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Mixed species gardens in Java and the transmigration areas of Sumatra, Indonesia: a comparison

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Abstract

This study compared mixed species gardens in Java with those maintained by the Javanese immigrants in Sumatra. Two villages (Sedayu in Lampung Province of Sumatra and Watulimo in East Java) were selected based on similarity in the ethnic backgrounds of the inhabitants and the structure and socioeconomic attributes of the mixed garden systems evaluated. Floristic richness of Sedayu gardens was lower than that of Watulimo (38 and 55 species respectively). Although the vertical (multi-tiered) and horizontal structures of the mixed species gardens at both locations were mostly similar, differences in the number of vertical strata and the suite of species were evident. Plantation crops such as *Theobroma cacao* and *Coffea* spp. formed the predominant components at Sedayu, while fruit trees dominated the Watulimo site. Relative proportion of household income generated by mixed gardening at the two locations was also variable. At Watulimo, it accounted for a meagre 2% of the total household income as against 92% in Sedayu, reflecting greater economic dependence on mixed gardens at the latter site. Although such a situation would encourage greater commercialization of the gardens, the Sedayu gardeners seemed to value the multiplicity of products from these gardens; thus making large scale shifts towards monoculture less likely.

Keywords: Cash crops, Commercialization, Species diversity, Transmigration, Vegetation structure.

Introduction

Mixed species gardens are intensive production systems involving multipurpose tree species, shrubs, and food crops. Apart from Kerala (India) where the traditional homegarden system is highly evolved (Kumar and Nair, 2004), such systems abound in Java (Indonesia; Wiersum, 2006). The Javanese people migrating to other parts of Indonesia also seem to have replicated this unique land use practice. Incidentally, migration from Java to the neighboring islands has been taking place since the Dutch colonial period in the early 19th century, and more recently through the government-sponsored transmigration project of the 1960s. Since the structure and arrangement of mixed species gardens generally reflect the local eco-climatic conditions and socioeconomic needs (Fernandez and Nair, 1986; Kumar et al., 1994), the gardens established by the transmigrants should differ from the original Javanese gardens. However, only a limited number of studies have described the "Javanese mixed gardens" at these newly colonized sites. In this paper, we compare the mixed gardens of Java with those maintained by the Javanese immigrants in Sumatra. In particular, the changes in structure and function of the gardens as influenced by land availability, environmental, economic, and social factors would be addressed.

Materials and Methods

Two villages on the islands of Sumatra (Sedayu in Lampung province) and Java (Watulimo in Trenggalek district) were selected based on similarity in the ethnic background of the residents. Sedayu lies in the transmigration area in the southern part of the Bukit Barisan mountain range at an altitude of 596 m above

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sea level (Fig. 1) with temperature regimes of 18 to 26°C (minimum) and 23 to 33°C (maximum). Dry season lasts from June to August, and rainy season is from November to May. Average annual rainfall ranges from 1,000 to 4,000 mm, being strongly influenced by the *El Niño* effect (Badan Meteorology dan Geofisika, 2001). Watulimo (East Java) is located at an altitude of 568 m above sea level; temperatures range from 18 to 28°C (minimum) and 22 to 34°C (maximum) with annual rainfall ranging from 2,000 to 3,000 mm (Badan Meteorology dan Geofisika, 2001). Approximately 130 families from Watulimo migrated to Sedayu in the late 1960s through the transmigration project, which typically allotted 2 ha of land to each household, including a home lot of 0.25 ha (Depnakertrans, 2004). The fieldwork reported in this paper was carried out from June to September 2003 in Sumatra and from November 2004 to January 2005 in Java.

At Sedayu, 35 out of the 68 households recorded at the local village office were randomly chosen. Since most households had more than one mixed gardens, sampling was restricted to those households in which such gardens formed the main source of income. As in Sedayu, 30 sample-sites (about half of the total households) were randomly selected at Watulimo. The selected gardens at both sites were mapped using GPS to provide information about its position and size, as well as measuring the distance to the respective owners' residences. Due to variations in garden size, a sample plot of 20 x 15 m was established in each garden and the diameter at breast height (DBH), total height, canopy structure, crown cover, and canopy height of all woody plants were measured, besides identifying the intercrops. Crown cover was estimated by projecting the canopy edge on the ground in four cardinal directions, while canopy height was determined using a Haga hypsometer.

