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Soil conditions, vegetation structure and biomass of a Javanese homegarden

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Abstract. The soil of a west Javanese homegarden was a clay-loam, humic Cambisol of medium fertility, with neutral to weak acid reaction. The 0.13 ha large garden contained about 60 plants species (excluding weeds), of which 39 supplied useful products and the remaining were ornamentals. Tree coverage was 81% and total ground cover, including ground litter and weeds was 99%. The vegetation was multi-layered. Total biomass was estimated to 126 t ha^{-1}, including 4.4 t ha^{-1} of ground litter. Of the total biomass, 95% belonged to the tree compartment; *Cocos nucifera, Eugenia aromatica* and *Lansium domesticum* alone constituted 75%.

The homegarden resembled young secondary forest both in structure and biomass, and may be considered as a man made forest kept in a permanent early successional state. The nutrient pool stored in the vegetation was generally low compared to the soil reserves. Only the pool sizes of N and K constituted a significant percentage (5.5 and 11.7%, respectively) of soil reserves.

It is concluded that the sustainability of the homegarden is connected to the medium fertile soil with large nutrient reserves, the large plant biomass directly and indirectly protecting the soil against erosion and drying, and a high species diversity providing a large variation in crop phenology and stability in nutritional supply. All this is in contrast to what has been experienced in most attempts of practising monoculture on sloping lands on Java.

1. Introduction

The cultivation of homegardens, and particularly on Java, has been emphasized as an example of a sustainable agroforestry management system, that has been practised for perhaps hundreds of years with no apparent loss of vigour or detrimental effects to the environment [Soemarwoto, 1987; Wiersum, 1982].

Homegardens cover approximately 20% of arable land on Java [Wiersum, 1982; Anonymous, 1988; Christanty et al., 1986], although this percentage also includes areas in the villages occupied by buildings and roads. In the province of West Java, where this study took place, homegardens covered 4046 km^2 in 1986 corresponding to 12% of the arable land or 9% of the total area. Homegardens are common, also in other parts of the humid tropics, and have been studied by many authors [Terra, 1953; Soemarwoto et al., 1975; Wiersum, 1982; Fernandes et al., 1984; Pinton, 1985; Fernandes and Nair, 1986; Okafor and Fernandes, 1987; Alvarez-Buylla Roces, 1989], but there are few empirical data on soil conditions, nutrient circulation or productivity.

In view of the present scenario of rapidly growing populations, leading to overexploitation of natural resources and possible irreversible environmental damage, there is a considerable need for knowledge about sustainable agricultural systems [National Research Council, 1982]. This situation is pronounced on Java where shortage of land forces peasants to cultivate still steeper slopes, formerly covered by forest, which causes major problems with erosion and which gives very small and short term returns [Barrau, 1985; Repetto, 1986; Anonymous, 1988]. The aim of the present study was to provide some basic data on the soil conditions and the vegetational features of a Javanese homegarden, from which the proposed sustainable nature and conservational effect of this management system can be evaluated. The productivity and nutrient cycling will be described in a following paper.

2. Study site

The homegarden of this study was located in the village Legokole, in the Soreang district about 20 km south of the province capital Bandung in West Java, Indonesia, at 107°31 east, 7°03 south, and approximately 700 m above sea level. Legokole had 550 registered inhabitants in July 1989, the majority of which were farmers.

The garden covered 1258 m^2, of which the house and buruan (buruan = area around house kept clean for social activities) occupied 336 m^2; hence the actual productive area was 922 m^2.

The bedrock underlying the area, consists of young volcanic deposits, composed of tuffs, lahars, breccias and andesitic to basaltic lavas of moderate to high permeability [Anonymous, 1983]. Generally the soils of the lower slopes, cultivated with rice, have gley/-humus associations and alluvial deposits with a depth of 60—90 cm. The soil on the higher slopes, where home-gardens and kebun-talun (annual-perennial rotation) systems are located are reddish-brown latosol associations and brown latosols, with a minimum depth of 90 cm [Anonymous, 1972].

