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Abstract

This paper investigates the types of agroforestry system that exist in Gunung Salak Valley, West Java, Indonesia in order to characterize the differences in their basic structure and associated crop plant diversity. Data were collected through rapid rural appraisal, field observation and focus groups, followed by household survey of a sample of 20 agroforestry farmers. Five main agroforestry systems (homegardens, fruit tree system, timber tree system, mixed fruit-timber system, and cropping in the forest understory) exist in the study area, and all of them exhibit a noticeable diversity in terms of both species composition and utilization. Products from farming accounted for an average 24% of household income. They comprised agroforestry products which contributed IDR 3.25 million/year and other agricultural products contributing IDR 1.66 million/ year. The observed agroforestry systems include not only a form of forest dominated by 'cultivated trees', but also an anthropogenic vegetation formation derived from agricultural antecedents. In land-use classifications agroforestry systems are not recogniged as forestry, but like forests they provide tree products and services. Classification will always be disfunctional if a binary system is applied, thus a more sophisticated approach should be adopted that incorporates the economic and environmental characteristics of a wider range of systems.

Keywords: Anthropogenic vegetation, species diversity, *hortus*, income, folk farmers

Introduction

The important and historic relationship of local people and forests is widely reported. The romanticism that external observers often associate with indigenous forest people is strong (Bahuch et al., 2001), particularly the image of nomadic bands of a few individuals living in harmony with nature. Tropical rainforests have often been perceived as 'virgin nature' and described as largely uninhabited, with only scattered groups of forest people (Michon, 2005). However, as is the case elsewhere in the tropics, in Southeast Asia, at present the vast majority of forested landscapes are inhabited by large groups of smallholder farmers, practicing some form of farming (Peng et al., 2014).

Several ethnobotanists consider the process of plant domestication and farming to have followed two divergent models (Michon, 2005): i) The *ager* model, an agricultural practice in open fields, ii) the *hortus* model, cultivation of crops in 'gardens'. The diverse agroforestry practices in Indonesia fit a range of models that integrate both biophysical and socio-economic benefits. Examples include: the *repong* dammar resin producing system of Krui, Lampung; the *tembawang* (fruit and timber) system of West Kalimantan; and the *parak* system (tree gardens on the slopes between the villages and forest) in Maninjau, West Sumatra (de Foresta et al., 2000; Mizuno et al., 2013).

This paper investigates the types of agroforestry system that exist in the Gunung Salak Valley, West Java, and the basic structural differences between them. Understanding such locally-developed systems can help inform improvements to policies to make them more compatible with local land-use practices. In addition, the history of agroforestry and the complex relationships between agriculture and forestry explain some misunderstandings about the concepts and classification of agroforestry. Contrary to common perception, the development of agroforestry practices has often been more closely related to agriculture than to forestry (Torquebiau, 2000), although Michon (2005) found that in Sumatra agroforestry systems are closer to forestry. This paper will further inform this debate with evidence from West Java.

Materials and Methods

Study site

The Gunung Salak region lies between 6º 32' 11.31" S and 6º 40' 08.94" S latitudes and between 106º 46' 12.04" E and 106º47' 27.42" E longitudes. The climate in this region is equatorial with

two distinct seasons[1], dry (April – October) and rainy (November – March). The soils are highly fertile and predominantly derived from volcanic sedimentary rocks (Badan Pusat Statistik, 2013).

Field data were collected from two purposively selected[2] sample villages, Sukaluyu and Tamansari, located in the northern valley of Gunung Salak. The villages have poor infrastructure facilities, and household incomes are mainly based on agricultural and forest products, in addition to wage labour and retailing (Badan Pusat Statistik, 2013). With the equatorial climate, many types of cereals, and a diversity of vegetables and fruit are harvested all year round from agricultural fields. Fruit, vegetables, bamboo, rattan and firewood are also collected from nearby forests.

Research method

Rapid rural appraisals (RRA) were used to collect basic socioeconomic and geographical information about the research site, including the types of local land use systems. Village mapping and key informant interview sessions were conducted in each village by involving the village head and three farmers, selected purposively based on their knowledge about the community and surrounding areas.

Two focus group discussion (FGD) sessions were conducted (one in each village) to characterize the existing agroforestry systems and their products from farmers' perspectives. The village heads and local farmer representative groups (consisting of eight to twelve farmers) were present in these sessions.

Field observation methods were used to identify the range of local agroforestry systems in the research site, and their structure, species, management and products. Observations were carried out in 25 locations which were decided based on the information gathered from the RRA and FGD. During the observation period, several pictures of local agroforestry systems were taken for the digital record, and relevant information was noted with the help of an expert local informant[3].

