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Changing pattern of species composition and species utilization in homegardens of Kerala, India

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Abstract: Tropical homegardens are traditional agroforestry systems with complex structure and multiple functions. These multi-species production systems are regarded as the model systems for designing sustainable agroecosystems. However, with the advent of market economy, mixed species tropical homegardens are being transformed into single species dominant homegardens. The objective of this study was to analyze the impact of homegarden transformation on species diversity and also changing pattern of usage of species wealth by farmers in Kerala. The plant diversity index values ranged from 1.02 to 2.97 with significantly ($P < 0.05$) greater value in old mixed-species homegardens (OMSHG) followed by new mixed-species homegardens (NMSHG), old single species dominant homegardens (OSSHG) and new single-species homegardens (NSSHG). About 65 % - 83 % of total number of naturally growing species in mixed species homegardens and 20 % - 30 % in single species dominant homegardens are managed. The ratio between actual usage of species and the potential uses of species in each homegarden was calculated. The value obtained for naturally growing species was significantly greater ($P < 0.05$) in the old homegardens than in new homegardens. We conclude that the knowledge base on the properties and potential uses of naturally growing species in homegardens is depleting due to transformation of homegardens into single species dominant systems.

Resumen: Los huertos familiares tropicales son sistemas agroforestales tradicionales con una estructura compleja y numerosas funciones. Estos sistemas productivos multiespecíficos están considerados como sistemas modelo para el diseño de agroecosistemas sostenibles. Sin embargo, con la llegada de la economía de mercado, los huertos familiares tropicales de especies mixtas están siendo transformados en huertos familiares dominados por una sola especie. El objetivo de este estudio fue analizar el impacto de esta transformación sobre la diversidad de especies, así como el patrón de cambio de uso de esta abundancia de especies entre los granjeros en Kerala. El índice de diversidad vegetal fluctuó entre 1.02 y 2.97, con un valor significativamente mayor ($P < 0.05$) en huertos familiares viejos multiespecíficos (OMSHG, siglas en inglés), seguidos por los huertos familiares nuevos multiespecíficos (NMSHG), huertos familiares viejos de dominancia monoespecífica (OSSHG) y huertos familiares nuevos monoespecíficos (NSSHG). Alrededor de 65 % - 83 % del número total de especies silvestres en los huertos familiares multiespecíficos y 20 % - 30 % in huertos familiares con dominancia monoespecífica están siendo manejados. Se calculó el cociente entre el uso real y los usos potenciales de las especies en cada huerto familiar; el valor obtenido para las especies silvestres fue significativamente mayor ($P < 0.05$) en los huertos familiares viejos que en los nuevos. Concluimos que el conocimiento basado en las propiedades y usos potenciales de las especies silvestres en los huertos familiares está disminuyendo debido a la transformación de huertos familiares en sistemas con dominancia monoespecífica.

Resumo: As hortas-de-casa nos trópicos são sistemas agroflorestais tradicionais com estruturas complexas e multi-funcionais. Estes sistemas de produção multi-espécies são consi-

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deradas como sistemas modelo para o delineamento de agro-ecossistemas sustentáveis. No entanto, com o advento da economia de mercado, estes sistemas mistos estão sendo transformados em hortas mono-específicas com uma única espécie dominante. O objectivo deste estudo foi o de analisar o impacte da transformação das hortas-de-casa na diversidade de espécies e também da alteração do padrão de uso da riqueza de espécies pelos agricultores de Kerala. Os valores do índice de diversidade de plantas variaram entre 1,02 a 2,97 com um valor significativamente mais elevado ($P < 0,05$) nas antigas hortas-de-casa multi-específicas (OMSHG), seguido pelas novas hortas de espécies mistas (NMSHG), antigas hortas com uma única espécie dominante (OSSHG) e novas hortas com uma única espécie (NSSHG). Cerca de 65 % a 83 % do número total de espécies vegetando naturalmente em hortas-de-casa de espécies mistas e 20 % - 30 % em hortas com uma única espécie dominante, são geridas. O ratio entre o uso actual das espécies e os seus usos potenciais, em cada horta-de-casa, foi calculado. O valor obtido para as espécies vegetando naturalmente foi significativamente maior ($P < 0,05$) nas hortas antigas do que nas novas. Concluiu-se que a base de conhecimentos sobre as propriedades e os usos potenciais das espécies vegetando naturalmente nas hortas-de-casa está a esgotar-se devido à transformação das hortas em sistemas mono-específicos dominantes.

Key words: Homegardens, mixed-species systems, single species dominant systems, species diversity, species usage.