Inventory of all plants in the sampled gardens was prepared and the frequency of occurrence of individual species (number of gardens in which a species occur divided by the total number of mixed species gardens studied) calculated. Sørensen's index of similarity, $ISs = \frac{2C}{A+B} \times 100$, where C is the total number of species common in both villages, A is the total number of species in Sedayu, and B is the total number of species in Watulimo (Mueller-Dombois and Ellenberg, 1974), was computed to assess the extent of convergence in species composition between the two sites. In addition, the garden owners were interviewed to elucidate the rationale behind garden structure, crop selection, income generated from cash crops, and income earned through activities other than gardening. Such information was also compared with previous reports on Javanese homegardens (e.g., Hoogerbrugge and Fresco, 1993).

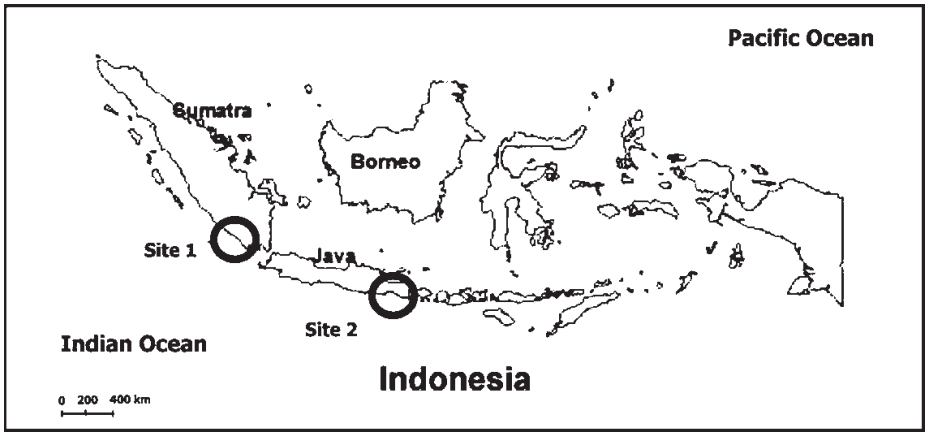

Figure 1. Location map showing the study sites at Sedayu (Site 1) and Watulimo (Site 2), Indonesia.

Results and Discussion

Size and distance to homesteads from the gardens

Garden size at both Sedayu and Watulimo varied considerably with values ranging from 0.18 to 1.46 ha and 0.04 to 1.5 ha respectively. The gardens located farther away from the homesteads at Watulimo were particularly larger than the proximate ones (Fig. 2). The high population pressure and the consequent reduced land availability at Watulimo may be responsible for this. The relatively better soil fertility at Watulimo (East Java Regional Development and Planning Board, 1998) also may have contributed to this situation; yet site fertility status is not a major determinant of garden size, which is typically a function of the household status (Achmad et al., 1978). At Sedayu, however, distance from the settlement was not a pre-disposing factor as evident from the wider scatter of data points and the relatively low R^2 value (Fig. 2). Coincidentally, acidic and low fertility soils are inherent features of this site (van Noordwijk et al., 1996). Although land farther away from settlements was available, the extra efforts needed to establish and maintain the gardens may have probably limited their size.

Species richness and income generation

The sampled gardens at Sedayu had a suite of 38 species. Of these, 17 were multipurpose woody perennials, 11 perennial fruit trees, four fruit yielding herbs, and six vegetables. The corresponding tally for total number of species at Watulimo was 55, including 14 multipurpose trees, 23 perennial fruits, eight fruit yielding herbs, and 10 vegetables. Species richness increased moderately with garden size at both locations, despite low R^2 values (Fig. 3). Sørensen's similarity index indicates a high degree of similarity (49.4%) in the floristic composition of the two sites. Indeed, 23 species consisting of eight multipurpose tree species, six perennial fruits, three fruit yielding herbs, and six vegetables were common. The most frequent species were *Mangifera indica* (80% and 87% of the gardens in Sedayu and Watulimo respectively) and *Musa acuminata* (66% and 76% at Sedayu and Watulimo respectively; Table 1).