The climate on Java is humid tropical with no pronounced dry season, that is, with no month receiving less than 60 mm of rain, and with mean monthly temperatures above 18 °C. This is designated 'Af' in the Køppen system of classification [Køppen, 1936]. According to the agro-climatic classification of Java made by Oldeman [1975], defining a dry month as one receiving less than 100 mm of rain, the study area has 2—4 consecutive dry months.

3. Methods

3.1. *Vegetation structure and biomass estimates*

For each individual tree the diameter at breast height (DBH) was measured. Using a clinometer, the height of stem as well as total tree height were also measured. A 54 m long and 8 m wide vegetation transect from east to west, was constructed by using these figures combined with drawings of all trees and their vertical projections [Michon et al., 1983].

The volume of each tree was estimated using the data on stem height and DBH and assuming a simple cylinder shape of the trunk. The measurements of volume were combined with density figures of a wood sample from each tree species. These data were compared with 4 different regression equations developed in natural forests. In the first the formula of Dawkins: Volume = 0.0368 × basal area at breast height × stem height was used [cited in Lundgren, 1978]. The volumes obtained this way were subsequently multiplied with the wood density of each species (see above). The three other regressions applied were established in natural forests in New Guinea [Edwards and Grubb, 1977], Panama [Golley et al., 1975] and Cambodia [Hozumi et al., 1969] (shown in Table 3).

Biomass of roots, branches, and leaves of each individual species was estimated using ratios of these compartments to stem biomass, as calculated from literature data of total harvests of the same species in a homegarden in the Saguling area [Ratnawati, 1986]. Biomass of fine roots was estimated from 100 random soil core samples, from which the roots were sieved, followed by drying and weighing. Biomass of banana plants, annuals and shrubs was estimated combining harvested biomass of a number of individual plants with plant density measurements of these species. Weed and ground litter biomass was determined by harvest of 10 random 0.25 m^2 quadrates. Percent of soil covered by tree canopies, shrubs, weeds and litter were estimated from 100 random points.

3.2. *Sampling of soil and plants*

Samples of soil and plants were collected for physical and chemical analyses. Duplicate soil samples were taken at 5, 35 and 135 cm depths from a soil profile, which was considered representative of the garden. Additional samples were collected from the surface soil in the buruan. Wood samples were collected from large branches, close to the trunk, except samples of *Cocos nucifera* and *Hibiscus macrophyllus* which were collected from the trunk of individuals cut down. Leaves from each species were collected from various places in the crown of several individuals and pooled, whereas samples of banana leaves and stems were collected from individuals cut down after fruit harvest. Samples of fruits were collected from material harvested by the owners. All samples were ovendried at 80 °C in Indonesia and analyzed upon return to Denmark at the University of Copenhagen.

3.3. *Soil and plant analysis*

Total nitrogen (N) was determined using the semi-micro Kjeldahl technique. Total calcium (Ca), magnesium (Mg), potassium (K) and iron (Fe) were determined with atomic absorption spectrophotometry (AAS) following digestion on a hot plate in HNO_3 diluted 1:1 with distilled water. Extractable K, Ca, Mg and Na were analyzed with AAS (Ca, Mg) and flame photometry (K, Na) after extraction with ammonium acetate (pH 7). For estimation of soil phosphorus, samples were extracted in 0.2 N H_2SO_4 followed by coulometric analysis with the molybdenum blue method. Total P in plants was determined after complete digestion in concentrated HNO_3 on a hot plate. After evaporation of the HNO_3 the solid remains were dissoluted in H_2SO_4 and analyzed as for extractable soil P. Humus was determined according to the method of Walkley and Black followed by potentiometric titration. The cation exchange capacity (CEC) was estimated by treating samples with Na-acetate (pH 8.2), ethanol and ammonium acetate (pH 7) and measuring the exchanged Na with a flame photometer. pH was measured in soil mixed with distilled water in the ratio 1:2.5.

Soil bulk density was determined by weighing ovendried core samples of known field volume. Texture was determined by the pipette method after removing organic matter by heating in 30% H_2O_2.

