AN ASSESSMENT OF THE ECOLOGICAL AND SOCIOECONOMIC BENEFITS PROVIDED BY HOMEGARDENS: A CASE STUDY OF KERALA, INDIA

By

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Homegardens are intensive land-use systems involving the management of woody species grown in deliberate association with herbaceous species, with or without livestock, managed within the compounds of individual homes. These systems, which are found mainly in the tropics and subtropics, are of immense importance in the socioeconomic settings of local communities. This dissertation examined the benefits provided by these systems, both to the individual household and to the community, based on a case study in the state of Kerala, in southern India.

The study of the economic benefits was a four-step process that started with listing the inputs and outputs that made up the annual financial cycle of these gardens. Then, a cost-benefit-analysis was conducted to estimate the net financial values for all the surveyed households. The next step was a sensitivity analysis of the risks posed by labor and market price fluctuations. The final step ascertained whether the homegardens were a better economic alternative for farmers than leasing or selling the land.

The ecological analysis focused mainly on estimating the ecological diversity of these systems. The species compositions were found to be fairly similar across different size categories of homegardens. The homegardens were similar to natural forests in the region, in terms of species richness and species diversity. Although land size seemed to be the biggest constraint for profit generation, it did not affect species composition or species diversity. Species richness was found to cause a slightly negative effect on profit values. Medicinal plants were also very important in these systems and were found in all the surveyed gardens. Members of the household, including females, spent considerable amount of their time in tending the homegardens. Intensity of both profit generation and household labor input was highest in the smallest gardens. The economic decision-making power was equally invested in male and female heads of household.

This study indicated that these agroforestry systems were economically profitable for the small-farm household, and were resilient to shifts in the prices of labor or commercial crops. Homegarden cultivation was estimated to be the better economic option for such landowners, even considering the opportunity costs for land and labor. These gardens have proven to be highly diverse systems, with a wide variety of plants designed to provide a wide range of benefits. These systems that have withstood the tests of both time and changing demands may provide models for sustainable agriculture for smallholder farmers.

CHAPTER 1
INTRODUCTION

Homegardens are unique agroforestry systems that are often described in detail, but whose biophysical and socioeconomic characteristics have not been extensively studied. These intensive land-use systems involving the deliberate management of multipurpose trees and shrubs (the woody component) grown in intimate association with herbaceous species (mainly annual, perennial, and seasonal agricultural crops), and livestock, are all managed within the compounds of individual homes (Fernandes and Nair, 1986). They are widespread throughout the tropics and are of immense importance in the socioeconomic structure of the rural communities (Michon et al., 1983, Soemarwoto, 1987). They provide both economic and social benefits that are essential to the nutritional welfare and security of the household. These gardens, with their diversified agricultural crops and trees, fulfill the basic needs of the local population. In addition, the multistoried arrangements of plants and relatively high species diversities prevent the environmental degradation that is commonly associated with monocultures (Nair, 1993). Thus these homegardens provide economical benefits while remaining ecologically sound and biologically sustainable.

Homegardens are of vital importance to the mainly subsistence-level existence of farmers in the tropics (Nair and Sreedharan, 1986; Swift and Anderson, 1993; High and Shackleton, 2000; Mendez et al., 2001). Many of the benefits provided to farmers by these gardens are unknown for lack of quantification of the products used by the household.

The Problem

Although homegardens have been extensively described, there is a lack of quantitative data about their benefits. The main reason that they have not been studied is that rigorous, widely applicable methodologies are not available, and those that have been developed for single-species systems are not applicable to such complex systems (Nair, 2001). There is a need to conduct both economic and ecological analyses of these systems so as to understand the potential benefits and identify potential risks associated with homegarden cultivation. Furthermore, traditional monoculture patterns degrade the soil fertility, necessitating the use of more and more fertilizers to maintain crop productivity (Swift and Anderson, 1993). Monoculture also increases pest and weed problems. Studies that focus on the biophysical aspects of these multi layered and multi functional systems might provide management help to households tempted to convert their homegardens into commercial enterprises, which may yield immediate economic benefit but ultimately may result in reduced soil fertility and productivity.

Many studies have documented homegarden species (Ninez, 1987; Soemarwoto and Conway, 1992; Drescher, 1996; and others), however, there needs to be an inventory of the products that are realized from and the costs that are input into these systems. Socioeconomic and cultural factors that influence homegardens also need to be properly documented. Many of these homegardens follow indigenous agricultural practices that are logical and rational, and have been followed for centuries. Loss of this traditional knowledge would be disastrous to the culture that defined the evolution of Kerala farmers and their knowledge of the land. The non-market benefits potentially provided by these systems, such as biodiversity, carbon sequestration, aesthetics and ornamentation, wildlife habitat provision, are likely to be very valuable to the subsistence farmers of the

tropics, but no quantified data are available to support this assumption. These benefits need to be considered when formulating any new government policy regarding agriculture in the tropics.

Broad-based analyses of the socioeconomic, cultural, and ecological aspects involved in homegarden design and cultivation are necessary, so that these systems, and their contribution to life in the tropics, can be viewed in their entirety - not just as a sum of its parts. Unless these multifaceted elements are considered together, the true role of these systems as contributors to sustainable agriculture cannot be realized.

Objectives

Objective 1: Financial Analysis for a Typical Homegarden Year

- Determine all market costs and benefits associated with the homegardens, and evaluate the financial values of homegardens.
- Assess the effect of variables such as land size, labor, age of homegarden, or gender, on the profitability of homegardens.
- Conduct sensitivity analyses associated with the cultivation of these gardens in terms of price increases in market outputs, and labor.
- Compare economic utility of the land to other potential alternatives.

Objective 2: Ecological Analysis

- Categorize observed species according to their various uses in the household.
- Calculate diversity indices for all sampled gardens, both in terms of species richness and evenness.
- Examine the planting patterns in gardens, and compare across different land size categories, and examine the role of medicinal plants.
- Estimate agroecological importance values of the primary species associated with the homegardens.

Objective 3: Discussion of Social and Cultural Components

- Examine the role of women in homegarden design and decision-making
- Assess the level of use and knowledge of commonly used fertilizers
- Examine the role of religion, medicinal plants, and conservation of indigenous knowledge.

Hypotheses

This study is based on the overall hypothesis that homegardens provide economic benefits and help maintain cultural requirements, while at the same time contributing to or maintaining the ecological diversity of the region. Specifically, it is hypothesized that a typical homegarden is resilient to economic fluctuations, provides intangible benefits to the farmer in addition to the economic benefits, and enables the farmer to generate a satisfactory level of financial profit. Furthermore, homegardens are ecologically sustainable, and the agroecology of the gardens and the economic and social needs of the household are inextricably linked.

CHAPTER 2
LITERATURE REVIEW

General Description of Homegardens

Homegardens are intensively cultivated agroforestry systems managed within the compounds of individual homes. They involve the deliberate management of multipurpose trees and shrubs (the woody component), grown in intimate association with herbaceous species (mainly annual, perennial, and seasonal agricultural crops), and livestock (Fernandes and Nair, 1986). Torquebiau (2000) further classifies them as agroforestry homegardens in order to avoid possible confusion with domestic vegetable gardens. Nair (1993) mentions *Pekarangan* gardens of Indonesia, the *Chagga* gardens in Tanzania, and the *Huertos Familiares* as excellent examples of these systems.

Many gardens are associated with outlying fields where shade-intolerant, staple food crops such as rice (*Oryza sativa*) and maize (*Zea mays*), are grown. Fernandes and Nair (1986) also defined two other types of tree gardens as plots immediately adjacent to the garden but with fewer trees and more staple food crops, and complex agroforests, which are plots further away in surrounding forests and consisting mainly of tree crops such as palms, rubber (*Hevea brasiliensis*), resin, and nut trees. These complex agroforests, also called village forest gardens, are structurally similar to homegardens but they are less diverse and usually oriented toward timber or other forms of cash production such as non-timber forest products. Furthermore, these village gardens are usually on commonly owned land, while homegardens are on private property.

