Agroforestry Systems **63:** 53–62, 2004.

Crop diversity and classification of homegardens in Central Sulawesi, Indonesia

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Received 24 February; accepted in revised form 31 October 2003

Key words: Cluster analysis, Floristic diversity, *In situ* conservation, Shannon index, Species composition, Vegetation structure

Abstract

Homegardens are considered a sustainable production system in the tropics, which contributes to biodiversity conservation. The aim of this study was the description of crop diversity, structure and management of homegardens in Central Sulawesi and their classification. In 30 homegardens randomly selected from three villages adjacent to the Lore Lindu National Park, species diversity and abundance were assessed and the Shannon index was calculated. Overall 149 crop species were identified, mainly fruit, vegetable, spice, or medicinal plants. The number of vegetation layers differed depending on age and size of homegardens. Cluster analysis of crop species composition was used to classify different garden types. Not only the spectrum of species cultivated in the homegardens but also the occurrence of these garden types was different among the three villages. This finding was supported by Sørensen's coefficient. Homegardens from one village, mainly inhabited by transmigrants, contrasted strongly with those from the other two. A markedly lower number of crop species was cultivated there, and species composition was clearly different. The number of crop species and species composition found in homegardens may be attributed to socio-economic conditions of garden keepers as well as to soil quality. Both productivity and sustainability can be enhanced, e.g., by improved soil fertility management such as applying available farm yard manure.

Introduction

Converting primary forest to frequently unsustainable agricultural lands has increased in many tropical regions including Central Sulawesi, Indonesia. Because forest margins, even in protected areas, are particularly concerned due to easy access, sustainable production systems urgently need to be promoted. Tropical homegardens are generally regarded as sustainable production systems (Abdoellah et al. 2001; Christanty 1990; Drescher 1998; Fernandes and Nair 1986; Jose and Shanmugaratnam 1993; Landauer and Brazil 1990; Soemarwoto and Conway 1992; Torquebiau 1992).

A homegarden is a clearly bounded piece of land cultivated with a diverse mixture of annual and perennial crops, and on which a house is built (Karyono 1990). The major functions of homegardens, especially in rural areas, are subsistence production and income generation (Soemarwoto and Conway 1992). Because of the high biodiversity existing in homegardens, a wide spectrum of multiple-use products can be generated with relatively low labour, cash or other inputs (Christanty 1990; Hochegger 1998; Soemarwoto and Conway 1992). Homegarden products, including those from animals reared in the gardens, often have higher nutritional value in terms of protein, minerals and vitamins, than field crops. In times or seasons of scarcity, homegardens, with their diverse products available year-round, contribute to food security (Christanty et al. 1986; Karyono 1990). They also fulfil many social, cultural and ecological functions (Abdoellah et al. 2001; Christanty 1990; Soemarwoto and Conway 1992). The multi-layered, forest-like vegetation structure of homegardens contributes substantially to the sustainability of this production system. Among others, this structure can protect the soil from erosion, offers a habitat to wild plants and animals, promotes a favourable microclimate, and makes efficient use of light, water and other resources (Christanty et al. 1986; Jose and Shanmugaratnam 1993; Karyono 1990; Torquebiau 1992).

Because of their large crop species and varietal diversity, homegardens are regarded as an ideal production system for *in situ* conservation of genetic resources (Watson and Eyzaguirre 2002). However, garden diversity varies according to ecological or socio-economic factors and/or characteristics of gardens or gardeners (Christanty et al. 1986). For example, species number and diversity were shown to be influenced by altitude of homegardens (Karyono 1990; Quiroz et al. 2002), homegarden size (Abdoellah et al. 2001) or age of gardens (Quiroz et al. 2002) as well as by age and other characteristics of the gardener (Leiva et al. 2002; Quiroz et al. 2002) or level of production intensity and market access (Michon and Mary 1994).

Many different types of homegardens have been reported from different tropical regions (e.g., Fernandes and Nair 1986; Landauer and Brazil 1990), which makes their classification difficult. They have most commonly been classified on the basis of garden characteristics that are easy to investigate, such as size (Jose and Shanmugaratnam 1993; Millat-e-Mustafa et al. 1996). As reviewed by Nair (1985), further criteria used to classify the agroforestry system 'homegarden' are structure (e.g., vertical stratification, integration of livestock) or socio-economics (e.g., level of inputs, subsistence/commercial production) (Christanty 1990; Michon and Mary 1994). Christanty (1990) also suggested that homegardens might be classified using the dominant plant species grown or the level of urbanisation. Despite the number of classification schemes proposed for tropical homegardens, none has been universally accepted.

