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Interdisciplinary analysis of homegardens in Nicaragua: micro-zonation, plant use and socioeconomic importance

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Abstract

The choice of plant species, their arrangement and management varies between and within tropical homegardens in the same community. Relationships between agroecological and socioeconomic characteristics of 20 homegardens were examined at Masaya, Nicaragua. Variables analyzed were micro-zonation (area allocation to specific uses and management), plant use and diversity, occupation, labor investment, and product, benefit and income generation. Data was collected through surveys, participatory mapping, plant inventories, direct observation and interviews. Ten different micro-zones and nine plant uses were identified. Fruit trees, shaded coffee and ornamentals were the most important zones. Plant diversity was high, with a sample total of 324 species. Homegardens were an important occupation, with average labor investments of 32.6 h family^{-1} week^{-1}. Families obtained at least 40 different plant products from homegardens, as well as the benefit of space for working and socializing. Six homegarden types were identified using a cluster analysis based on biophysical variables. Types reflected the relationship between income generation and the number and types of zones and plant species present. Labor inputs were high considering the small size of the homegardens (average size 3,240 m^2), although no clear relationships between labor investment and plant and zone type or number were observed. Homegarden management strategies of plant selection and zonation were affected both by family choices and external forces. Although dependence on homegardens may vary according to specific conditions at a given time, they seem to be a consistent, flexible resource used to meet a diversity of needs. The methodological approach used in this paper may be appropriate for the study of other traditional agroecosystems since it includes both biophysical and socioeconomic variables, essential for understanding these complex systems.

Introduction

Tropical homegardens are traditional agroforestry systems characterized by the complexity of their structure and multiple functions (Fernandes and Nair 1986). Homegardens have attracted considerable research attention during the past three decades (Wojtkowski 1993), mainly due to the following reasons: 1) they contain characteristics which make them an interesting model for research and the design of sustainable agroecosystems, including efficient nutrient cycling, high biodiversity, low use of external inputs and soil conservation potential (Torquebiau 1992; Jensen 1993a, b; Jose and Shanmugaratnam 1993; Gliessman 1998); and 2) homegardens have been shown to provide a diverse and stable supply of socioeconomic products and benefits to the

families that maintain them (Niñez 1987; Christanty 1990; Lok 1998a).

Intrinsic to the nature of homegardens are the intimate relationships that exist between their human and agroecological components (Mergen 1987). Thus, to fully understand how homegardens function, and what benefits they provide to their users, it becomes necessary to integrate and then analyze both socioeconomic and biophysical aspects of these systems (Nair 1993; Lok 1998b). Although this fact has been recognized in the homegarden literature, interdisciplinary studies addressing these issues are few, particularly in Central America (Budowski 1990; Landauer and Brazil 1990a).

A promising approach to reach a better understanding of homegardens is to address the underlying reasons for their design, management and plant species selection. These can be analyzed, to a great extent, by focusing on existing homegarden micro-zonation (area allocation to specific uses and management; hereafter referred to as zonation and zones). Such zones have been documented by several authors (Brierley 1985; Alvarez-Buylla et al. 1989; Abdoellah 1990; Okigbo 1990; Padoch and de Jong 1991), but rarely used as a unit of analysis. An exception to this is Lok (1998a), in which different case studies are presented that make use of the concept of zones. Homegarden zones are easily visualized and their location, size and plant species composition reflect deliberate management strategies. Plants and their local uses, which are included in zones, provide additional information on a farmer's management priorities and socioeconomic needs. To complete the analysis, the above information can be integrated with data on the socioeconomic importance that homegardens hold for the people that manage and conserve them.

The main objective of this study was to examine the relationship between the socioeconomic importance of homegardens and the type and diversity of management zones and plant species present.

Study area

Research was conducted in the village of San Juan de Oriente, Masaya, Nicaragua, 11°59′ N and 86°06′ W. Mean annual precipitation is 1500 mm, with nearly all rainfall between May and October. Altitude is 450 m.a.s.l., with a mean annual temperature of 26 °C. Soils are clayey loams of volcanic origin. The village dates from the period of Spanish colonization (1521–1821), has strong indigenous roots and a long tradition of homegardening. The main agricultural products in the area are coffee (*Coffea* spp.), ornamentals and fruit trees. Several types of bananas and plantains (*Musa* spp.), maize (*Zea mays*) and beans (*Phaseolus vulgaris*) are also grown for local consumption. Handcrafting is an important economic activity at the site, and the village has acquired a reputation for its pre-Columbian style ceramics. Its proximity to Managua, Nicaragua's capital, and two other important urban centers (Granada and Masaya), ensures markets for agricultural products and handicrafts. Most of the homegardens are thought to be at least 50 years old. The study area and the individual homegardens which were evaluated were previously selected in 1993–1995 by the CATIE/IDRC homegarden project. This project facilitated contacts with collaborating families and provided useful secondary information.

