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The diversity of plant species, the types of plant uses and the estimate of carbon stock in agroforestry system in Harapan Makmur Village, Bengkulu, Indonesia

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Abstract. *Wiryono, Puteri VNU, Senoaji G. 2016. The diversity of plant species, the types of plant uses and the estimate of carbon stock in agroforestry system in Harapan Makmur Village, Bengkulu, Indonesia. Biodiversitas 17: 249-255.* Homegardens are a traditional form of agroforestry commonly found in rural areas in Indonesia, where a variety of agricultural crops and forest trees are grown in a mixed system. To some extent, the traditional homegardens resemble natural forest in vegetation structure and composition. The objective of this study was to know the diversity of plant species, the types of plant uses and the estimate of carbon stock in homegardens in, Harapan Makmur Village, Central Bengkulu District, Bengkulu Province, Indonesia. The field work was conducted in 2013. The data of uses were collected through interview, while data on vegetation were gathered from measurement. The data were analyzed qualitatively and quantitatively. The results showed that 101 species of plants were found in the homegardens, with a Shannon-Wiener diversity index of 0.99 for trees. The most dominant species of trees was *Hevea brasiliensis* Willd (rubber tree) with an importance value index of 127 %. For saplings and shrubs, rubber was also the most dominant with 169 individuals, while for herbs, *Agrostis* sp. was the most dominant species with an average coverage of 25.8 %. The community used plants for several purposes: 41 species for food, 21 for fire wood, 13 for ornamental plants, 11 for medicines, 7 for construction wood, 6 for shade trees, 2 for handy craft, 4 for hedge, 3 for forage, and 2 for coloring. Twenty three species were not used. The estimate of carbon stock in trees was 95.2 ton ha^{-1}.

Keywords: Agroforestry, homegardens, carbon stock, species diversity

INTRODUCTION

Having vast area of wet tropical forest, Indonesia is rich in biodiversity. However, large-scale forest exploitation which have been done for several decades has caused massive deforestation, which in turn can reduce biodiversity. Within the period of 2000-2009, the total area of deforestation in Indonesia was 15.6 million hectares (FWI 2011). Conversion of natural forest into oil palm plantation has been a driving force of deforestation in Indonesia, and most the oil palm plantation is located in Sumatra (Saxon and Roquemore 2011). Not only large plantation companies, but also farmers grow oil palm in their land. The farmers sell their oil palm fruit to the collectors who will sell the fruit to companies. Not only dry land, even rice field has been converted to oil palm plantation which threatens food security (Wildayana 2015).

Fortunately, some villagers still maintain agroforestry system in their homegardens. Agroforestry is a farming system, combining agricultural crops and forest trees. Agroforestry can also be defined as a dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels (Mead 2004). It is a traditional farming system practiced in many parts of the world. In developing countries, this system has been practiced until today, but even in Europe it was a general practice until Middle Ages (King 1987). Agroforestry system may balance the goal of agricultural development and conservation of soil, water, regional climate and biodiversity (Schroth et al. 2004). The role of agroforestry in biodiversity conservation has been recognized, and recently, there have been a growing interest on the role of carbon sequestration in agroforestry system (Takimoto et al 2009, Kessler et al 2012).

The objective of this study was to know the diversity of plant species, the types of plant uses and the estimate of carbon stock in home gardens in Hamlet II of Harapan Makmur Village, in Pondok Kubang Sub-District, Central Bengkulu District, Bengkulu Province, Indonesia.

MATERIALS AND METHODS

Study area

This study was conducted in Hamlet II, Harapan Makmur Village, Pondok Kubang Sub-District, Central Bengkulu District, Bengkulu Province, Indonesia (Figure 1), from January to May 2013. Additional data were taken in early March 2016. Most of the residents are Javanese.