The relative proportions of household income derived from gardening at our study locations were vastly different. For instance, at Watulimo, the mixed gardens contributed just 2% of the household income (income from wood, fruits and other crops divided by total

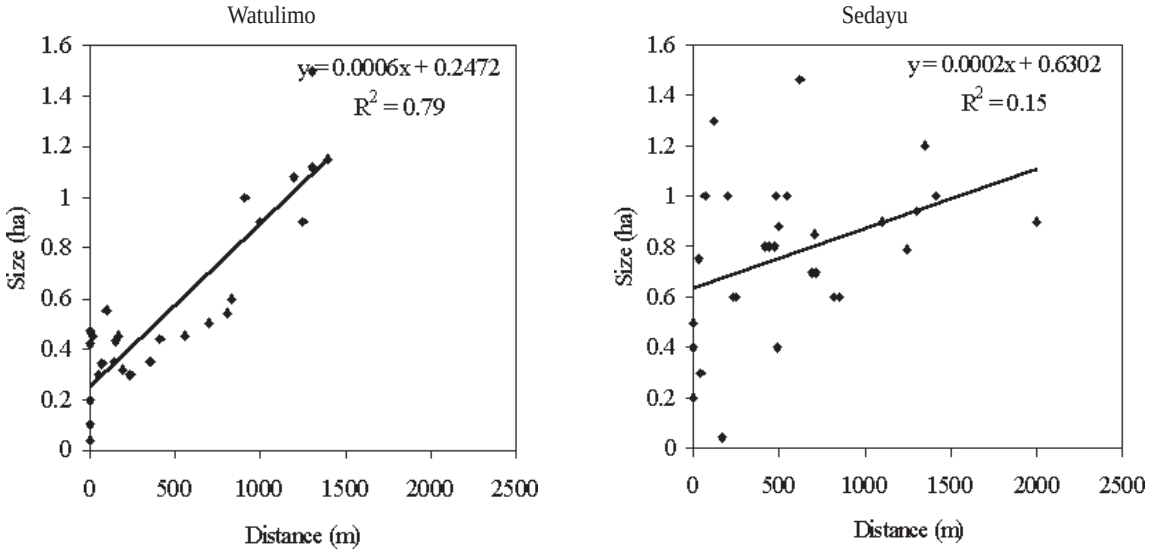

Figure 2. Garden size in relation to the distance to the homestead at Watulimo and Sedayu in Indonesia.

Table 1. Plant species found exclusively in the mixed species gardens of Watulimo and Sedayu (Indonesia), and those found in the at both study sites, their primary uses, and percentage frequency of occurrence (total number of gardens where a particular species occur by the total number of gardens in that sample).