Introduction

A homegarden represents an operational farm unit which integrates trees with field crops and sometimes domestic animals around the homestead (Singh 1987; Rico-Gray *et al.* 1990). This farming system has attained international popularity due to the fact that the basic objective of the system is ensuring the sustained availability of multiple products (Michon *et al.* 1983), besides generating employment and cash income (Padoch & Jong 1991). According to Nair (1983), homegardens exemplify many agroforestry characteristics, i.e. the intimate mix of diversified agricultural crops and multipurpose trees fulfill most of the basic needs of the local population, while the multi-storied configuration and high species diversity of the homegardens help to reduce the environmental deterioration commonly associated with monocultural production systems. It is also pointed out that the average size of a homegarden, in several tropical and subtropical regions, is much less than a hectare (Nair & Sreedharan 1986). Very often, such small-sized landuse systems with monocropping are not viable, particularly in the rural ecosystems (Jose & Shanmugaratnam 1993). Thus, multi-tiered and multi-species structure is essentially the major feature identified for homegarden's socio-economic adaptability and stability, biological balance and resilience, and sustained productivity at a low-level equilibrium (Peyre *et al.* 2006). Home-gardens are often comparable, in terms of species diversity, with the nearby wet evergreen and semi-evergreen forests (Chandrashekara 1995). They are also regarded as the informal experimental stations for transfer, trial and adaptation of domesticated species. According to Ninez (1987) homegardens represent a "genetic back stop", preserving species and varie-ties that are not economic in field production and are planted in small scale for the reasons of taste preference, tradition, or availability of planting material. It is a known fact that in the tropical and subtropical countries many traditional communities have quite rich traditional knowledge and practices to conserve natural ecosystems and associated biodiversity. Similarly in these regions, many farming communities have traditional knowledge and practices for managing crop diversity and using bioresources sustainably; homestead farming is not an exception to this (Chandrashekara 1996).

Several authors (Michon & Mary 1994; Peyre *et al.* 2006) have pointed out that during the past few decades traditional homegardens have been subjected to different transformation processes in response to the changing socio-economic and cultural scenario. Wiersum (2006) described the factors such as introduction of typical Javanese homegardens into new regions due to the transmigra-

tion from the islands of Java to other islands, replacement of (semi) subsistence home-gardens by commercially oriented homegardens and development of urban-lifestyles in the rural area which is leading to the change of household dependency on production to include activities in the manufacturing or service and trade sectors, which are responsible for the transformation of homegardens in Indonesia. Limited information is available to highlight the consequences of the drastic structural and functional modifications, including the homogenization of homegarden structure and use of external inputs, on biodiversity and environmental conservation and the productivity (Wiersum 2004). However, the impact of modernization of homegardens on the farmers' knowledge-base on species diversity and use patterns are not documented.

In Kerala, homestead farming is the most prevalent landuse systems covering about 88 % of the total land holding and about 41 % of the total cultivable area of the State. Despite the fact that the average size of the traditional homegardens is much less than a hectare (0.5 ha: Nair & Sreedharan 1986), they possess multi-tiered and multi-species structure which is essentially the major feature identified for their socio-economic adaptability and stability, biological balance, and sustainable productivity at a low-scale equilibrium (Jose & Shanmugaratnam 1993). However, traditional homegardens are subject to different conversion processes linked to socio-economic changes. Thus, homegardens of Kerala can now broadly be categorized into mixed-species homegardens and single species dominant homegardens. Aim of this paper is thus to analyse these to categories of homegardens for species diversity, farmers' knowledge related to the uses of different species and changing pattern in usage of species wealth in each homegarden type.

Materials and methods

Study area

The study was conducted in Vazhikadavu Panchayat (a Panchayat is a group of villages which constitute the basic unit of rural administration. Each Panchayat generally covers between two to twenty villages, depending on the size of the villages), Malappuram District, Kerala located between 76º 19' and 76º 23' E longitude and 11º 23' and 11º 25' N latitude. The average family size in the Panchayat is 4 individuals. When adult male and female members of each family are considered, 99 % of them are literate and among them 10 % are post-graduates, 40 % are graduates while the rest with primary or secondary education. About 97 % of the landholdings are less than 2 hectares with majority of the landholders being agriculturists (Chandrashekara *et al.* 2008).

Climate

The climate in the study area is typically monsoonic with annual rainfall varying from 1621 mm to 3271 mm (mean over 1990 - 2007: 2312 mm). More than 65 % of annual rainfall is drawn from the southwest monsoon during June-August period. The northeast monsoon, which sets in October and lasts till the end of November, accounts for much less rainfall (hardly 25 % of annual rainfall). The mean annual maximum and minimum temperatures are 35 ºC and 15 ºC, respectively. Soils are acidic (pH 5.6 - 6.2) and gravelly clay loam. In general, soils are poor in total nitrogen (0.05 - 1.2 %), available phosphorus (7.4 - 14.0 ppm), exchangeable potassium (0.15 - 0.23 Cmol (+) kg^{-1}) and organic carbon (1.0 - 2.0 %) (Chandrashekara *et al.* 2008).

Selection of homegardens

In Vazhikadavu Panchayat, an area of 10.08 km^2 (4.2 km x 2.4 km) was selected and divided into 200 m x 200 m grids. Grid intersection points were marked using Geographic Positioning System. Out of 264 grid intersection points thus obtained, fifty three points were in the homegardens while the remaining points were in other landuse systems such as paddy fields, degraded forests, and monoculture plantations of coconut, arecanut, rubber, cashew and teak. Representatives of fifty three homegardens were invited for a formal discussion. During the discussion, it was recorded that out of fifty three homegardens, twenty one homegardens were between 16 to 20 year old age group (hereafter old homegardens) and the remaining were between 12 to 16 year old age group (hereafter new homegardens). Further visits to these homegardens and discussions with the farmers indicated that eleven old homegardens were characterized by the cultivation of more than three perennial crop species (tree species such as jackfruit, mango, nutmeg, etc. and palms like coconut and arecanut) and no single species showed dominance in terms of density. These homegardens were considered as mixed-species home-

gardens (hereafter old mixed-species homegardens; OMSHG). Similarly, ten new homegardens were also mixed-species homegardens (hereafter new mixed-species homegardens; NMSHG). In ten old homegardens and twenty two new homegardens, single species dominance (either coconut or arecanut) was recorded and they are termed as old single-species homegarden (OSSHG) and new single-species homegardens (NSSHG), respectively. The size of the homegardens ranged from 0.75 to 1.0 ha. For detailed studies, thirty two homegardens, eight from each type, were randomly selected.