A separate set of semi-structured questionnaires was used to carry out a survey with the farmers

[1] In the study site rainfall occurs throughout the year, but based on its intensity seasons are divided into two, where heavy rainfall occurs in the rainy season.
[2] Villages were selected based on their watershed location, i.e. middle (Sukaluyu) and upper (Tamansari).
[3] One resident of the study site, who had considerable knowledge of local land use systems, products, markets and institutions, was employed as an expert local informant.

who are practicing agroforestry. Purposive sampling restricted to well-managed[4] agroforestry farms is used, which restricted the sample size to 20 farms. It was estimated that they represent about 30% of the total agroforestry farms in the study villages. The sample agroforestry farms are highly dispersed because monoculture agriculture is the most common practice dominating the landscape of the study area. A questionnaire targeting the socioeconomic characteristics of farm households including education, land allocation and income, was developed for the structured interviews, and pre-tested on two households. The product value of crops has been calculated based on the amount produced in one production year.

Results

Socioeconomic characteristics of agroforestry farmers

The average total landholding per agroforestry farming family is 0.98 ha, with 0.85 ha allocated to agroforestry (Table 1). Besides agroforestry, some have land (0.11 ha) allocated permanently for cultivation of crops such as hill rice. The annual household income from all sources averaged IDR 20.15 million (US$ 2015). Products from farming accounted for 24% of household income. They comprised agroforestry products which contributed IDR 3.25 million/year per household and other agricultural products which contributed IDR 1.66 million/year. Therefore, the income per area of land is four times lower for the agroforestry land than the land used for other agricultural crops. Off-farm sources (76% of total household income) include casual and skilled labour, shopkeeping, home industries and services. The key informant reported that engaging in off-farm income-generating activities limits the household labour available for agriculture, which makes agroforestry appropriate for them because it requires comparatively less labour input.

Table 1 Household and farming characteristics of agroforestry farmers in Gunung Salak (n= 20) for the year 2013

Household and farming characteristics	Mean	Minimum	Maximum
Distance to the village center (minutes of walking)	23.45	10	30
Distance to the edge of nearest forest (minutes of walking)	10.60	2	30

[4] Some farmers started agroforestry farming but after a few years gave up planting the understory, for various reasons (e.g. lack of management interest or capital). Thus many agroforestry farms were converted to simple tree orchards, and these are excluded from the sample.

Age of farmer	53.50	30	73
Education of farmer (year of schooling)	5	0	12
Members per household	6.7	2	10
Total land area (ha)	0.98	0.11	4.00
Total agroforestry area (ha)	0.85	0.05	4.00
Total cropland (other than agroforestry) (ha)	0.11	0.00	1.00
Total homestead area (ha)	0.02	0.00	0.08
Total annual income from all sources (million IDR)	20.15	10	76.80
Total annual income from agroforestry land (million IDR)	3.25	0.15	12.07
Total annual income from cropland (million IDR)	1.66	0.00	14.50

Types and characteristics of agroforestry in the study site

The informants from FGDs stated that the agroforestry systems are used mainly to provide products to support the livelihoods, and are based on traditional knowledge and mainly developed from farmers' own trials. Five types of agroforestry system were found in the study area, and all conform to the *hortus* model described above.

1) Homegardens

Tree growing in the home compound is a long-standing tradition, consisting of an assemblage of plants which includes trees, shrubs and herbaceous plants. Contrary to a superficial appearance of a random assemblage, the gardens were usually carefully structured and purposefully managed. The ground layer is usually partitioned into two, with the lower-most (<1 m height) dominated by a range of vegetable and medicinal plants, and the second layer (1-3 m height) composed of food plants e.g. banana and yam (Table 2). Various fruit trees, including rambutan and star gooseberry, some of which would continue to grow taller, dominate the intermediate layer of 3-10 m height. The upper tree layer consisted of timber and fruit trees, with 35%-70% of tree cover being 10-20 m in height and the remainder being taller upper canopy and emergent tree crowns.

Figure 1 Homegardens in the research site. Photo © Syed Rahman

2) Fruit tree system

These have been established on former swidden and other agriculture fields, through the planting of fruit trees and understory crops (Table 1.2). This is generally a permanent system, as the fruit trees, including durians and mangoes, are productive for a long time period. The individual fruit trees are established and maintained as integrated components of the system continuously over time with over-mature trees being individually replaced whenever needed. This maintains a high, closed canopy of trees with dense undergrowth and high levels of agro-biodiversity. Some of them have been converted into mixed tree gardens (fruit and timber), a focus on fruit production has resulted from the recent increase in demand from markets. It was observed that fruit trees represent the main permanent structure of the system, comprising 25%-60% of the canopy cover which is more than 15 m in height.