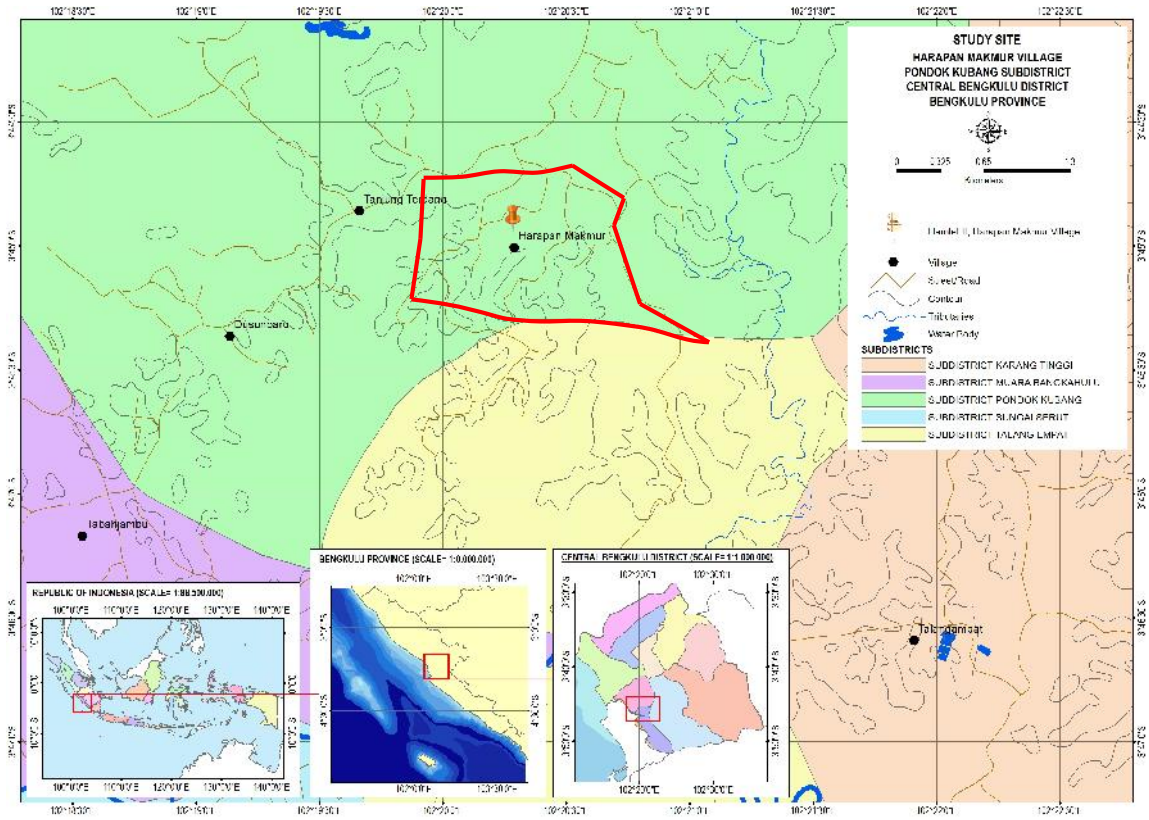

Figure 1. Study site in Harapan Makmur Village, Pondok Kubang Sub-District, Central Bengkulu District, Bengkulu Province, Indonesia

Sampling of vegetation

Sampling of vegetation was done in 23 homegardens, or 20% of the total homegardens. The plants were categorized into three categories based on its size and growth form: (i) tree: a woody plant having a diameter at breast height (dbh) $\geq$ 10 cm and height $\geq$ 3 m; (ii) sapling or shrub: woody plant with dbh < 10 cm and height < 3m; and (iii) herb: non-woody plant (it could be woody at old age). Coconut and oil palm were categorized as trees, while banana was considered a shrub. Every name of plant in the selected homegarden was recorded. To get data for quantitative measurement (diversity index, importance value index and carbon stock of trees, abundance of shrubs and average cover of herbs) for each home garden, 10 m x10 m quadrates were made for tree sampling with sampling intensity of 20%. Within each 10 m x10m quadrate, a 4 m x4m quadrate was made for sampling of shrubs and saplings, and a 1 m x1m quadrate was made for sampling of herbs.

The dbh (130 cm above the ground), local names, scientific names, number of individuals and height of trees in the 10 m x10m quadrates were recorded. For shrubs and saplings, only the local names, scientific names and number of individuals were recorded. For herbs, the local names, the scientific names and percentage of coverage were recorded. The data of plant uses were collected through interview with 23 respondents, 11 of whom were farmers, 10 farming laborers, 1 civil servant and 1 mechanic. Based on the education, 15 of respondents graduated from elementary school, 3 junior high school, 3 senior high school, 1 did not finish elementary school and 1 graduated from university.