Homegardens, with their diversified agricultural crops and trees, are of vital importance to the subsistence economy of many areas in the tropics (e.g. Nair, 1993; High and Shackleton, 2000). Human population density is usually high in these areas, and the average size of landholding is less than one hectare. The most conspicuous characteristics of all homegardens are their layered canopy arrangements and admixture of compatible species, with each component occupying a specific place and function (Nair, 1993). Most homestead systems consist of an herbaceous layer near the ground and a tree layer at higher levels. The herbaceous layer can be partitioned into two, with the lower layer consisting of vegetable and medicinal plants; and the upper layer composed of food plants such as cassava (*Manihot esculenta*), papaya (*Carica papaya*), banana (*Musa* spp.), yam (*Dioscorea esculenta*), and other vegetables and tubers. The tree layer usually has two levels as well, with the lower tree level consisting of medium-sized trees (10 to 20 m high) and fully-grown timber and fruit trees occupying the uppermost layer (more than 25 m high). Fruit trees, some of which could continue vertical development, could occupy an intermediate layer (3 to 10 m high).

Livestock

Livestock contribute significantly to the household income of small-scale homegardens in many developing countries, while fulfilling many social and cultural needs (Wilson, 1995). In some of the very small gardens, where land is a constraint to production, livestock are sometimes the main income generators, serving as cash buffers and capital reserves (Devendra and Thomas, 2002) and also contributing to the nutrient cycling in the system (Thorne and Tanner, 2002). Livestock also offer opportunities for milk and meat-processing ventures, thus increasing employment especially in rural areas. They can be used to control weeds in perennial tree crop systems, and to control insect

pests. Integration of animals with cropping systems provides means to sustainably intensify agricultural production and contribute to the nutrient cycling in the system. For example, 80% of the N supplies to the soil are made via the manure-compost pathway (Pilbeam et al., 2000). A study of banana-based homegardens (*kibanja*) in Bukoba district in Tanzania showed that nutrient balances were negative for homegardens without cattle (Baijikya and Piters, 1998). The relatively good banana production in those gardens without cattle, and owned by resource-poor farmers might be explained by the fact that some farmers find other nutrient-saving solutions by keeping small ruminants like goats and sheep, while others make compost heaps and recycle crop residues. Livestock also promote the adoption of adaptive management techniques. In Burkina Faso, farmers employ traditional practices such as live hedges to protect their homegardens from animals (Ayuk, 1997). These live hedges also provide additional sources of income such as food and timber.

Biopesticide Use in Homegardens

Biopesticides are now commonly used in many parts of the developing world. These techniques involve using natural methods such as biopesticides and natural predators to control pests and diseases. Some of the methods used in the surveyed gardens are shown in Table 2.1. The methods of preparation are from the Kerala Agricultural University, Technical Bulletin-13 (1998). While assessing homegarden benefits, it is important to understand the various methods used by the farmers to reduce costs and improve production. The various processes that underline the farmer's decisions to use a particular type of pesticide should also be understood. In Kerala, these information levels are very high among the farmers. Although the preparation methods

can be obtained from the local agricultural offices, the farmers mainly utilize the information as passed through generations of farmers in the family.

Table 2-1 Biopesticides used in Kerala gardens, their uses and methods of preparation.

Biopesticide	Method of preparation	Uses
Tobacco solution	100g tobacco wastes steeped in 1 liter of water for 24 hours. Filter tobacco solution, and add to 24g of bar soap dissolved in water (KAU, 1998)	Controls aphids and other vegetable crop pests
Neem cake (veppu pinakku) or neem kernel suspension	Grind neem kernels into coarse powder. Dip cloth bag with 1g of powder in 1 liter of water, for 12 hours.	Repellant against locusts, grasshoppers, and other chewing insects.
Bar soap solution or fish oil soap	Dissolve bar soap in hot water.	Bar soap solution can be used against aphids, and fish oil soap is effective against plant lice
Neem oil (veppu enna)	Oil obtained from the leaves, and kernels.	Serves as anti-feedant, when sprayed on vegetables
Bordeaux mixture (Broad-spectrum fungicide)	Dissolve 10g of powdered copper sulfate in 500 ml of water. Pour mixture in milk of lime solution	Broad spectrum fungicide

Methods of preparation are from Kerala Agricultural University – Technical Bulletin 13 'Nutrition Garden' and uses are from Bulletin 13 and from farmer responses. Local names are in italics.

Ecology of Homegardens

Personal preferences, socioeconomic status and culture seem to be the main determinants of the appearance, function, and structure of homegardens (Christanty, 1990). The rural gardens usually have more layers of plant canopy and thus are more complex than the urban gardens. The crops and trees planted in a homegarden are carefully arranged to provide for specific functions and benefits, which are primarily economic in nature. But the difference between typical agricultural systems and homegardens is that these gardens also enable continuance of various essential ecological

processes that occur in natural tropical forest ecosystems, such as regeneration and conservation of soil, nutrient and water cycling (Nair and Sreedharan, 1986).

Studies dealing with the biophysical aspects of homegardens are still limited although the urgency of this need is beginning to come through. Although these systems are touted as sustainable and close to natural forest systems in function and processes (Torquebiau, 1992; Jose and Shanmugaratnam, 1993; Ewel, 1999), the quantitative evidence to substantiate these claims is still inadequate. There have been many studies that describe the homegardens with detailed plant inventories, descriptions, and planting patterns (Table 2-2). Many recent studies have attempted to measure the floristic composition of homegardens (e.g. Leuschner and Khaleque, 1987; Karyono, 1990; Esquivel and Hammer, 1992; Moreno-Black, 1996; Mendez et al., 2001; Wezel and Bender, 2003). The main problem with these studies is that, although they provide an excellent resource for researchers and scientists, they do not follow a uniform pattern of analysis. Furthermore, methodology and data collection practices also vary widely across studies. Methods of estimating ecological diversity indices and basic statistical sampling methods as discussed in forest vegetation studies (eg. Krebs, 1985; Margurran, 1988; Reed and Mroz, 1997) can also be utilized for homegarden studies and some researchers have used this ecological approach to estimating homegarden plant diversities (Kumar et al., 1994; Drescher, 1996; Vogl et al., 2002; Wezel and Bender, 2003). These studies do not follow a uniform pattern of study, and use different indices, however, they are one step ahead in accurately classifying and studying the diversity of these systems. For example, Kumar et al. (1994) used Simpson's diversity index in homegardens in Kerala

state, India, and concluded that floristic diversity decreased with increasing garden sizes. Drescher (1996) used the Shannon-Weiner index to reach similar conclusions.

Benefits Commonly Attributed to Homegardens

Production Benefits from Trees

Homegardens tend to have some tree output that can be used for long-term production and sale for profit. Palms are traditionally of significant importance in small farm management as sources of edible fruits, oil, green vegetables, fiber, thatch, construction wood, fuel wood and other useful products (Johnson, 1988), and are often found in Kerala homegardens. These plants, especially the coconut palm (*Cocos nucifera*), whose growth and planting patterns enable successful growing of other crops in between or under them (Nair and Sreedharan, 1986), the date palm (*Phoenix dactilifera*), and the areca palm (*Areca catechu*), can be grown with annual or perennial crops and thus can be effectively utilized in homegarden systems, and provide a source of market income. Kerala is known for many varieties of palm trees (Renuka, 1999) and therefore, palms are of special importance in any homegarden study in Kerala.

Trees incorporated into agricultural systems have been found to yield greater payoffs than continuous agricultural monocropping (Leakey and Tomich, 1999), which might explain the results of a study conducted in the floodplains of the Peruvian Amazon (de Jong 2001), which found that farmers choose to include trees in their plantain, cassava-corn homegarden systems because the value of the tree products offsets the decreased yield of the annual or short cyclic crop. Similarly, tree crops retained for their timber value are often highly valued in many parts of South and Southeast Asia. Fruit cropping is an attractive option to some highland villagers. Fruit systems are able to

provide valuable market benefits and services, of which some have significant economic objectives (Withrow-Robinson et al., 1999).

Other high-value tree products are also capable of producing significant export earnings for farmers, for example, teak wood (*Tectona grandis*) in Asia is a very highly priced wood traditionally used for furniture and construction. Products from Cinderella species (trees whose products are traditionally non-timber) such as neem (*Azadirachta indica*) and other agroforestry tree species can also be used as a source of income for the household (Leakey, 1999). These trees are retained as standing stock of wood, along with the herbaceous crops, and are looked on as an asset by the farmer, to be utilized for a variety of reasons including medicinal reasons, gums, resins, and green manure.

Nutrition and Food Availability

Nutrition and food supply are major aspects of homegardens. Food crops are not only widely prevalent (Caron, 1995; Mendez et al., 2001; Vogl et al., 2002), but they also provide a significant portion of the household nutritional requirement in many homegardens around the world. Any failure to provide such sustenance probably arises from ineffective setup, design and implementation of these systems (Immink, 1990). If the homegardens are large enough to plant a sufficient number of tubers or cereals, they can also provide the household's basic food supply. For example, Cuban homegardens are significant as food suppliers, especially because of low-paid alternate employment and minimal food provisions by the government (Wezel and Bender, 2003).