The fractional mykorrhiza colonization of fine roots in 10 composite soil samples, each consisting of 10 random soil core samples of surface soil, was determined as described in [Michelsen and Rosendahl, 1990].

4. Results

4.1. *Soil conditions*

According to the FAO/UNESCO system [FAO/UNESCO, 1976] the soil (Table 1) is a humic cambisol. The texture is clay loam to sandy clay loam. The low soil compaction as evidenced from the bulk density, the high pH and CEC and the low level of Na, indicates favourable conditions for plant growth. Although the soil is classified as 'humic' there is no major accumulation of organic matter. Based on general classification guidelines [Landon, 1984], individual element levels (Table 1) were medium for extractable Ca and P, and high for extractable K and Mg. Total N was low to medium, but as for P the analyses applied does not permit precise judgement about the actual availability to the plants. Fe constituted about 5% of the soil dry mass. Total nutrient reserves of the upper 100 cm of the soil, corresponding to the volume in which roots could be observed, constituted 18.0, 5.8, 10.9, 49.1

Table 1. Physical and chemical properties of the homegarden soil.

	Profile			Buruan	Fishpond mud	
	0—10 cm	35—40 cm	135—140 cm	0—10 cm		
Density g/cm^3	1.31	1.20	1.10	1.10	n.d.	
Texture Sand	35.0	50.1	51.5	46.7	n.d.	
(%) Silt	31.5	26.6	22.5	30.6	n.d.	
Clay	33.4	23.3	22.9	22.9	n.d.	
Conductivity (μS/cm)	81.7	184.3	96.9	117.5	n.d.	
pH	6.6	7.1	7.1	6.3	6.8	
CEC meq/100 g	33.1	35.9	28.3	31.2	32.2	
Base sat. (%)	40	40	42	39	33	
Humus (%)	2.4	2.1	1.3	1.6	3.9	
$CaCO_3$ (%)	0.5	0.2	0.1	0.1	0.2	
Nutrients mg/100 g:						Soil nutrient reserve (0—100 cm), t/ha
N (total)	166.0	133.3	97.3	95.5	276.5	18.0
P (extractable)	34.6	54.2	13.2	49.1	88.5	5.8
K (extractable)	56.8	48.8	90.3	77.0	44.0	6.4
(total)	80.5	92.4	109.2	127.1	86.9	10.9
Ca (extract.)	302	437	231	250	242	47.9
(total)*	317	444	93	196	126	49.1
Mg (extract.)	91.7	46.7	85.2	91.2	79.1	7.8
(total)	405.2	281.0	255.3	401.4	370.8	40.5
Fe (total)	5137.7	4874.5	5203.9	5184.6	4238.7	615.8
Na (extract.)						0.6

Table 2. Plant species occurring in the homegarden in Legokole, their local and common English name and the use of species. Abbreviations: F = fruit, FW = fuelwood, D = dying agent, S = spice, T = timber, M = medical, V = vegetable, R = root, crop, O = ornamental.