Homegardens of Indonesia, particularly those of Java, have been investigated in some depth (e.g., Abdoellah et al. 2001; Christanty et al. 1986; Jensen 1993; Karyono 1990; Soemarwoto and Conway 1992). On the other hand, even basic information about homegardening in the Indonesian island of Sulawesi is still lacking. In association with the multidisciplinary German-Indonesian collaborative research program STORMA (Stability of Rainforest Margins in Indonesia, SFB 552), this study aimed to describe crop diversity, structure and management of homegardens in Central Sulawesi, and classify them based on crop diversity.

Materials and methods

Study area

The study was conducted from March to November 2001 in the Napu Valley (1°23'-37' S, 120°18'-20' E), located at the eastern margins of the Lore Lindu National Park in Central Sulawesi, about 100 km south of the province capital, Palu. In the Napu Valley, annual precipitation is about 2,000 mm and mean temperature is 21 °C. Altitude is around 1,100 m asl. and the natural vegetation is classified as lower montane rain forest (Whitten et al. 1987). Soils are mostly Cambisols and Fluvisols.

The density of human population in the area is low (8 per km^2), however, since 1980 the growth rate has markedly increased due to transmigration. Most inhabitants are farmers, and off-farm employment opportunities are scarce. Major agricultural production systems include paddy rice (*Oryza sativa*), mixed agroforestry (mainly coffee (*Coffea arabica; C. canephora*) and cacao (*Theobroma cacao*) for export), or annual crops (such as maize (*Zea mays*), beans (*Phaseolus vulgaris*) or groundnuts (*Arachis hypogaea*)) under rainfed conditions. Large areas of the Napu Valley are under fallow or degraded grassland.

For this research, three villages were chosen, which differed in their market access and origin of inhabitants (Table 1).

Wuasa is the administrative centre of the Napu Valley with a junior highschool, a small hospital, many shops and offices as well as a market place. Rompo is a small village surrounded by forest, reachable only on a dirt road. Siliwanga was founded only recently for settling transmigrant families mostly from Bali. For ease of understanding, the three villages were labelled 'market village' (Wuasa), 'forest village' (Rompo), and 'transmigrant village' (Siliwanga).

Table 1. Characteristics of the three villages studied in the Napu Valley, Central Sulawesi, Indonesia.

	Wuasa	Rompo	Siliwanga
Year of foundation	1892	1915	1992
Inhabitants (no.)	1,800	200	500
Ethnicity	Mixed	> 75% indigenous	> 75% migrants
Distance to paved road	0 km	10 km	0 km

Sources: Zeller et al. (2001) and Kehlenbeck (unpublished).

Data sampling

Ten households with homegardens were randomly selected in each village. In Wuasa and Rompo, households were selected out of the sample chosen by Zeller et al. (2001), and in Siliwanga from the village household list. Information about local knowledge and management of homegardens was gathered through individual interviews of the gardeners. The unstructured questionnaire used included questions on age and function of the homegarden, previous land use of the garden area, inputs and outputs, problems of homegarden management, use of homegarden products, etc. Secondary data concerning household characteristics, such as age, formal education, ethnic group, or occupation of the household members partly was made available by STORMA.

Homegarden size was measured, excluding the area occupied by the house. Complete inventories were carried out to assess total plant diversity (number of species and varieties) and abundance of crops and ornamentals. The occurrence of weeds was documented but not quantified. Plants were recorded with local and/or scientific names. All individual plants were assigned to one of five strata (0-1 m; 1-2 m; 2-5 m; 5-10 m; > 10 m) for vertical structure analysis, as suggested by Karyono (1990) and Abdoellah et al. (2001). Based on gardeners' information and literature (e.g., Rehm and Espig 1991; Verheij and Coronel 1992, and further volumes of the PROSEA series), crop species were classified into one of the following main use categories: spice, fruit, vegetable, stimulants/sugar, medicinal, staple food, wood, multiple-purpose-tree (MPT), and other (e.g., fodder, wrapping material).

Twenty soil samples per garden were randomly collected at 0-15 cm depth and mixed for chemical analysis (pH, total C and N, available P and K). pH was measured in soil mixed with 0.01 *M* $CaCl_2$-solution in the ratio 1:2.5. Total C and N were determined by C/N-Autoanalyser. For estimation of available P and K, samples were extracted in Calcium-acetate-lactate-solution (pH 4.1) (Schüller 1969) followed by colorimetric analysis of P with the molybdenum blue method, and K by flame photometry.