Watulimo			Sedayu			Common at both locations			
Species	Primary Uses*	Frequency of occurrence (%)	Species	Primary Uses*	Frequency of occurrence (%)	Species	Primary Uses*	Frequency of occurrence (%)	
								Watulimo	Sedayu
Aegle marmelos	2,3,7	7	*Aleurites molucana*	3,4,6,7	5	*Anacardium occidentale*	2,3,4,6,9	66	19
Amaranthus dubius	3,8	69	*Alstonia scholaris*	3,5,7,9	22	*Carica papaya*	2,3,8	45	17
Annona muricata	2,3	69	*Annanas cosmosus*	2	20	*Cocos nucifera*	2,4,7	28	13
Annona squamosa	2,3	55	*Anthocephalus cadamba*	4,6,7	16	*Curcuma domestica*	3,6,8	48	25
Arenga pinnata	1,3,10	72	*Archidendron pauciflorum*	2,3,4,11	22	*Durio zibethinus*	2,7	54	25
Artocarpus heterophyllus	1,2,7,8	38	*Areca catechu*	4,6,10	13	*Guatenum gnenom*	2,3,8	72	9
Averrhoa carambola	2,3	45	*Azadirachta indica*	3,5,7	14	*Ipomea batatas*	1,8	72	13
Averrhoa bilimbi	2,3,6	55	*Cinnamomum burmannii*	3,4,6,9	24	*Lansium domesticum*	2,7	45	16
Canarium indicum	2,3,7	76	*Coffea arabica*	9	15	*Mangifera indica*	2,3,7	87	80
Capsicum frutescens	3,6,8	45	*Coffea robusta*	9	14	*Melia azedarach*	3,4,5,7	63	24
Chrysophyllum cainito	2,3,7	41	*Peronema canescens*	7	13	*Manihot esculenta*	1,8	41	12
Citrus amblycarpa	2,3,6	76	*Piper nigrum*	6	24	*Musa acuminata*	2,8	76	66
Citrus aurantifolia	2,3,6	76	*Swietenia macrophylla*	3,7	16	*Myristica fragrans*	3,6,7	72	23
Citrus grandis	2,3	55	*Theobroma cacao*	3,4,9,	22	*Nephelium lappaceum*	2,7	38	19
Cucumis sativus	3,8	45	*Vanilla planifolia*	3,4,6	25	*Pandanus amaryllifolius*	6,9,10	64	28
Cynometra cauliflora	2,7	86				*Parkia speciosa*	3,6,7,8,11	31	16
Garcinia dulcis	2,3,7	31				*Persea gratissima*	2,3,4	41	11
Garcinia mangostana	2,3,10,11	72				*Piper betle*	3,8,10	17	15
Guazuma ulmifolia	3,7	59				*Psidium guajava*	2,3,7	72	22
Mangifera foetida	2,3,7	34				*Tamarindus indica*	3,6,7	69	2
Mangifera indica	*2,7*	48				*Tectona grandis*	3,7,11	66	24
Mangifera minor	2,7	62				*Syzigium aromaticum*	6,9	55	29
Mangifera odorata	2 4,7	41				*Zingiber officinale*	3,4,6,9	14	16
Manilkara achras	2,4,7	8							
Morinda citrifolia	2,8	62							
Musa brachycarpa	2,8	45							
Musa sapientum	*3,6,7*	83							
Ricinus communis	1	14							
Salacca zalacca	8	38							
Solanum melongena	1,3,7	41							
Spondias cytherea	6,9	66							
Syzigium aquaeum	3,6,9	48							
Syzigium cuminii	3,6,7	7							

*Key: 1=food;2=fruit;3=medicine;4=oil;5=resin;6=spice,7=wood;8=vegetable;9=stimulan;10=dye;11=tannin.

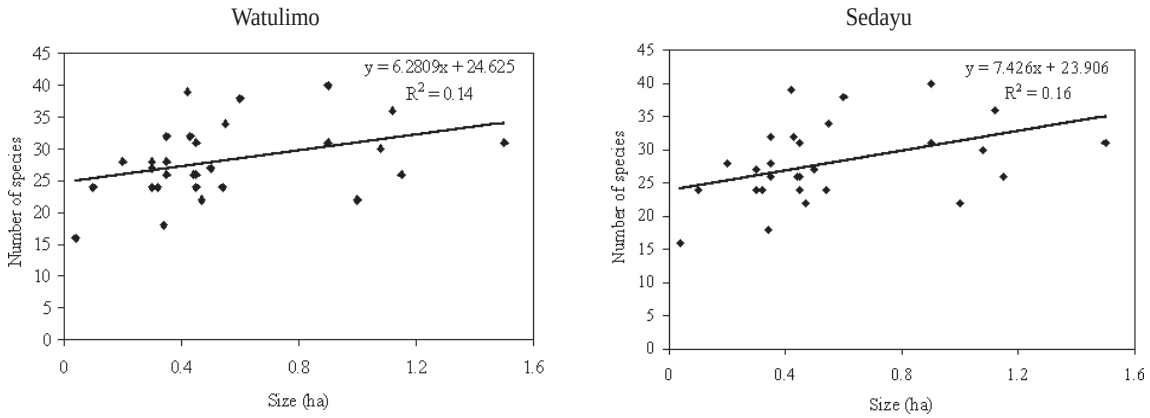

Figure 3. Species richness in relation to garden size at Watulimo and Sedayu, Indonesia.

income; Fig. 4); indeed, most of the gardeners earned their livelihood through employment outside the gardens. Previous studies in Java, however, indicate that 9 to 51% of the total income is derived from homegardening activity (Hoogerbrugge and Fresco, 1993). The relatively lower proportion of income generated from the gardens probably gives little incentive to the villagers for introducing commercial species and more intensive management practices. Consequently, fruit trees and vegetables dominated the Watulimo gardens and the produce was mostly used for domestic consumption rather than market sale.