Latin name	Family	Local name	English common name	Use	No. in Fig. 1
Trees:					
Annona muricata	Annonaceae	sirsak	soursop	F	9
Artocarpus heterophyllus	Moraceae	nangka	jackfruit	F/T	10
Calliandra surinamensis	Mimosideae	kalliandra	—	FW/D	
Cocos nucifera	Palmae	kelapa	coconut	F/FW	6
Coffea caneophora	Rubiaceae	kopi	coffee	drink	7
Eugenia aquea	Myrtaceae	jambu air	rose apple	F	13
Eugenia aromatica	Myrtaceae	cengkeh	clove	S	3
Gnetum gnemon	Gnetaceae	tangkil	—	F	
Hibiscus macrophyllus	Malvaceae	tisuk	—	T	11
Kleinhovia hospita	Sterculiaceae	bintinu	—	FW	
Lansium domesticum	Meliaceae	pisitan	langsat	F	5
(2 variants)[a]		kokosan	langsat	F	
Mangifera foetida	Anacardiaceae	manga/limus	mango	F	
Musa paradisica	Musaceae	pisang	banana	F/V	4
Parkia speciosa	Leguminoseae	petal	locus bean	V	8
Pithecellobium lobatum	Leguminoceae	jengkol	—	V	
Psidium guajava	Myrtaceae	jambu batu	guava	F	2
Toona sureni	Meliaceae	suren	—	T	1
Zalaccca edulis	Palmae	salak	snakefruit	F	12
Shrubs/annuals:					
Ananas comosus	Bromeliacae	nanas	pineapple	F	
Anthyrium sp.	Araceae	kuping gajah		O	
Apalandra sp.	Acantaceae	—		O	
Canne edulis	Cannaceae	ganyong	—	R	
Canna hybrida	Cannaceae	bunga tasbih		o	
Carica papaya	Caricaceae	papaya	papaya	F	
Ciscus discolor	Vitaceae	—		O	
Codiaeum variegatum	Euphorbiaceae	puring		O	
Colocasia esculenta	Araceae	talas	taro	R/V	
Cordyline fruitcosa	Agavaceae	hanjuang		O	
Cucurma domestica	Zingiberaceae	kunir	turmeric	S	
Cymbogon citratus	Graminaceae	sereh	lemon grass	S	
Dahlia rosea	Asteraceae	dahlia		O	
Dieffenbachia pulcherima	Araceae	—		O	
Dioscorea alata	Dioscoreaceae	ubi manis	yam	R	
Euphorbia sp.	Euphorbiaceae	—		O	
Ficus benjamina	Moraceae	beringin		O	
Hibiscus rosa-sinensis	Malvaceae	bunga sepatu		O	
Homalomena punicum	Araceae	cariang	—	V	
Ipomea batatas	Convolvulaceae	ubi jalar	sweet potato	R	
Irisine herbstii	Amaranthaceae	irisin		O	
Kalanchoe pinnata	Crassulaceae	cocor bebek		O	

Table 2 (Continued).

Latin name	Family	Local name	English common name	Use	No. in Fig. 1
Lablab niger	Leguminoceae	kacang peda	hyacinth bean	V	
Languas galanga	Zingiberaceae	laja	galangal	S	
Luffa acutangula	Cucurbitaceae	oyong	loofah	V/M	
Manihot utilissima	Euphorbiaceae	singkong	cassava	R/V	
Ophiopogon humetes	Liliaceae	daun lilin		O	
Pandanus sp.	Pandanaceae	pandan		O	
Phaeomeria speciosa	Zingeberaceae	honje	—	S	
Pilea cardieri	Urticaceae	muiara		O	
Piper betle	Piperaceae	sirih	betel wine	M	
Pleomele eliptica	Agavaceae	daun suji	—	D	
Rhoeo sp.	Commelinaceae	—		O	
Saccharum officinarium	Graminaceae	tebu	sugar cane	S	
Sansiviera trifasciata	Liliaceae	tapal munding		O	
Sauropus androgynus	Euphorbiaceae	katuk		O	
Sechium edule	Cucurbitaceae	waluh	chayote	V	
Sericocalyx crispus	Acanthaceae	—		O	
Solanum nigrum	Solanaceae	leunca	black nightsha.	V	
Tagetes erecta	Asteraceae	narjis		O	
Xanthosoma violaceum	Araceae	talas	tannia	R/V	

[a] Taxonomic position not clear. Kokosan had hairy leaves and twigs, Pisitan not.