Along with the nutritional benefits, homegardens provide potential food security to the householder. Since the diverse mixture of crops is harvested at different times, a constant supply of food in some form or the other is available from these homegardens, at all times of the year. Rural farmers continue to rely on their homegardens to enhance

household food security against the risks presented by monocropping systems (Jose and Shanmugaratnam, 1993).

Improving the Role of Women in Agriculture

These gardens contain possibilities of increasing family participation in the production and contribution toward family well-being. Okigbo (1990) attributed the development of the homegarden as a regular feature of the traditional farming system in parts of tropical Africa, in part to the division of labor between the sexes. Women traditionally cooked soups and sauces, and needed the continuous availability of the condiment plants, spices and vegetables grown in the homegardens. In another study conducted in Thailand, homegardens managed primarily by women were among a series of resource areas that were efficiently utilized (Moreno-Black et al., 1996). These womens' gardening practices created intensive interaction between the physical and social environment and they were increasing their management and manipulation of non-domesticated resources. They were the principal land-owners and were heavily involved in economic activity, especially in the marketing of fruits, vegetables and cooked foods. The women who developed and maintained these systems used gardening as a way to express their autonomy and worth within the village setting.

Some studies on the role of family members in homestead agriculture pointed to women being the main participants in homegardens. An analysis of land use in Pananao, in the Dominican Republic showed that women were responsible for providing homegarden products to the household, for working in the gardens, and for controlling the resources and processes of the gardens (Rocheleau, 1987). Similarly, the *Chitemene* system in northeast Zambia showed that women's homegardens were increasingly important sources of both food and cash. In a study conducted in the homegardens of

Lusaka, Zambia (Drescher, 1996), it was found that women tended to have higher species diversity in their homegardens than men, and utilized different strategies to improve soil fertility in semi urban, and rural areas. Studies examining the effect of gender in agriculture are increasingly being conducted (Ramamurthy, 2000, Raynolds, 2002), but research documenting the effect of homegarden farming on gender relations in tropical agriculture remains limited.

Aesthetics and Ornamentation

The homegarden is often a haven for the family members of rural communities to relax and gather together after a hard day's work. They are often focal community meeting points. The gardens sometimes have a variety of flowers and other ornamental decorations. Some villages use these homegardens as a way to gain recognition for the village as a whole (Moreno-Black et al., 1996). The villagers are proud of the way their gardening contributes to the beauty of the village. In several tropical cultures, these ornamental flowers and some other selected plants are used for ritualistic and cultural reasons.

Other Businesses

Homegardens often allow for the setup of small cottage industries that provide an additional source of income to the household. For example, the traditional art of pickling mangos and other fruits is a lucrative cottage industry. Another potential cottage industry involves using non-food materials from the garden, such as coconut fiber (coir), which has traditionally been used in the production of mats, ropes and other products, and can be sold to local markets.

Medicinal Uses

Homegardens can be used to grow certain traditional herbs and spices. Traditional medicine and medical properties of plants are fields that are currently generating much interest among researchers. Plant based medicinal systems, although in practice for thousands of years, are now coming to the forefront and attempts are being made to recognize their medicinal properties (for example, see Scartezzini and Speroni, 2000; On et al., 2001).

The traditional Indian system of medicine, Ayurveda, utilizes no artificial chemicals, and instead relies on the medicinal properties of herbs and other plants. The first congress on Ayurveda was held in 2001, in Kochi, India, and was attended by scholars and doctors from India and around the world. The Congress, organized by the Union Ministry of Health and Family Welfare, along with the Swadesi Science Movement, was conceived as a platform on which to establish Ayurveda in the global arena. Homegardens, especially in the more rural areas, are reservoirs of species that can be used for many medical purposes. Many regional and local publications are available, which expound the virtues of these plants (for example, Balakrishnan, 1994; Tajuddin et al. 1996; Abraham, 2001; Nedumancheri, 2002), and the farmers are also cognizant enough of these benefits that they retain specific medicinal plants to realize certain desired benefits. [1]

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1 Personal communication:

Abraham, C. 2001. Karshika naatarivukal (Malayalam). Avanti Publications. Kerala, India.

Balakrishnan, V.V. 1994. Chedikalum Avayude Oushadhagunangalum. (Malayalam)DC Books. Kerala, India

Nedumancheri, S. 2002. Veettumuttathe Aushadhachedikal (Malayalam). Sincere Publications. Kerala, India

Existing Studies

Many existing studies provide detailed descriptions and specific analyses of homegardens. Brownrigg (1985), in her annotated bibliography, lists several hundred references. Each geographic region exhibits certain unique characteristics that influence the structure and function of its gardens. Variations exist even within similar geographic areas, as a result of conditions that are both socio-economic and naturally created. More recently, Kumar and Nair (2004) have published an excellent review of the state of homegarden literature and the scientific progress that has been made in the past decades of study. They conclude that homegardens fulfil economic, social, and cultural needs and provide biological conservation and carbon sequestration benefits, yet their virtues are not recognized in measured quantities.

In an assessment of four types of homegardens representing four eras in the Chao Praya Basin in Thailand, Gajaseni and Gajaseni (1999) studied the ecological rationalities behind the harmony among humans, homegardens, and the environment. They found that a species' utility was the main reason for its selection in the homegarden. The farmers had various practices chosen due to factors such as plant species, the system, and the environment. These gardens offered the possibility of highly efficient use of space, light, water and nutrients. The practice of never completely harvesting these gardens meant minimal nutrient export; and high amounts and biodiversity of litter biomass contributed to the high efficiency of nutrient cycling. Padoch and de Jong (1991), in their study of 21 gardens in the sparsely populated Peruvian Amazon, also describe great variability and species diversity in size and composition. Their research also indicated several uses for

homegarden species, including food, medicine, and ornamentals. Mendez et al. (2001) also observed similar uses for homegarden species in Nicaragua. Homegardens have also been observed to provide important avenues for the production of environmentally sustainable types of fruits and vegetables even in urban areas, and to enhance the nutrition of the urban poor in South America (Madaleno, 2000).

Sri Lanka also offers wide possibilities for homegarden research, being home to the famous Kandy gardens. These gardens, located in the Kandy district of Sri Lanka, combine intensely managed mixtures of agriculture, forestry, and livestock, and are usually small, following the rule, "smaller the farm, the more intense the cultivation" (Ranasinghe, 1995). In the hill agroecosystems of Nepal, the characteristic features of the gardens are their organic bases (Semwal and Maikhuri, 1996), with farmyard manure as the primary input. Much has been written about the Javanese homegardens, which are famous for their multilayer arrangements, set in areas with extremely high population densities (Michon et al., 1983; Soemarwoto and Conway, 1992). These gardens, cared for primarily by women, are storehouses of genetic diversity, with several species only partly domesticated (Soemarwoto and Conway, 1992).

African homegardens have also been widely described. Okafor and Fernandes (1987) write that a large number of potentially valuable species are being lost in southern Nigeria because of the high rate of forest clearing. This loss further enhances the value of compound farms as priceless germplasm banks of traditionally important multipurpose tree species. The famous *Chagga* homegardens of Tanzania (Fernandes et al., 1984) and the gardens of Lusaka in Gambia (Drescher, 1996) provide subsistence income to the householders, while also providing some liquid income.

Homegardens, although mainly tropical in nature, have also been found in the temperate zone. A brief review of the agroforestry systems in present day United Kingdom presented a modern example of a forest garden including fruit trees and bushes, medicinal herbs, and vegetables (Carruthers, 1996).

Non-Market Benefits

Homegarden owners attribute high values to homegardens for their social, aesthetic and habitat functions, rather than just as a place for growing subsistence and/or cash crops (Nair and Sreedharan, 1986). Many studies have attempted to value and provide methodologies of valuation for non-market benefits, ranging from the seminal work by Peters et al. (1989) to a very recent publication (Alavalapati and Mercer, 2004) that provides coverage of applied economic and policy analysis techniques for agroforestry professionals. Research that actually implements the theories relating to valuation of non-economic benefits of agroforestry is still limited. Some studies have attempted to value environmental benefits such as soil conservation (Ehui et al., 1990) and nitrogen fixing (Stone et al., 1993); to develop approaches to valuing carbon fluxes (Cline, 1992); to value wildlife conservation using analysis of travel costs (Benson, 1994); and most recently to use the contingent valuation method (CVM) to value non-tangible resources (Mitchell and Carson, 1989). Price (1995) also attributes Hedonic pricing, which values environmental, social, locational and structural attributes of countryside activities, and Recreational agroforestry as potential methods that can be used. But these methods are all prone to problems with interpretation of results, and problems with realizing real and tangible values from study participants.