Phytosociological analysis

Through fortnightly visits over a period of one year, species present in each homegarden were identified using regional flora (Gamble 1928; Sivarajan & Mathew 1997) and the check list was prepared.

In each homegarden, twelve quadrats, each of 10 m x 10 m size were marked. All trees and palms present in each quadrat were identified, counted and the Gbh (girth measured at 1.37 m above the ground level) was recorded. To estimate the density and basal area of shrub community, four sub-quadrats, each of 5 m x 5 m of size, nested in each of the quadrats laid for tree enumeration were used. For estimating herb density, four sub quadrats, each of 1 m x 1 m, nested in each of the quadrats laid for tree enumeration were used. Since herb density was more and measurement of girth of individual plant of herbs, particularly of trailing herbs was tedious and time consuming, their biomass was estimated. All herbs within each sub-quadrat were uprooted, sorted into different species and weighed after air drying for constant weight. Density-based species diversity index values were calculated for the tree and shrub communities using the following equation (Shannon & Wiener 1963):

$$H= -\sum(n_i/N) \times \ln (n_i/N)$$

Where, n_i= Density of a species
and N= Density of all species

Species diversity index value for the herb community was calculated based on biomass of individual species using the above formula.

Species usage patterns in homegardens

After preparing the checklist of species present in the selected thirty two homegardens, a meeting attended by about fifty farmers was organized, during which the uses of each plant species in general and plant parts in particular known to the farmers were recorded. Thus number of potential uses of individual species as perceived by the farmers was recorded.

Subsequently, each homegarden was visited along with the residents to record the species and plant part(s) of each species being used. During the visit and at the time of species inventory, species were categorized into two groups namely (a) species planted by the farmer and (b) species growing naturally and either managed or not managed by the farmer. Depending on the requirements of the species, both planted species and naturally growing managed species are subjected to different management practices such as sanitary pruning, rejuvenating pruning, canopy pruning, cutting of low branches, weeding, fertilization, control of pests and diseases, protection from competitors and watering. The number of actual uses of each species present in the homegarden was recorded and the ratio between the number of actual uses of a species in a homegarden and the number of potential uses of that species was calculated.

Statistical analyses

The significance of differences between four types of homegardens for each parameter such as plant density, basal area, species diversity index value, number of managed species, ratio between the number of actual uses of a species in a homegarden and the number of potential uses of that species ratio between number of actual uses were tested separately by analysis of variance (ANOVA). Differences were deemed to be significant when $P < 0.05$ according to the Least Significant Difference (LSD) Tests.

Results and discussion

The Kerala homegardens traditionally represent a complex system with cultivated, semi-cultivated and retained plants, mainly perennials and semi-perennials (Chandrashekara & Sankar 2008). In the present study, 185 species are recorded from 32 homegardens (Appendix Table 1). Available literature from Kerala also indicated that over 170 species were recorded from an inventory made in 228 randomly selected homegardens in the State (Sankar & Chandrashekara 2002) and 179 species from 80 homegardens in a village (Jose 1991). Inventory of plants in the live fenced 60 homegardens of Kerala registered 68 species (Chandrashekara *et al.* 1997). Thus, Kumar & Nair (2004)

aptly regarded homegardens 'as the glorious examples of species diversity in cultivated and managed plant communities'.

Coconut palm (*Cocos nucifera*), arecanut palm (*Areca catechu*), mango (*Mangifera indic*a) and jackfruit trees (*Artocarpus heterophyllus*) have been recorded from 31, 30, 28 and 21 homegardens, respectively (Appendix Table 1). In sixteen homegardens, coconut palm is the most dominant overstorey species and in the remaining 16 homegardens the species is co-dominant with arecanut palm, mango, jackfruit tree and other fruit and multipurpose trees. Thus, as reported elsewhere in Kerala, in the study area also 'the coconut palms form the architectural base of the homegardens around which the other components are orchestrated' (Jose & Shanmugaratnam 1993).

One of the striking features of homegardens of Kerala is the wide variation in tree density and basal area. For instance, Kumar *et al.* (1994) estimated 239-319 individuals ha^{-1} from homegardens located in different agroclimatic zones of the State. Similarly, Sankar & Chandrashekara (2002) reported tree and palm density of 750 to 4600 individuals ha^{-1} from seven agroclimatic zones. However, in the present study trees and palm density ranged from 466 to 1378 individuals ha^{-1}, with significantly higher ($P < 0.05$) values in the mixed species homegardens than in single species dominant homegardens (Table 1). Thus it may be concluded that farmers who maintain significantly large number of species also have the traditional technical know-how to maintain a large number of individuals of each species. On the other hand, homegardeners who maintain the single species dominant system prefer to possess low stand density. The higher stand density in mixed species homegardens can be attributed to the multi-strata canopy structure of the system. The vertical stratification provides a gradient in light and relative humidity, which creates different niches for enabling various species and their individuals to exploit them (Kumar & Nair 2004). In the OMSHGs, shrub density and herb biomass were significantly higher ($P < 0.05$) than in all other systems. However, in general, no significant difference ($P > 0.05$) in density and basal area/biomass herb and shrub components in OSSHG, NMSHG and NSSHG was recorded; this may be due to inter-site differences in understorey management.