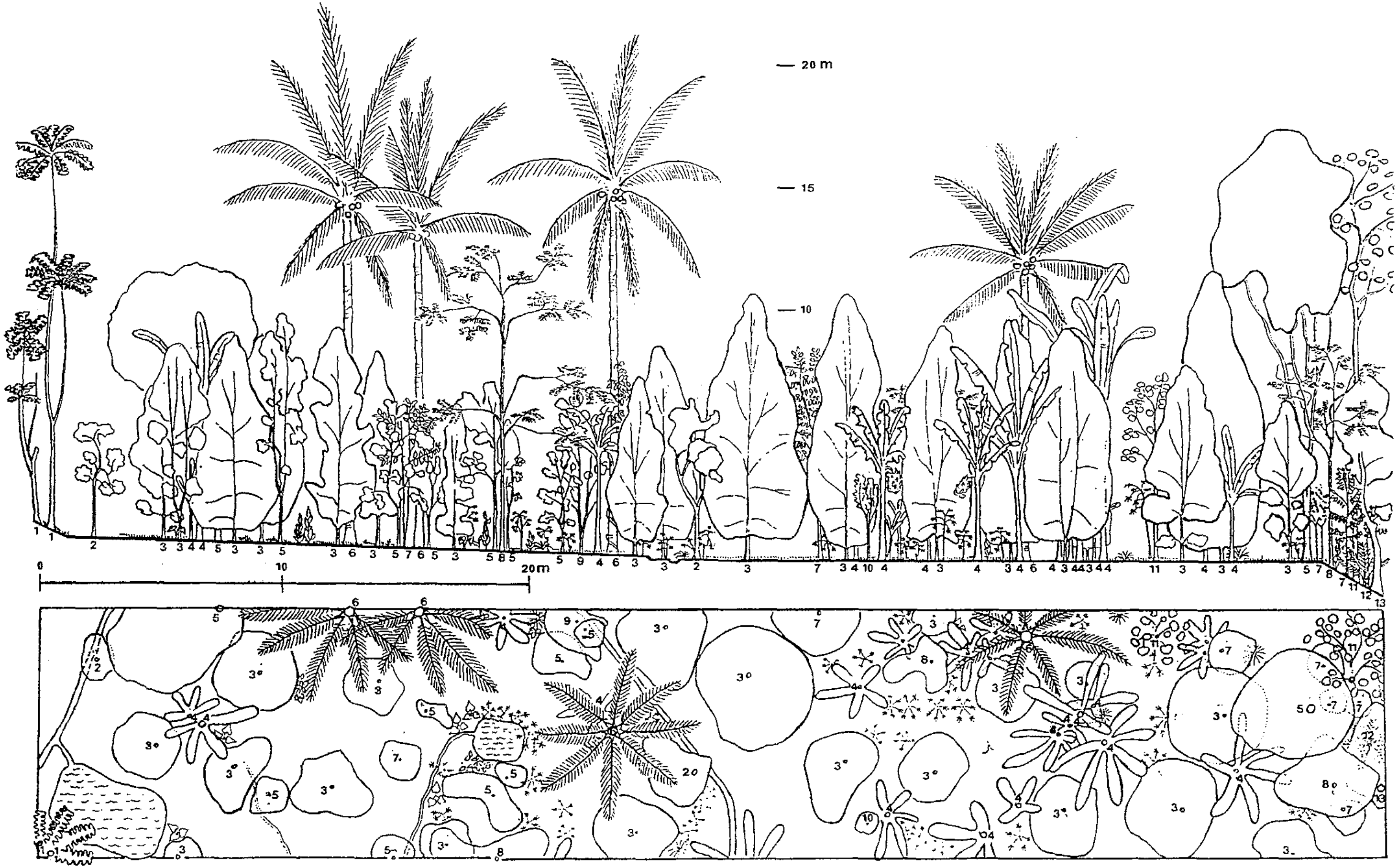
and 40.5 t ha^{-1} for N, P, K, Ca and Mg, respectively. Total Ca did not differ much from the extractable amounts which indicates that most of the CA was bound in the organic fraction.

In the 'buruan' topsoil where the surface is kept clean of weeds and litter, humus and N concentration were lower, P and K higher and Ca and Mg similar as compared to those of the topsoil of the profile. The buruan topsoil in many ways resembled the mineral soil at 135—140 cm depth, except from being more acid.

4.2. *Species composition*

The vegetation was very diverse with 60 identified species, of which 39 were crops and 21 were ornamentals (Table 2). In addition there was a number of unidentified weed species. Trees mainly provided various fruits, but also vegetables, timber, fuelwood and spices. Shrubs and annuals produced root crops, vegetables and spices. Many species were used for multiple purposes.