Table 2-3 provides some of the available literature on the non-market benefits of homegardens. Some of these benefits such as soil conservation and nutritional security

are extremely difficult to quantify, considering these are multi-use systems, and therefore the entire homegarden and its structure and function cannot be considered as uniform across the garden area.

Table 2-2 Selected homegarden literature according to different geographic locations

Homegarden literature by geographic area	References
Africa	Baijukya and Piters (1998), Fernandes et al. (1984), Okafor and Fernandes (1987), High and Shackleton (2000), Ayuk (1997), Fernandes et al., (1984), Rugalema et al. (1993&1995), Okigbo (1990), Abdoellah (1990), Drescher (1996)
East and South east Asia	Gajaseni and Gajaseni (1999), Jensen (1993), Soemarwoto and Conway (1992), Christanty (1990), Wiersum (1982), Lawrence (1996), Vasey (1985), Dove (1994), Salafsky (1995), Moreno-Black et al. (1996), Michon and Mary (1994), Withrow-Robinson et al. (1999), Jacob and Alles (1987), Michon (1983), Michon et al. (1983), Kaya et al. (2002)
South Asia	Ranasinghe (1995), Caron (1995), Nair and Sreedharan (1986), Dash and Misra (2001), Leuschner and Khaleque (1987), Millat-e-Mustafa et al. (1996), Nair and Sreedharan (1986), Jose and Shanmugaratnam (1993), Semwal and Maikhuri (1996), Chandrashekhara (1996), Mammen et al. (1993), Salam et al. (2000), Shanavas and Kumar (2002), Neupane and Thapa, 2001.
Mexico, Central America, and South America	Esquivel and Hammer (1992), Mendez et al. (2001), Padoch and de Jong (1991), Wezel and Bender (2003), Benjamin et al. (2001), De Jong (2001), McGrath (1998), Madaleno (2000), Brierly (1985), De Clerck and Negreros-Castillo (2000), Budowski (1990), Smith (1996), Muniz-Miret et al. (1996), Schulz et al. (1994), Rocheleau (1987), Pinton (1985), Posey (1985), Rico-Gray et al. (1991).

Table 2-3 Potential non-market benefits from homegardens

Benefits	Description	Key References
Nutrition	A significant portion of family's nutritional requirements met from homegardens.	Immink (1990), Caron (1995); Mendez et al. (2001); Vogl et al. (2002), Wezel and Bender (2003).
Ornamentation and Aesthetics	Provision of some ornamental benefits. Oasis of beauty and relaxation in the midst of the travails of everyday life, therefore providing leisure. Improves quality of life	Christanty (1990), Moreno-Black (1996)
Soil Conservation/ Preservation	The mixture of herbaceous species and woody species helps in the conservation of soil and provides essential nutrients.	Fernandes and Nair (1986)
Food Security and Nutrition	Average of five annual crop species in each homegarden. These crops are staggered so that something is available for harvest throughout the year. The constant supply of food, harvested continuously throughout the year provides a sense of security to the family.	Christanty et al. (1986), Karyono, (1990), Torquebiau (1992), Jose and Shanmugaratnam (1993), Gajaseni and Gajaseni (1999).
Self Sustenance	Perception of achievement arising from the knowledge that the family's sustenance is and can be provided by the fruits of the one's own labor and grown in the backyard.	
Family Participation and Empowerment of women in agriculture	Home gardens allow for all family members to be involved in some form or other. It allows for greater participation by the female members, thereby perhaps increasing their feelings of self worth	Moreno-Black (1996)

Scope for Future Research

In a study conducted on the traditional agroecosystems of Thrissur, India, to investigate the long-term effects on various soil properties using adjacent forests as a standard for comparisons, it was found that crop-species composition and richness had long-term positive impacts on soil carbon stocks, thus implying their importance in soil

fertility management and carbon sequestration (Russell, 2002). Since the importance of tree species and their role in biodiversity and carbon sequestration is understood (Delaney and Roshetko, 1999; Nelson and de Jong, 2003; Montagnini and Nair, 2004), the role of homegardens in carbon sequestration provides scope for further research.

Homegardens have long been considered a scientific mystery. These systems have prevailed with intensive cultivation for hundreds of years, yet the production remains consistent. These gardens, not only provide economic benefits to the householder, but also cultural and social benefits. Furthermore, the biophysical aspects of homegardens such as soil conservation effects and potential for carbon sequestration are ecological benefits to both the farmer and to the community. It is important to understand the rationale behind the synchronicity of all these three factors – economic, ecological and social – that allow for the consistent functioning of these systems.

CHAPTER 3
STUDY AREA

Location of Study Area

This study was conducted in the state of Kerala, in southern India (Fig. 3-1). Kerala state covers an area of 38, 863 sq. km, which comprises a mere 1.18% of the area of the country as a whole. The state is densely populated (31,838,619 people as of March 1, 2001), with a population density of 819 people per sq. km (Government of India census, 2001). Forested land covers 10,292 sq. km, including 1887 sq. km of private forests (Forest Survey of India, 1993). The forests in Kerala are classified as southern tropical wet evergreen and semi - evergreen, southern tropical moist deciduous, southern tropical dry deciduous, montane sub tropical, and forest plantations. The coast runs 580 km, bounded by the Arabian Sea to the west. The soils of Kerala state can be broadly classified as Oxisols (50%), Inceptisols (25%), Entisols (20%), and Alfisols (5%) (Nair and Sreedharan, 1986).

Nearly 50% of the state's population depends upon agriculture as their means of livelihood (Directorate of Economics and Statistics, 2000-2001), and agriculture contributes 21.38% to the state income. According to the Government of India census (2001), Kerala possesses a per capita land area of 0.13 ha, and the per capita cultivated land, including paddy fields and plantation crops, is 0.10 ha. As of 1995-1996, 332,483 individual landholdings were found to be less than 1.0 ha in size, and were classified as marginal landholdings. However, it is not clear whether homegardens are included in this calculation because this land, especially those plots of land that are small in size, are

considered more residential areas rather than agricultural land. The homegardens sampled in this study were all within the government of Kerala category of marginal landholdings, and were an average of 0.34 ha not including the actual residential building.

Kerala is divided into fourteen districts, of which the district of Thrissur was randomly selected as the study site. Thrissur, commonly called the cultural capital of Kerala, is a major tourist attraction and is a district with a fairly even distribution of rural and urban centers. Thrissur district is bounded by Malappuram district in the north, Palakkad district to the east, and Ernakulam district to the south. It lies between 10º 0' and 10º 47' north latitudes, and 75º 55' and 76º 54' east longitudes.

Thrissur experiences a tropical climate, with plentiful summer monsoons. The dry season ranges from February to May, and the Southwest monsoons follow, from June to September. The months of October and November experience the effects of the retreating monsoon, and this is an important time for rice-paddy farming. The rains cease by the end of December. The normal average annual rainfall of Kerala state is 3107.5 mm, and that of Thrissur district is 3262.0 mm (Government of Kerala, Statistics for Planning, 2002).

Kerala is a unique land with a unique history. It is the only state in India with a sex ratio of 1.058 females to 1.0 male, as opposed to a national figure of 0.936 females to 1.0 male. Kerala also has the highest literacy rate in the country, with over 94%, as opposed to the national average of 65 %. Kerala culture and history follow unique patterns, with several communities following a matrilineal society (Trautmann, 1995). Kerala also has relatively high (more than 20% of population) percentages of Christian and Moslem

populations, along with the majority Hindu populace. The only existing Jewish population (under 100 people) in India and Asia belongs to Kerala.