The density-based index of diversity for trees and palm components ranged from 1.02 to 2.97 with significantly higher ($P < 0.05$) values in OMSHG followed by NMSHG, OSSHG and NSSHG. Similarly, species diversity index values for herbs and shrubs are also more in mixed species homegardens. These observations also sup-port the fact that MSHGs are the systems where several crops/plant species are not only present but also where the density is distributed well among a large number of species, unlike in the single species dominant species system.

Joint species inventory by the research team and the homegardeners in each homegarden enabled to categorise the species into planted and managed species and naturally grown species. Further analysis of species composition indicated that the number of planted and managed species in OMSHG, OSSHG and NMSHG is not significantly different ($P > 0.05$), while comparatively less in NSSHGs ($P < 0.05$) (Table 2). However, naturally growing species were significantly more ($P > 0.05$) in OMSHG followed by NMSHG, OSSHG and NSSHG.

The study also revealed that the homegardeners do not manage all naturally growing plants. It was also noticed that a given naturally growing species that is managed in one homegarden may not be managed in the other homegarden. According to the farmers several factors are considered before managing or not managing a given naturally growing species. For instance, generally species which are sparsely distributed with poor density and biomass are not managed. On the other hand, farmers manage those species which adversely affect the growth and yield of major crops in the garden. Farmers also pointed out that they do not spend time and energy for managing the seasonal and herbaceous species and those species whose uses are unknown to them. Data collected on the management of naturally growing species has revealed that about 65 % - 83 % of total number of such species in mixed species homegardens and only 20 % - 30 % in single species dominant homegardens are managed.

On an average, 73 % to 87 % of total number of species present in a homegarden is being used by the homegardeners for one or more purposes (Table 2). The study also showed a significant variation ($P < 0.05$) in the usage of planted species and naturally growing species in a homegarden. It is discernible that 91 % to 95 % of total number of planted species are being used. However, only about 44 % to 77 % of total number of naturally growing species are put under some uses.

Table 1. Basic information on vegetation in homegardens of in Vazhikkadavu Panchayat, Kerala, India. Values are Mean ± SE, N = 8 homegardens. Values in a row with same alphabets in the superscript are not significantly different at the level of P value > 0.05.

Parameter	OMSHG§	OSSHG	NMSHG	NSSHG
Total number of species	52 ± 1.3^{a}	37 ± 1.1^{b}	39 ± 2.3^{b}	18 ± 0.5^{c}
		Trees and palms		
Density (individuals ha^{-1})	1378 ± 55^{a}	490 ± 48^{b}	1204 ± 73^{a}	466 ± 53^{b}
Basal area (m^{2} ha^{-1})	17.5 ± 1.83^{a}	8.9 ± 1.38^{bc}	14.5 ± 1.81^{b}	7.5 ± 0.85^{c}
Species diversity index (H)	2.97 ± 0.12^{a}	1.26 ± 0.33^{b}	2.52 ± 0.08^{c}	1.02 ± 0.13^{b}
		Shrubs		
Density (individuals ha^{-1})	562 ± 38^{a}	412 ± 16^{b}	527 ± 41^{c}	376 ± 23^{b}
Basal area (cm^{2} ha^{-1})	333 ± 21^{a}	312 ± 26^{a}	269 ± 44^{a}	269 ± 33^{a}
Species diversity index (H)	2.26 ± 0.08^{a}	2.13 ± 0.22^{a}	2.36 ± 0.32^{a}	1.89 ± 0.12^{b}
		Herbs		
Density (individuals ha^{-1})	312 ± 21^{a}	258 ± 25^{a}	179 ± 27^{b}	218 ± 24^{a}
Biomass (g m^{-2})	1147 ± 70^{a}	779 ± 126^{b}	530 ± 94^{b}	677 ± 94^{b}
Species diversity index (H)	3.75 ± .0.23^{a}	2.34 ± 0.42^{b}	2.98 ± 0.39^{c}	1.98 ± 0.33^{b}

OMSHG§ : Old mixed-species homegarden; OSSHG: Old single-species dominant homegarden; NMSHG: New mixed-species homegarden; NSSHG: New single-species dominant homegarden.

Table 2. Basic statistics on the potential uses and actual usage of planted and managed species and naturally grown, managed or not managed species in homegardens of in Vazhikkadavu Panchayat, Kerala, India. Values are Mean ± SE, N = 8 homegardens. Values in a row with same alphabets in the superscript are not significantly different at the level of P value > 0.05.

