceptional case occurs in Nypa a ecosystem which there is dissimilarity in all growth stages. In Nypa, similarity analysis was undertaken for the other species which had regenerated in that ecosystem, but none were found. However, in the man-made ecosystem of monoculture coconut, only very limited species change is evident due to the management activities in the systems.

Table 6. Matrix similarity species among growth stage in Banyuasin and Musi Banyuasin

	Seedling	Sapling	Pole	Tree
Undisturbed Mangrove				
Seedling	1	0.61	0.54	0.59
Sapling		1	0.64	0.69
Pole			1	0.67
Tree				1
Nypa clump				
Seedling	1	0.00	0.00	0.00
Sapling		1	0.00	0.00
Pole			1	0.00
Tree				1
Shrub on swamp				
Seedling	1	0.42	0.20	0.29
Sapling		1	0.65	0.36
Pole			1	0.48
Tree				1
Coconut Monoculture				
Seedling	1	0.00	0.00	0.00
Sapling		1	0.00	0.07
Pole			1	0.00
Tree				1
Logged over Forest low density				
Seedling	1	0.54	0.32	0.43
Sapling		1	0.54	0.55
Pole			1	0.44
Tree				1

3.2 Carbon stock analysis

3.2.1 Carbon stocks at land use level

Above-ground carbon stock estimation of Banyuasin and Musi Banyuasin was performed in four carbon pools: above ground biomass (tree and understorey), litter and necromass, except for undisturbed mangrove. The understory in mangrove dominated by *Rhizophora* sp. is very limited, because of root occupation and the low light intensity reaching the forest floor. Movement of litter and necromass in the mangrove ecosystem is affected by the tide flow.

In this study included the carbon stock data of Musi Rawas collected by SITH-ITB which focused on live tree component. Details of the results, plot number and land use systems in each district are described in Table 7.

Table 7. Aboveground carbon stock in various land use systems

District	Land use	No. of plots	Carbon stock (Mg ha $^{-1}$)				
			Tree	Necromass	Understorey	Ltter	Total
Banyuasin	Undisturbed mangrove	3	99.2	-	-	-	99.2
	Nypa clump	3	0	0	8.5	3.2	11.7
	Shrub on swamp	6	14.2	1.6	3.9	3.2	22.9
	Coconut monoculture	3	42.0	0	1.5	2.4	45.8
Musi Banyuasin	Logged over forest-low density	5	52.1	9.1	1.4	1.9	64.6
Musi Rawas*)	Undisturbed forest	5	204.5	-	-	-	204.5
	Logged over forest-high density	6	105.6	-	-	-	105.6
	Rubber agroforest	24	75.2	-	-	-	75.2

*) collected by SITH-ITB

The survey results showed that in undisturbed forest (Musi Rawas) stored carbon is around 204.5 Mg ha^{-1}, in high density logged-over forest (Musi Rawas) it is 105.6 Mg ha^{-1} and in low density logged-over forest of Musi Banyuasin it is 64.6 Mg ha^{-1}. Undisturbed mangrove of Banyuasin has stored carbon of 99.2 Mg ha^{-1} while the carbon stock in non-woody Nypa is about 11.7 Mg Ha^{-1} and in shrub is 22.9 Mg Ha^{-1}. Tree-based man-made ecosystems consisted of coconut with carbon stock of about 45.8 Mg Ha^{-1} and rubber agroforestry with about 75.2 Mg Ha^{-1}. Trees contribute around 62–90% to the total carbon stock in tree-based systems for both natural and man-made ecosystems, while necromass and understorey contribute 1.5–9% each. Litter contributes 1.9–3.2% of the total carbon stock in the systems.

4. Discussion

4.1 Tree diversity and composition

4.1.1 Tree species richness

Tropical forest is often the source of high biological diversity and provides various functions. However in degraded forest still composed of native forest and remnant trees, the diversity depends on the degradation and disturbance level as well as the regeneration process period. In ecosystems, trees play an important role in providing habitat to other biodiversity, including animals, other plants and even microorganisms. Tree species richness and the tree community structure are considered as diversity indicators for certain land uses. More complex biodiversity is indicated by greater species richness and a more complex stand structure and in certain ecosystems this will be more stable and provide more functions.

Low density logged-over forest in Musi Banyuasin has the highest number of tree species in every growth stage, followed by shrub on swamp. Remnant trees found in the land use systems after disturbance impact on the high species richness in the tree stage. Lower species richness in the seedling stage may be caused by canopy closure during the succession process to which only certain species can adapt. Low species richness of poles in logged-over forest is assumed to be the result of competition between pioneer species that regenerate as soon as disturbance occurs and sub-climax or remnant climax trees. Different types of disturbance occur in shrub on swamp. Periods of inundation in the rainy season and burning in the dry season mean some species cannot survive, while some adaptive fast-growing species regenerate and thus increase the diversity index.

The natural ecosystem of Nypa and mangrove supports fewer species than terrestrial ecosystems. Nypa, a native to the coastline and estuarine habitats, is known to form pure stands which can be classified as a typical land use where there are rarely found woody tree species in the area. High density clumps of Nypa mean other species have no chance to regenerate. In man-made ecosystems, such as smallholder monoculture coconut in Banyuasin, human interference is the main factor affecting tree species richness. Regular weeding and land management have eliminated non-commodity species.

4.1.2 Species diversity

Generally, natural ecosystems in Indonesia have a high diversity index at exery growth stage compared to man-made ecosystems. Logged-over forest in Musi Banyuasin has a high tree diversity index greater than for the Shannon-Wiener index in saplings, poles and trees, but is only at the medium level for seedlings. High canopy closure during the succession process may be one of many factors resulting in the lower level of seedling diversity along with human disturbance.

Although the logged-over forest has been encroached by logging activity, the sexerity and intensity of disturbance is still tolerated by many species including light-demanding species and shade-tolerant species which are able to survive. The rate of disturbance from logging activity and other human activity in the forest has not changed the entire ecosystem condition, but rather has only made partial changes to the vegetation composition, as seeds can germinate and seedlings have the opportunity to mature.

Monoculture coconut has a low diversity index and does not provide a chance for non-targeted species to survive. Man-made ecosystems such as coconut monoculture are established for economic purposes. This ecosystem is usually established by land clearing which removes all the vegetation on a certain area. Remaining forested areas as sources of seed are far from the plantation and settlement, so that seeds of wild species can only be brought in by a seed dispersal agent, but then subsequent weeding activity can thwart the survivability of wild species.

4.1.3 Dominant species

Commonly, there is no single dominant species in a natural ecosystem (Leigh 2004). However, some species tend to dominate in disturbed areas depending on the level of disturbance and the period after disturbance. The dominance of certain species after disturbance can be used as an indicator of the disturbance level and period. *Pternandra caerulescens* is dominant in the logged-over forest of Musi Banyuasin. This species is found under the canopy in undisturbed and disturbed forests. In disturbed forests, this species is usually present as a pre-disturbance remnant (Slik 2009). In shrub on swamp, the dominant species in each growth stage is *Melaleuca leucadendra.* This species is known for its capability to grow in marshy conditions that are inundated and burnt periodically, so that this species is found in every growth stage, while other species that are not able to adapt to the disturbances will not survive.

Species dominant across the growth stages in the mangrove ecosystem are relatively constant. *Sonneratia caseolaris* and *Avicennia alba* are species found in each growth stage; this species is commonly found along the coast in mangroves and in the intertidal zone. In the mangrove ecosystem, plot placement will determine the result. Different substrate types are overgrown by certain species. The man-made ecosystem of monoculture coconut is dominated by the targeted commodity species in the tree stage, while in the younger stage usually the seedling is a result of seed germination from parent trees or naturally regenerated species.