Data analysis

Data were analysed using the statistical package SPSS 8.0. Differences between means were determined by Kruskal Wallis H-Test. To compare floristic similarity between the three villages, Sørensen's coefficient was calculated (Magurran 1988). Species density (no. of spp./100 m^2) and Shannon-Index H' were also calculated for every garden (Magurran 1988). For classification of homegardens, a cluster analysis considering the occurrence of crop species (presence/absence) was performed, applying squared Euclidean distances as a measure of dissimilarity and the average linkage method. For this paper, the most appropriate statistical classification was chosen by selecting a cut off point at a dissimilarity of 10.5.

Results

The homegardens surveyed were established one to 38 years ago and ranged from 240 to 2,400 m^2 in size. In the market village, homegardens were significantly older than in the forest or transmigrant villages. In the transmigrant village, homegardens were managed by younger and smaller families, who owned smaller farms than in the market or forest villages (Table 2). In the three villages, homegarden sizes were not significantly different, however, their proportions in relation to the overall farm sizes.

The main function of the homegardens in these three villages was to supply the gardeners' families with non-staple food, chiefly fruits, vegetables and spices. About 70% of the gardeners obtained some cash income from their homegardens through sales of coffee, cocoa or surplus of fruits or spices. All gardeners reared animals in their gardens both for home consumption (e.g., chicken, duck, dog) and/or for sale (e.g., pig, cattle). Gardeners mostly regarded the production of fruits, vegetables, spices, tubers, medicines, etc. coming from their gardens as adequate. The productivity of this system, however, seems

Table 2. Characteristics of the surveyed households and homegardens in three villages of the Napu Valley, Central Sulawesi, Indonesia.

	Market village Wuasa		Forest village Rompo		Transmigrant village Siliwanga	
	Median	Range	Median	Range	Median	Range
Age of household head (years)	52a	31-65	45ab	21-55	33b	25-41
Household members (no.)	8a	3-10	5ab	3-11	4b	3-6
Farm size (ha)	3.1a	0.8-11.4	2.1ab	1.0-9.6	1.2b	0.3-3.5
Homegarden size (m^2)	720a	236-1,134	560a	287-1,450	820a	464-2,383
Proportion of garden of farm (%)	2.2a	0.8-12.4	3.8ab	0.7-8.8	6.2b	1.8-28.7
Age of homegarden (years)	22a	11-34	9b	1-38	8b	1-9

Medians in a row followed by different letters are significantly different at $P \leq 0.05$; Sources: Survey data from STORMA (subproject A4) and Kehlenbeck (unpublished).

Table 3. Chemical properties of homegarden topsoil (0-15 cm) in three villages of the Napu Valley, Central Sulawesi, Indonesia.

	Market village Wuasa		Forest village Rompo		Transmigrant village Siliwanga	
	Mean	Range	Mean	Range	Mean	Range
pH ($CaCl_2$)	5.6a	4.9-6.3	5.2b	4.2-6.1	4.8c	4.1-5.3
C_{total} (%)	1.9a	1.3-2.2	2.3a	1.2-3.4	3.2b	2.5-4.5
N_{total} (%)	0.15a	0.11-0.19	0.19a	0.11-0.29	0.25b	0.18-0.35
P (mg/kg)	122a	37-231	54b	6-118	15c	7-25
K (mg/kg)	205a	94-315	164a	68-290	137a	88-256

Means in a row followed by different letters are significantly different at $P \leq 0.05$.

largely underutilised. For example, some fruits such as guava (*Psidium guajava*) and water apple (*Syzygium aqueum*) were rarely used for human consumption and the gardeners were widely unaware of the nutritional value of vegetables. Gardens were partly not tended and mature tree fruits, tomatoes (*Lycopersicon esculentum*) and eggplants (*Solanum melongena*) were left to rott.

Few or no external inputs, like chemical fertiliser or pesticides, were applied. Instead of external inputs, 60% of the gardeners used 'alternative' methods for pest control (e.g., spraying soap-suds, cutting off infested plant parts, dusting with ash) and nearly 80% of them applied organic fertilisers, mainly animal manure and mulch, or ash. Though, half of the 18 gardeners, who reared pigs in their homegardens, did not use pig-manure as a fertiliser because they were unaware of its value.

Soil fertility varied among the three villages. In the transmigrant village, mean pH value and P level of garden soils were markedly lower, and C and N contents were significantly higher than in the market or forest villages (Table 3).