Methodology

Information on 20 families and their homegardens was compiled from January to August 1996. Micro-zones are spatial areas deliberately allocated to particular species and management, as perceived by the farmer. In order to quantify the extent and use of zones, a map of each homegarden was elaborated with the farmer using participatory methods; i.e., farmers led researchers through homegardens, identifying, describing and discussing zones, general topography and plant location as well as use. Areas allocated to zones were identified by farmers according to their main function. Subsequently, researchers returned to measure the areas of the zones identified and described by the farmers (to the nearest m^2). These figures were then expressed as percentages of total homegarden area. Although most zones had multiple functions, the main function as reported by the farmer was used for classification purposes. Complete inventories were carried out to

document plant diversity, abundance and location. Plant uses were defined by farmers in interviews, some of which were carried out while walking through their homegarden. Most plants had multiple uses but were likewise classified by their main use. Plants were also classified according to their growth habit.

In order to define homegarden function, as perceived by farmers, two main questions were asked: 1) What is the main purpose you maintain your homegarden for?; and 2) What is the most important product or benefit your homegarden provides? These answers were then cross-checked with information from previous interviews, direct observations, field survey data and informal conversations. This analysis originally yielded six homegarden types (e.g., ornamental, mixed production). Based on these functional groupings, different cluster analyses were run utilizing both socioeconomic and biophysical variables, but maintaining the number of groups from the *a priori* field classification in order to contrast farmer's perceptions, based on the function of their homegardens, with statistical classifications. Cluster analyses were done using Ward's minimum variance method to identify homegarden types, with squared Euclidean distances used as a measure of dissimilarity. In this paper, the most compatible statistical classification, which matched field-based functional classification in 85% of the cases, was used. This was obtained using the following agroecological variables, which were standardized to zero mean and variance one: 1) number of management zones; 2) number of plant uses; 3) number of plant species; and 4) total homegarden area. The contribution of these variables to the formation of clusters was ascertained through a stepwise, variable discriminant analysis (SAS Institute 1987). Between group comparisons for each variable were evaluated with a one-way analysis of variance.

Results

Management zones

Homegardens ranged in size between 200 and 14,000 m^2, with an average of 3,240 m^2. Ten different management zones were identified (Table 1). The number of zones per homegarden ranged between two and six, with a mode of three. All homegardens had a minimum of two zones, one of which was the residential zone. Residential, fruit trees, ornamentals with shade trees and shaded coffee were the most frequent zones in the homegardens, and in total accounted for more than 75% of homegarden area. On average, most homegarden area was allocated to fruit trees (37%), and residence (25%). Shaded coffee and ornamentals with shade trees were allocated 14–16% of the total area. The average coverage of each of the other zones was 3% or less of the total homegarden area. Due to the large differences in homegarden size, the average value for each zone as a percentage of the total area should be used with caution. For example, as homegarden size increases, the percentage of the total area allocated to the residential area decreases. In the smallest homegarden, 51% of the total area was allocated to the residence, while in the largest homegarden, the residence took only 3% of the total area.

A correlation analysis of zones present in at least five homegardens, indicated positive, significant relationships between the total homegarden area and areas allocated to: residential uses (r = 0.54, $P < 0.01$); fruit trees (r = 0.76, $P < 0.004$); and shaded coffee (r = 0.97, $P < 0.0003$). Total homegarden area affected the number of zones only in smaller homegardens. In medium to large homegardens, the total area was not clearly related to the number of zones present. When present, shaded coffee was the largest zone in the homegarden.

Location of zones was deliberate in most homegardens. Farmers chose specific areas for zones and their components based on practical considerations, plant requirements and soil conditions. For example, ornamentals and herbaceous crops were always close to the household in order to facilitate constant watering and weeding, to safeguard against theft, and to provide easy access to potential buyers (Figure 1). When present, seedlings for transplanting and certain food crops were usually allocated to areas of high soil fertility and organic matter content (see ditch area in Figure 1). Shaded coffee and tree zones were farthest from the residential area, since they need less daily care or safeguarding.