Data analyses

Diversity index

Shannon-Wiener index of diversity was calculated for trees, with the following formula:

$$H = -\sum_{i=1}^{s} (pi)(\log pi)$$

Where:

H = species diversity index

s = number of species

Pi= proportion of species i= ni/N (number of trees of species i/total number of trees)

Mueller-Dombois and Ellenberg (1974)

Importance value index

Importance value index was calculated for each tree species, using this formula:

IV= relative density + relative frequency + relative dominance

Density

$$\text{Density of species i} = \frac{number\ of\ trees\ of\ species\ i}{area\ of\ quadrats}$$

$$\text{Relative density of species i} = \frac{\text{Density of species i}}{\text{Density of all species}} \times 100\ \%$$

Frequency

$$\text{Frequency of species i} = \frac{\text{number of quadrats where species i was found}}{\text{total quadrats}}$$

$$\text{Relative frequency of species i} = \frac{\text{Frequency of species i}}{\text{frequency of all species}} \times 100\ \%$$

Dominance

$$\text{Dominance of species i} = \frac{\text{Basal area of species i}}{\text{area of quadrats}}$$

$$\text{Relative dominance of species i} = \frac{\text{Dominance of species i}}{\text{Dominance of all species}} \times 100\ \%$$

Mueller-Dombois and Ellenberg (1974)

Carbon stock

Carbon stock was estimated for trees. The carbon stock was estimated indirectly through biomass estimate. The stored biomass was estimated using allometric equations summarized in Sari et al 2011 (Table 1) because these formula were the results of previous researches.

Table 1. Allometric equations to estimate carbon for some species of trees

Types of plants or species	Allometric equations
Tree with branches (in general)	$AGB = 0.11\ \rho\ D^{2.62}$
Tree without branches	$AGB = \pi\ \rho\ H\ D^2/40$
Bamboo	$AGB = 0.131\ D^{2.28}$
Paraserianthes falcataria	$AGB = 0.0272\ D^{2.831}$
Tectona grandis	$0.0272\ D^{2.2227}$
Acacia mangium	$0.0528\ (D^2)^{\ 1.3612}$
Swietenia macrophylla	$0.048\ D^{2.08}$

Note: D: diameter (cm), H: tree height (m) ; ρ: wood density (g cm^{-3}), the value of which for each species is taken from ICRAF 2013. For species which have no information of ρ, the value of ρ was assumed to be the same as that of another species having similar physical properties. The below ground biomass for mixed forest is about 0.37 of above ground biomass and the carbon stock is 0.47 of biomass (IPCC 2006).

RESULTS AND DISCUSSION

Species diversity and dominance

A total of 101 plant species were found in Hamlet II of Harapan Makmur Village, 38 of which were trees with diameter ≥ 10 cm. Some plants were intentionally planted, and the others grew naturally. In another agroforestry system in the form of bamboo-tree gardens in West Java, Okubo et al (2010) found 42 planned and utilized species and 19 associated non-use species of plants with diameter > 10 cm. Also in West Java, Manurung et al (2008) found 52 tree species in *dudukuhan*, a traditional tree garden.

The Shannon-Wiener index of tree species diversity was 0.99. The Shannon-Wiener index value for home-gardens in this study was similar to the index values for dudukuhans in West Java. Dudukuhans value varied from 1.31 for mixed timber-fruit systems, to 1.18 for mixed fruit-timber-banana-annual crop systems, to 1.10 for fallow gardens (similar to secondary forests), to 0.44 for timber systems (Manurung et al 2008). Although agroforestry system has lower species diversity than natural forest (Kessler et al 2012), the plant diversity in agroforestry system is certainly higher than in single-species plantation. Amid the trend of conversion from agroforest into single species plantation in Indonesia (Feintrenie et al 2010) the attitude of Harapan Makmur villagers to maintain their agroforest is commendable.

Among trees, rubber tree, *Hevea brasiliensis* Willd, had the highest importance value index (127.0%), followed by oil palm tree or *Elaeis guineensis* L (28.4%), and coconut or *Cocos nucifera* L. (24.5%). Other trees had much lower importance value index (Table 2).

Among shrubs and saplings, rubber plant also had the highest number of individuals, 159, followed by banana or *Musa* sp. with 51 individuals, robusta coffee (*Coffea canephora* Pierre ex A. Froehner), 41, and arabica coffee (*Coffea arabica* L.) 21. Other species had much lower values (Table 3).

Most trees and shrubs in homegardens do not grow naturally, but are intentionally planted, so their abundance reflects the preference of the owners. Economic consideration is one the main factors determining the selection of crops (Feintrenie et al 2010). The dominant tree and shrub species must have important economic or cultural values. Rubber tree, oil palm and coffee are the main crops found in people's plantation in Bengkulu because they have relatively high economic value. This finding was similar to study in homegarden systems in Lampung, another province of Sumatra (Roshetko et al 2002).

Traditionally, Bengkulu farmers have planted coffee and rubber trees, but in the last two decades, oil palm has been the most important plantation crop in Bengkulu, even in all Sumatra provinces. Sixty percent of oil palm in Indonesia is found in Sumatra (Pricewater Coopers 2010). Palm oil area in Indonesia grew 11.5 percent annually from 1997 to 2000, and by 15.8 percent annually from 2000 to 2007 (Saxon and Roquemore 2011). It is not surprising that the expansion of oil palm plantation is one of the main driving forces of deforestation in Sumatra. Not only plantation companies, but also individual farmers grow oil palm tree, who will then sell their oil palm fruit to companies.