Dominance is an indicator of species composition in a habitat (Lohbeck et al 2014), where the dominance of a species refers to its relative importance in its habitat (Chase et al 2003), which determines the degree of influence of the species in the habitat. The dominance of a certain species provides major ecosystem services, but it doesn't mean that other species have a minor role in ecosystem services. Each species has a specific role to provide ecosystem services, especially the more complex the variation of the species in a land use; usually the ecosystem service that is provided is more balanced and sustainable. A change in the dominance of species in certain land uses can indicate the occurrence of the disturbance.

4.1.4 Similar species among land uses and growth stages

A similarity index is a comparison of the vegetation composition in terms of the species and their abundances on an ecological site. A similarity index determines how closely the current vegetation community resembles either the potential natural community or some other reference community. The similarity index value varies between 0 and 1, where 0 indicates very dissimilar and 1 indicates very similar.

Very low similarity, even dissimilarity, is found among the land use systems in the sample plots of Banyuasin and Musi Banyuasin. Differences species composition among land uses causes different characteristics of the ecosystem. Geographical factors—particularly the location and type of land use that separate land uses—can inhibit seed dispersal. In this case, considering distances where samples are not adjacent to each other, the dispersal of tree seed also depends on geographical position and the distance between land uses; therefore seed brought by some dispersal agents is unable to reach distant locations. More over the sampled land use types are very different which indicates that, the species composition of each land use is basically different.

Natural regeneration, especially in old-growth forest, often consists of a multi age distribution (Scheff 2012) which has a balance in species regeneration which means there are certain species in every growth stage. For a disturbed land use, such as logged-over forest, which is composed of various type of species, the appearance of a fast-growing species due to the succession process can occur, while remnant slow growing species or climax species are also still found.

However, the similarity level among the growth stages varies. A medium similarity level (about 40–60%) occurs in natural ecosystems of logged-over forest, shrub on swamp and undisturbed mangrove. Pristine ecosystems tend to have a high similarity among growth stages, with a natural land use, especially old-growth forest, often consisting of a multi age distribution (Scheff 2012) which has a balance of regenerating species which means certain species are present in every growth stage.

Based on those parameters, logged-over forest is the most ecologically valuable in terms of providing ecosystem services, particularly for biodiversity conservation. High species richness, a high diversity index value and high similarity among growth stages indicate that this ecosystem will be a stable ecosystem without human disturbance.

4.2 Aboveground carbon stock

Aboveground carbon stock at the plot level depends on the tree size, tree density and wood density of each species in the system. Tree-based natural ecosystems tend to store high amount of carbon stocks compared to man-made ecosystems.

Based on the results, undisturbed forest in Musi Rawas stores around 204.51 Mg ha^{-1} of carbon, while in logged-over forest, high stand density stores 105.59 Mg ha^{-1}, low stand density stores 64.62 Mg ha^{-1} and undisturbed mangrove stores 99.2 Mg ha^{-1}. However, the value of the carbon stock in logged-over forest is relatively low (compared to similar land uses in another study), due to the absence of old trees with large diameters, because of logging activity. The logged-over area is the result of encroachment for logging and some area has been converted to plantation. The value of logged-over forest can be higher at another location. For comparison, the estimated carbon stock value for forest land use types varies around 50–200 Mg ha^{-1}, depending on the forest condition. Normally, Indonesian forests have been estimated to store carbon stocks in the range 161–300 Mg ha^{-1} (Murdiyarso et al 1995), but according to Lasco (2002) the carbon stock of South East Asian forest varies between 40 and 250 Mg ha^{-1}. The wide range of estimated carbon stock in the samples is caused by the different condition and different types of disturbance that affect the forest. The factors that influence the carbon value in logged-over forest could be included the number of commercially extractable species as well as the location of the land use, where accessible locations tend to be disturbed more often. The period of disturbance also differs in each logged-over forest, so that the condition in earlier-logged forest may differ from that of one logged later (Rahayu et al 2005). Increasing the number of sampled plots to cover all typical land use variation will give a representative result; especially for the land use with random stand conditions such as occur in the natural land use.

The study in Musi Banyuasin and Banyuasin found that understory and necromass distribution to total carbon stock is about 1.5–9%. This is similar to previous study in Sumberjaya, Lampung, where the proportion of understorey and necromass was similar—only around 8% of total carbon stock (Van Noordwijk et al 2007). Nypa mainly store carbon in the fronds and stems, compared with trees, nypa relatively stored lower biomass and carbon content. Undisturbed mangrove has various tree structures, with mature trees are quite dominating the sampled land use systems. Compared to other undisturbed mangrove in Papua and North Sumatra where the carbon stock reaches more than 100 Mg ha^{-1}, the carbon stock in Banyuasin is categorized as medium level. Monoculture coconut in Banyuasin holds similar carbon stock to other places in Indonesia (about 40–50 Mg ha^{-1}), while the rubber agroforest in Musi Rawas has similar carbon stock to rubber agroforest in Jambi (70–80 Mg ha^{-1}). The estimated carbon stock for both land use systems are quite high. In man-made land use systems the management play role in affecting the number of stored carbon, so that the estimated value of carbon stock may vary, even close to the carbon values in natural forests.

5. Conclusions

In terrestrial and use system, low density logged-over forest is considered as a sustainable ecosystem due to its high tree species richness, high diversity index and medium similarity among growth stages. This system contains a medium level of carbon stock compared to undisturbed forest. This ecosystem may provide ecosystems services, particularly as biodiversity habitat and for carbon stock. The second layer ecosystem supporting biodiversity and carbon stock is shrub on swampy area. Both logged-over forest and shrub are potential ecosystems to be conserved through mitigation action, particularly by avoiding CO_2 emission and biodiversity losses. In terms of carbon stock, rubber agroforest is an important man-made ecosystem to be developed as part of mitigation action as it contains relatively high carbon stock. Mangrove is also another important ecosystem that contains high carbon stock, has good habitat for biodiversity, supports aquatic biodiversity and has other physical functions such as preventing coastal abrasion. Even though, only holding low carbon stock and low species richness, Nypa ecosystems may be important in the coastal area. Other functions and indicators of environmental services of Nypa may need to be studied.

6. References

Chase JM and Leibold MA. 2003. *Ecological Niches: Linking Classical and Contemporary Approaches*. Chicago: University of Chicago Press. http://dx.doi.org/10.7208/chicago/9780226101811.001.0001

Chave J, Andalo C, Brown S, Cairns MA, Chambers JQ, et al.. 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia* 145:87-99. DOI 10.1007/s00442-005-0100-v.

Colwell RK. 2009. Biodiversity: Concepts, Patterns and Measurement. In: Lexin SA (ed.). *The Princeton Guide to Ecology*. Princeton: Princeton University Press. pp. 257–263.

Curtis JT, McIntosh RP. 1950. The interrelations of certain analytic and synthetic phytosociological characters. *Ecology* 31: 434-455.

Hairiah K, Rahayu S, 2007. *Petunjuk praktis Pengukuran karbon tersimpan di berbagai macam penggunaan lahan*. Bogor, Indonesia: World Agroforestry Centre, ICRAF Southeast Asia. ISBN 979-3198-35-4. 77 pp.

Hairiah K, Dewi S, Agus F, Velarde S, Ekadinata A, et al. 2011. *Measuring Carbon Stocks Across Land Use Systems: A Manual*. Bogor, Indonesia: World Agroforestry Centre (ICRAF), SEA Regional Office, 154 pp.

Harris NL, Brown S, Hagen SC, Saatchi SS, Petroxa S, et al. (2012) Baseline map of carbon emissions from deforestation in tropical regions. *Science* 336: 1573–1576.

IPCC. 2006. Default biomass conxersion and expansion factors. *IPCC Guidelines for National Greenhouse Gas Inxentories, Volume 4 – Agriculture, Forestry and Other Land Use*. Kanagawa, Japan: Intergoxernmental Panel on Climate Change. ISBN 4-88788-032-4

Lasco RD. 2002. Forest Carbon Budgets in Southeast Asia Following Harxesting and Land use Change. In: Impacts of Land Use Change on the Terrestrial Carbon Cycle in the Asia Pacific Region. *Science in China*, 45: 76-86

Leigh D, Puyraxaud D, Terborgh S,Wright SJ. 2004. Why do some tropical forests have so many species of trees? *Biotropica* 36, 447-473.