	OMSHG§	OSSHG	NMSHG	NSSHG
		Number of species		
Planted and managed	23 ± 1.0^{a}	25 ± 1.3^{a}	19 ± 2.2^{a}	10 ± 1.0^{b}
Naturally grown, managed or not managed.	29 ± 1.8^{a}	11 ± 1.0^{b}	20 ± 1.6^{c}	8 ± 1.0^{b}
All	52 ± 1.3^{a}	37 ± 1.1^{b}	39 ± 2.3^{b}	18 ± 0.5^{c}
		Number of species being used		
Planted and managed	21 ± 0.8^{ab}	24 ± 1.2^{a}	17 ± 2.2^{b}	9 ± 0.9^{c}
Naturally grown, managed or not managed.	22 ± 2.1^{a}	8 ± 0.6^{b}	15 ± 1.7^{c}	4 ± 1.0^{b}
All	44 ± 1.8^{a}	32 ± 1.0^{b}	32 ± 2.0^{b}	13 ± 0.6^{c}
		Total number of potential uses of species		
Planted and managed	87.9 ± 3.7^{a}	96.9 ± 4.7^{a}	65.0 ± 8.2^{b}	43.5 ± 4.1^{b}
Naturally grown, managed or not managed.	82.1 ± 8.5^{a}	31.3 ± 2.8^{a}	62.8 ± 3.4^{b}	23.6 ± 3.7^{b}
All	170 ± 10.0^{a}	128 ± 5.2^{b}	128 ± 9.1^{b}	67 ± 4.3^{c}
		Total number of actual usage of species		
Planted and managed	44.4 ± 2.0^{ab}	51.6 ± 4.3^{a}	35.8 ± 3.2^{b}	23.0 ± 1.1^{c}
Naturally grown, managed or not managed.	27.3 ± 3.7^{a}	9.6 ± 0.7^{bc}	17.3 ± 2.1^{b}	3.4 ± 0.8^{c}
All	71.6 ± 4.0^{a}	61.3 ± 4.6a^{b}	53.0 ± 3.2^{b}	26.4 ± 1.0^{c}
		Ratio (in %) between actual usage and potential uses of species		
Planted and managed	50.9 ± 2.5^{ns}	53.1 ± 2.5^{ns}	57.0 ± 3.0^{ns}	55.0 ± 3.8^{ns}
Naturally grown, managed or not managed	32.2 ± 2.0^{a}	32.9 ± 4.5^{a}	27.1 ± 2.3^{ab}	14.2 ± 3.6^{b}
All	42.4 ± 1.3^{ns}	47.8 ± 2.8^{ns}	41.8 ± 1.3^{ns}	40.6 ± 3.0^{ns}

OMSHG§ : Old mixed-species homegarden; OSSHG: Old single-species dominant homegarden; NMSHG: New mixed-species homegarden; NSSHG: New single-species dominant homegarden.

Mean number of potential uses of all species in a given homegarden ranged from 67 in case of NSSHGs and 170 in OMSHGs. When the planted species alone are considered, total potential uses are significantly more ($P < 0.05$) in old home gardens than in new homegardens. However, total number of potential uses of naturally growing species is significantly greater in OMSHG than in NMSHG.

The ratio between actual usage of species and the potential uses of species in each homegarden was calculated. The value ranged from 41 % to 48 % without significant difference between ($P > 0.05$) homegarden types. When similar calculation was made for planted species, the value obtained for naturally growing species was significantly higher ($P < 0.05$) in the old homegardens than in new homegardens.

Conclusions

Homegardens of Kerala have been changing from mixed crop farming system to cash-crop dominant system. It may be pointed out here that based on the structural and functional characteristics and dynamics, homegardens of Kerala have been categorized into traditional homegardens, adapted traditional homegardens, incipient modern homegardens and modern homegardens (Peyre *et al.* 2006). While the old mixed species homegardens (OMSHG) of the present study could be equated with the traditional homegardens of Peyre *et al.* (2006), old single species dominant homegardens (OSSHG) may represent either incipient modern homegardens or adapted traditional homegardens. On the other hand, the new mixed species homegardens (NMSHG) and new single species homegardens (NSSHG) can be included under incipient modern homegardens and modern homegardens categories, respectively. Such a transformation from traditional homegardens to modern homegardens has implication on species diversity as the number of species, particularly naturally grown species, are less in the modernized homegardens. Similarly, actual usage of naturally growing species in the homegardens was also less in the modernized homegardens. It may also be pointed out here that the homegardeners' knowledge on the properties and potential uses of homegarden species are not spread well among the homegardeners of the study area. Even in the old mixed species homegardens, low value for the ratio between actual usage of species and the potential uses of species (42 % to 47 %) was recorded. Changing socio-economic conditions and available alternate resources (eg. inorganic fertilizer, allo-pathic medicine etc.) are possibly responsible for the depletion of traditional knowledge on use of plant diversity in the homegardens and decline in the usage of naturally growing species; with more pronounced impact in modernized homegardens. In view of the fact that traditional homegardens are ecologically sustainable (Jose & Shanmugaratnam 1993) and still the traditional knowledge on species diversity, cultivation and management of components of homegardens are prevailing; attempts may be made to revive the economically viable and ecologically sustainable mixed species homegardens.

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References

Chandrashekara, U.M. 1995. Ecological and economic benefits of tree components in homestead farming systems of Kerala. pp. 104-108. *In*: P.P. Pillai & R.P. Nair (eds.) *Understanding Ecologically Sustainable Economic Development*. Institute of Planning and Applied Economic Research, Dr. John Mathai Centre, Thrissur, Kerala.

Chandrashekara, U.M. 1996. Strengths and weaknesses of traditional systems of bamboo cultivation in rural Kerala. *Agroforestry Forum* **7**: 21-23.

Chandrashekara, U.M., M. Balasundaram, K.V. Sankaran, M.P. Sujatha, R.V. Varma, B.K. Senapati & Manviak Sahgal. 2008. *Conservation and Sustainable Management of Belowground Biodiveristy in the Kerala Part of nigiri Biosphere Reserve*. KFRI Research Report No. **316**. Kerala Forest Research Institute, Peechi, India.

Chandrashekara, U.M. & S. Sankar. 2008. Ecological and socioeconomic dimensions of homegardens of Kerala. pp. 247-260. *In*: M. Connan & W. Chen (eds.)

Gardens, City Life and Culture. Dumbarton Oaks, Washington DC.