Table 1. Zonation in 20 homegardens, Nicaragua.

Home garden code	Zones[a, b] (percentage of total area)										Total	
	1	2	3	4	5	6	7	8	9	10	# Zones	Area (m^2)
7	–	–	51	49	–	–	–	–	–	–	2	211
5	68	–	32	–	–	–	–	–	–	–	2	250
10	–	–	42	58	–	–	–	–	–	–	2	475
2	55	–	45	–	–	–	–	–	–	–	2	478
8	–	–	53	22	–	–	–	–	20	5	4	513
3	6	58	30	7	–	–	–	–	–	–	4	656
12	–	–	35	61	–	–	–	–	4	–	3	810
19	77	–	12	–	–	–	–	–	–	11	3	975
16	27	–	73	–	–	–	–	–	–	1	3	1,039
18	76	–	18	–	–	–	–	–	–	6	3	1,048
14	–	80	20	–	–	–	–	–	–	–	2	1,289
9	–	33	17	25	21	–	4	–	–	–	5	1,656
17	90	–	7	3	–	–	–	–	–	–	3	2,075
13	53	–	20	–	18	–	–	–	9	–	4	3,387
1	–	53	19	11	14	0.2	3	–	–	–	6	4,499
15	85	–	8	8	–	–	–	–	–	–	3	4,583
4	26	33	11	24	–	–	6	–	–	–	5	5,159
6	67	–	9	–	0.4	16	–	8	–	–	5	10,095
11	6	66	4	14	6	–	5	–	–	–	6	11,597
20	96	–	3	1	–	–	–	–	–	–	3	14,000
Average (%)	37	16	25	14	3	1	1	0.4	2	1	3.5	3,240
Frequency	13	6	20	12	5	2	4	1	3	4	–	–

[a] 1) Fruit trees; 2) Shaded coffee; 3) Residential; 4) Ornamentals with shade trees; 5) Multi-purpose trees (trees used for fuelwood, timber, forage and as an ornamental); 6) Herbaceous crops (herbaceous food crops and medicinal plants); 7) Ornamentals with vine-crop shade; 8) Grass (used for handicraft production); 9) Other (space used for storage or working); 10) Ornamentals with artificial shade.

[b] For areas of zones in m^2, see Méndez (1996).

Zones of natural regeneration of multi-purpose trees were allowed and encouraged when convenient to the farmer. This is exemplified in Figure 1 by the different locations of zone 5. In this particular homegarden, these areas are composed of naturally regenerating stands of *Calycophyllum candidissimum*, a multi-purpose tree used mostly for firewood and posts. The farmer encouraged the natural stands by weeding and controlling shade around them.

Plant uses

A total of 324 plant species with nine different main uses were identified (Table 2; for a detailed list of species, including common, scientific and family names, see Méndez (1966)). Plant species diversity per homegarden ranged between 22 and 106, with an average of 70. At least six of the nine plant uses were found in all homegardens. Fruit trees, medicinals, *Musa* spp., multi-purpose trees, ornamentals and plants for timber and construction were present in more than 85% of the homegardens.

Multi-purpose trees were important as sources of firewood and posts. The most frequent species in this category were *Gliricidia sepium*, *Bursera simarouba*, and *Simarouba glauca*. *Cordia alliodora* and *Dyphisa robinioidies* were the most frequent timber species, followed by *Tabebuia rosea*, *Albizia guachapele* and *Cedrela odorata*. A cucurbit (*Sechium edule*), used for family consumption, and passion fruit (*Passiflora edulis*), which is sold, were the most important food crops. Perennials and shade-loving crops were preferred over light-demanding species (e.g., maize, beans, vegetables), which were found in only one homegarden. Most ornamental species were indoor