The third most important tree species was coconut. This is a versatile plant. Most parts of this tree are usable, although the people of Harapan Makmur Village only used its leaves and fruit for food, beverage and handy craft. The coconut fruit has economic value, and the people of Harapan Makmur not only used the fruit for their own daily use, but also sold it in the market. In another study, in Batu Ampar Village, South Bengkulu District, Wiryono and Lipranto (2013) found coconut the most used species in the village.

Among shrubs, banana or *Musa* sp. was the second most abundant, after rubber plant. The people of Harapan Makmur consumed their own banana fruit and sold the fruit

in the market. They also made handy craft from the banana leaves. Banana is one of the oldest cultivated plants on earth and is found in many parts of the world. It is also a versatile species. Its fruit contains much energy and vitamins, and most of its parts have medicinal values (Kumar et al 2012).

Among herbs, *Agrostis* sp had the highest average coverage (25.8), followed by *Imperata cylindrica* L. (17.0), *Dicranopsis linearis* (Burn.f.) Underw (13.6), lawn grass or *Axonopus compressus* (Sw) P. Beauv (12.0), *Eragrostis tenella* (L.) P. Beauv. Ex Roem et. Schult. (12), *Spigelia anthelmia* (10) (Table 4). Unlike trees and shrubs, most of the herbs were not intentionally planted and was not used, so some of them have no local names.

Type of uses

Out of 101 species of plants found in home gardens, 79 species were used by the people of Hamlet II of Harapan Makmur Village for their daily uses and for sale. In another study, villagers living near Bukit Daun Protected Forest Area, in Kepahiang District, Bengkulu Province used 95 species of plants from their land (Sunesi and Wiryono 2007). In Keramat Mulya, Soreang District, West Java Province, the villagers used only 42 plant species from their traditional bamboo-tree gardens (Okubo et al 2010). In Kabena Island, Southeast Celebes Province, villagers used 65 species of plants for their daily uses (Rahayu and Rugayah 2010).

The people of Hamlet II used 41 species of plants for food, 21 for firewood, 11 for medicines, 10 for ornamental plants, 7 for construction wood, 6 for beverage, 4 for hedge, 3 for forage, 3 for shade trees, 2 for handy craft, and 2 for coloring agent.

The most used part of plant for food was fruit (69%), followed by leaf (14%), tuber (8%), rhizome (6%) and stem (3%). The food consisted of three categories, namely fruit, vegetable and seasoning. Some of plants for food were consumed and some were sold. In Batu Ampar Village, South Bengkulu District, villagers used only 35 plant species for food (Wiryono and Lipranto 2013)

The fruits of plants were not only used as food, but also for beverage. No other parts of plants were used as beverage. Most of fruits were made into juice, except for coconut, robusta coffee (*Coffea canephora*) and arabica coffee (*Coffea arabica*). To give color on food, the people of Harapan Makmur Village used leaves of fragrant pandan (*Pandanus amaryllifolius)* to give green color and rhizomes of turmeric (*Curcuma domestica* Vall) give yellow color.

Homegarden is a source of firewood. Actually all trees and shrubs can be used as firewood, but the people of Harapan Makmur Village used only 21 species for firewood. Their selection of trees might be based on the easiness to get the wood and the quality of the wood as firewood. Both branches and trunk were used to firewood. The trunks of seven species were also used as construction wood. One of species for construction wood was *Tectona grandis* or teak, which has very high quality wood. This species was brought from Java. Some species were native species of Bengkulu, e.g. *Dysoxylum mollissimum* Blume and *Cinnamomum porrectum* Roxb.

Table 2. Five species of trees with the highest importance value index in the study area

Local names	Scientific names	Family	Rdo	RF	RDe	IVI
Karet	*Hevea brasiliensis* Willd	Euphorbiaceae	31.8	29.4	65.8	127.0
Sawit	*Elaeis guineensis* L	Palmaleceae	22.5	3.7	2.2	28.4
Kelapa	*Cocos nucifera* L	Arecaceae	7.8	12	4,6	24,5
Durian	*Durio zibethinus* Murray	Bombaceae	5.4	8.7	5.3	19.3
Kayu bawang	*Dysoxylum mollissimum* Blume	Burseraceae	3.0	9.4	5.0	17.4

Note: Rdo: relative dominance; RF: relative frequency; RDe: relative density; IVI: importance value index.