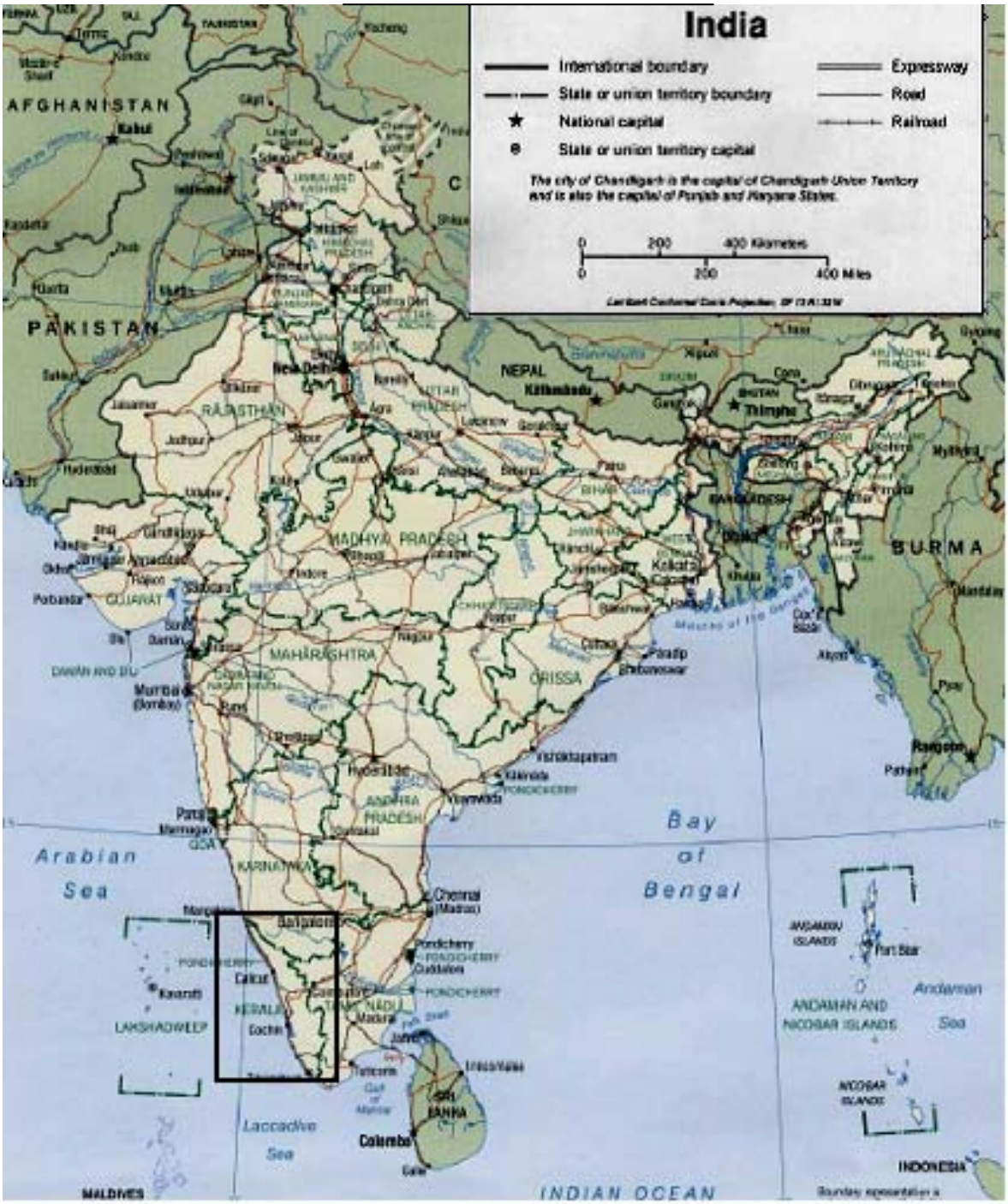

Figure 3-1 Map of India highlighting the state of Kerala. Reprinted with permission from the Perry Castaneda Library Map Collection – University of Texas Online Map Library

Kerala Homegardens

Homegardens are a very common feature of Kerala's landscape. They are not only a necessary feature to provide household subsistence, but also an ecological necessity. Kerala being a region experiencing heavy monsoon rains, it might be advantageous to have dense vegetation surrounding the cultivated areas in order to reduce soil erosion and better absorb excess rain water. Although the rise of cash crop monocultures such as rubber plantations (*Hevea brasiliensis*) has threatened the continuity and persistence of the homegardens, the small and marginal farmers of Kerala continue to rely on their gardens for household subsistence.

All the homegardens in the study followed a multilayered canopy arrangement. In those gardens where the tree canopy has not already developed, the farmers deliberately followed a planting arrangement so as to eventually allow for such a multilayer arrangement. The canopy structure generally followed the descriptions as set forth by Nair (1993) and Jose and Shanmugaratnam (1993). All gardens had at least three levels of canopy. The first layer consisted of plants under 2 m height, such as vegetables, tuber crops, grasses, medicinal plants, and ornamentals, some of which were planted in pots. The second layer consisted of herbaceous crops such as bananas, shrubs such as papaya and trees such as short varieties of arecanut palms, mango (*Mangifera indica*), and cacao (*Theobroma cacao*), between 2 and 10 m in height. The uppermost layer constituted trees over 10 m in height, such as coconut palms, jackfruit (*Artocarpus heterophyllus*), breadfruit (*Artocarpus altilis*), and rubber.

Some of the food crops commonly produced are vegetables such as okra (*Abelmoschus esculentus*), chillies (*Capsicum* spp.), spinach (*Amaranthus* spp.), and beans, and tuber crops such as cassava, sweet potatoes (*Ipomoea batatas*), yams, and

arrowroots (*Maranta arundinacea*). Along with the food crops produced by the annual and perennial species, the woody species provide fruits, nuts or other forms of food. Some of these crop products can be used for cash purposes, for example, coconut, banana, cacao, cashew (*Anacardium occidentale*), and spices such as cardamom (*Elettaria cardamomum*), cloves (*Syzygium aromaticum*), vanilla (*Vanilla planifolia*) and nutmeg (*Myristica fragrans*). Mangrove species such as *Acanthus illicifolius*, *Carbera odollam*, and *Rhizophora conjugata* are common in the homegardens of backwater areas of Kerala (Tejwani, 1987).

When plantation crops such as cacao, coconut, coffee (*Coffea* spp.), and black pepper (*Piper nigrum*) form dominant components of a homegarden system, they are often referred to as plantation-crop combinations (Nair, 1993). But the differences between the subsistence homegarden and the plantation-crop system are unclear, and if any differences do exist, they are mainly socioeconomic. Equally important are pulses such as cowpea (*Vigna unguiculata*), black gram (*Vigna mungo*), and others, which provide a protein supplement to the human diet (Nair and Sreedharan, 1986).

Livestock rearing is also undertaken in most of these gardens. The animals are maintained for milk, meat, eggs and other dairy products. Cattle and poultry were the most commonly found animals in these homegardens. However, other lucrative livestock ventures included raising pigs, ducks, fish, and goats. Some homegardens also practiced sericulture (raising silkworms for silk production), and apiculture (raising and maintaining bees for the production of honey). A few of the gardens raised ornamental fish, such as varieties of angelfish (*Pterophyllum scalare*) and goldfish (*Carassius auratus*).

Family labor is utilized for management of these systems. All members of the house participate in the day to day working of the homegardens to varying degrees. Both male and female members of the household participate in both the labor and in the economic decision making processes. Hired laborers are employed according to need. Labor is an increasingly expensive commodity in Kerala, and daily wage for male laborers can be as high as Rs. 200/day (approximately $4) in urban areas. Labor is hired mainly for skilled tasks such as coconut harvesting.

Organic waste material from the household, and animal manure, are often the only sources of nutrients added to the homegardens. In the trend toward modernization, several gardens are now reporting increased use of chemical fertilizers especially for cash crops such as bananas and rubber. The total fertilizer consumption for the state of Kerala for 1999-2000 was 211,632 tons, of which N fertilizer comprised 87,061 tons, P (in the form of P_2O_5) comprised 43,975 tons, and K (in the form of potash, K_2O) comprised 80,326 tons (Kerala Department of Agriculture, 1999-2000). Fertilizer use varies greatly depending on a number of factors including cropping systems, soil types, and socioeconomic conditions. The local government agricultural agencies provide subsidies (50% reduction) on fertilizer purchases for those farmers who own a minimum area of land (currently at approximately 0.2 hectares).

Size Demographics of Homegardens Used in this Study

The homegardens selected for this study were all less than 1.0 ha in size, which is classified as 'marginal' landholding by the government of Kerala. Most of the farmers surveyed reported that the land has been traditionally in their families for generations. Eighty-five gardens were initially surveyed as part of the sample. It was later decided by the researchers that gardens that are more than 1.0 hectare in area would not be included

in the study because it was evident that these relatively large gardens functioned more as plantations than as homegardens. Ten gardens were eliminated for this reason, and the remaining 75 gardens were divided into four size categories (Table 3-1).