Lohbeck M, Poorter L, Martínez-Ramos M, Rodriguez-Velázquez J, van Breugel M, et al. 2014. Changing drixers of species dominance during tropical forest succession. *Functional Ecology* 28, 1052-1058. http://dx.doi.org/10.1111/1365-2435.12240

Murdiyarso D, Wasrin UR. 1995. Estimating land use change and carbon release from tropical forest conxersion using remote sensing techniques. *Journal of Biogeography* 22: 715-721

Rahayu S, Lusiana B, van Noordwijk M. 2005. *Carbon Stock Monitoring in Nunukan, East Kalimantan: A Spatial and Modelling Approach.* Bogor, Indonesia: World Agroforestry Centre SE Asia. pp. 21-34.

Scheff RJ. 2012. *The Development of Old-Growth Structural Characteristics in Second-Growth Forests of the Cumberland Plateau*. Kentucky, USA: Eastern Kentucky Unixersity. on line Theses and Dissertations. Paper 116.

Slik JWF. 2009 onwards *Plants of Southeast Asia*. Web. 16 June 2017. http://www.asianplant.net/Melastomataceae/Pternandra_coerulescens.htm.

van Noordwijk M, Rahayu S, Hairiah K, Wulan YC, Farida A, et al. 2002. Carbon stock assessment for a forest-to-coffee conxersion landscape in Sumberjaya (Lampung, Indonesia): from allometric equation to land use change analysis. *Science in China* 45: 75-86.

van Noordwijk M, Rahayu S, Wulan YC, Farida A, Verbist B. 2007. *Karbon Tersimpan di Hutan dan Agroforestri berbasis Kopi di Sumberjaya, Lampung Barat, Extrapolasi pengukuran di tingkat lahan ke tingkat DAS*. Poster. Bogor, Indonesia: World Agroforestry Centre - ICRAF, SEA Regional Office.

Appendix. Tree species checklist for each land use in Bayuasin and Musi Banyuasin Districts

No.	Scientific name	Land use				
		Undisturbed mangrove	Nypa	Shrub on swamp	Coconut monoculture	Logged over forest
1	*Acacia mangium*			v		
2	*Alstonia scholaris*			v		
3	*Alstonia spatulata*			v		
4	*Ancistrocladus tectorius*					v
5	*Antidesma coriaceum*					v
6	*Antidesma montanum*					v
7	*Aphania senegalensis*					v
8	*Archidendron clypearia*			v		
9	*Areca catechu*				v	
10	*Artocarpus elasticus*					v
11	*Artocarpus kemando*					v
12	*Artocarpus* sp.					v
13	*Avicennia alba*	v				
14	*Baccaurea jaxanica*					v
15	*Barringtonia reticulata*			v		v
16	*Bridelia insulana*					v
17	*Bruguiera cylindrica*	v				
18	*Bruguiera gymnorrhiza*	v				
19	*Buchanania arborescens*					v
20	*Buchanania sessilifolia*					v
21	*Campnosperma coriaceum*			v		
22	*Cleistanthus myrianthus*					v
23	*Cleistanthus sumatranus*					v
24	*Coccoceras sumatranum*					v
25	*Cocos nucifera*				v	
26	*Combretocarpus rotundatus*			v		
27	*Cratoxylum formosum*					v
28	*Cryptocarya ferrea*					v
29	*Cynometra ramiflora*					v
30	*Dalbergia pinnata*					v
31	*Dehaasia microcarpa*					v
32	*Dillenia excelsa*					v
33	*Diospyros frutescens*					v
34	*Dryobalanops oblongifolia*					v
35	*Dysoxylum alliaceum*					v
36	*Elaeagnus* sp.			v		v
37	*Elaeocarpus glaber*					v
38	*Elaeocarpus palembanicus*			v		
39	*Eugenia aquea*					v
40	*Euodia latifolia*			v		v
41	*Fagraea crenulata*				v	

No.	Scientific name	Land use				
		Undisturbed mangrove	Nypa	Shrub on swamp	Coconut monoculture	Logged over forest
42	*Fagraea fragrans*					v
43	*Ficus annulata*			v		
44	*Ficus retusa*					v
45	*Flacourtia rukam*					v
46	*Fragraea fragrans*					v
47	*Ganua motleyana*					v
48	*Garcinia atroxiridis*					v
49	*Garcinia parxifolia*					v
50	*Garcinia* sp.1					v
51	*Gardenia tubifera*					v
52	*Glochidion rubrum*					v
53	*Gluta renghas*					v
54	*Gnetum latifolium*					v
55	*Goniothalamus malayanus*			v		
56	*Gynotroches axillaris*			v		
57	*Gynotroches axillaris*			v		
58	*Horsfieldia subglobosa*			v		
59	*Ixora grandifolia*					v
60	*Lagerstroemia speciosa*					v
61	*Litsea cassiaefolia*					v
62	*Litsea oppositifolia*					v
63	*Litsea* sp.					v
64	*Lophopetalum jaxanum*			v		
65	*Macaranga amissa*			v		
66	*Macaranga hypoleuca*			v		v
67	*Macaranga motleyana*					v
68	*Macaranga pruinosa*				v	
69	*Melaleuca leucadendra*			v		
70	*Melastoma malabathricum*			v		
71	*Memecylon oligoneurum*					v
72	*Microcos paniculata*					v
73	*Muntingia calabura*					v
74	*Nauclea obtusa*					v
75	*Nauclea obtusa*					v
76	*Nephelium lappaceum*			v		
77	*Nephelium ramboutan-ake*					v
78	*Nephelium* sp.					v
79	*Nypa fruticans*	v	v			
80	*Plectronia glabra*					v
81	*Ploiarium alternifolium*			v		
82	*Polyalthia lateriflora*			v		
83	*Pternandra caerulescens*			v		v
84	*Pternandra caerulescens*			v		

No.	Scientific name	Land use				
		Undisturbed mangrove	Nypa	Shrub on swamp	Coconut monoculture	Logged over forest
85	*Quercus* sp.					v
86	*Rhizophora apiculata*	v				
87	*Rhizophora mucronata*	v				
88	*Rinorea bengalensis*					v
89	*Semecarpus sp.*					v
90	*Shorea pauciflora*					v
91	*Sonneratia caseolaris*	v				
92	*Spatholobus littoralis*					v
93	*Symplocos adenophylla*					v
94	*Symplocos cochinchinensis*					v
95	*Syzygium chloranthum*					v
96	*Syzygium claxiflorum*					v
97	*Syzygium jambosoides*			v		v
98	*Syzygium leptostemon*					v
99	*Syzygium lineatum*					v
100	*Syzygium muelleri*			v		
101	*Syzygium palembanicum*			v		
102	*Syzygium* sp. 1					v
103	*Syzygium* sp. 2					v
104	*Syzygium* sp. 3					v
105	*Syzygium tetrapterum*			v		
106	*Teijsmanniodendron coriaceum*					v
107	Unidentified bangkinang					v
108	Unidentified bedi					v
109	Unidentified kelempang					v
110	Unidentified kudun					v
111	Unidentified kukulang					v
112	Unidentified melesire					v
113	Unidentified mengkel					v
114	Unidentified merajelai					v
115	Unidentified pasir					v
116	Unidentified pelangas					v
117	Unidentified sale					v
118	Unidentified sengijau					v
119	Unidentified Sp. 519			v		
120	Unidentified Sp. 520			v		
121	Unidentified sp. 609			v		
122	Unidentified sp. 704					v
123	Unidentified sp. 8.2.5					v
124	Unidentified Sp. vx			v		
125	Unidentified Sp. ww			v		
126	Unidentified Sp. vx			v		
127	Unidentified Sp. zz			v		