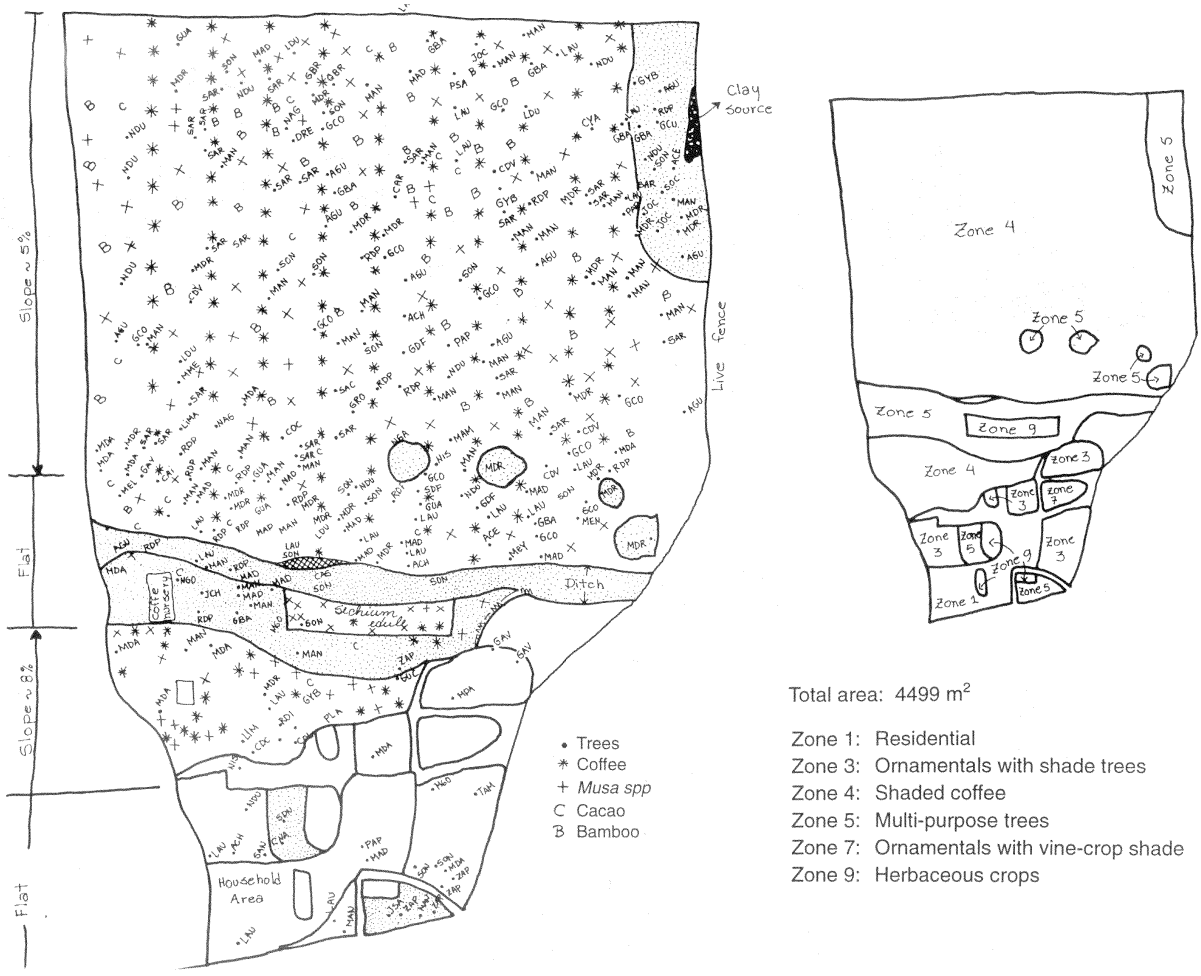

Figure 1. Map of homegarden 1 (Masaya, Nicaragua), depicting plant components in six different management zones (letters next to tree symbols represent codes for common names in Spanish).

Table 2. Plant use, growth habit and species diversity in 20 Nicaraguan homegardens.

Plant use	Growth habit	Frequency	Total number of species
Fruit production (trees)	Woody perennial	20	37
Multi-purpose (trees)	Woody perennial	20	35
Musa spp. (fruits)	Perennial herbaceous	20	3
Ornamental	Herbaceous[a]	19	180
Timber/construction (trees)	Woody perennial[b]	19	14
Medicinal	Herbaceous[a]	18	24
Food (crops)	Herbaceous[a]	17	9
Food/Spice (crops)	Perennial shrub	15	3
Multi-purpose (plants)	Herbaceous[a]	10	19
Sample total:			324

[a] Includes annual and perennial herbaceous plants.
[b] Includes timber trees and bamboo.

plants and flowers, which were grown under different degrees and types of shade, either directly in the soil or in pots or bags. Diversity was highest for ornamentals (180 species), followed by fruit, multi-purpose and timber/construction trees (86 species in these three categories). Only three perennial shrub species were found.