Table 3-1 Land size categories of 75 surveyed homegardens of Thrissur district, Kerala, India

Category (hectares)	Household encountered Nos.	Percentage	Total landholding size (ha)	Mean landholding size (ha)
Small (0.01-0.26)	24	32	1.68	0.07
Medium (0.261-0.52)	14	18	2.75	0.19
Large (0.521-0.78)	10	13	3.31	0.33
Commercial (0.781-1.0)	27	36	17.82	0.66

History of Cultivation

Respondents were asked about the length of time their family has been cultivating the gardens. All homegardens that have been in cultivation by a particular family for over a hundred years were assigned the standard value of 100 unless the farmer had pertinent documentation. Based on that, the surveyed homegardens have been in cultivation for an average of 52.7 years. But it has to be noted that these ages are only indicative of farmers' memories. Many respondents, who reported that their land had been in cultivation for several generations, could not furnish proof nor could they verify this information because the land had been passed down for generations.

CHAPTER 4
FINANCIAL ANALYSIS OF HOMEGARDENS

Introduction

Rigorous field studies that apply the well known economic theories and methodologies are quite few in the case of homegardens (Nair, 2001). One of the major constraints to undertaking such studies stems from an observation made by Scherr (1992) regarding the lack of guidelines for data collection and analysis. Preliminary economic analyses in Central America and the Caribbean have indicated that many agroforestry systems are profitable at real discount rates of 20 percent or higher (Current et al., 1995), yet more substantial economic studies relating to homegardens are limited. The economic worth of homegardens is especially difficult to quantify due to three reasons: these systems have high, yet variable levels of biodiversity, making data collection time-intensive and error-prone; these systems provide some benefits that are designed to be of particular use to certain farmers only; and finally, most of these systems have existed many hundreds of years so that the benefits realized in the past cannot be accurately quantified because of lack of existing data.

Homegardens, although primarily used for subsistence purposes of the household, are increasingly being used to generate cash income (Christanty, 1990; Torquebiau, 1992; Mendez et al., 2001). They are also used to generate non-market benefits such as aesthetics, ornamentation, improved food quality and nutritional security to the farmer (Karyono, 1990; Jose and Shanmugaratnam, 1993; Drescher, 1996). The aim of this chapter is to use a combination of different economic methods to assess the current

tangible financial status of existing homegardens and provide a set of guidelines for data collection and analysis, based on the case study in Kerala, India. Economic methods included cost-benefit analysis for one year, a sensitivity study to ascertain economic resilience to market fluctuations, and classification of economic contributions by different factors in homegardens. The net values of these gardens have also been compared to other available economic alternatives. The role of household and hired labor, and the role, if any, of gender in profit generation is also briefly investigated.

Economic Methodology

Seventy-five homegardens in Thrissur district in Kerala, India, were randomly selected and systematically (based on location) inventoried during October 2002 – February 2003. These homegardens were located in both rural and semi-urban areas. A comprehensive survey was administered and productivities of all homegardens were estimated. The values of the products were determined according to existing market prices and shadow prices of medicinal plants. Those farmers who were interviewed were the key decision-makers in the selected homegardens. Land classifications for this study were done on the basis of economic production and function. For example, in a homegarden with a land area of 1.0 hectare, if the major crops were coconut and areca, the garden was classified as a coconut-areca system. These classifications were useful in understanding overall production schemes of the gardens.

The steps used to conduct a financial analysis of typical Kerala homegardens in a steady state were the following:

- Account the costs and benefits for the farmer over a period of one year. Cost and benefit sources were determined based on the farmers' records, as well as inventory of the gardens. Plant productivities were based both on yield estimates and farmer records. Market values were determined based on existing prices.

- Assess the economic resilience of homegardens to market shifts in labor or crop price patterns by conducting sensitivity analyses.
- Generate an economic index to assess the primary contributors to the income generated by the homegarden.
- Compare homegardens with other economic alternatives to evaluate the option that would provide optimal economic utility to the farmer

Costs and benefits were valued at the actual existing prices that these farmers encountered at market-time. Many of the costs had already been incurred, such as one-time costs for building wells and for the initial preparation of land, but they were added to the total cost involved in maintaining the garden if incurred during the lifetime of the farmer who owned and farmed the property during the time of the study. The benefits realized from these costs are usually continuous and stretch over several years. Therefore, the yearly worth of these benefits has also been added to the annual profit generated from these gardens.

Opportunity Costs of Land and Household Labor

Both household labor and land values might present high levels of opportunity costs in many geographic locations. The land tenure and ownership system in Kerala makes land a very valuable commodity in an increasingly land-deprived social system. Furthermore, the land occupied by the homegarden almost always houses the residential building, and these homes are usually passed on to the next generation. Therefore, it is unlikely that a homegarden will be sold on its own, without the residential building. However, in order to refrain from inflating the financial worth of these systems while adhering to the observed social and cultural norms of the land, the opportunity costs of land have been assigned values equivalent to the rate at which farmers were able to lease

out all or parts of their lands. This rent rate was calculated to be an average of Rs.12,350 per hectare of land per year.

Input of household labor is a component that needs to be factored into any economic valuation. For the purpose of this study, opportunity cost of household labor is calculated as a function of time, where $\mathbf{OC_{HL}}$**=** ***f (t*labor rate),*** where t is the time spent in the garden. If the daily rate for a hired male laborer in that particular area was Rs.70, and the farmer put in an average of four hours work in his garden per day, the household labor costs were calculated to be Rs. 35(30) = 1050 per month.

Components of the Annual Financial Cycle of a Kerala Homegarden

Based on farmer surveys and farm inventories, Table 4-1 presents the inputs and outputs that are the main components of the annual finances of a typical Kerala homegarden in steady state. Inputs were determined as any monetary contribution to the annual economic cycle of the garden and were generally found to be comprised of human labor, seeds, organic and chemical fertilizer, hired labor, one-time costs such as barn maintenance and equipment (if incurred during the year of study), and associated transportation costs.

Some of the associated maintenance costs included transportation of products to market, husking of coconuts, and the harvesting of coconuts, arecanuts, and other market products. Except for transportation, these tasks were usually allotted to the hired labor, as a part of their daily duties. The farmers sometimes employed a system called '*karar*', in which a part of the commercial system was leased as a whole to a buyer, who would undertake all associated tasks, such as harvesting, transporting and selling, in return for providing a fixed sum to the farmer.

Table 4-1 Components of the annual finances of a typical homegarden in steady state, in Thrissur District, Kerala, India.

Inputs	Outputs
Fertilizers	Household products
Seeds and seedlings	Market products
Animal feed	Animal products (milk, meat, dairy)
One-time expenses	Long-term benefits (timber)
Maintenance operations	Medicinal plants
Land cost	Intangible benefits
Household labor	
HL_1=0, HL_2= Daily wage rate	

Note: Intangible benefits have not been quantified in this study

Such local barter systems might exist in other geographic locations around the world, and any financial analysis should take into account these individual practices and the social and cultural factors that influence these decisions.

The tangible benefits derived from the garden included products used for market sale, milk and other livestock products, and goods used for household consumption such as food, firewood and medicinal plants. The economic productivities and values were calculated for the monetary value that could be obtained from the local market for all products from the past year, including those used for household consumption. For example, if a farmer used two coconuts per week for household use, the price of these nuts at the existing market rate was added to the total yearly income of that particular garden.

All economically important species were inventoried and the production over the period of one year was estimated based on both farmer reports and yield data from Kerala Agricultural University (see KAU, 2002). The economic inventory included medicinal plants that might or might not have been used by the farmer over the course of the one-year, but were occupying space in the garden because the farmer considered them essential. The values of these medicinal species were included in those instances where

the farmer had occasion to utilize a medicinal plant, by using the shadow pricing mechanism of estimating the cost involved in obtaining a similar benefit elsewhere.

Timber or value of wood products usually implies a significant amount of economic value. Many of the homegardens had a significant amount of timber and any timber that was used or sold in the year of study has been included in the financial worth of the garden. Furthermore, and more pertinent to the small landowner, the branches and small twigs from these trees were often used as firewood, and were often collected by family members on a daily basis. This served an important use for the household in terms of conserving electricity and saving on cooking gas expenses.