Crop diversity

A total of 149 crop species were identified, about 25 of which were classified according to their predominant use each as spice, fruit, vegetable, medicinal, or wood and timber plants. The remaining species were used for beverages and stimulants, staple food, fodder, wrapping or handicraft; six species were considered multi-purpose trees. The species cultivated most frequently were mango (*Mangifera indica*), banana (*Musa x paradisiaca*), guava, tomato, coffee, cacao, chilli (*Capsicum annuum*), turmeric (*Curcuma longa*), lemon grass (*Cymbopogon citratus*), basil (*Ocimum basilicum*), fragrant screw pine (*Pandanus amaryllifolius*), taro (*Colocasia esculenta*), sweet potato (*Ipomoea batatas*), and cassava (*Manihot esculenta*) (Kehlenbeck, unpublished data). For some crops, several varieties were cultivated, e.g., 25 varieties of banana, 13 of chilli, and 6 each of mango, cacao and sweet potato. In addition to crops, 72 ornamental species and 41 weed species were identified. However, about half of the weed species were also considered of some medicinal value.

The spectrum of species cultivated in homegardens was different among the three villages. There was a higher similarity of crop species composition between the market village Wuasa and the forest village

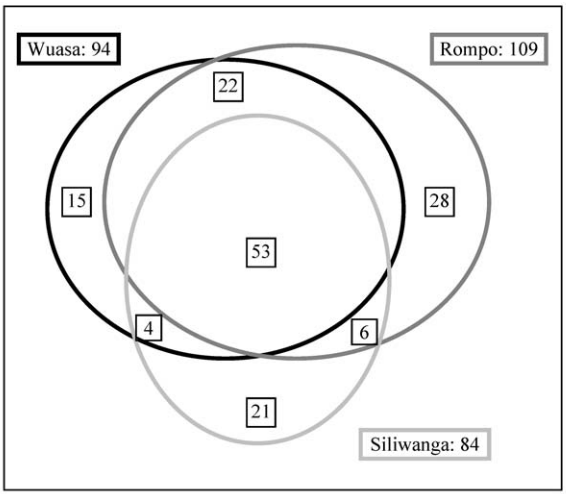

Figure 1. Number of species that occurred in homegardens of all three villages surveyed in the Napu Valley, Central Sulawesi, Indonesia (inner circle), and in only two or one village (outer circle segments); behind the village name, the total number of species identified in this village is given.

Rompo (Sørensen's coefficient 74%) than between Wuasa and the transmigrant village Siliwanga (Sørensen's coefficient 64%) or Rompo and Siliwanga (Sørensen's coefficient 61%). A total of 53 crop species were common to all villages (Figure 1), including the fruits banana, mango, and guava; the root and tuber crops cassava, sweet potato, and taro; the spices chilli, lemon grass, basil, and turmeric; and the cash crops coffee and cacao. Fifteen crop species including cabbage (*Brassica oleracea*) and potato (*Solanum tuberosum*) grown mainly for sale were found exclusively in the market village. Likewise, 28 species were exclusively found in the forest village, among them mainly forest tree species, used for construction, fuel wood, shade tree, medicine, fruit, or for mystical reasons. In the transmigrant village, 21 crop species were exclusively grown, e.g., tea (*Camellia sinensis*), tree cassava (*Manihot glaziovii*), or special medicinal plants, brought from the native place of the settlers.

Total number of crop species as well as average number of species per garden, species density and diversity (Shannon's H') were highest in the forest village, intermediate in the market village and lowest in the transmigrant village (Table 4). A significantly lower mean number of spice, vegetable and wood/timber plants, and a greater number of multipurpose tree species were grown in the transmigrant village compared to the market and forest villages (Figure 2).

Structure

In all homegardens, crop species number decreased from the lower to the higher strata, however, not continuously. A higher proportion of crop species was found in the third than in the second layer.

In small gardens (< 900 m^2), the highest proportion of crop species occurred in the first layer (0-1 m), while in large gardens (> 900 m^2), it was contained in the third layer (2-5 m) (Figure 3). In small gardens, the proportion of species in the upper strata (> 2 m) was generally smaller than in the large gardens. In most of the small gardens, no strata higher than 5 m were found.

Unlike the vertical distribution of species, the proportion of crop plant individuals per garden decreased continuously towards higher strata (Figure 4). Small gardens showed a higher proportion of individuals in the first stratum (0-1 m), however, a significantly lower proportion in the higher strata than the large gardens.