At Sedayu, however, alternative sources of income were hard to find and activities such as weeding and harvesting in mixed species gardens owned by other villagers constituted the principal source of income. Some non-timber forest product (NTFP) collection was observed; but the forests near Sedayu being a national park, this is illegal. Moreover, an increased level of law enforcement in recent times has curbed the villagers' tendency for NTFP collection to some extent. Thus a greater dependence on income generated from the mixed gardens (>90% of household income; Fig. 4) has prompted the villagers at Sedayu to focus more on high value plantation crops to augment returns. An example of this is the shift away from coffee (*Coffea* spp.) in the mid 1990s. Previously, the villagers in Sedayu, as elsewhere on Sumatra, preferred to plant coffee because of the high market price for beans. When coffee prices crashed, however, most of these were replaced with other cash crops, retaining just enough coffee plants to produce beans for home consumption. The main cash crop in Sedayu gardens currently is cacao

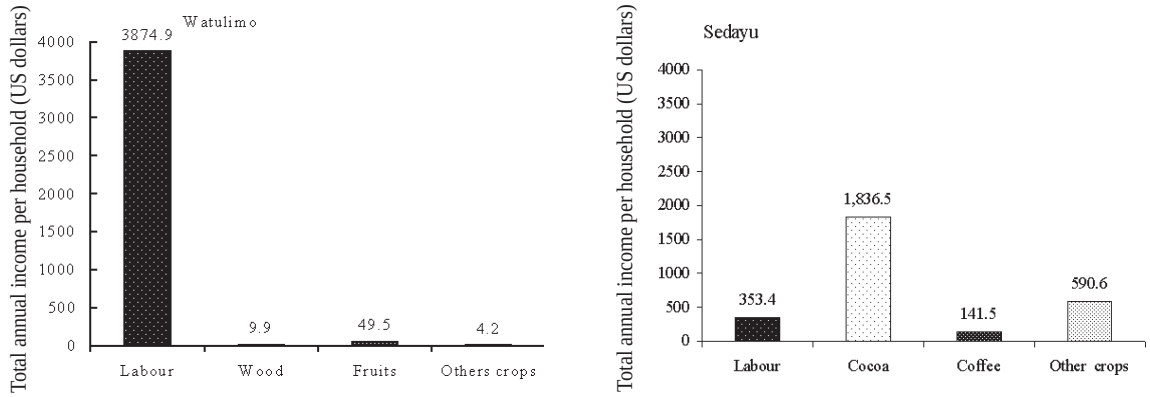

Figure 4. Income generation by the villagers at Watulimo and Sedayu, Indonesia (labour means emplyment outside the gardens).

(*Theobroma cacao*); with coffee (*Coffea arabica* and *C. robusta*) forming a distant second. Coconut (*Cocos nucifera*), avocado (*Persea americana*), twisted cluster bean (*Parkia speciosa*), pepper (*Piper nigrum*), vanilla bean (*Vanilla planifolia*), clove (*Syzygium aromaticum*), bitter nut (*Gnetum gnemon*), and ginger (*Zingiber officinale*) are also grown occasionally.

Structure of mixed species gardens

The Sedayu mixed species gardens showed no clear planting pattern. However, the hardwood trees (e.g., *Tectona grandis*, *Peronema canescens*, and *Swietenia* spp.) occupied the farm borders, primarily for property demarcation. This probably contrasts the Watulimo gardens, which were all fenced. Also, the garden owners preferred scattered planting of trees for aesthetic purpose. Vegetable and spice planting systems at both locations were similar, and they occupied areas, which are easily accessible.