Use of external inputs

Very few external inputs, in the form of hired labor and small, infrequent applications of synthetic fertilizers and pesticides, were used in most homegardens. Homegardens 4 and 11 utilized fertilizer formulas (N-P-K, at unknown concentrations) for ornamentals, coffee and passion fruit, usually once a year. Most families agreed that they could not afford to buy external inputs or hire outside labor. In homegardens 1, 4, 6 and 11, farmers claimed that fertility was maintained by keeping a diversity of plants that shed leaves and branches, which 'feed the soil'. In these gardens, litter was allowed to decompose or was piled as compost. In other homegardens, litter was occasionally burned.

Demographics and literacy

The 20 families contained a total of 144 individuals, with an average of seven members per family (47% male). Age distribution, based on national categories for economic activity, show 40% of individuals between ages 29 and 59; 28% between ages 10 and 19; 24% below age 10; and 8% of individuals with ages above 59. Literacy of individuals six years or older was high (89%). Children's attendance at the elementary level (grades 1–6), and to a lesser extent at the secondary and university levels, was considered very important by all families.

Occupations

The following five occupations were reported by 85% of the sample population: 1) homegardener; 2) student; 3) handcrafter; 4) household worker; and 5) miscellaneous jobs outside the homegarden. The remaining 15% of the population were children below the age of six, and a man of 80, who had no occupation. The high number of individuals reported as students was consistent with the age distribution, which shows that almost 68% of the sample was below age 25. In the case of women, most if not all were involved in household and homegarden chores, apart from other work. Handcrafting was the second most frequent activity for women and the third for men. Men worked more frequently outside the household than women. Outside work was limited to agricultural or urban labor or small-scale commercial activities. The sample contained only one person with a specialized trade other than handcrafting (photography). Homegardens were the third most frequent activity for both sexes. In the case of the men, it was somewhat more important, since an additional 22% reported it as a half-time activity.

Labor investment

An average of three individuals per family regularly contributed labor to homegarden management, distributed almost equally between men (52%) and women (48%). Most of the individuals who worked in homegardens were over 25 years of age. According to most of the families, they prefer that children and adolescents devote their time to school work, and they are only asked to help sporadically. Average labor input for the 20 homegardens was reported as 32.6 h family^{-1} week^{-1} (Figure 2). The amount of labor invested per family in homegarden management varied according to family size and occupation. Homegardens 3, 4, 9, 11 and 12, which received high levels of labor input, were one of the most important occupations for the corresponding families. Families 1, 6 and 10 also reported the homegarden as one of their main occupations, but in these cases only one individual worked full time in the homegarden, with sporadic help from other family members. In homegardens 8, 9 and 17, the families were involved in miscellaneous occupations and the high labor investment in the homegardens was due to the large number of individuals who contributed sporadic labor. Lowest figures for labor input were seen in homegardens 2 and 5 (both with 4.0 h family^{-1} week^{-1}), whose owners were handcrafters, and homegarden 16 (6.0 h family^{-1} week^{-1}), whose owners have outside employment. Labor invested in homegarden 20, the largest unit, was mostly for controlling fallow

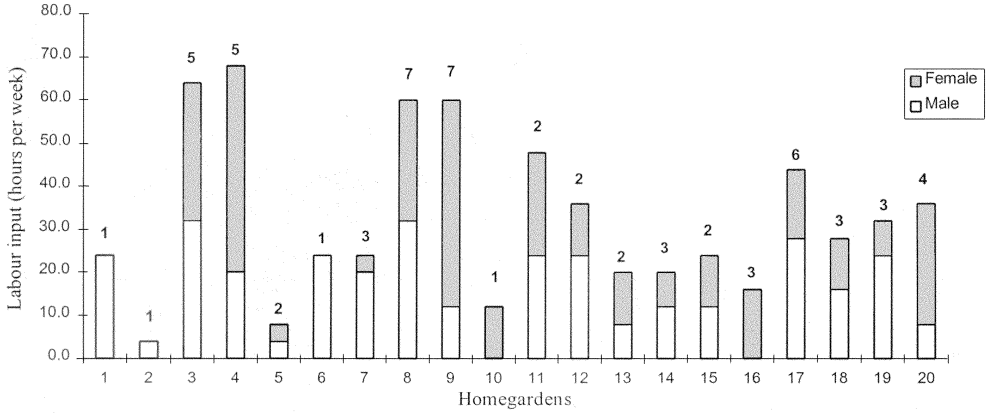

Figure 2. Labor input by gender in 20 Nicaraguan homegardens. Numbers above columns represent the total number of individuals that contributed labor to homegarden management.

vegetation in order to prevent fires in the dry season.