Table 3. Five species of saplings and shrubs with the highest number of individuals in the study area

Local names	Scientific names	Families	Number of individuals
Karet	*Hevea brasiliensis* Willd	Euphorbiaceae	159
Pisang	*Musa* sp.	Musaceae	51
Kopi robusta	*Coffea canephora* Pierre ex A.Froehner	Rubiaceae	41
Kopi arabika	*Coffea arabica* L.	Rubiaceae	21
Singkong	*Manihot utilissima* Pohl.	Euphorbiaceae	9

Table 4. Five species of herbs with the highest average cover in the study area

Local names	Scientific names	Families	Average coverage (%)
_	*Agrostis* sp.	Poaceae	25.8
Ilalang	*Imperata cylindrica* L.	Poaceae	17.0
Paku resam	*Dicranopsis linearis* (Burn.f.) Underw	Gleicheniaceae	13.6
Rumput kerbau	*Axonopus compressus* (Sw) P. Beauv	Poaceae	12.6
	Eragrostis tenella (L.) P. Beauv. Ex Roem et. Schult.	Poaceae	12.5

Table 5. The local names, scientific names, families and uses of plants found in the study area

Local names	Scientific names	Families	Parts of plants used	Types of uses
Used plants				
Gandarusa	*Justicia gandarussa* L	Achantaceae	ALL	MED, FENCE
Bayam	*Amaranthus spinosus* L	Amaranthaceae	LEAF	FOOD
Jeger ayam	*Celosia cristata* L	Amaranthaceae	ALL	ORN
Bawang daun	*Allium fistulosum* L	Amaryllidaceae	LEAF	FOOD
Bacang	*Mangifera foetida* Lour	Anacardiaceae	FRT, TRK, BRC	FOOD
Mangga	*Mangifera indica* L	Anacardiaceae	FRT, TRK, BRC	FOOD, BEV, FRW
Srikaya	*Annona muricata* L	Annonaceae	FRT	FOOD
Pulai hitam	*Alstonia angustiloba* Miq	Apocynaceae	TRK	FRW, CON
Tapak dara	*Catharanthus roseus* (L.) G.Don	Apocynaceae	ALL	ORN
Talas	*Colocasia esculenta* (L.) Schott	Araceae	TUB	FOOD
Pinang	*Areca catechu* L	Arecaceae	FRT, ALL	MED, FEN
Kelapa	*Cocos nucifera* L	Arecaceae	LEAF, FRT	FOOD, BEV, CRF
Sawit	*Elaeis guineensis* L	Arecaceae	FRT	FOR SALE
Salak	*Salacca zalacca* (Gaertner) Voss	Arecaceae	FRT	FOOD
Puding merah	*Cordyline fruticosa* L	Asparagaceae	ALL	ORN
Suji	*Dracaena angustifiola* Roxb	Asparagaceae	ALL	ORN
Lidah martua	*Sansevieria trifasciata* Prain	Asparagaceae	ALL	ORN
Kemangi	*Ocimum basilicum* L	Asteraceae	LEAF	MED, FOOD
Kalpataru	*Hurea crepitans* L.	Barringtoniaceae	ALL	SHADE
Kapuk	*Ceiba pentandra* (L.) Gaertn	Bombacaceae	BRC	FRW
Durian	*Durio zibethinus* Murray	Bombacaceae	FRT, TRK, BRC	FOOD, FRW, CON
Nanas	*Ananas comosus* (L.) Merr	Bromeliaceae	FRT	FOOD
Kayu bawang	*Dysoxylum mollissium* Blume	Burseraceae	TRK, BRC	FRW, FENCE, CON
Ganyong	*Canna discolor* Lindl.	Cannaceae	TUB	FOOD
Pepaya	*Carica papaya* L	Caricaceae	FRT, LEAF	MED, FOOD
Ubi rambat	*Ipomoea batatas* L	Convolvulaceae	TUB	FOOD
Gambas	*Luffa acutangula* (L.) Roxb	Cucurbitaceae	FRT	FOOD
Cemara kipas	*Thuja orientalis* L	Cupressaceae	ALL	ORN
Bunga euphorbia	*Euphorbia milii* Des Moul	Euphorbiaceae	ALL	ORN
Karet	*Hevea brasiliensis* Willd	Euphorbiaceae	SAP	FOR SALE
Jarak	*Jatropha curcas* L	Euphorbiaceae	SAP	MED
Singkong	*Manihot utilisima* Pohl	Euphorbiaceae	LEAF, TUB	FOOD
Katu	*Sauropus androgynus* (L.) Merr	Euphorbiaceae	LEAF	FOOD
Akasia	*Acacia mangium* Willd	Fabaceae	TRK, BRC	FRW, CON
Flamboyan	*Delonix regia* (Boj. ex Hook.) Raf	Fabaceae	TRK, BRC	FRW
Gamal	*Gliricidia sepium* (Jacq.) Kunth ex Walp	Fabaceae	TRK, LEAF	FEN, FOR
Lamtoro	*Leucaena leucocephala* Lamk	Fabaceae	TRK, BRC	FRW
Sengon	*Paraserianthes falcataria* L	Fabaceae	TRK	FRW
Jengkol	*Pithecellobium jiringa* Prain	Fabaceae	FRT, TRK, BRC	FOOD, FRW
Melinjo	*Gnetum gnemon* L	Gnetaceae	LEAF, FRT	FOOD
Manggis	*Garcinia mangostana* L	Guttiferae	FRT, TRK, BRC	FOOD, FRW
Jati	*Tectona grandis* Linn. F	Lamiaceae	TRK, BRC	FRW, CON
Kayu gadis	*Cinnamomum porrectum* Roxb	Lauraceae	TRK, BRC	FRW, CON
Alpokat	*Persea americana* Mill	Lauraceae	FRT, TRK, BRC	FOOD, BEV, FRW
Bunga sepatu	*Hibiscus rosa-sinensi*s L	Malvaceae	ALL	ORN
Duku	*Lansium domesticum* (Osbeck) Sahni & Bennet var. *duku*	Meliaceae	FRT, TRK, BRC	FOOD, FRW
Mahoni	*Swietenia macrophylla* King	Meliaceae	TRK, BRC	FRW, CON
Nangka	*Artocarpus heterophyllus* Lam.	Moraceae	FRT, TRK, BRC, LEAF	FOOD, FRW, FOR
Sukun	*Artocarpus indicus* L. F	Moraceae	ALL	FOOD
Pisang	*Musa* sp.	Musaceae	LEAF, FRT	FOOD, CRF
Jambu biji	*Psidium guajava* L	Myrtaceae	BH, OBT	FOOD, FRW, SHD
Jambu air	*Syzygium aqueum* Burm. F	Myrtaceae	FRT, TRK, BRC	FOOD, FRW, SHD
Jambu bol	*Syzygium malaccense* (L.) Merr. & Perry	Myrtaceae	FRT	FOOD, SHD
Bunga pukul empat	*Mirabilis jalapa* L	Nyctaginaceae	ALL	ORN
Belimbing	*Averrhoa carambola* L	Oxalidaceae	FRT	FOOD
Pandan	*Pandanus amaryllifolius* Roxb	Pandanaceae	LEAF	FOOD, COL
Kacang tanah	*Arachis hypogeae* L	Papilionaceae	FRT	FOOD
Serai	*Andropogon nardus* L	Poaceae	TRK, LEAF	FOOD