No.	Scientific name	Land use				
		Undisturbed mangrove	Nypa	Shrub on swamp	Coconut monoculture	Logged over forest
128	Unidentified tampang					v
129	Unidentified tegumasoh					v
130	Unidentified tumpang					v
131	*Uxaria littoralis*					v
132	*Vatica pauciflora*					v
133	*Vatica* sp. 1					v
134	*Vatica* sp. 2					v
135	*Vernonia arborea*			v		
136	*Vitex pinnata*					v
137	*Vanthophyllum ellipticum*			v		
138	*Vanthophyllum flaxescens*					v
139	*Ziziphus calophylla*					v
	Number of tree species	**7**	**1**	**38**	**4**	**96**

WORKING PAPERS WITH DOIs

2005

1. Agroforestry in the drylands of eastern Africa: a call to action
2. Biodiversity conservation through agroforestry: managing tree species diversity within a network of community-based, nongovernmental, governmental and research organizations in western Kenya.
3. Invasion of *prosopis juliflora* and local livelihoods: Case study from the Lake Baringo area of Kenya
4. Leadership for change in farmers organizations: Training report: Ridar Hotel, Kampala, 29th March to 2nd April 2005.
5. Domestication des espèces agroforestières au Sahel : situation actuelle et perspectives
6. Relevé des données de biodiversité ligneuse: Manuel du projet biodiversité des parcs agroforestiers au Sahel
7. Improved land management in the Lake Victoria Basin: TransVic Project's draft report.
8. Livelihood capital, strategies and outcomes in the Taita hills of Kenya
9. Les espèces ligneuses et leurs usages: Les préférences des paysans dans le Cercle de Ségou, au Mali
10. La biodiversité des espèces ligneuses: Diversité arborée et unités de gestion du terroir dans le Cercle de Ségou, au Mali

2006

11. Bird diversity and land use on the slopes of Mt. Kilimanjaro and the adjacent plains, Tanzania
12. Water, women and local social organization in the Western Kenya Highlands
13. Highlights of ongoing research of the World Agroforestry Centre in Indonesia
14. Prospects of adoption of tree-based systems in a rural landscape and its likely impacts on carbon stocks and farmers' welfare: The FALLOW Model Application in Muara Sungkai, Lampung, Sumatra, in a 'Clean Development Mechanism' context
15. Equipping integrated natural resource managers for healthy Agroforestry landscapes.
17. Agro-biodiversity and CGIAR tree and forest science: approaches and examples from Sumatra.
18. Improving land management in eastern and southern Africa: A review of policies.
19. Farm and household economic study of Kecamatan Nanggung, Kabupaten Bogor, Indonesia: A socio-economic base line study of Agroforestry innovations and livelihood enhancement.
20. Lessons from eastern Africa's unsustainable charcoal business.
21. Evolution of RELMA's approaches to land management: Lessons from two decades of research and development in eastern and southern Africa
22. Participatory watershed management: Lessons from RELMA's work with farmers in eastern Africa.
23. Strengthening farmers' organizations: The experience of RELMA and ULAMP.
24. Promoting rainwater harvesting in eastern and southern Africa.
25. The role of livestock in integrated land management.
26. Status of carbon sequestration projects in Africa: Potential benefits and challenges to scaling up.

27. Social and Environmental Trade-Offs in Tree Species Selection: A Methodology for Identifying Niche Incompatibilities in Agroforestry *[Appears as AHI Working Paper no. 9]*

28. Managing tradeoffs in agroforestry: From conflict to collaboration in natural resource management. *[Appears as AHI Working Paper no. 10]*

29. Essai d'analyse de la prise en compte des systemes agroforestiers pa les legislations forestieres au Sahel: Cas du Burkina Faso, du Mali, du Niger et du Senegal.

30. Etat de la recherche agroforestière au Rwanda etude bibliographique, période 1987-2003

2007

31. Science and technological innovations for improving soil fertility and management in Africa: A report for NEPAD's Science and Technology Forum.

32. Compensation and rewards for environmental services.

33. Latin American regional workshop report compensation.

34. Asia regional workshop on compensation ecosystem services.

35. Report of African regional workshop on compensation ecosystem services.

36. Exploring the inter-linkages among and between compensation and rewards for ecosystem services CRES and human well-being

37. Criteria and indicators for environmental service compensation and reward mechanisms: realistic, voluntary, conditional and pro-poor

38. The conditions for effective mechanisms of compensation and rewards for environmental services.

39. Organization and governance for fostering Pro-Poor Compensation for Environmental Services.

40. How important are different types of compensation and reward mechanisms shaping poverty and ecosystem services across Africa, Asia & Latin America over the Next two decades?

41. Risk mitigation in contract farming: The case of poultry, cotton, woodfuel and cereals in East Africa.

42. The RELMA savings and credit experiences: Sowing the seed of sustainability

43. Yatich J., Policy and institutional context for NRM in Kenya: Challenges and opportunities for Landcare.

44. Nina-Nina Adoung Nasional di So! Field test of rapid land tenure assessment (RATA) in the Batang Toru Watershed, North Sumatera.

45. Is Hutan Tanaman Rakyat a new paradigm in community based tree planting in Indonesia?

46. Socio-Economic aspects of brackish water aquaculture (*Tambak*) production in Nanggroe Aceh Darrusalam.

47. Farmer livelihoods in the humid forest and moist savannah zones of Cameroon.

48. Domestication, genre et vulnérabilité : Participation des femmes, des Jeunes et des catégories les plus pauvres à la domestication des arbres agroforestiers au Cameroun.

49. Land tenure and management in the districts around Mt Elgon: An assessment presented to the Mt Elgon ecosystem conservation programme.

50. The production and marketing of leaf meal from fodder shrubs in Tanga, Tanzania: A pro-poor enterprise for improving livestock productivity.

51. Buyers Perspective on Environmental Services (ES) and Commoditization as an approach to liberate ES markets in the Philippines.

52. Towards Towards community-driven conservation in southwest China: Reconciling state and local perceptions.
53. Biofuels in China: An Analysis of the Opportunities and Challenges of Jatropha curcas in Southwest China.
54. Jatropha curcas biodiesel production in Kenya: Economics and potential value chain development for smallholder farmers
55. Livelihoods and Forest Resources in Aceh and Nias for a Sustainable Forest Resource Management and Economic Progress
56. Agroforestry on the interface of Orangutan Conservation and Sustainable Livelihoods in Batang Toru, North Sumatra.

2008

57. Assessing Hydrological Situation of Kapuas Hulu Basin, Kapuas Hulu Regency, West Kalimantan.
58. Assessing the Hydrological Situation of Talau Watershed, Belu Regency, East Nusa Tenggara.
59. Kajian Kondisi Hidrologis DAS Talau, Kabupaten Belu, Nusa Tenggara Timur.
60. Kajian Kondisi Hidrologis DAS Kapuas Hulu, Kabupaten Kapuas Hulu, Kalimantan Barat.
61. Lessons learned from community capacity building activities to support agroforest as sustainable economic alternatives in Batang Toru orang utan habitat conservation program (Martini, Endri et al.)
62. Mainstreaming Climate Change in the Philippines.
63. A Conjoint Analysis of Farmer Preferences for Community Forestry Contracts in the Sumber Jaya Watershed, Indonesia.
64. The highlands: a shared water tower in a changing climate and changing Asia
65. Eco-Certification: Can It Deliver Conservation and Development in the Tropics.
66. Designing ecological and biodiversity sampling strategies. Towards mainstreaming climate change in grassland management.
67. Towards mainstreaming climate change in grassland management policies and practices on the Tibetan Plateau
68. An Assessment of the Potential for Carbon Finance in Rangelands
69 ECA Trade-offs Among Ecosystem Services in the Lake Victoria Basin.
69. The last remnants of mega biodiversity in West Java and Banten: an in-depth exploration of RaTA (Rapid Land Tenure Assessment) in Mount Halimun-Salak National Park Indonesia
70. Le business plan d'une petite entreprise rurale de production et de commercialisation des plants des arbres locaux. Cas de quatre pépinières rurales au Cameroun.
71. Les unités de transformation des produits forestiers non ligneux alimentaires au Cameroun. Diagnostic technique et stratégie de développement Honoré Tabuna et Ingratia Kayitavu.
72. Les exportateurs camerounais de safou (Dacryodes edulis) sur le marché sous régional et international. Profil, fonctionnement et stratégies de développement.
73. Impact of the Southeast Asian Network for Agroforestry Education (SEANAFE) on agroforestry education capacity.
74. Setting landscape conservation targets and promoting them through compatible land use in the Philippines.
75. Review of methods for researching multistrata systems.