3) Timber tree system

This is a rotational system, based on planting of a selected timber species, e.g. teak or jabon, that makes up 30-70% of the canopy tree cover, above various types of understory crop, e.g. yams. This system is also generally established on former swidden and other agriculture fields. In principle, stands of timber trees are harvested at a time when their diameter reaches a size to yield useful timber, after which they are either immediately replaced through natural regeneration or planting, or the land use is reverted to seasonal crops for a few years before being planted to trees again.

Figure 2 Timber trees of jabon with understory crops in the research site. Photo © Syed Rahman

4) Mixed fruit-timber system

This system is generally practiced on land where the farmers previously planted seasonal cash crops, including swidden cultivation fields. It is characterized by high species diversity and usually three to four vertical canopy strata of intimately mixed plant species leading to a total tree canopy cover of 35-70%. The selection of crops for cultivation in the understory is based on their shade tolerance and these crops are established while tree species grow up over the years with gradual canopy coverage. After harvesting of timber, they are usually not replaced by planting new timber trees. In contrast fruit trees are maintained to continue fruit production for a longer period of time.

5) Forest understory system

On a limited scale, primarily only for household consumption, farmers cultivate cassava, banana, yam, and pineapple in the forest area bordering homesteads and farmland with only a small management input, little disturbance to the forest and no appreciable deforestation. After harvesting the crops are replanted. This is an example of forest farming.

Table 2 Harvested agroforestry products observed in the study site and reported by farmers during FGDs

Local or English name	Scientific name	System in which cultivated [a]	Income category[b]	Uses [c]
Vegetables				
Bean	*Dolichos lablab*	H, F, T	B	1, 2
Cassava	*Manihot utilissima*	H, F, T,M, U	B	1, 2
Chilli	*Capsicum annuum*	H, F, T	B	1, 2
Cincau	*Cylea barbata*	H, F, T	A	1, 2
Cowpea	*Vigna sinensis*	F, T,	B	1, 2
Cucumber	*Cucumis sativus*	H, F, T,	B	1, 2
Eggplant	*Solanum melongena*	H, T	B	1, 2
Melinjo	*Gnetum gnemon*	H	C	1, 2
Okra	*Abelmoschus esculentus*	H	B	1, 2
Pumpkin	*Cucurbita pepo*	F, T	B	1, 2
Spinach	*Spinacia oleracea*	H	B	1, 2
Sweet potato	*Ipomoea batatas*	H, F,T	B	1, 2
Taro	*Colocasia esculenta*	H, F, T	C	1,2
Tomato	*Lycopersicon esculentum*	F, T	B	1, 2
Yam	*Dioscorea* spp.	H, F,T, M, U	B	1,2
Cereals/oil seed crops				
Maize	*Zea mays*	F, T	A	1, 2
Hill rice	*Oryza javanica*	F, T	A	1, 2
Sunflower	*Helianthus annuus*	F, T	A	2
Peanut	*Arachis hypogaea*	F,T	B	1,2
Spices				
Ginger	*Zingiber officinale*	H, F, M	A	1, 2
Lemongrass	*Cymbopogon citratus*	H, T	A	1,2
Glangal	*Alpinia galanga*	H	B	1,2
Nutmeg	*Myristica fragrans*	H, F	A	1, 2
Fruits and Nuts				
Avocado	*Persea americana*	H	A	1, 2
Banana	*Musa* spp.	H, T, U	A	1, 2

Betel nut	*Areca catechu*	H	A	1,2
Coconut	*Cocos nucifera*	H	A	1, 2
Durian	*Durio zibethinus*	H, F	A	1, 2
Guava	*Psidium guajava*	H	A	1, 2
Jackfruit	*Artocarpus heterophyllus*	H	A	1, 2
Lemon	*Citrus limonum*	H	A	1, 2
Mango	*Mangifera indica*	H, F	A	1, 2
Menteng	*Baccaurea racemosa*	H	A	1, 2
Papaya	*Carica papaya*	H	A	1, 2
Pineapple	*Ananas comosus*	H, U	A	1, 2
Rambutan	*Nephelium lappaceum*	H	A	1, 2
Star gooseberry	*Phyllanthus acidus*	H	A	1, 2
Water apples	*Eugenia* spp.	H	A	1, 2
Timber				
Teak	*Tectona grandis*	H, T, M	A	2
Jabon	*Anthocephalus cadamba*	H, T, M	A	2
Litsea	*Litsea* spp.	H, T, M	A	2
Sengon	*Albizia falcataria*	H, T, M	A	2

[a] The cultivation system: H = Homegardens, F = Fruit tree system, T = Timber tree system, M = Mixed fruit-timber system, U = Forest understory. [b]The income categories high (A), medium (B) and low (C) are based on the market value of the total amount harvested per hectare. [c] Uses: 1 = Domestic consumption, 2 = Sold at the market.