Classification

Applying cluster analysis, 10 groups of homegardens were distinguished (Figure 5). Groups 1 and 2 were constituted by seven gardens each, mainly from the market and forest villages, while group 3 included nine gardens, predominantly from the transmigrant village. The remaining seven groups contained only one garden each, which were mainly from the market or the forest village.

In all homegardens of group 1, chilli and sweet potato were grown, but only some tree species and never the commonly grown jackfruit (*Artocarpus heterophyllus*). Only 16 species, of which 44% were spices, occurred in the majority of these gardens. In the gardens of group 2, fruit or tree species such as jackfruit, banana, guava, water apple, cacao, and arabica-coffee were always present. Of the 34 species, which were common to the greater part of these gardens, 32% were fruit species and only 24% were spices. In all homegardens of group 3, taro, cassava, and arabica-coffee occurred. Only 21 species were common to the majority of these gardens, among them 29% fruit species, 19% stimulant species and frequently multipurpose tree species. All gardens of group 3 were managed by transmigrant families, including one garden in the market village Wuasa. In the individual gardens of groups 4 to 10, more tree species were grown than in the other groups. Each individual gar-

Table 4. Crop diversity of homegardens in three villages of the Napu Valley, Central Sulawesi, Indonesia.

	Market village Wuasa		Forest village Rompo		Transmigrant village Siliwanga	
	Mean	Range	Mean	Range	Mean	Range
Total species (no.)	94	–	109	–	84	–
Mean spp./ garden (no.)	35a	15-55	37a	21-54	28a	18-41
Mean spp. density (no./100 m^2)	5.6ab	3.9-10.6	6.1a	2.7-8.1	3.5b	1.2-6.5
Mean Shannon index H'	2.6a	1.6-3.2	2.8a	2.2-3.2	2.1b	1.3-2.6

Means in a row followed by different letters are significantly different at $P \leq 0.05$.

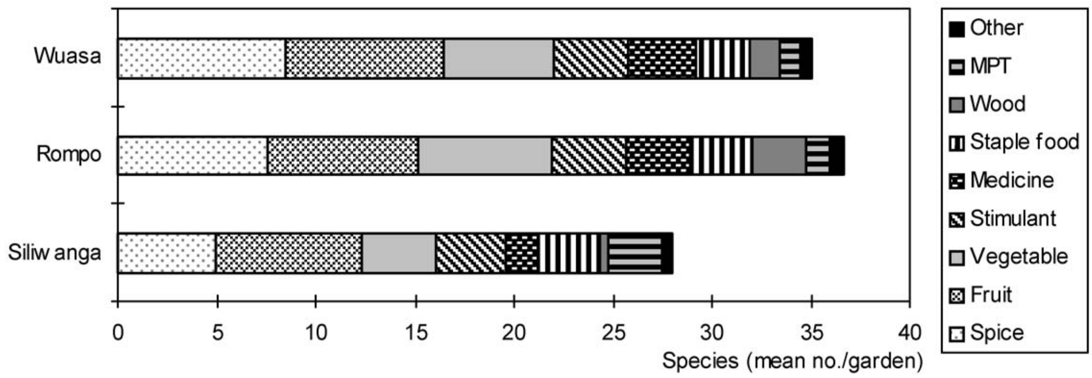

Figure 2. Plant species (mean no.) of different use categories per garden in three villages of the Napu Valley, Central Sulawesi, Indonesia.

den was characterised by a special set of crop species occurring exclusively in this particular garden, for example, rare medicinal plants in garden no. 1 or tolerated forest species in garden no. 11.

Although the cluster analysis was performed only on the basis of species composition, marked differences were also found with regard to mean garden age and size, number of crop species and Shannon index among groups 1 to 3. On the basis of species composition (Figure 5) and these additional garden characteristics, the 30 homegardens were classified into the following four major types:

– Small, moderately old, species- and tree-poor spice gardens (group 1)
– Medium-sized, old, species-rich fruit tree gardens (group 2)
– Large, rather young, species- and tree-poor gardens of transmigrant families (group 3)
– Diverse assemblage of rather old, individual gardens with a very high crop diversity (groups 4-10)

Discussion and conclusions

Classification

The cluster analysis of crop species presence/absence appears to be an efficient, practicable method for a reproducible classification of homegardens. It also supported the earlier finding with Sørensen's coefficient that the ranges of plant species in the homegardens of the market village Wuasa and the forest village Rompo were more similar than those of Wuasa and the transmigrant village Siliwanga or Rompo and Siliwanga (see also Figure 1). Leiva et al. (2002) reported similar differences in species composition caused by ethnicity of gardeners in Guatemala. Moreover, the homegarden types classified in this study were reflected in significant differences of other characteristics such as garden age and size or level of diversity.