76. Study on economical viability of *Jatropha curcas* L. plantations in Northern Tanzania assessing farmers' prospects via cost-benefit analysis
77. Cooperation in Agroforestry between Ministry of Forestry of Indonesia and International Center for Research in Agroforestry
78. "China's bioenergy future. an analysis through the Lens if Yunnan Province
79. Land tenure and agricultural productivity in Africa: A comparative analysis of the economics literature and recent policy strategies and reforms
80. Boundary organizations, objects and agents: linking knowledge with action in Agroforestry watersheds
81. Reducing emissions from deforestation and forest degradation (REDD) in Indonesia: options and challenges for fair and efficient payment distribution mechanisms

2009

82. Mainstreaming climate change into agricultural education: challenges and perspectives
83. Challenging conventional mindsets and disconnects in conservation: the emerging role of eco-agriculture in Kenya's landscape mosaics
84. Lesson learned RATA garut dan bengkunat: suatu upaya membedah kebijakan pelepasan kawasan hutan dan redistribusi tanah bekas kawasan hutan
85. The emergence of forest land redistribution in Indonesia
86. Commercial opportunities for fruit in Malawi
87. Status of fruit production processing and marketing in Malawi
88. Fraud in tree science
89. Trees on farm: analysis of global extent and geographical patterns of agroforestry
90. The springs of Nyando: water, social organization and livelihoods in Western Kenya
91. Building capacity toward region-wide curriculum and teaching materials development in agroforestry education in Southeast Asia
92. Overview of biomass energy technology in rural Yunnan (Chinese – English abstract)
93. A pro-growth pathway for reducing net GHG emissions in China
94. Analysis of local livelihoods from past to present in the central Kalimantan Ex-Mega Rice Project area
95. Constraints and options to enhancing production of high quality feeds in dairy production in Kenya, Uganda and Rwanda

2010

96. Agroforestry education in the Philippines: status report from the Southeast Asian Network for Agroforestry Education (SEANAFE)
97. Economic viability of Jatropha curcas L. plantations in Northern Tanzania- assessing farmers' prospects via cost-benefit analysis.
98. Hot spot of emission and confusion: land tenure insecurity, contested policies and competing claims in the central Kalimantan Ex-Mega Rice Project area
99. Agroforestry competences and human resources needs in the Philippines
100. CES/COS/CIS paradigms for compensation and rewards to enhance environmental Services

101. Case study approach to region-wide curriculum and teaching materials development in agroforestry education in Southeast Asia
102. Stewardship agreement to reduce emissions from deforestation and degradation (REDD): Lubuk Beringin’s Hutan Desa as the first village forest in Indonesia
103. Landscape dynamics over time and space from ecological perspective
104. Komoditisasi atau koinvestasi jasa lingkungan: skema imbal jasa lingkungan program peduli sungai di DAS Way Besai, Lampung, Indonesia
105. Improving smallholders’ rubber quality in Lubuk Beringin, Bungo district, Jambi province, Indonesia: an initial analysis of the financial and social benefits
106. Rapid Carbon Stock Appraisal (RACSA) in Kalahan, Nueva Vizcaya, Philippines
107. Tree domestication by ICRAF and partners in the Peruvian Amazon: lessons learned and future prospects in the domain of the Amazon Initiative eco-regional program
108. Memorias del Taller Nacional: “Iniciativas para Reducir la Deforestación en la region Andino - Amazónica”, 09 de Abril del 2010. Proyecto REALU Peru
109. Percepciones sobre la Equidad y Eficiencia en la cadena de valor de REDD en Perú –Reporte de Talleres en Ucayali, San Martín y Loreto, 2009. Proyecto REALU-Perú.
110. Reducción de emisiones de todos los Usos del Suelo. Reporte del Proyecto REALU Perú Fase 1
111. Programa Alternativas a la Tumba-y-Quema (ASB) en el Perú. Informe Resumen y Síntesis de la Fase II. 2da. versión revisada
112. Estudio de las cadenas de abastecimiento de germoplasma forestal en la amazonía Boliviana
113. Biodiesel in the Amazon
114. Estudio de mercado de semillas forestales en la amazonía Colombiana
115. Estudio de las cadenas de abastecimiento de germoplasma forestal en Ecuador http://dx.doi.org10.5716/WP10340.PDF
116. How can systems thinking, social capital and social network analysis help programs achieve impact at scale?
117. Energy policies, forests and local communities in the Ucayali Region, Peruvian Amazon
118. NTFPs as a Source of Livelihood Diversification for Local Communities in the Batang Toru Orangutan Conservation Program
119. Studi Biodiversitas: Apakah agroforestry mampu mengkonservasi keanekaragaman hayati di DAS Konto?
120. Estimasi Karbon Tersimpan di Lahan-lahan Pertanian di DAS Konto, Jawa Timur
121. Implementasi Kaji Cepat Hidrologi (RHA) di Hulu DAS Brantas, Jawa Timur. http://dx.doi.org/10.5716/WP10338.PDF
122. Kaji Cepat Hidrologi di Daerah Aliran Sungai Krueng Peusangan, NAD,Sumatra http://dx.doi.org/10.5716/WP10337.PDF
123. A Study of Rapid Hydrological Appraisal in the Krueng Peusangan Watershed, NAD, Sumatra. http://dx.doi.org/10.5716/WP10339.PDF

2011

124. An Assessment of farm timber value chains in Mt Kenya area, Kenya
125. A Comparative financial analysis of current land use systems and implications for the adoption of improved agroforestry in the East Usambaras, Tanzania
126. Agricultural monitoring and evaluation systems

127. Challenges and opportunities for collaborative landscape governance in the East Usambara Mountains, Tanzania
128. Transforming Knowledge to Enhance Integrated Natural Resource Management Research, Development and Advocacy in the Highlands of Eastern Africa http://dx.doi.org/10.5716/WP11084.PDF
129. Carbon-forestry projects in the Philippines: potential and challenges The Mt Kitanglad Range forest-carbon development http://dx.doi.org10.5716/WP11054.PDF
130. Carbon forestry projects in the Philippines: potential and challenges. The Arakan Forest Corridor forest-carbon project. http://dx.doi.org10.5716/WP11055.PDF
131. Carbon-forestry projects in the Philippines: potential and challenges. The Laguna Lake Development Authority's forest-carbon development project. http://dx.doi.org/10.5716/WP11056.PDF
132. Carbon-forestry projects in the Philippines: potential and challenges. The Quirino forest-carbon development project in Sierra Madre Biodiversity Corridor http://dx.doi.org10.5716/WP11057.PDF
133. Carbon-forestry projects in the Philippines: potential and challenges. The Ikalahan Ancestral Domain forest-carbon development http://dx.doi.org10.5716/WP11058.PDF
134. The Importance of Local Traditional Institutions in the Management of Natural Resources in the Highlands of Eastern Africa. http://dx.doi.org/10.5716/WP11085.PDF
135. Socio-economic assessment of irrigation pilot projects in Rwanda. http://dx.doi.org/10.5716/WP11086.PDF
136. Performance of three rambutan varieties *(Nephelium lappaceum* L.*)* on various nursery media. http://dx.doi.org/10.5716/WP11232.PDF
137. Climate change adaptation and social protection in agroforestry systems: enhancing adaptive capacity and minimizing risk of drought in Zambia and Honduras http://dx.doi.org/10.5716/WP11269.PDF
138. Does value chain development contribute to rural poverty reduction? Evidence of asset building by smallholder coffee producers in Nicaragua http://dx.doi.org/10.5716/WP11271.PDF
139. Potential for biofuel feedstock in Kenya. http://dx.doi.org/10.5716/WP11272.PDF
140. Impact of fertilizer trees on maize production and food security in six districts of Malawi. http://dx.doi.org/10.5716/WP11281.PDF