Labor inputs by gender were varied, and seemed to depend more on the number of women and men than on assigned roles for the different sexes. An exception was homegarden 4, where a clear division of tasks was observed in the commercial production of coffee and fruit trees, managed by the men of the family, and of ornamental plants, which were managed by the women. Homegarden 11 was the only one in which outside labor was hired, usually during peak months of coffee and passion fruit harvest.

Products and benefits

A total of 40 different plant products, destined both for home consumption and sales, were obtained from homegardens. The most frequently reported plant products were fruits from different trees, several *Musa* spp. (bananas and plantains) and ornamental plants (Table 3). Additionally, nine families reported space for handcrafting as an important service. All of the families acknowledged the homegarden's role as a place to relax, socialize, enjoy shade and where children could play safely.

Important commercial products included ornamental plants, the main source of income from a number of homegardens, coffee (*Coffea arabica*), passion fruit (*Passiflora* spp.) and coriander (*Eryngium foetidum*), which were most commonly sold to intermediaries who bought directly from the homegardens. Secondly, and less frequently, farmers would sell directly at the markets in Masaya, Granada or Managua (all between 45–120 minutes by bus). Other products that were sold frequently were coconuts (*Cocos nucifera*), different varieties of oranges, limes and lemons (*Citrus* spp.), basil (*Oximum micranthum*), lemongrass (*Cymbopogon citratus*) and bamboo (*Bambusa* spp.). Most of the other products were mainly used for family consumption. Some ornamental producers had developed a more selective clientele consisting of households and retail nurseries in Managua. Coffee was generally sold directly to a processor located in the town. Handicrafts were sold in individual homes or through cooperatives.

Income generation

The 20 families obtained their income from four main sources (Table 4). The most frequently cited source of income was homegardens, mentioned by 14 families. Homegardens also represented the highest average percentage of income. Handcrafting and outside work were the second most important income sources, each cited by 10 families. Families 1, 11 and 12 generated all of their income from homegarden production, whereas families 2 and 5 gained all their income from handcrafting and family 19 from commerce. All other families obtained their income from at least two different sources.

Table 3. Frequency and destiny of plant products reported in 20 Nicaraguan homegardens.

Plant use categories and species (if available) as reported by farmers[a]	Frequency (n = 20)	Sales (%)[b]	Home consumption (%)[b]
Fruit production (trees)	**18**	**15**	**85**
Aguacate (*Persea americana*)	3	0	100
Coco (*Cocos nucifera*)	8	19	81
Cítricos (*Citrus* spp.)	15	34	56
Grocea (*Phyllantus acidus*)	1	0	100
Guayaba (*Psidium guajava*)	1	0	100
Jocote (*Spondias purpurea*)	3	0	100
Mamón (*Melicoccus bijugatus*)	2	0	100
Mango (*Mangifera indica*)	10	7	93
Melocotón (*Averrhoa carambola*)	1	0	100
Nancite (*Byrsonima crassifolia*)	1	0	100
Tamarindo (*Tamarindus indica*)	2	0	100
Multi-purpose (trees)	**5**	**4**	**96**
***Musa* spp.**	**17**	**17**	**83**
Ornamental (herbaceous plants)	**12**	**100**	**0**
Timber/construction (trees and bamboo)	**6**	**60**	**40**
Cedro (*Cedrela odorata*)	2	0	100
Bambú (*Bambusa vulgaris*)	4	90	10
Medicinal (herbaceous plants)	**3**	**32**	**68**
Albahaca (*Oximun micranthum*)	1	80	20
Zacate limón (*Cymbopogon citratus*)	1	80	20
Food (herbaceous plants)	**8**	**22**	**78**
Chayote (*Sechium edule*)	4	0	100
Chiltoma (*Capsicum* spp.)	2	0	100
Culantro (*Eryngium foetidum*)	1	100	0
Granadilla (*Passiflora quadrangularis*)	3	62	38
Maíz (*Zea mays*)	1	20	80
Piña (*Ananas comosus*)	1	0	100
Pitahaya (*Hylocereus trigonus*)	1	0	100
Quequisque (*Xanthosoma sagittaefolium*)	1	20	80
Food/Spice (perennial shrubs)	**9**	**26**	**74**
Achiote (*Bixa orellana*)	4	0	100
Cacao (*Theobroma cacao*)	1	0	100
Café (*Coffea arabica*)	4	58	42
Multi-purpose (herbaceous plants)	**1**	**0**	**100**

[a] In some cases, farmers provided species and in others only broader use categories.
[b] Averages for the sample.