Economic theory argues that the highest social utility is attained when producers adopt practices generating the highest rates of return to all available resources, including all costs and benefits (Scherr, 1992), and planners prefer investment in those activities yielding the highest rates of return to total resources or total labor used. However, the adoption decision for farmers is more complicated, especially in the case of homegardens where they reside within the confines of the agricultural property. These decisions may be influenced by desire to maximize utility of family labor, returns to land, or even nutritional security. Two alternatives to homegarden cultivation have been considered in this study in order to understand the extent to which farmer needs and desires affect the pure cash flow into the homegarden system: Option 1 entails selling the entire property and the house (assuming that selling the property without the house might prove to be improbable in the case of Kerala state); and Option II leases the agricultural land to another farmer while the owner resides in the same house. Both options would allow for the decision-making farmer to seek employment (work as laborer) elsewhere, assuming

there is a steady demand for labor, yet they would have to pay to attain all benefits from the homegarden. Option 1 would also require that the farmer seeks an alternate residence.

Analysis

The collected data were analyzed using basic economic methods of benefits and costs comparison, where Net Financial Worth of homegardens = B_r-C_r

Where, B = benefits, C = costs, and r = year of study

Homegarden products were categorized as having one of three levels of economic utility; Primary utility: those that are essential to the household, such as cassava, coconuts, and banana; secondary utility: those that are not absolutely essential but without which the household might suffer from nutritional deficiencies or other loss, such as gourd vegetables, spinach (*Amaranthus* spp.), and medicinal plants.; and tertiary utility: those that are grown primarily for personal pleasure, such as decorative plants and flowers, such as roses (*Rosa* spp.). Some plants are grown for both decorative and medicinal purposes, such as hibiscus (*Hibiscus* spp.). The value of primary utility plants can be quantified, the value of the secondary category including medicinals can be estimated using shadow pricing, and the tertiary category provides mainly intangible benefits. All plant species are listed in Chapter 5, Tables 5-4 and 5-5.

The sensitivity analyses were conducted by adding a 10% increment to the price of hired labor, and reduction of 10% in market prices of coconut, arecanut and banana, which are the main market crops in Kerala. Data were analyzed using *Statistica, Minitab* and *Excel* statistical software. Various statistical procedures utilized in the analysis included Analysis of Variance (ANOVA) to compare characteristics of different size categories of homegardens, comparison of means using t-tests assuming unequal

variances and multivariate regression analyses to determine predictors of homegarden profit.

Preliminary Field Results

The 32 homegardens surveyed in the preliminary study (conducted in 2001) were assessed for frequency of occurrence of species deemed economically useful by the respondent. No formal survey was administered. All results were assessed by personal interviews, and a garden inventory. Table 4-2 presents the frequency of occurrence of 'most important' crops, as assessed by homegarden farmers. Frequency of occurrence does not imply equal abundance, but it enhances understanding of species selection in randomly selected homegardens by calculating the number of gardens in which a particular species was observed in the preliminary study, thus perhaps attesting to its importance to the farmer. The abundance was not considered for the preliminary study.

Table 4-2 Frequency of occurrence of crops considered economically most important in 32 homegardens of Thrissur district, Kerala, India.

Plant species	Scientific Name	Frequency of occurrence (%)
Coconut	*Cocos nucifera*	100
Jackfruit	*Artocarpus heterophyllus*	56.3
Mango	*Mangifera indica*	78.1
Arecanut	*Areca catechu*	81.3
Banana	*Musa spp.*	100
Tuber crops	*Dioscorea spp.; Colocasia spp.*	34.4
Cacao	*Theobroma cacao*	12.5
Cassava	*Manihot esculenta*	56.3
Papaya	*Carica papaya*	87.5

Note: Frequency of occurrence does not imply abundance. It is used here as a potential indicator of importance to the farmer.

Coconut was the most economically important crop according to farmers and occurred in all surveyed plots. Although cacao was considered as an economically important crop by over 50% of the farmers, it occurred in only four of the gardens.

Results

The 75 gardens included in this project had a mean landholding size (excluding the residential area) of 0.34 ha (SE=0.03 ha); median 0.26 ha. The smallest garden was only 0.01 ha in area, and the largest was 1.0 ha. Although homegardens greater than one hectare in size were initially included in the data collection as part of the random sample, they were not included in the analysis because they were deemed to be very large farms that showed more characteristics of sole-crop farming than those of a traditional homegarden. The gardens included in the study were divided into four groups according to median increments of 0.26 ha: *Small* ≤ 0.26 ha; 0.26 ha < *medium* ≤ 0.52 ha; 0.52 ha < *large* ≤ 0.78 ha; 0.78 ha < *commercial* ≤ 1.0 ha. According to these classifications, there were 24 'small' gardens, 14 'medium' sized gardens, 10 'large' gardens, and 27 'commercial' sized gardens.

Economic Values of Homegardens and Annual Economic Profit

The existing financial worth of all the surveyed gardens were estimated based on the quantitative values of the costs and benefits experienced in the year of study.

Table 4-3. Mean financial value of homegardens for 2002-2003 (in Rupees), based on the benefits and costs of 75 gardens surveyed in Thrissur District, Kerala, India.

Size of homegarden	Mean financial value (Rupees)	Mean financial value, including opportunity costs of land and household labor (Rupees)
Small (≤ 0.26 ha, n=24)	62,261	46,284
Medium (> 0.26 ha, ≤ 0.52 ha, n=14)	157,524	132,759
Large (> 0.52 ha, ≤ 0.78 ha, n=10)	256,639	225,116
Commercial (> 0.78 ha, ≤ 1.0 ha, n=27)	275,967	214,899

Financial worth measured in Rupees (1.00 $US ~ Rs. 47, October, 2003).

All 75 homegardens generated a positive economic value for the year 2001-2002 (Appendix B) and an average of these values in rupees is presented in.Table 4-3.

Intensity of Profit-Generation

The various levels of intensity of cultivation as indicated by the generation of profit per unit area (mean profit / sq.m of homegarden) were calculated for the four land-size categories (Table 4-4). The intensity of profit generation was highest in the small gardens.

Table 4-4. Intensity of profit generation across different size categories of homegardens in Thrissur District, Kerala, India.

Homegarden Size		Mean Profit / sq.m (Rupees/year)	Standard Error
Small	(n=24)	84.28a	10.72
Medium	(n=14)	68.80b	9.61
Large	(n=10)	76.64a	11.48
Commercial	(n=27)	40.61c	4.15

Notes: The letters a,b,c following a value indicate significant changes in means at $\alpha = 0.05$. Means were compared using t-tests assuming unequal variances. Intensity refers to the mean profit generated per sq. m of cultivated area in the homegarden.

The commercial sized gardens yielded an average profit of Rs.40.61 per sq.m, and the smallest gardens yielded more than double that of commercial gardens average profit with more than Rs.84 per sq.m. This indicates that although the net production was higher in the larger gardens (Table 4-3), the intensity of production was much greater in the small gardens.

Economic Importance of Homegarden Species

The most importance contributors to the economic profit generated by homegardens were coconut, arecanut and banana (including both cooking and dessert varieties). The distributions of profit varied across garden sizes. The other important categories of economic importance in the homegarden were milk production, cashew

trees and spice plants (Appendix C presents the percentage of homegarden profit contributed by 9 different categories). Household consumption formed a significant percentage of the profits (more than 50%) in the smaller gardens, while the larger and commercial gardens invested most of their homegarden to the commercial production of coconut and arecanut.

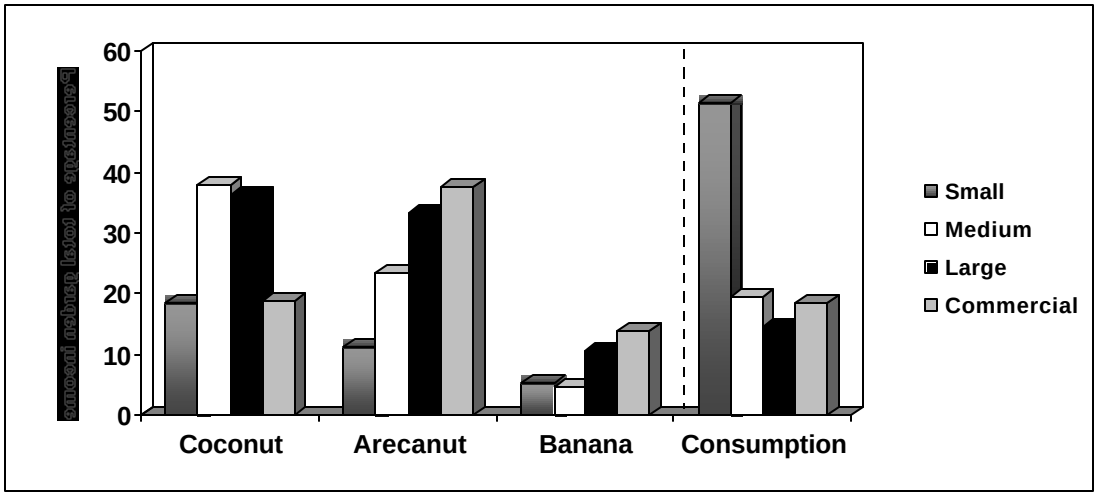

Figure 4-1. Contribution of three crop categories and extent of household use in total profit generated by different size classes of homegardens in Thrissur district, Kerala, India. Note: Seventy five homegardens were included in this study.