Regarding vertical structure, both at Sedayu and Watulimo, the gardeners seemed to plan meticulously the spatial organization of crops taking into consideration the light requirements of individual species. For example, the tallest species having foliage that can tolerate full sunlight generally occupy the top strata, while short statured species that are either shade tolerant or require high humidity usually occur in the lower strata. Furthermore, at Sedayu, the light-demanding *Coffea* spp. is grown in the open to make efficient use of sunlight, while shade tolerant *Theobroma cacao* is planted in the subcanopy, which is consistent with the findings of Christanty et al. (1986).

Inter-site variations in the vertical structure of the gardens were also evident at the study locations. For instance, three horizontal canopy strata could be delineated at Sedayu, viz., top (10 to 15 m above ground level), middle (5 and 10m), and ground strata (0 to 5m; Fig. 5). Species commonly found in the upper stratum are timber and fruit trees such as *Peronema canescens*, *Swietenia mahagoni*, *Alstonia scholaris* and *Durio zibethinus*. *Theobroma cacao* and *Coffea* spp. occupied the middle stratum while the lowest stratum consisted of subsistence vegetables. Canopy coverage for the three strata on average were 15, 34 and 25% respectively. However, at Watulimo, a more complex vertical structure was discernible with five layers: 10 to 15m, 5 to 10m, 2 to 5m, 1 to 2m and 0 to 1m above ground level (Fig. 6). Although the floristic composition of the highest and lowest strata was similar at both locations, in the second layer at Watulimo, fruit species such as *Nephelium lappaceum*, *Mangifera* spp., and *Psidium guajava* were

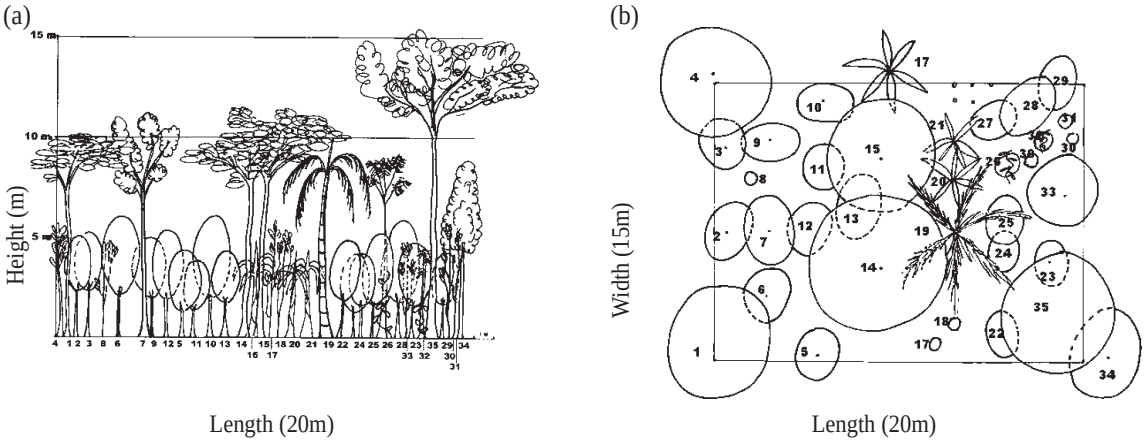

Figure 5. Schematic representation of the structure of a typical mixed species garden at Sedayu, Indonesia: (a) height distribution; (b) canopy coverage of species over a 20 x 15m sample plot [*Nephelium lappaceum* (1,14), *Theobroma cacao* (2,3,5,6,9–13,22–25,27–29), *Coffea robusta* (8,17,18,30–32), *Psidium guajava* (4), *Parkia speciosa* (7), *Guatenum gnenom* (15), *Musa acuminata* (16,20,21), *Cocos nucifera* (19), *Vanilla planifolia* (26,32), *Melia azedarach* (33), *and Syzigium aromaticum* (34)].