Rumput kerbau	*Axonopus compressus* (Sw). P. Beauv	Poaceae	LEAF	FOR
Rumput jepang	*Zoysia japonica* Steud	Poaceae	ALL	ORN
Mawar	*Rosa* sp.	Rosaceae	ALL	ORN
Jabon	*Anthocephalus cadamba Miq*	Rubiaceae	TRK	FRW
Kopi arabika	*Coffea arabica* L	Rubiaceae	FRT, TRK, BRC	BEV, FRW
Kopi robusta	*Coffea canephora* Pierre ex A. Froehner	Rubiaceae	FRT, TRK, BRC	FOOD, FRW
Asoka	*Ixora coccinea* L	Rubiaceae	ALL	ORN
Mengkudu	*Morinda citrifolia* L	Rubiaceae	FRT	MED
Jeruk nipis	*Citrus aurantifolia* (Ch. & P.) Sw	Rutaceae	LEAF, FRT	FOOD, FRW, SHD
Rambutan	*Nephelium lappaceum* L	Sapindaceae	FRT, TRK, BRC	FOOD, FRW, SHD
Sawo	*Achras zapota* L	Sapotaceae	FRT	FOOD
Cabe besar	*Capsicum annuum* L	Solanaceae	FRT	FOOD
Cabe rawit	*Capsicum frutescens* L	Solonaceae	FRT	FOOD
Terong bulat	*Solanum blumei* L	Solanaceae	FRT	FOOD
Tomat	*Solanum lycopersicum* L	Solanaceae	FRT	FOOD
Rimbang	*Solanum torvum* Sw	Solanaceae	FRT	FOOD
Coklat	*Theobroma cacao* L	Sterculiaceae	FRT, TRK, BRC	FOOD, FRW
Mahkota dewa	*Phaleria macrocarpa* (Scheff.) Boerl	Thymelaeaceae	FRT	MED
Lidah buaya	*Aloe vera* (L.) Burm.f	Xanthorrhoeaceae	ALL	MED, ORN
Kunyit	*Curcuma domestica* Vall	Zingiberaceae	LEAF, RHI	FOOD, MED, COL
Jahe	*Zingiber officinale* Roscoe	Zingiberaceae	RHI	FOOD, MED
Non used plants				
Pegagan	*Centella asiatica* L	Apiaceae	_	NONE
Rumput sambora	*Ageratum* sp.	Asteraceae	_	NONE
Kerinyu	*Chromolaena odorata* L	Asteraceae	_	NONE
Batang babi	*Cyanthillium cinereum* (L.) H. Rob	Asteraceae	_	NONE
Jatong kuda	*Synedrella nodiflora* (L.) Gaertner	Asteraceae	_	NONE
Widelia	*Wedelia trilobata* (L.) Hitchc	Asteraceae	_	NONE
Rumput tapung	*Kyllinga nemoralis* L	Cyperaceae	_	NONE
Patikan kebo	*Chamaesyce hirta* (L.) Millsp	Euphorbiaceae	_	NONE
Meniran	*Phylantus amarus* L	Euphorbiaceae	_	NONE
Bunga telang	*Clitoria* sp.	Fabaceae	_	NONE
Putri malu	*Mimosa pudica* Duchass & Walp	Fabaceae	_	NONE
Paku resam	*Dicranopteris linearis* (Burm. f.) Underw	Gleicheniaceae	_	NONE
_	*Spigelia anthelmia* L	Loganiaceae	_	NONE
Harendong bulu	*Clidemia hirta* (L.) D. Don	Melastomaceae	_	NONE
Keduruk	*Melastoma malabathricum*	Melastomaceae	_	NONE
Sesuruhan	*Peperomia pellucida* L	Piperaceae	_	NONE
_	*Agrostis* sp.	Poaceae	_	NONE
_	*Eragrostis tenella* (L.) P. Beauv.ex Roem et.Schult	Poaceae	_	NONE
Ilalang	*Imperata cylindrica* L	Poaceae	_	NONE
Jagung	*Zea mays s*sp.. *Mays* L	Poaceae	_	NONE
Paku-pakuan	*Pteris vittata* L	Pteridaceae	_	NONE
Pecut kuda	*Stachytarpheta jamaicensis* (L). Vahl.	Verbenaceae	_	NONE