Discussion

In Gunung Salak, agroforestry practices can be classified into five systems which belong to the *hortus* model based on the diversity of species cultivated, and structural as well as functional diversity. These systems are characterized by the establishment of a high, closed canopy with dense undergrowth and high levels of agro-biodiversity; a close integration of trees with local crops, and utilization of the principle of multifunctionality in their management. Although these systems are designed for production, they are all characterized by high ecological diversity in terms of species composition and economically in terms of their range of products and patterns of utilization.

The canopy cover of observed trees on agroforestry land ranged between 30% and 70%. However, this still lies outside the FAO (2000) definition of forest. While it does have a tree canopy cover > 10% and often exists in patches > 0.5 ha, it does not meet the criterion of being "not primarily under agricultural land use". The FAO definition specifically excludes stands of trees established primarily for agricultural production, for example fruit tree plantations. However, the FAO definition of forest is not a matter of function as both forests and agroforestry systems provide tree products and services. Rather it is an arbitrary distinction of perception. Therefore, Roshetko et al. (2008) have argued for the recognition of agroforestry that surpasses the minimum thresholds of tree canopy cover and area as "forests".

The agroforestry systems documented in this study are not only a form of forest like 'cultivated trees', but also of 'anthropogenic vegetation'. Growing trees is a traditional practice in the research site which has been derived from agricultural antecedents, e.g. swidden[5], through farmers' long experience of trials of new practices and has mainly been used to produce livelihood necessities.

Agroforestry farmers in the research site own small areas of land (0.98 ha) but allocate a high proportion to agroforestry (0.85 ha). It was surprising that the farmers reported annual income from agroforestry to be much lower per land area (IDR 3.25 million/0.85 ha) than income from remaining agricultural land (IDR 1.66 million/0.11 ha). Two possible explanations for this mismatch between farmers' reporting of incomes and their decisions over land use are the time scale of income and the importance of other benefits and costs of each system. The income from products harvested from both systems was based on farmers' reports of their income during the one most recent production year. However, for most of the farmers the timber trees in their agroforests had yet to reach harvestable maturity and in some cases fruit trees had yet to grow to maturity and achieve maximum yield. Since tree species have a longer juvenile period compared with agricultural crops e.g. rice, income from agroforestry systems will be much lower during the years of establishment phase (Rahman et al., 2008).

While the landholdings per family were small (ca. 1 ha), high yields of agricultural crops can be obtained per area of land provided that there is sufficient input of labour. Given the importance of off-farm income (equating to 76% of total income) available labour, rather than

[5] By planting damar trees in the swidden areas at Jambi, Indonesia, farmers have managed to re-create a new forest landscape (Michon, 2005).

available farmland, is the most economically limiting resource for most of the households. Most do not have the available labour to intensively cultivate agricultural crops in all arable lands. Therefore, practicing more permanent agroforestry systems is appropriate for them. These systems require less labour input, while still increasing (or maintaining) their natural capital value. These factors are all likely to contribute to the spontaneous tree product diversification through smallholder agroforestry, as has been observed elsewhere in Indonesia and tropical Asia (Snelder and Lasco, 2008).

Conclusions

The agroforestry systems in Gunung Salak share the properties of forests, yet economically and culturally they are an important component of farming systems. In areas where agroforestry is less well established the introduction of tree culture into subsistence monocropping cycles can represent a viable strategy for agricultural diversification. Such a strategy needs to be informed by the local productive activities, especially existing farming systems and livelihood strategies. Of particular importance for government agencies is to improve the dissemination of information about successful management practices and the availability of any necessary materials not currently available to farmers, e.g. loans (Rahman et al., 2012). Given the properties that agroforestry shares with both agricultural and forest systems, their classification will always be problematic if a binary system is applied. Therefore a more sophisticated approach should be adopted that incorporates the economic and environmental characteristics of a wider range of systems.

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