Classification of homegardens

Six types of homegardens were identified by the cluster procedure (Table 5). Variables related to zonation and total area (Z and T) had the most weight in the clustering. All variables made a significant ($P < 0.0001$) contribution to the clustering procedure, as determined by a discriminant analysis. The ANOVA detected significant differences between types ($P < 0.001$) for each variable.

Type A homegardens ('Ornamental') were small and specialized in the production of ornamentals for sale. All of their space, with the exception of the residential zone, was devoted to ornamental zones. Ornamentals were grown in different associations allowing for little production of fruits, firewood, bananas and herbaceous crops for family consumption. Although diversity in these gardens was near the sample mean (70 spp.), the bulk of the species richness was con-

Table 4. Percentage of total income by source in 20 Nicaraguan homegardens.

Homegarden number	Source of income (%)			
	Homegarden	Handcrafting	Commerce	Outside work
1	100	–	–	–
2	–	100	–	–
3	50	50	–	–
4	50	–	–	50
5	–	100	–	–
6	50	50	–	–
7	30	40	30	–
8	40	60	–	–
9	30	–	–	70
10	50	–	–	50
11	100	–	–	–
12	100	–	–	–
13	–	30	–	70
14	30	–	–	70
15	40	–	–	60
16	–	60	–	40
17	–	30	–	70
18	10	–	–	90
19	–	–	100	–
20	10	10	–	80
Frequency	14	10	2	10
Average (%)	34.5	26.5	6.5	32.5

centrated in the ornamental category. Families in this group obtained a relatively high percentage of income from their homegardens and invested a medium amount of labor as compared to the other homegarden types (Table 6).

Type B homegardens ('Handcrafting') were small, had the lowest number of plant species, and together with type A homegardens, a minimal number of zones. Tree mixtures were the predominant plant component. The function of these homegardens was to provide space and shade for handicraft manufacturing, an activity involving the entire family almost full time. These families invested the lowest amount of labor in homegarden management and reported no income from homegarden products.

Subsistence homegardens (type C) were of medium size and produced almost exclusively for household consumption in relatively few zones. *Musa* spp., fruit trees and herbaceous crops were the predominant components. Species diversity was medium, compared to the rest of the sample, and sales were sporadic and restricted to nearby neighbours. In this group, similar labor investments as in type A were observed, but a much lower percentage of income came from homegarden products (see Table 6).

In type D homegardens (Handcrafting and mixed production), there were two sub-groups, which accounted for the 15% discrepancy between the statistical and the functional classifications. Homegardens 3 and 8, combined handcrafting and plant production for sale and family consumption. Homegardens 9 and 15 utilized homegarden products in an equal fashion, but were not engaged in handcrafting. All of the homegardens in this type were of medium size and had a relatively high number of species and zones. The highest labor inputs were observed in this group. This seemed to be a result of the large number of individuals that contributed labor to homegarden work. Family income was obtained from at least two different sources, and income generation from homegarden products was medium as compared to the other types.

Mixed production homegardens (type E) were

Table 5. Nicaragua homegarden classification based on cluster analysis ($P < 0.001$).

Homegarden type and numbers	Homegarden No.	Variables (averages per type)[a]			
		S	U	Z	T
A. Ornamental (3)	7, 10, 12	75	7	2	499
B. Handcrafting (3)	2, 5, 14	35	7	2	672
C. Subsistence (5)	13, 16, 17, 18, 19	48	8	3	1,705
D. Handcrafting and mixed production (4)	3, 8, 9, 15	89	9	4	1,852
E. Mixed production (4)	1, 4, 6, 11	95	9	6	7,838
F. Minimal management (1)	20	96	9	3	14,000

[a] S: Total number of plant species; U: Number of plant uses; Z: Number of management zones; T: Total area (m^2).