In this study, a classification of homegardens based on common criteria, which were easy to assess (e.g., homegarden size, number of vegetation layers, integration of livestock, level of inputs) did not seem practicable because there were no obvious differences between the homegardens surveyed apart from size. A classification based on some characteristics such as

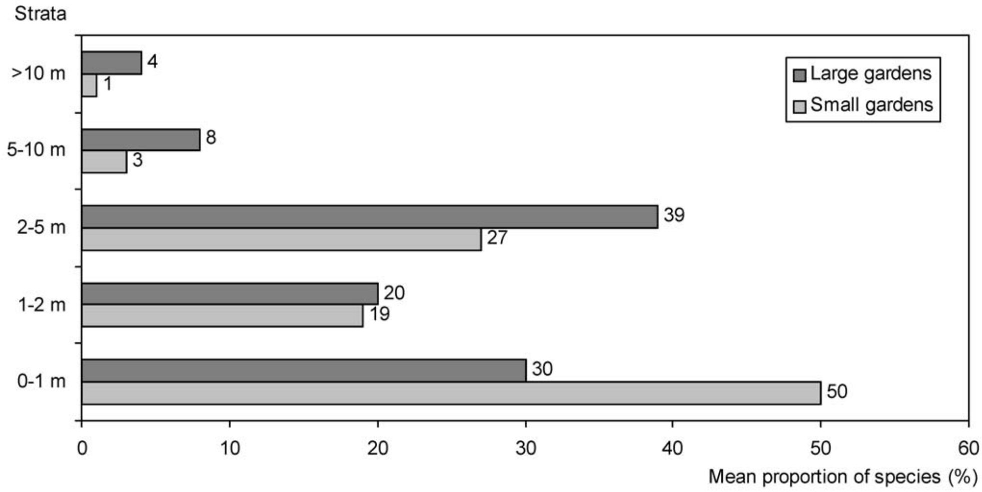

Figure 3. Mean proportion of crop species occurring in different strata in small (N=20) and large (N=10) homegardens in three villages of the Napu Valley, Central Sulawesi, Indonesia.

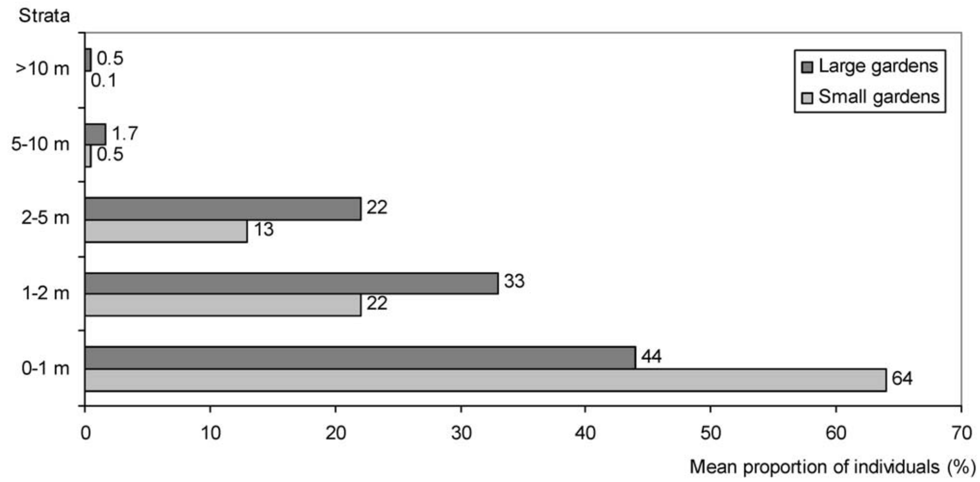

Figure 4. Mean proportion of individuals of crop species occurring in different strata in small (N=20) and large (N=10) homegardens in three villages of the Napu Valley, Central Sulawesi, Indonesia.

traditional, subsistence-oriented versus modern, market-orientated production, as suggested by Christanty (1990), could be biased by individual ways of assessing these selected criteria by the researcher. Cluster analysis of crop species composition has been applied in homegarden research only recently, e.g., by Leiva et al. (2002) in Guatemala and Quiroz et al. (2002) in Venezuela. Despite the greater expertise and time demanded to collect and compute the data as compared to the widely used methods based on common criteria, pattern analysis of species composition is relevant with regard to conservation strategies and, hence, deserves wider application.