Altogether 169 individual trees (including *Musa*) occurred in the garden corresponding to a density of 1833 individuals per hectare. The number of shrubs and annuals was subject to some variation during the study period. Many above-ground parts of *Canna* and taros tended to wilt during the dry


20 m
15
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10
20m

season whereas cassava stem grafts regularly were planted, even in the dry season.

On average 18% of the total fine root biomass was colonized by vesicular-arbuscular mykorrhiza.

4.3. *Vegetation structure*

4.3.1. *Horizontal structure*

Although trees were growing all over the cultivated part of the garden, they tended to be concentrated along its margins. Approximately 50% of all individual trees occurred within 2 m distance from the garden edge, an area which equalled about 25% of the total area. The remaining central part of the garden consisted of a more monotonous mixture of *E. aromatica* and bananas, single individuals of other species and open spots with annual crops.

In the cultivated part of the garden, 99% of the soil surface was covered by the tree canopy, shrubs, annuals or ground litter. The projections of the tree canopy alone covered about 80% of the surface. Annuals tended to be concentrated in the openings of the tree canopy where light conditions were most favourable.

4.3.2. *Vertical structure*

The vertical structure (Fig. 1) of the vegetation consisted of a ground layer from 0—1 m that, primarily in the openings of the tree canopy, was occupied by *Canna edulis*, taros, pineapples, young cassavas and various weeds. A second stratum between 1 and 4 m height was composed by older cassavas, papaya, coffee and young fruit trees of banana, guava, jackfruit and *Zalacca edulis*. The latter were trees already selected by the owner for future production. More than 70% of the trees in the profile were represented in the layer from 4—11 m, dominated by cloves, bananas and *Lansium domesticum*. The uppermost layer from 11 m up to nearly 23 m consisted of scattered coconuts, *Lansium*, Toona, *Hibiscus macrophyllus* and *Parkia speciosa*.

4.4. *Biomass*

Although there were large variations for individual species, the total estimates of stem biomass were in the same order of magnitude for the 5 calculation procedures compared (Table 3); only the regression of Edwards and Grubb [1977] giving somewhat higher values. The calculation applied in this study resulted in an estimate of 60.0 t ha^{-1}, only 2% less than the average of 61.5 t ha^{-1} of the 4 other regressions derived from literature

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Fig. 1. Vegetation profile along a 54 m long transect through the homegarden in Legokole, West Java. Numbers on trees refer to species names in Table 2.

Table 3. Stem biomass of the homegarden estimated by 5 different methods.

Species	No. of indiv.	Biomass kg (in garden)				
		Method applied				
		(a)	(b)	(c)	(d)	(e)
A. heterophyllus	4	217	180	456	396	347
Annona muricata	2	7	34	37	35	22
Cocos nucifera	7	2692	1575	2475	2379	2588
Coffea caneophora	15	74	552	198	238	118
Eugenia aqua	1	23	27	89	71	53
Eugenia aromatica	28	966	1363	796	714	639
Gnetum gnemon	1	2	22	6	9	3
Hibiscus macrophyllus	5	197	185	207	184	203
Lansium domesticum	17	1080	1051	1576	1382	1192
Mangifera foetida	1	40	43	68	54	39
Parkia speciosa	3	49	84	86	75	72
Persea americana	1	2	16	8	10	4
Pithecellobium lobatum	1	23	33	39	32	20
Psidium guajava	3	27	91	84	74	40
Toona sureni	2	118	106	86	71	89
Total		5515	5366	6210	5724	5428
Total t ha^{-1}		60	58	67	62	59

(a) Volume = Area at breastheight × stem height (this study).

(b) Volume = 0.0368 + 0.545 × area at breastheight × height, Dawkins 1961 cited in [Lundgren, 1978].
Data from a and b are combined with measured mass volume from each species to give biomass.

(c) Dry weight (kg) = $(0.2076X - 1.0193)^2$, where X = girth at breastheight (cm) [Edwards and Grubb, 1977].

(d) Dryweight (g) = $(10.82 + 2.109X)^3$, where X = DBH (cm) [Golley et al., 1975]. Includes branchwood; hence reduced with 20% = average fraction of total biomass constituted by branchwood in total harvest data from homegarden in W Java [Ratnawati, 1986].