2012

141. Fortalecimiento de capacidades para la gestión del Santuario Nacional Pampa Hermosa: Construyendo las bases para un manejo adaptativo para el desarrollo local. Memorias del Proyecto. http://dx.doi.org/10.5716/WP12005.PDF
142. Understanding rural institutional strengthening: A cross-level policy and institutional framework for sustainable development in Kenya http://dx.doi.org/10.5716/WP12012.PDF
143. Climate change vulnerability of agroforestry http://dx.doi.org/10.5716/WP16722.PDF
144. Rapid assesment of the inner Niger delta of Mali http://dx.doi.org/10.5716/WP12021.PDF
145. Designing an incentive program to reduce on-farm deforestationin the East Usambara Mountains, Tanzania http://dx.doi.org/10.5716/WP12048.PDF
146. Extent of adoption of conservation agriculture and agroforestry in Africa: the case of Tanzania, Kenya, Ghana, and Zambia http://dx.doi.org/10.5716/WP12049.PDF

147. Policy incentives for scaling up conservation agriculture with trees in Africa: the case of Tanzania, Kenya, Ghana and Zambia http://dx.doi.org/10.5716/WP12050.PDF
148. Commoditized or co-invested environmental services? Rewards for environmental services scheme: River Care program Way Besai watershed, Lampung, Indonesia. http://dx.doi.org/10.5716/WP12051.PDF
149. Assessment of the headwaters of the Blue Nile in Ethiopia. http://dx.doi.org/10.5716/WP12160.PDF
150. Assessment of the uThukela Watershed, Kwazaulu. http://dx.doi.org/10.5716/WP12161.PDF
151. Assessment of the Oum Zessar Watershed of Tunisia. http://dx.doi.org/10.5716/WP12162.PDF
152. Assessment of the Ruwenzori Mountains in Uganda. http://dx.doi.org/10.5716/WP12163.PDF
153. History of agroforestry research and development in Viet Nam. Analysis of research opportunities and gaps. http://dx.doi.org/10.5716/WP12052.PDF
154. REDD+ in Indonesia: a Historical Perspective. http://dx.doi.org/10.5716/WP12053.PDF
155. Agroforestry and Forestry in Sulawesi series: Livelihood strategies and land use system dynamics in South Sulawesi http://dx.doi.org/10.5716/WP12054.PDF
156. Agroforestry and Forestry in Sulawesi series: Livelihood strategies and land use system dynamics in Southeast Sulawesi. http://dx.doi.org/10.5716/WP12055.PDF
157. Agroforestry and Forestry in Sulawesi series: Profitability and land-use systems in South and Southeast Sulawesi. http://dx.doi.org/10.5716/WP12056.PDF
158. Agroforestry and Forestry in Sulawesi series: Gender, livelihoods and land in South and Southeast Sulawesi http://dx.doi.org/10.5716/WP12057.PDF
159. Agroforestry and Forestry in Sulawesi series: Agroforestry extension needs at the community level in AgFor project sites in South and Southeast Sulawesi, Indonesia. http://dx.doi.org/10.5716/WP12058.PDF
160. Agroforestry and Forestry in Sulawesi series: Rapid market appraisal of agricultural, plantation and forestry commodities in South and Southeast Sulawesi. http://dx.doi.org/10.5716/WP12059.PDF

2013

161. Diagnosis of farming systems in the Agroforestry for Livelihoods of Smallholder farmers in Northwestern Viet Nam project http://dx.doi.org/10.5716/WP13033.PDF
162. Ecosystem vulnerability to climate change: a literature review. http://dx.doi.org/10.5716/WP13034.PDF
163. Local capacity for implementing payments for environmental services schemes: lessons from the RUPES project in northeastern Viet Nam http://dx.doi.org/10.5716/WP13046.PDF
164. Seri Agroforestri dan Kehutanan di Sulawesi: Agroforestry dan Kehutanan di Sulawesi: Strategi mata pencaharian dan dinamika sistem penggunaan lahan di Sulawesi Selatan http://dx.doi.org/10.5716/WP13040.PDF
165. Seri Agroforestri dan Kehutanan di Sulawesi: Mata pencaharian dan dinamika sistem penggunaan lahan di Sulawesi Tenggara http://dx.doi.org/10.5716/WP13041.PDF
166. Seri Agroforestri dan Kehutanan di Sulawesi: Profitabilitas sistem penggunaan lahan di Sulawesi Selatan dan Sulawesi Tenggara http://dx.doi.org/10.5716/WP13042.PDF
167. Seri Agroforestri dan Kehutanan di Sulawesi: Gender, mata pencarian dan lahan di Sulawesi Selatan dan Sulawesi Tenggara http://dx.doi.org/10.5716/WP13043.PDF

168. Seri Agroforestri dan Kehutanan di Sulawesi: Kebutuhan penyuluhan agroforestri pada tingkat masyarakat di lokasi proyek AgFor di Sulawesi Selatan dan Tenggara, Indonesia. http://dx.doi.org/10.5716/WP13044.PDF
169. Seri Agroforestri dan Kehutanan di Sulawesi: Laporan hasil penilaian cepat untuk komoditas pertanian, perkebunan dan kehutanan di Sulawesi Selatan dan Tenggara http://dx.doi.org/10.5716/WP13045.PDF
170. Agroforestry, food and nutritional security http://dx.doi.org/10.5716/WP13054.PDF
171. Stakeholder Preferences over Rewards for Ecosystem Services: Implications for a REDD+ Benefit Distribution System in Viet Nam http://dx.doi.org/10.5716/WP13057.PDF
172. Payments for ecosystem services schemes: project-level insights on benefits for ecosystems and the rural poor http://dx.doi.org/10.5716/WP13001.PDF
173. Good practices for smallholder teak plantations: keys to success http://dx.doi.org/10.5716/WP13246.PDF
174. Market analysis of selected agroforestry products in the Vision for Change Project intervention Zone, Côte d'Ivoire http://dx.doi.org/10.5716/WP13249.PDF
175. Rattan futures in Katingan: why do smallholders abandon or keep their gardens in Indonesia's 'rattan district'? http://dx.doi.org/10.5716/WP13251.PDF
176. Management along a gradient: the case of Southeast Sulawesi's cacao production landscapes http://dx.doi.org/10.5716/WP13265.PDF

2014

177. Are trees buffering ecosystems and livelihoods in agricultural landscapes of the Lower Mekong Basin? Consequences for climate-change adaptation. http://dx.doi.org/10.5716/WP14047.PDF
178. Agroforestry, livestock, fodder production and climate change adaptation and mitigation in East Africa: issues and options. http://dx.doi.org/10.5716/WP14050.PDF
179. Trees on farms: an update and reanalysis of agroforestry's global extent and socio-ecological characteristics. http://dx.doi.org/10.5716/WP14064.PDF
180. Beyond reforestation: an assessment of Vietnam's REDD+ readiness. http://dx.doi.org/10.5716/WP14097.PDF
181. Farmer-to-farmer extension in Kenya: the perspectives of organizations using the approach. http://dx.doi.org/10.5716/WP14380.PDF
182. Farmer-to-farmer extension in Cameroon: a survey of extension organizations. http://dx.doi.org/10.5716/WP14383.PDF
183. Farmer-to-farmer extension approach in Malawi: a survey of organizations: a survey of organizations http://dx.doi.org/10.5716/WP14391.PDF
184. Seri Agroforestri dan Kehutanan di Sulawesi: Kuantifikasi jasa lingkungan air dan karbon pola agroforestri pada hutan rakyat di wilayah sungai Jeneberang
185. Options for Climate-Smart Agriculture at Kaptumo Site in Kenyahttp://dx.doi.org/10.5716/WP14394.PDF