Chandrashekara, U.M., S. Sankar, P.K. Shajahan, M.E. Blowfield & E.R. Boa. 1997. Fencing patterns in homegardens of Kerala, India: a case study. *Range Management & Agroforestry* **18**: 41-53.

Gamble, J.S. 1928. *Flora of the Presidency* of *Madras*. **3** Volumes. Adlered & Son Limited, London.

Jose, D. 1991. *Homegardens of Kerala: Small and marginal farmers' response to change in agrarian structure and environmental constraints*. Dissertation, Agricultural University of Norway, Norway.

Jose, D. & N. Shanmugaratnam. 1993. Traditional home gardens of Kerala: A sustainable human ecosystem. *Agroforestry Systems* **24**: 203-213.

Kumar, B.M. & P.K.R. Nair. 2004. The enigma of tropical homegardens. *Agroforestry Systems* **61**: 135-152.

Kumar, B.M., S.J. George & S. Chinnamani. 1994. Diversity, structure and standing stock of wood in the home gardens of Kerala in Peninsular India. *Agroforestry Systems* **25**: 243-262.

Michon, G. & F. Mary. 1994. Conversion of traditional village gardens and new economic strategies of rural household in the area of Bogor, Indonesia. *Agroforestry Systems* **25**: 31-58.

Michon, G., J. Bompard, P. Hecketsweiler & C. Ducatillion. 1983. Tropical forest architectural analysis applied to agroforestry in the humid tropics, the example of traditional village agro-forestry in West Java. *Agroforestry Systems* **1**: 117-129.

Nair, M.A. & C. Sreedharan. 1986. Agroforestry farming system in the homesteads of Kerala, Southern India. *Agroforestry Systems* **4**: 339-363.

Nair, P.K.R. 1983. Agroforestry with coconuts and other tropical plantation crops. pp. 80-102. *In*: P.A. Huxley (ed.) *Plant Research and Agroforestry*. International Council for Research in Agroforestry, Nairobi.

Ninez, V.K. 1987. Household gardens: theoretical considerations on an old survival strategy. *Agricultural Systems* **23**: 167-186.

Padoch, C. & W. de Jong. 1991. The homegardens of Santa Rosa: diversity and variability in an Amazonian agricultural system. *Economic Botany* **45**: 166-175.

Peyre, A., A. Guidal, K.F.Wiersum & F. Bongers. 2006. Dynamics of homegarden structure and function in Kerala, India. *Agroforestry Systems* **66**: 101-115.

Rico-Gray, V., F.J.G. Garcia, A. Chemas, A. Puch & P. Sima. 1990. Species composition, similarity, and structure of Mayan homegardens in Tixpeual and Tixcacaltuyub, Yucatan, Mexica. *Economic Botany* **44**: 470-487.

Sankar, S. & U.M. Chandrashekara. 2002. *Development and Testing of Sustainable Agroforestry Models in Different Agroclimatic Zone of Kerala with Emphasis on Socio-cultural, Economic, Technical and Institutional Factors Affecting the Sector*. KFRI Research Report 234. Kerala Forest Research Institute, Peechi, Kerala, India.

Shannon, C.F. & W. Wiener. 1963. *The Mathematical Theory of Communication*. University of Illinois Press, Urbana, IL.

Singh, G.B. 1987. Agroforestry in the Indian sub-continent: past, present and future. pp. 117-138. *In*: H.A. Steppler & P.K.R. Nair (eds.) *Agroforestry: A Decade of Development*. International Centre for Research in Agroforestry, Nairobi.

Sivarajan, V.V. & P. Mathew. 1997. *Flora of Nilambur (Western Ghats of Kerala)*. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Wiersum, K.F. 2004. Forest gardens as an intermediate land-use system in the nature-culture continuum: characteristics and future potential. *Agroforestry Systems* **61**: 123-134.

Wiersum, K.F. 2006. Diversity and change in homegarden cultivation in Indonesia. pp. 13-24. *In*: B.M. Kumar & P.K.R. Nair (eds.) *Tropical Home-gardens: A Time-tested Example of Sustainable Agroforestry*. Springer, The Netherlands.

Appendix Table 1. Species observed in homegardens and number of potential uses of each species as perceived by the farmers of Vazhikkadavu Panchayat, Kerala, India. N = 8 homegardens.