(e) Dryweight (kg) = $0.0396(D^2 \times H)^{0.9326}$ where D = DBH in cm and H = height in (m) [Hozumi et al., 1969].

[Lundgren, 1978; Edwards and Grubb, 1977; Ratnawati, 1986; Hozumi et el., 1969].

The total biomass of the homegarden (Table 4) was 126.4 t ha^{-1}, of which 122.0 t ha^{-1} was live biomass (including stemwood). Trees constituted 116.4 t ha^{-1} corresponding to 97% of total live biomass. *C. nucifera, E. aromatica* and *L. domesticum* together accounted for more than 75% of this figure. In contrast annuals and shrubs together only constituted 2.1 t ha^{-1} or 1.7% and weeds 1.6 t ha^{-1} (1.3%). Fine roots accounted for 1.9 t ha^{-1} or 1.6% of the total live biomass.

Table 4. Biomass and nutrient allocation in homegarden.

	Dryweight t ha^{-1}	Elements kg ha^{-1}				
		N	P	K	Ca	Mg
Trees:						
Stem	61.4	461	40	332	290	67
Branch	15.4	88	4	35	115	16
Leaves	8.7	131	8	118	71	25
Roots	29.2	212	18	125	159	34
Fruits	1.7	15	3	39	6	3
subtotal	116.4	907	72	648	642	145
Annuals/shrubs:						
Shoot	1.1	17	2	26	12	3
Root	1.0	5	<1	17	1	1
subtotal	2.1	21	2	43	13	4
Weeds	1.6	22	6	53	10	6
Fine roots	1.9	13	2	n.d.	n.d.	n.d.
Litter	4.4	32	3	7	25	11
Total biomass	126.4	995	85	751	690	165
Biomass reserve in % of soil avail. reserves		5.5 (*)	1.5	11.7	1.4	2.1

* = total N.

4.5. *Nutrients in biomass*

Weeds had the highest concentrations of all nutrients and wood the lowest (Table 5). Tree leaves came second for N and Ca, whereas annuals were second for P and K. Except for the high concentration in weeds, P values did not differ much between compartments.

The great majority of nutrients was located in the tree biomass (Table 4), of which 40—46% was in the stems alone. In terms of nutrient storage, nutrient rich tissues gain more importance than what their share of biomass indicates. Although tree leaves constituted only 6.8% of total biomass, they contained 13.2% of N, 9.4% of P, 15.7% of K, 10.3% of Ca and 15.2% of Mg. Similarly, annual crops and weeds together accounted for 2.9% of total biomass, but stored 9% of P and 12% of K.

Compared to the available soil pool of nutrients (Table 1 and 4), biomass storage is small except for K that constituted 11.7%.

Table 5. Concentration of nutrients in biomass compartments (% dry weight).

	N	P	K	Ca	Mg
Trees:					
Wood	0.75	0.07	0.34	0.47	0.11
Leaves	1.50	0.09	1.34	0.81	0.29
Fine roots	0.69	0.10	n.d.	n.d.	n.d.
Annual crops (root + shoot)	1.01	0.11	2.03	0.63	0.18
Weeds	1.91	0.47	4.60	0.83	0.48
Litter	0.98	0.09	0.23	0.77	0.34

n.d. = not determined.

5. Discussion

5.1. *Soils and fertility*

The soils of Java are generally considered as fertile, although in fact, 50% are classified as 'less fertile' by Rumavas [1986]. The soil analysis in the present study indicates that the homegardens of Legokole are located on juvenile, medium fertile soil, which are far from being depleted by weathering and leaching [Mohr and Van Baren, 1954], and developed with no ferralitic properties. There were no obvious limitations to plant growth, neither chemical nor physical, although literature data suggests that Legokole and the Soreang district are close to the limit of the ecological range of homegarden practice, both in terms of altitude [Terra, 1953], and water supply [Oldeman, 1975]. Furthermore, high productivity was maintained without the application of industrial fertilizers. Occasionally, however, mud from the fishponds was applied, and the free living ducks and chicken also contributed with some manure. As in most studied homegardens [Amber, 1986; Wiersum, 1984], no signs of erosion could be observed, except on some of the walking paths, although the homegardens were situated on sloping land. The litter layer seems to be the most important protective factor against erosion, since removal of the litter greatly increases erosion, whereas removal of trees has a much smaller effect [Amber, 1986].