2015

186. Agroforestry for Landscape Restoration and Livelihood Development in Central Asia http://dx.doi.org/10.5716/WP14143.PDF

187. “Projected Climate Change and Impact on Bioclimatic Conditions in the Central and South-Central Asia Region” http://dx.doi.org/10.5716/WP14144.PDF
188. Land Cover Changes, Forest Loss and Degradation in Kutai Barat, Indonesia. http://dx.doi.org/10.5716/WP14145.PDF
189. The Farmer-to-Farmer Extension Approach in Malawi: A Survey of Lead Farmers. http://dx.doi.org/10.5716/WP14152.PDF
190. Evaluating indicators of land degradation and targeting agroforestry interventions in smallholder farming systems in Ethiopia. http://dx.doi.org/10.5716/WP14252.PDF
191. Land health surveillance for identifying land constraints and targeting land management options in smallholder farming systems in Western Cameroon
192. Land health surveillance in four agroecologies in Malawi
193. Cocoa Land Health Surveillance: an evidence-based approach to sustainable management of cocoa landscapes in the Nawa region, South-West Côte d’Ivoire http://dx.doi.org/10.5716/WP14255.PDF
194. Situational analysis report: Xishuangbanna autonomous Dai Prefecture, Yunnan Province, China. http://dx.doi.org/10.5716/WP14255.PDF
195. Farmer-to-farmer extension: a survey of lead farmers in Cameroon. http://dx.doi.org/10.5716/WP15009.PDF
196. From transition fuel to viable energy source Improving sustainability in the sub-Saharan charcoal sector http://dx.doi.org/10.5716/WP15011.PDF
197. Mobilizing Hybrid Knowledge for More Effective Water Governance in the Asian Highlands http://dx.doi.org/10.5716/WP15012.PDF
198. Water Governance in the Asian Highlands http://dx.doi.org/10.5716/WP15013.PDF
199. Assessing the Effectiveness of the Volunteer Farmer Trainer Approach in Dissemination of Livestock Feed Technologies in Kenya vis-à-vis other Information Sources http://dx.doi.org/10.5716/WP15022.PDF
200. The rooted pedon in a dynamic multifunctional landscape: Soil science at the World Agroforestry Centre http://dx.doi.org/10.5716/WP15023.PDF
201. Characterising agro-ecological zones with local knowledge. Case study: Huong Khe district, Ha Tinh, Viet Nam http://dx.doi.org/10.5716/WP15050.PDF
202. Looking back to look ahead: Insight into the effectiveness and efficiency of selected advisory approaches in the dissemination of agricultural technologies indicative of Conservation Agriculture with Trees in Machakos County, Kenya. http://dx.doi.org/10.5716/WP15065.PDF
203. Pro-poor Biocarbon Projects in Eastern Africa Economic and Institutional Lessons. http://dx.doi.org/10.5716/WP15022.PDF
204. Projected climate change impacts on climatic suitability and geographical distribution of banana and coffee plantations in Nepal. http://dx.doi.org/10.5716/WP15294.PDF
205. Agroforestry and Forestry in Sulawesi series: Smallholders’ coffee production and marketing in Indonesia. A case study of two villages in South Sulawesi Province. http://dx.doi.org/10.5716/WP15690.PDF
206. Mobile phone ownership and use of short message service by farmer trainers: a case study of Olkalou and Kaptumo in Kenya http://dx.doi.org/10.5716/WP15691.PDF
207. Associating multivariate climatic descriptors with cereal yields: a case study of Southern Burkina Faso http://dx.doi.org/10.5716/WP15273.PDF
208. Preferences and adoption of livestock feed practices among farmers in dairy management groups in Kenya http://dx.doi.org/10.5716/WP15675.PDF

209. Scaling up climate-smart agriculture: lessons learned from South Asia and pathways for success http://dx.doi.org/10.5716/WP15720.PDF

210. Agroforestry and Forestry in Sulawesi series: Local perceptions of forest ecosystem services and collaborative formulation of reward mechanisms in South and Southeast Sulawesi http://dx.doi.org/10.5716/WP15721.PDF

211. Potential and challenges in implementing the co-investment of ecosystem services scheme in Buol District, Indonesia. http://dx.doi.org/10.5716/WP15722.PDF

212. Tree diversity and its utilization by the local community in Buol District, Indonesia http://dx.doi.org/10.5716/WP15723.PDF

213 Vulnerability of smallholder farmers and their preferences on farming practices in Buol District, Indonesia http://dx.doi.org/10.5716/WP15724.PDF

214. Dynamics of Land Use/Cover Change and Carbon Emission in Buol District, Indonesia http://dx.doi.org/10.5716/WP15725.PDF

215. Gender perspective in smallholder farming practices in Lantapan, Phillippines. http://dx.doi.org/10.5716/WP15726.PDF

216. Vulnerability of smallholder farmers in Lantapan, Bukidnon. http://dx.doi.org/10.5716/WP15727.PDF

217. Vulnerability and adaptive capacity of smallholder farmers in Ho Ho Sub-watershed, Ha Tinh Province, Vietnam http://dx.doi.org/10.5716/WP15728.PDF

218. Local Knowledge on the role of trees to enhance livelihoods and ecosystem services in northern central Vietnam http://dx.doi.org/10.5716/WP15729.PDF

219. Land-use/cover change in Ho Ho Sub-watershed, Ha Tinh Province, Vietnam. http://dx.doi.org/10.5716/WP15730.PDF

2016

220. Agroforestry and Forestry in Sulawesi series: Evaluation of the Agroforestry Farmer Field Schools on agroforestry management in South and Southeast Sulawesi, Indonesia. http://dx.doi.org/10.5716/WP16002.PDF

221. Farmer-to-farmer extension of livestock feed technologies in Rwanda: A survey of volunteer farmer trainers and organizations. http://dx.doi.org/10.5716/WP16005.PDF

222. Projected Climate Change Impact on Hydrology, Bioclimatic Conditions, and Terrestrial Ecosystems in the Asian Highlands http://dx.doi.org/10.5716/WP16006.PDF

223. Adoption of Agroforestry and its impact on household food security among farmers in Malawi http://dx.doi.org/10.5716/WP16013.PDF

224. Agroforestry and Forestry in Sulawesi series: Information channels for disseminating innovative agroforestry practices to villages in Southern Sulawesi, Indonesia http://dx.doi.org/10.5716/WP16034.PDF

225. Agroforestry and Forestry in Sulawesi series: Unravelling rural migration networks.Land-tenure arrangements among Bugis migrant communities in Southeast Sulawesi. http://dx.doi.org/10.5716/WP16035.PDF

226. Agroforestry and Forestry in Sulawesi series: Women’s participation in agroforestry: more benefit or burden? A gendered analysis of Gorontalo Province. http://dx.doi.org/10.5716/WP16036.PDF

227. Kajian Kelayakan dan Pengembangan Desain Teknis Rehabilitasi Pesisir di Sulawesi Tengah. http://dx.doi.org/10.5716/WP16037.PDF