Eleven species of plants were used as traditional medicines. The most part of plant used as medicines was fruit (5 species), followed by leaf (4), rhizome (2) and sap (1). If the respondents for this study included a practicing traditional healer, the result might have been higher. In a village next to Harapan Makmur Village, the Tanjung Terdana Village, a traditional healer used 31 plant species for medicines (Nurliana 2011).

Homegardens in Hamlet II of Harapan Makmur Village usually had clear boundary from one another. The villagers used bricks, wood, wire or living plants or hedge as the border of home gardens. Four species of plants were used as living fence or hedge.

In the front yard, the people of Hamlet II planted ornamental plants and shade trees. Some species were planted as ornamental plants because of their bright flower, some for their characteristic crown and some for their characteristic leaves. The leaves of jackfruit *Artocarpus heterophyllus* Lamk and and quick stick *Gliricidia sepium* (Jacq.) Kunth ex Walp., lawn grass *Axonopus compressus* (Sw). P. Beauv were used as forage.

Carbon stock

The estimate of above ground tree biomass of trees was 147.8 ton ha^{-1}, below ground 54.7 ton ha^{-1}, and the total 202.5 ton ha^{-1}. With an average carbon stock estimated at

0.47 of biomass, the above ground carbon stock was 69.5 ton ha^{-1}, below ground carbon stock 25.7 ton ha^{-1} and total 95.2 ton ha^{-1}. The above ground biomass in the agroforestry system in Hamlet II was lower than that of Asian rain tropical broadleaf forest, which was 220 ton ha^{-1} (IPCC 2013), but higher than that in agroforestry system in Kalikunto watershed in Malang, East Java, which was 42.1 ton ha^{-1} (Hairiah et al. 2010).

To conclude, homegarden systems of Hamlet II, Harapan Makmur Village resembled tree garden systems in Lampung and West Java; maintained biodiversity, contained significant carbon stocks, and provided livelihood for the villagers.

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REFERENCES

Feintrenie L, Schwarze S, Levang P. 2010. Are local people conservationists? Analysis of transition dynamics from agroforests to monoculture plantations in Indonesia. Ecol Soc 15 (4): 37.