5.2. *Vegetation structure*

More than one third of all 171 previously reported plant species in the village Legokole [Hadikusumah, 1981], were represented within the 1258 m^2 large garden. This species richness is comparable to that in natural forests and the wide array of productive species, with different phenology, offers a great deal of nutritional stability throughout the year. Traditionally the homegardens have been used as reserves of food, particularly in the period between successive rice harvests, when rice may become in short supply [Christanty et al., 1986; Soemarwoto, 1987]. The species number of the Javanese homegarden can vary considerably [Karyono, 1979]. The distance to market is one decisive factor determining the species number; the closer the market is, the more the owner concentrates on a few commercial crops [Christanty et al., 1986]. In the homegarden at Legokole, the 28 individuals of the commercial crop *Eugenia aromatica* dominated the structure and constituted 22% of the total garden biomass.

The vegetation structure, the dominance of trees and the plant biomass of 122 to ha^{-1} in the homegarden at Legokole are similar to reported figures from young, 12—25 years old natural forests and plantations [Bruijnzeel, 1983; Nye and Greenland, 1960; Rodin and Basilevich, 1967]. Also, the average nutrient concentrations of the various vegetation fractions and ground litter are in general quite similar to average values reported from tropical natural forests and plantations [Bruijnzeel, 1983; Jayebo and Moore, 1964; Jordan, 1985; Lundgren 1978; Nye and Greenland, 1960; Whitmore, 1984]. The homegarden is kept permanently in a juvenile state, which is ideal from a productional view, since it assures a constantly high growth rate. The structure of the homegarden, however, is not similar to that previously described from a 'village-forest-garden' in Bogor, west Java [Michon et al., 1983], where the trees are larger and many of them have umbrella shaped crowns, a characteristic which resembles late successional stages in tropical rain forests [Richard, 1952]. Even the largest trees in Legokole are smaller than those in Bogor and with more cone shaped crowns and an open canopy allowing a more widespread undergrowth of crops. This difference probably has to do with the ownership; the 'village-forest-garden' in Bogor being communal ground in the village and therefore less intensively managed, and with a somewhat different species composition.

5.3. *Role of homegardens*

There is no obvious support yet to the belief that the diversity of the homegarden ecosystem renders it more stable than monoculture, since some of the most diverse natural ecosystems on earth: rainforests and coral reefs are among the most vulnerable to disturbances [Dover and Talbot, 1987], in particular man made pertubations [Jordan, 1985]. One of the few attempts to more objectively quantify stability of polycultures, in terms of risk of yield falling below a given limit [Mead et al., 1986], showed intercrop systems to be less risky, hence more stable, than monocrop systems. At present there is not sufficient data available from homegardens to conduct this kind of analysis. It is clear however that the wide array of products with different phonology offers a great deal of nutritional stability throughout the year.

Furthermore, the indirect effect of trees providing a litter cover on the soil as well as organic material which improves the soil structure, is very important in stabilizing the soil layer. Where monoculture has been introduced on sloping land on Java, major erosional problems have occurred [Repetto, 1986; Barrau, 1985], which, in addition to topsoil removal, include siltation of fishing waters, of hydropower facilities and of coral reefs. That is, the effects reach far beyond the cultivated areas. In general the removal, or reduction, of the tree cover causes major changes in the hydrological balance, i.e. increased runoff [Lal, 1989], which means greater amplitudes in water transport and perhaps even a drier local climate, [Kartawinata, 1980; Dickenson, 1980, Salati, 1985], both factors inhibitive to crop growth.

As forest like ecosystems, homegardens may therefore be very important as a low-input productive unit, that stabilizes the sloping land, the hydrological balance as well as the nutritional supply. To quantify these effects more specifically, further research is needed.

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