228. Selection of son tra clones in North West Vietnam. http://dx.doi.org/10.5716/WP16038.PDF

229. Growth and fruit yield of seedlings, cuttings and grafts from selected son tra trees in Northwest Vietnam http://dx.doi.org/10.5716/WP16046.PDF
230. Gender-Focused Analysis of Poverty and Vulnerability in Yunnan, China http://dx.doi.org/10.5716/WP16071.PDF
231. Seri Agroforestri dan Kehutanan di Sulawesi: Kebutuhan Penyuluhan Agroforestri untuk Rehabilitasi Lahan di Sumba Timur, Nusa Tenggara Timur, Indonesia. http://dx.doi.org/10.5716/WP16077.PDF
232. Agroforestry and Forestry in Sulawesi series: Agroforestry extension needs for land rehabilitation in East Sumba, East Nusa Tenggara, Indonesia. http://dx.doi.org/10.5716/WP16078.PDF
233. Central hypotheses for the third agroforestry paradigm within a common definition. http://dx.doi.org/10.5716/WP16079.PDF
234. Assessing smallholder farmers' interest in shade coffee trees: The Farming Systems of Smallholder Coffee Producers in the Gisenyi Area, Rwanda: a participatory diagnostic study. http://dx.doi.org/10.5716/WP16104.PDF
235. Review of agricultural market information systems in |sub-Saharan Africa. http://dx.doi.org/10.5716/WP16110.PDF
236. Vision and road map for establishment of a protected area in Lag Badana, Lower Jubba, Somalia. http://dx.doi.org/10.5716/WP16127.PDF
237. Replicable tools and frameworks for Bio-Carbon Development in West Africa. http://dx.doi.org/10.5716/WP16138.PDF
238. Existing Conditions, Challenges and Needs in the Implementation of Forestry and Agroforestry Extension in Indonesia. http://dx.doi.org/10.5716/WP16141.PDF
239. Situasi Terkini, Tantangan dan Kebutuhan Pelaksanaan Penyuluhan Kehutanan dan Agroforestri di Indonesia. http://dx.doi.org/10.5716/WP16142.PDF
240. The national agroforestry policy of India: experiential learning in development and delivery phases. http://dx.doi.org/10.5716/WP16143.PDF
241. Agroforestry and Forestry in Sulawesi series: Livelihood strategies and land-use system dynamics in Gorontalo. http://dx.doi.org/10.5716/WP16157.PDF
242. Seri Agroforestri dan Kehutanan di Sulawesi: Strategi mata pencaharian dan dinamika sistem penggunaan lahan di Gorontalo. http://dx.doi.org/10.5716/WP16158.PDF
243. Ruang, Gender dan Kualitas Hidup Manusia: Sebuah studi Gender pada komunitas perantau dan pengelola kebun di Jawa Barat. http://dx.doi.org/10.5716/WP16159.PDF
244. Gendered Knowledge and perception in managing grassland areas in East Sumba, Indonesia. http://dx.doi.org/10.5716/WP16160.PDF
245. Pengetahuan dan persepsi masyarakat pengelola padang aavana, Sebuah Kajian Gender di Sumba Timur. http://dx.doi.org/10.5716/WP16161.PDF
246. Dinamika Pengambilan Keputusan pada komunitas perantau dan pengelola kebun di Jawa Barat. http://dx.doi.org/10.5716/WP16162.PDF
247. Gaharu (eaglewood) domestication: Biotechnology, markets and agroforestry options. http://dx.doi.org/10.5716/WP16163.PDF
248. Marine habitats of the Lamu-Kiunga coast: an assessment of biodiversity value, threats and opportunities. http://dx.doi.org/10.5716/WP16167.PDF
249. Assessment of the biodiversity in terrestrial landscapes of the Witu protected area and surroundings, Lamu County Kenya. http://dx.doi.org/10.5716/WP16172.PDF
250. An ecosystem services perspective on benefits that people derive from biodiversity of Coastal forests in Lamu County, Kenya http://dx.doi.org/10.5716/WP16173.PDF

251. Assessment of the biodiversity in terrestrial and marine landscapes of the proposed Laga Badana National Park and surrounding areas, Jubaland, Somalia. http://dx.doi.org/10.5716/WP16174.PDF

2017

252. Preferensi Petani terhadap Topik Penyuluhan dan Penyebaran Informasi Agroforestri di Indonesia. http://dx.doi.org/10.5716/WP16181.PDF
253. Seri Agroforestri dan Kehutanan di Sulawesi: Keanekaragaman hayati jenis pohon pada hutan rakyat agroforestri di DAS Balangtieng, Sulawesi Selatan. http://dx.doi.org/10.5716/WP16182.PDF
254. Potensi dan Tantangan dalam Pengembangan Skema Ko-Investasi Jasa Lingkungan di Kabupaten Buol, Indonesia. http://dx.doi.org/10.5716/WP17008.PDF
255. Keragaman Jenis Pohon dan Pemanfaatannya oleh Masyarakat di Kabupaten Buol, Indonesia. http://dx.doi.org/10.5716/WP17009.PDF
256. Kerentanan dan preferensi sistem pertanian petani di Kabupaten Buol, Indonesia. http://dx.doi.org/10.5716/WP17010.PDF
257. Dinamika Perubahan Penggunaan/Tutupan Lahan Serta Cadangan Karbon di Kabupaten Buol, Indonesia. http://dx.doi.org/10.5716/WP17011.PDF
258. The Effectiveness of the Volunteer Farmer Trainer Approach vis-à-vis Other Information Sources in Dissemination of Livestock Feed Technologies in Uganda. http://dx.doi.org/10.5716/WP17104.PDF
259. Agroforestry and Forestry in Sulawesi series: Impact of agricultural-extension booklets on community livelihoods in South and Southeast Sulawesi. http://dx.doi.org/10.5716/WP17125.PDF
260. Petani Menjadi Penyuluh, Mungkinkah? Sebuah Pendekatan Penyuluhan dari Petani ke Petani di Kabupaten Sumba Timur. http://dx.doi.org/10.5716/WP17145.PDF
261. Dampak Perubahan Tutupan Lahan terhadap Kondisi Hidrologi di Das Buol, Kabupaten Buol, Sulawesi Tengah: Simulasi dengan Model Genriver. http://dx.doi.org/10.5716/WP17146.PDF
262. Analisis Tapak Mata Air Umbulan, Pasuruan, Jawa Timur. Kajian elemen biofisik dan persepsi masyarakat. http://dx.doi.org/10.5716/WP17147.PDF
263. Planned comparisons demystified. http://dx.doi.org/10.5716/WP17354.PDF
264. Soil health decision support for NERC digital soil platforms: A survey report. http://dx.doi.org/10.5716/WP17355.PDF
265. Seri Pembangunan Ekonomi Pedesaan Indonesia: Menanam di bukit gundul: Pengetahuan masyarakat lokal dalam upaya restorasi lahan di Sumba Timur. http://dx.doi.org/10.5716/WP17356.PDF
266. Tree diversity and carbon stock in three districts of Kutai Timur, Pasir and Berau, East Kalimantan http://dx.doi.org/10.5716/WP17357.PDF
267. Tree Diversity and Carbon Stock in Various Land Use Systems of Banyuasin and Musi Banyuasin Districts, South Sumatera http://dx.doi.org/10.5716/WP17358.PDF

The World Agroforestry Centre is an autonomous, non-profit research organization whose vision is a rural transformation in the developing world as smallholder households increase their use of trees in agricultural landscapes to improve food security, nutrition, income, health, shelter, social cohesion, energy resources and environmental sustainability. The Centre generates science-based knowledge about the diverse roles that trees play in agricultural landscapes, and uses its research to advance policies and practices, and their implementation that benefit the poor and the environment. It aims to ensure that all this is achieved by enhancing the quality of its science work, increasing operational efficiency, building and maintaining strong partnerships, accelerating the use and impact of its research, and promoting greater cohesion, interdependence and alignment within the organization.

United Nations Avenue, Gigiri • PO Box 30677 • Nairobi, 00100 • Kenya
Telephone: +254 20 7224000 or via USA +1 650 833 6645
Fax: +254 20 7224001 or via USA +1 650 833 6646
Email: worldagroforestry@cgiar.org • www.worldagroforestry.org

Southeast Asia Regional Program • Sindang Barang • Bogor 16680
PO Box 161 • Bogor 16001 • Indonesia
Telephone: +62 251 8625415 • Fax: +62 251 8625416
• Email: icraf-indonesia@cgiar.org
www.worldagroforestry.org/region/southeast-asia
blog.worldagroforestry.org