S. No.	Species	Number of potential uses	Number of homegardens in which the species present			
			OMSHG§	OSSHG	NMSHG	NSSHG
1	*Abelmoschus esculentus*	5	2	0	4	1
2	*Abrus precatorius*	3	1	0	0	1
3	*Achyranthes aspera*	2	3	0	1	2
4	*Acorus calamus*	1	4	2	1	1
5	*Adathoda vasica*	4	6	3	2	0
6	*Adiantum lunulatum*	1	0	0	0	2
7	*Aegle marmelos*	4	3	1	0	0
8	*Aerva lanata*	9	8	6	3	3
9	*Ageratum conyzoides*	3	1	0	3	2
10	*Allamanda cathartica*	2	3	0	1	0
11	*Aloe vera*	2	2	3	1	0
12	*Alstonia scholaris*	1	3	1	3	0
13	*Alysicarpus vaginalis*	2	1	1	1	1
14	*Amaranthus gangeticus*	2	3	6	5	0
15	*Anacardium occidentale*	7	3	4	3	0
16	*Ananas sativus*	1	6	6	2	2
17	*Andrographis paniculata*	3	3	0	2	1
18	*Annona squamosa*	4	1	1	3	2
19	*Areca catechu*	5	8	8	7	7
20	*Aristolochia indica*	2	4	3	3	2
21	*Artocarpus heterophyllus*	6	8	6	4	3
22	*Artocarpus hirsutus*	3	3	2	2	0
23	*Asparagus racemosus*	1	2	1	2	0
24	*Averrhoa bilimbi*	2	2	3	1	0
25	*Azadirachta indica*	5	4	1	5	2
26	*Bacopa monnieri*	5	2	1	3	0
27	*Bambusa bambos*	4	4	0	1	3
28	*Bauhinia purpurea*	2	2	0	1	1
29	*Bauhinia tomentosa*	1	0	0	1	0
30	*Biophytum sensitivum*	2	3	1	3	3
31	*Boerhaavia diffusa*	4	2	4	2	1
32	*Bridelia retusa*	1	0	1	1	0
33	*Butea monosperma*	5	3	0	1	0
34	*Caesalpinia pulcherrima*	4	3	1	1	1
35	*Calicopteris floribunda*	3	7	6	3	2
36	*Calophyllum inophyllum*	3	1	1	2	0
37	*Calotropis gigantea*	3	3	0	1	1
38	*Cananga odorata*	0	0	0	0	1
39	*Capsicum annum*	2	6	7	3	1

Contd...

Appendix Table 1. Continued.

Sl No.	Species	Number of potential uses	Number of homegardens in which the species present			
			OMSHG§	OSSHG	NMSHG	NSSHG
40	*Cardamine hirsuta*	4	2	0	3	1
41	*Cardiospermum halicacabum*	5	5	5	2	0
42	*Carica papaya*	3	8	8	1	0
43	*Carissa carandas*	1	1	0	1	0
44	*Cassia occidentalis*	4	3	1	1	0
45	*Cassia tora*	1	1	0	2	0
46	*Catharanthus roseus*	4	1	0	2	1
47	*Centella asiatica*	5	3	0	3	2
48	*Ceratopteris sp.*	1	1	0	0	1
49	*Cinnamomum verum*	2	0	0	0	1
50	*Citrus medica*	2	0	4	1	0
51	*Cleome viscosa*	2	1	0	0	0
52	*Clerodendron paniculatum*	3	1	1	1	0
53	*Clitoria ternatea*	2	1	0	1	1
54	*Cocos nucifera*	9	8	8	7	8
55	*Coffea robusta*	3	2	0	2	0
56	*Coleus aromaticus*	1	3	2	2	0
57	*Coleus parviflora*	1	1	1	1	0
58	*Colocasia esculenta*	2	1	1	2	1
59	*Commelina benghalensis*	1	2	0	1	0
60	*Corchorus acutangulus*	1	1	0	0	1
61	*Cordia myxa*	2	0	1	0	0
62	*Costus speciosus*	1	0	0	1	0
63	*Cucumis sativus*	2	1	0	2	1
64	*Curculigo orchioides*	1	3	3	2	1
65	*Curcuma longa*	2	3	0	4	2
66	*Cyathula prostrata*	2	1	2	1	1
67	*Cyclea peltata*	1	4	2	2	1
68	*Cynadon dactylon*	2	7	6	2	2
69	*Cyperus rotundus*	1	8	5	3	2
70	*Desmodium triflorum*	2	0	1	1	0
71	*Dioscorea esculenta*	2	1	0	1	0
72	*Eclipta alba*	5	5	3	4	0
73	*Elettaria cardamomum*	2	1	0	1	0
74	*Emblica officinalis*	4	6	4	3	1
75	*Emilia sonchifolia*	2	2	3	2	2
76	*Erythrina indica*	1	2	0	0	0
77	*Eugenia jambosa*	2	1	2	4	1
78	*Eupatorium odoratum*	3	4	1	4	1
79	*Euphorbia hirta*	2	2	0	0	0

Contd...

Appendix Table 1. Continued.

Sl No.	Species	Number of potential uses	Number of homegardens in which the species present			
			OMSHG§	OSSHG	NMSHG	NSSHG
80	*Ficus asperima*	1	0	1	0	0
81	*Garcinia gummi-gutta*	2	4	3	2	1
82	*Gardenia jasminoides*	1	1	1	0	1
83	*Gliricidia sepium*	6	4	1	2	0
84	*Gloriosa superba*	1	0	1	0	0
85	*Glycosmis pentaphylla*	4	3	0	0	0
86	*Gmelina arborea*	2	0	0	1	0
87	*Gomphrena decumbens*	0	0	0	1	0
88	*Grewia tiliaefolia*	2	0	1	1	0
89	*Haevea brasiliensis*	1	0	1	1	0
90	*Haldina cordifolia*	3	0	2	0	0
91	*Hedychium coronarium*	1	1	0	1	0
92	*Helicteres isora*	5	1	1	2	1
93	*Heliotropium indicum*	1	0	1	0	1
94	*Hemidesmus indicus*	3	3	2	1	2
95	*Hibiscus rosa-sinensis*	2	8	6	3	1
96	*Hibiscus tiliaceus*	2	1	0	1	0
97	*Holarrhena antidysenterica*	4	4	0	0	0
98	*Hygrorrhiza aristata*	0	1	0	0	0
99	*Hyptis capitata*	0	1	0	0	0
100	*Hyptis sauveolens*	2	0	2	1	0
101	*Ichnocarpus frutiscens*	1	3	1	0	1
102	*Ipomoea batatas*	1	1	0	0	0
103	*Isachne globosa*	1	5	6	0	1
104	*Ischaemum rugosum*	1	5	6	0	1
105	*Ixora coccinea*	4	8	7	0	0
106	*Justicia simplex*	0	1	0	0	0
107	*Knoxia corymbosa*	0	1	0	0	0
108	*Lantana camera*	3	1	0	0	0
109	*Lawsonia inermis*	2	3	2	1	1
110	*Leucas aspera*	4	1	2	1	2
111	*Ludwigia parviflora*	2	1	0	0	0
112	*Macaranga peltata*	4	4	1	1	2
113	*Mangifera indica*	4	8	8	7	5
114	*Manihot utilissima*	2	2	2	6	1
115	*Manilkara achras*	1	0	0	1	1
116	*Maranta arundinacea*	2	1	0	1	0
117	*Michelia champaca*	5	0	0	2	1
118	*Mimosa pudica*	1	1	1	0	0
119	*Mimusops elengi*	3	0	1	0	0
120	*Mollugo pentaphylla*	2	1	0	0	0