Table 6. Average labor and income generation per Nicaraguan homegarden type, as defined by cluster analysis.

Homegarden types	Average % income from homegarden	Average weekly labor input (hrs)	Average # of individuals that contribute labor to homegardens
A. Ornamental	60	24	2
B. Handcrafting	0	9	2
C. Subsistence	2	28	3
D. Handcrafting and mixed production	40	52	5
E. Mixed production	75	41	2
F. Minimal management	10	36	4

large and contained the highest number of species and zones. Two of these families were entirely dependent on homegarden production for consumption and income. The other two obtained at least half of their income from homegarden products. Labor inputs were the second highest for all of the types. Shaded coffee and ornamentals were the most important zones in these gardens.

Only one type F homegarden was recorded, and was consequently considered an outlier. It was unusually large, with few zones, and a relatively high number of species. It was managed by two families heavily dependent on non-agricultural activities (carpentry). Only 3% of this homegarden was used for residences and gardening.

Discussion and conclusions

In general, labor investments were high considering the small size of the homegardens. These figures differed considerably from labor investment reported in homegardens of several Asian countries, Mexico and Peru, which ranged between 13–110 man-days $year^{-1}$ (Torquebiau 1992; Hoogerbrugge and Fresco 1993). The amount of labor invested in a homegarden was, not surprisingly, related to the size of the family (labor availability) and its dependence on the homegarden. Children and young adults (below age 25) did not engage regularly in homegarden work. High labor investment did not necessarily translate into a higher number of zones or plant species. Two of the most intensively managed homegardens (i.e., with a high number of zones and plant species) in the type E category had labor inputs below the sample mean (homegardens 1 and 6). In both of these cases, one person who was very knowledgeable and experienced worked full-time to maintain the homegarden. This suggested that the quality and consistency of the labor were more influential on homegarden agroecological characteristics than the quantity of work hours invested.

Through the classification, homegarden types with different agroecological and socioeconomic characteristics were clearly identified. In order to maintain farmer perception, as reflected in the functional types identified in the field, a cluster analysis based on agroecological variables only was selected. Further assessment of socio-economic variables is needed in order to be able

to include them as part of a cluster analysis which provides a realistic classification corresponding to the way these farmers allocate their land to different uses. The classification further corroborates the high functional and structural diversity of homegardens that has been previously observed in other parts of the world (Brownrigg 1985; Fernandes and Nair 1986; Landauer and Brazil 1990b; Nair 1993).

In general, all homegardens contained a high diversity of plant species and uses, with the highest diversity in larger homegardens that were managed both for consumption and income generation (type E). The number of species per plant use reflected both a desire for variety in products for consumption (fruit trees, and different types of timber and firewood) as well as marketable items such as coffee, passion fruit and ornamentals.

The degree of dependence on the homegarden as a source of income influenced the types and numbers of zones and plant species that were present. In larger homegardens, ornamental and coffee zones were both present when families were dependent on the garden for at least half of their income (type E). In smaller homegardens that are used for income generation, ornamental zones occupy most of the homegarden area (type A). Homegardens that were not used to generate income were mostly devoted to fruit trees (types B and C).

Homegarden management strategies (exemplified here through zonation and plant species selection) were mostly affected by a family's income generating options and personal choices. With a few exceptions (homegardens 1, 11 and 12), homegardens at the site remained a flexible and complementary source of income, which is consistent with previous studies (Niñez 1987; Torquebiau 1992). This seems particularly important given the low-paying nature of the outside work in which most family members engaged (mostly manual agricultural or urban labor). For those families that did not depend on products for consumption or income, homegardens were important as space for work (type B) and relaxation. Although dependence on homegardens may vary according to specific conditions at a given time (i.e., availability of cash paying jobs), they remain a flexible resource that is consistently drawn upon to meet the needs of the family.

This study was an initial attempt to do an interdisciplinary analysis of tropical homegardens. A clear advantage to this approach is the inclusion of both biophysical and socioeconomic data, essential for understanding these complex systems. This approach can be used in rapid appraisals since it only requires basic interviews, sketches of zones (maps) and identification of plant uses to acquire a good, initial understanding of local homegarden design. In-depth agroecological and socioeconomic studies can proceed from there. This methodological approach should be appropriate for other traditional agroecosystems, but its further applicability needs to be tested in different ecological and socioeconomic conditions.

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