Diversity

As most of the gardens studied did not play an outstanding role for the typical paddy rice-based farming system, the total plant diversity (α) of the homegardens investigated, including 149 crop and 72 ornamental species, as well as the average per garden were rather high and comparable to plant diversity of homegardens studied in other regions of Indonesia. Researching one single village in Java each, Abdoellah et al. (2001) listed a total of 195 plant species in 92 homegardens at 1,250 m asl., while Soemarwoto and Convay (1992) documented 272 plant species in

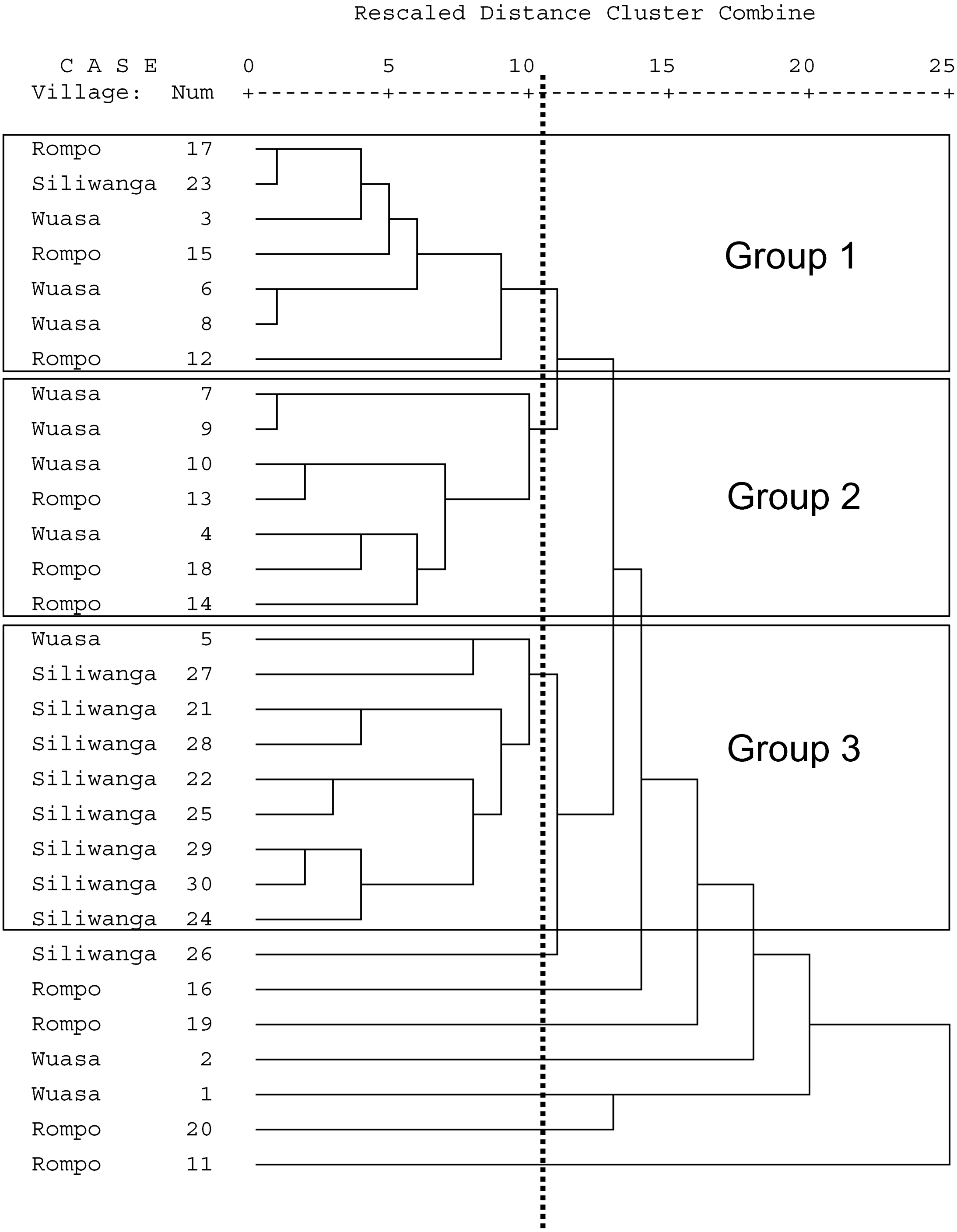

Figure 5. Dendrogram classifying 30 homegardens in three villages of the Napu Valley, Central Sulawesi, Indonesia, according to their species composition (Num: Serial number of homegarden surveyed; groups 4 to 10 are not marked specifically).