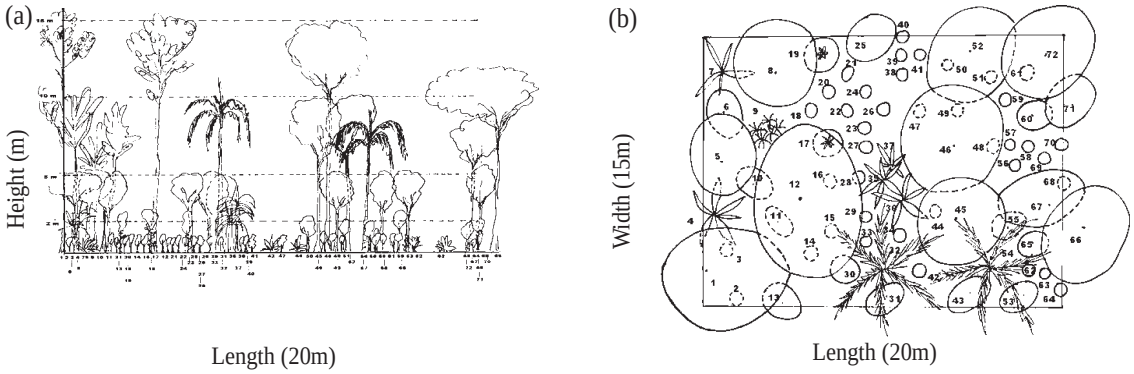

Figure 6. Schematic representation of the structure a typical mixed species garden at Watulimo, Indonesia: (a) vertical distribution of species; (b) canopy coverage of species over a 20 x 15m plot [*Amaranthus dubius* (57,58,69,70), *Arenga piñata* (54), *Artocarpus heterophyllus* (10), *Averrhoa bilimbi* (50), *Citrus grandis* (65,55), *Cocos nucifera* (32), *Ctrus amblycarpa* (11), *Cucumis sativus* (51), *Curcuma domestica* (49,61), *Guatenum gnenom* (52), *Ipomea batatas* (62,63), *Mangifera foetida* (72), *M. indica* (20,30,43,60), *M. odorata* (53), *Manihot esculenta* (2,3,14–16,18,20–24,26–29,33,34,38–41,44), *Morindra citrifolia* (6), *Musa acuminata* (35–37), *M. brachycarpa* (4,7), *Nephelium lappaceum* (45,66), *Pandanus amaryllifolius* (42,44), *Parkia speciosa* (5,8), *Persea gratissima* (68), *Piper betle* (19,17), *Salacca zalacca* (9), *Solanum melongena* (47), *Swietenia macrophylla* (1), *Syzigium aromaticum* (71), *S. aquaeum* (31), *Tectona grandis* (46), *and Zingiber officinale* (48)].

abundant. The third layer consisted of species such as *Citrus* spp., *Averrhoa* spp., and *Musa* spp., while *Manihot esculenta* and *Salacca zalacca* were frequently observed in the fourth layer. Canopy coverage of different strata were 12, 33, 26, 8 and 9% respectively.

A comparison of the data presented in Table 1 also suggests that species richness of individual gardens in Watulimo was significantly greater than that of Sedayu. The five-stratum structure of the Watulimo gardens may have contributed to this higher species richness and diversity. Some changes in floristics and structure of the tropical homegardens have been predicted as a function of commercialization, e.g., fewer species (intermediate diversity) and input intensive management (Kumar and Nair, 2004). However, such trends were not discernible in the mixed species gardens of Sedayu and Watulimo, implying a differential development trajectory for the mixed species gardens of Java and Sumatra, compared to the traditional homegarden systems.

Conclusions

Despite the common heritage of the gardeners and that gardening knowledge is generally passed along the family-lines, some differences in floristic attributes and structure of the gardens maintained by the two communities were evident. This study suggests that quite apart from the inheritance of traditional knowledge, one of the predisposing factors in deciding the structure and composition of the mixed species gardens is the relative economic dependence the farmers have on such systems. At Sedayu, for instance, the farmers derived a substantial proportion of the household income (over 90%) from the mixed species gardens compared to their counterparts at Watulimo. This also implies a greater awareness by the Sedayu garden owners on the need to augment income through introduction of new species based on market demands. Despite the number of species (total and per garden basis) being less, gardeners at Sedayu seemed to value the multiplicity of products from such gardens. That is, beyond cash income generation, such gardens often provide diverse products and services including food and medicine yielding herbs for household consumption. Consequently, widespread commercialization and a shift towards monospecific systems appear less likely in Sedayu. Having said that, economic considerations greatly influence the rate at which species diversity and homegarden practices will change within these gardens.

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