FWI [Forest Watch Indonesia]. 2011. The potret of Indonesian forest 2000-2009. Forest Watch Indonesia, Jakarta.

Hairiah K, Dewi S, Agus F, et al. 2010. Measuring Carbon Stocks Across Land Use Systems: A Manual. World Agroforestry Centre (ICRAF), SEA Regional Office, Bogor, Indonesia.

ICRAF. 2013. Wood Density. In: Tree Functional Attributes and Ecological Database. ICRAF, Bogor. http://db.worldagroforestry.org/wd [May 2013].

IPCC. 2006. IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, In: Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K. (eds). IGES, Tokyo, Japan.

Kessler M, Hertel D, Jungkunst HF, Kluge J, Abrahamczyk S, et al. 2012. Can joint carbon and biodiversity management in tropical agroforestry landscapes be optimized? PLoS ONE 7 (10): e47192. doi:10.1371/journal.pone.0047192

King KFS.1987. The history of agroforestry. In: Steppler HA, Nair PKR (eds) Agroforesty, a Decade of Development. International Council for Research in Agroforetsry, Nairobi.

Kumar KPS, Bhowmik D, Duraivel S, Umadevi M. 2012. Traditional and medicinal uses of banana. J Pharm Phytochem 1 (3): 51-63.

Manurung GE, Roshetko JM, Budidarsono S, Kurniawan I. 2008. Dudukuhan tree farming systems in West Java: How to mobilize self-strengthening of community-based forest management? In: Snelder DJ, Lasco R (eds). Smallholder Tree Growing for Rural Development and Environmental Services, Springer, Berlin.

Mead DJ. 2004. Agroforestry. In: Forests and Forest Plants. Vol 1. Encyclopedia of Life Science Systems. EOLSS Publishers, Oxford UK.

Mueller-Dombois D, Ellenberg H. 1974. Aims and Methods in Vegetation Ecology. John Willey & Sons. New York.

Nurliana S 2011. The traditional knowledge of Lembak Tribe on the diversity of medicinal plants in two villages in Bengkulu. Seminar Proceedings on Conservation of Tropical Plants: The Current Condition and the Future Challenge. LIPI, Bogor. [Indonesian].

Okubo S, Parikesit, Harashina K, Muhammad D, et al. 2010. Traditional perennial crop-based agroforestry in West Java:the trade off between on-farm biodiversity and income. Agrofor Syst 80:17-31.

Pricewater Coopers. 2010. Palm Oil Plantation. Industry Landscape, Regulatory and Financial Review. Pricewater Coopers, Jakarta.

Rahayu M, Rugayah. 2010. Local knowledge and utilization of plants by local communities Kabaena Island, Southeast Sulawesi. Berita Biologi 10 (1): 67-75. [Indonesian]

Roshetko JM, Delaney M, Hairiah K, Purnomosidhi P. 2002. Carbon stocks in Indonesian homegarden systems: Can smallholder systems be targeted for increased carbon storage? Am J Altern Agric 17:138-148.

Sari RR, Hairiah K, Widianto, at al. 2011. Potency of natural forest and agroforestry as stock of carbon in Prigen Sub-district, Pasuruan. Proceedings of National Seminar Commemorating the 47th Anniversary of Faculty of Forestry, Gadjah Mada University, Yogyakarta. [Indonesian]

Saxon E, Roquemore 2011. Palm Oil. In: Boucher D, Elias P, Lininger K, et al. (eds.). The Root of the Problem. What is the Driving Force of Tropical Deforestation Today? Tropical Forest and Climate Initiative. Union of Concerned Scientists, Washington, DC.

Scrotch G, da Fonseca GAB, Harvey CA, et al. (eds). 2004. Agroforestry and Biodiversity in Tropical Landscape. Island Press, Washington DC.

Sunesi I, Wiryono. 2007. The diversity of plant species utilized by villagers living near protected forest in Kepahiang District, Bengkulu Province. Indonesian J Agric Sci, Special Edition (3): 432-439.

Takimoto A, Nair, VD, Nair PKR. 2009. Contribution of trees to soil carbon sequestration under agroforestry systems in the West African Sahel. Agrofor Syst 76:11-25.

Wildayana E. 2015. Formulating rice fields conversion control to oil palm plantations in tidal wetlands of South Sumatra, Indonesia. J Wetlands Environ Manag 3 (2): 72-78

Wiryono, Lipranto. 2013. The diversity of locally useful species Batu Ampar village near Bukit Raja Mandara protected forest area in South Bengkulu District. Jurnal Manusia dan Lingkungan 20 (2):119-127.