Contd...

Appendix Table 1. Continued.

Sl No.	Species	Number of potential uses	Number of homegardens in which the species present			
			OMSHG§	OSSHG	NMSHG	NSSHG
121	*Momordica charantia*	2	0	1	2	0
122	*Moringa oleifera*	8	7	7	4	0
123	*Morus alba*	2	7	7	4	0
124	*Murrya koenigii*	2	0	1	0	0
125	*Musa paradisiaca*	8	4	5	4	1
126	*Musa sapientum*	8	8	7	2	6
127	*Mussaenda frondosa*	2	8	7	2	6
128	*Myristica fragrans*	2	2	2	0	1
129	*Ocimum basilicum*	5	3	1	1	2
130	*Ocimum sanctum*	5	1	0	1	0
131	*Oldenlandia umbellata*	6	6	2	2	0
132	*Olea dioica*	2	1	1	0	0
133	*Oplisminus compositus*	1	0	1	1	0
134	*Oxalis corniculata*	5	3	0	2	0
135	*Paspalum scorbiculatum*	1	1	1	2	0
136	*Passiflora edulis*	2	5	6	2	0
137	*Passiflora foetida*	3	1	0	0	0
138	*Peperomia pellucida*	2	2	1	2	0
139	*Phyllanthus amarus*	2	1	0	1	0
140	*Phyllanthus urinaria*	2	0	1	0	0
141	*Physalis minima*	2	0	1	0	0
142	*Pilea microphylla*	0	4	0	0	0
143	*Piper betel*	1	1	0	0	0
144	*Piper longa*	3	0	0	7	1
145	*Piper nigram*	2	1	0	1	0
146	*Pothos scandens*	2	4	2	3	3
147	*Pouzolzia indica*	0	0	2	0	0
148	*Pseudarthria viscida*	1	1	0	0	0
149	*Psidium guajava*	3	1	2	0	0
150	*Pteris sp.*	2	7	8	1	3
151	*Ricinus communis*	7	0	2	0	0
152	*Salvia splendens*	0	0	0	1	0
153	*Schleichera oleosa*	4	0	0	2	0
154	*Scoparia dulcis*	6	1	1	1	0
155	*Sida rhombifolia*	3	2	1	1	2
156	*Solanum torvum*	3	4	0	1	2
157	*Solanum melongena*	2	0	1	0	1
158	*Solanum nigrum*	5	0	1	3	1
159	*Sphaeranthus indicus*	5	4	0	3	1
160	*Spilanthus acmella*	5	1	1	1	0

Contd...

Appendix Table 1. Continued.

Sl No.	Species	Number of potential uses	Number of homegardens in which the species present			
			OMSHG§	OSSHG	NMSHG	NSSHG
161	*Stachytarpheta indica*	2	3	2	1	0
162	*Streblus asper*	0	0	1	0	0
163	*Strychnos nux-vomica*	3	1	0	1	0
164	*Swietenia macrophylla*	1	1	0	1	0
165	*Synedrella nodiflora*	1	1	0	1	0
166	*Syzigium cuminii*	4	1	0	0	0
167	*Tabernaemontana coronaria*	1	3	0	2	0
168	*Tamarindus indicus*	5	1	0	1	0
169	*Tectona grandis*	3	4	1	2	0
170	*Terminalia cattapa*	5	4	4	5	6
171	*Terminalia paniculata*	3	1	1	1	0
172	*Theobroma cacao*	2	4	2	1	1
173	*Thespesia populnea*	4	0	0	1	0
174	*Trema orientalis*	3	1	1	2	0
175	*Trichosanthes cucumeriana*	2	1	0	2	0
176	*Tridax procumbens*	1	1	0	3	0
177	*Triumfetta rhomboidea*	1	3	0	0	0
178	*Urena lobata*	1	1	0	2	0
179	*Vernonia cinerea*	6	0	0	1	0
180	*Vetiveria zizanoides*	1	0	4	2	0
181	*Vigna unguiculata.*	1	0	0	1	1
182	*Waltheria indica*	0	5	5	3	1
183	*Wrightia tinctoria*	2	1	0	0	0
184	*Zingiber officinale*	2	2	0	0	0
185	*Zizyphus oenoplea*	2	2	0	2	0

OMSHG§ : Old mixed-species homegarden; OSSHG: Old single-species dominant homegarden; NMSHG: New mixed-species homegarden; NSSHG: New single-species dominant homegarden.