41 homegardens in the lowlands. Wezel and Bender (2003) only registered a total of 101 crop species with also considerably lower mean Shannon indices (1.63-1.79) per village in a comparable study performed in 31 homegardens of 3 villages in Cuba. Mean Shannon indices vary widely in tropical homegardens and

are reported from 0.93 in rural Zambia (Drescher 1998) to almost 3.0 in West Java, Indonesia (Karyono 1990).

Depending on the socio-economic status and occupation of the gardener, garden functions ranged from ornamental to kitchen garden. However, typical differences were found among gardens of the three villages. The relatively higher crop diversity in the remote forest village Rompo (Table 4) could have resulted from poor market access, which encouraged subsistence-orientated production. The lower crop diversity in the market village Wuasa, on the other hand, may have resulted from the availability of fruits, vegetables, spices and medicines in the market and shops nearby and less so from market-oriented production. It is known that proximity of markets and the associated commercialisation may lead to a loss of homegarden diversity (Michon and Mary 1994). In the transmigrant village Siliwanga, which has moderate market access, the low crop diversity may have been caused by additional factors. In this village, garden area accounts for a larger proportion of the farms than in the other two villages (Table 2). Thus, they play a more important role in the production of staple crops. This is illustrated, for example, by the mean number of 280 cassava plants per garden as opposed to 61 in the market and 22 in the forest village (Kehlenbeck, unpublished data). Besides ethnicity, soil fertility may also have played a role (Table 3). Low soil fertility could be among the reasons for the lower mean number of spice and vegetable species per homegarden in Siliwanga (Figure 2). According to Landon (1991), many vegetables have a high P demand and not all crop species can cope with acid soils. Since personal preferences of the gardeners might also have influenced diversity and species composition, research is needed to quantify the effects of particular factors on crop diversity in these homegardens in Central Sulawesi. A better understanding of these dependencies could prove crop diversity to be an integral factor of sustainability for tropical homegardens.

Structure

Not all homegardens investigated possessed a multilayered vegetation structure, which offers advantages in reduction of soil erosion or efficient use of resources. Smaller homegardens as well as the younger ones of the transmigrant village Siliwanga often lacked the upper strata. Abdoellah et al. (2001) also observed the lack of vegetation layers higher than 5 m in the majority of small homegardens. Karyono (1990) reported only 1.3% of all species and 5.7% of all individuals in the upper layer ($>$ 10 m) in Javanese homegardens with an average size of 230 m^2. Hochegger (1998), on the other hand, noted 32% of all species in the layer above 10 m for homegardens in Sri Lanka, which were rather old and very large.

Age and size of homegardens could influence their vegetation structure. Contrary to the findings of Christanty et al. (1986) or Jose and Shanmugaratnam (1993), the vegetation structure of old and large homegardens of the Napu Valley was very different from that of the natural primary forest nearby. Height, density and diversity of vegetation were not comparable to forest, a finding also reported by Gajaseni and Gajaseni (1999) and Hochegger (1998). The homegardens investigated resembled rather a secondary forest kept in its young state as suggested by Jensen (1993).

In some homegardens, there were patches without ground cover or litter layer due to repeated hoeing and burning of all residues. Ground cover and litter layers protect the soil from erosion (Hochegger 1998; Karyono 1990). As a consequence of this clearing, parts of some homegardens in the Napu Valley suffered from soil erosion and loss of soil organic matter. Therefore, the sustainability of gardens managed in the same way should be questioned. The insufficient use of available farm yard manure or organic fertilisers by some gardeners may have accentuated the low soil fertility. This probably has restricted the full expression of this system's production potential, despite its high crop diversity and the wide range of resulting products. The contribution of homegarden products to the livelihood of garden keepers not only in Sulawesi but throughout the tropics (Drescher 998) should be improved through education and extension services, which have largely ignored this system as such.

Acknowledgements

Field work was partly supported financially by the German Academic Exchange Service (DAAD). Many thanks to all the people in Wuasa, Rompo and Siliwanga, specially to the 30 respondent families, for their cooperation and ready help during the field survey. The support provided by members and staff of

STORMA (SFB 552) in Bogor, Palu and Göttingen is also gratefully acknowledged, particularly subproject 'Economic Analysis of Land Use Systems of Rural Households' (A4) for making available their survey data set. We also thank Prof. N. Claassen for providing laboratory facilities for carrying out soil analyses, and Ramadhanil Pitopang (Herbarium Celebense 'CEB') for assistance in plant identification.

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