Sensitivity Analyses

Sensitivity analyses are important when evaluating the economic benefits of homegardens in order to ascertain the extent to which these systems are susceptible to shifts in the prices of labor and market products. A majority of the surveyed households (96%) reported the prices of hired labor to be the most restrictive aspect of managing these systems, and coconut, arecanut and banana as the most economically important crops.

Table 4-5 Sensitivity analyses to ascertain the economic resilience of 75 homegardens of Thrissur district, Kerala, India, to price fluctuations in labor and three economically significant crops.

Sensitive Categories	Percent Response in Financial Worth (Based upon a 10% change in price)			
	Small	Medium	Large	Commercial
P of hired labor	0.28	1.12	0.24	0.31
P of coconut	1.0	2.0	2.8	1.0
P of arecanut	0.81b	1.65b	2.21b	2.46a
P of banana	0.42	0.35	0.74	0.92

Note: P indicates existing market price.
a indicates significant statistical difference at $\alpha = 0.05$. The means were compared between small (n=24), medium (n=14), large (n=10), and commercial (n=27) using t-tests assuming unequal variances.

Table 4-5 indicates the changes in net value of the gardens when the labor prices are increased by 10%, and the market prices of coconut, arecanut, and banana are reduced by 10%. Some of the gardens were also very dependent on rubber, but rubber was mainly found in the large gardens, in the form of a sole crop. Furthermore, rubber has been providing fairly consistent prices during the past several years. Therefore, it was excluded from the sensitivity analysis.

Very low changes in annual profit value occurred across all classes of homegardens, ranging from 0.24% to 2.46%. The only statistically significant difference across means was the effect of raised arecanut prices in the commercial gardens, which ranged from 2.46% for commercial gardens to 0.81% for the small gardens.

What Factors Affect the Financial Value of Homegardens?

Statistical analyses using multivariate regression methods were used to assess the effects, if any, of various factors on the financial values of the surveyed homegardens. The values (Table 4-6) indicated that land size and age were both slight predictors of profit, while labor, both household and hired, and gender, did not display the ability to predict an increase or decrease in the net financial worth.

Table 4-6. Land size (sq. m) and number of years in cultivation are predictors of homegarden economic worth in Thrissur district in Kerala, India, as indicated by multivariate regression analysis

	B	Standard error of B	P values
Intercept	4.61	0.073	0.000
Land Size	0.007	0.056	< 0.005
Age of garden	0.003	0.001	0.017

Note: $r^2 = 0.455$, Adj. $r^2 = 0.447$.
Labor (both household and hired) and gender of main decision maker were not significant indicators of homegarden profit.

From the above data, we can model our financial value predictor equation as follows

Net financial value of homegarden = 4.61 + 0.007 (x_1) + 0.003 (x_2),

Where x_1 = land area in sq.m, x_2 = number of years in cultivation

This model indicates that the financial value of Kerala homegardens increases with increasing land size and with increase in numbers of years of cultivation. It is to be noted that number of hours of household or hired labor, and gender of the decision maker in the household are not correlated to net profitability. This model, while relevant to Kerala state, can potentially be used to construct similar such models for homegardens in other geographic locations. Biophysical aspects such as soil quality might also contribute to the financial value of the garden, and these aspects need to be further investigated.

Timber

All timber and other wood products sold or consumed by the household were factored into the financial calculations. The Kerala Protected Tree Act states that standing wood belonging to ten protected species cannot be transported across public Kerala roads with out a permit[2]. This act mandates that owners cannot cut trees for commercial sale

[2] From personal communications with B. Mohan Kumar, Head of Agroforestry, Kerala Agricultural University, Thrissur District, Kerala, India

without a permit, and thus ensures the retention and conservation of old-growth timber. In spite of the bureaucracy associated with high value timber species, the Kerala gardens had an average of 4.4 timber species (Table 4-7). Every surveyed farmer considered these trees as a long-term investment and even those farmers who perceived themselves to be under severe financial constraints did not consider selling or cutting these trees as an optimum option.

Table 4-7 Average number of timber species in 75 homegardens in Thrissur district, Kerala, India

Homegarden size category		Average total # of useful species	Average # of timber species in homegardens
Total	(n=75)	20.1	4.4
Small	(n=24)	18.5	3.5
Medium	(n=14)	20.0	4.3
Large	(n=10)	22.6	4.7
Commercial	(n=27)	22.3	5.0

Household Labor

Almost all the gardens hired labor, especially for the more arduous tasks such as felling coconuts and arecanuts, and preparing the land for application of fertilizers, and irrigation. However, the bulk of the labor input into these systems is from the members of the household. Table 4-8 presents a summary of the household labor input in the 75 surveyed homegardens.

A significant change in total household labor input is observed between the small gardens (4.2 hours/day/garden) and commercial gardens (11.2 hours/day/per garden), at $p \leq 0.005$. But there is also a significant increase in intensity of labor input, with 43.9 person days per year being invested in 100 sq.m of land in the small gardens and only 9.1 person days per year invested into 100 sq.m of land in the commercial gardens. This

implies that the higher intensity of profit generation in the small gardens could be in part due to the higher intensity of labor invested in the garden.

Table 4-8 Household labor characteristics in 75 homegardens in Thrissur district, Kerala, India

	Small	Medium	Large	Commercial
Daily input of household labor (hours/day/garden)	4.2a	5.5a	3.1a	11.22b
Intensity of household labor (persondays/100 sq.m/year)	43.9a	14.6b	15.9b	9.21ab

Note: a,b indicate statistically significant difference between means, using t-tests assuming unequal variances.

Gender Dynamics in Kerala Homegardens

Studies have shown that although rural women in Asia play an important role in agriculture (Chacko, 1975; Gleason, 1988; Kaur and Sharma, 1991), disparities in gender distribution of labor still exist. In Kerala, however, there are high levels of participation by women, in agriculture. The average number of hours put in by women in small homegardens is greater than the hours put in by men. This implies that women manage the subsistence household, where the land is primarily used for feeding the family. However, the commercial sized homegardens also have a very high household labor input by women and high levels of participation, thus suggesting that women are also very much involved in the financial health and productivity of the garden.

Kerala is the most literate state in India. According to the 2002 Government of India census, nearly 94.5% of the state is literate. It is also the only state in India with a higher female to male ratio (1056-1000). Kerala has been much studied by anthropologists and historians for their matriarchal system of family (Trautmann, 1995). In this system, the women traditionally have full ownership of the family land, and property is usually passed down to women. Although current civil codes have negated

this property code, to ensure equal opportunity for both the male and female children of the house, remnants of this system are evident by the fact that women in Kerala are generally powerful in terms of family dynamics. They are also very involved in all agricultural activities, including economic decision-making.

Our hypothesis is that such high levels of involvement in agriculture, which is the main income producing activity of the household, has contributed to the general empowerment and advancement of women in Kerala. Out of the 75 households surveyed, eight were female dominated homegardens, and nine gardens were completely run by men; here the word 'dominated' implies that the economic decision making power was concentrated in either the male or the female head of the household. However, as can be seen in Table 4-9, there were no statistically significant differences in the intensity of profit generation. This implies that women are actively involved in the homestead agroforestry in Thrissur district.

Table 4-9. Intensity of profit generation in female and male operated homegardens, based on 75 homegardens from Thrissur District, Kerala, India.

Category	Number of homegardens	Profit (rupees)/100 sq.m/year
Female dominated	8/75	83.09
Male dominated	9/75	61.8
Equal Participation	58/75	63.64

Note: USD 1 ~ Rupees 47, October 2002 – February 2003

Most landowners overwhelmingly claimed to have equal ownership, rights, and decision-making ability between male and female heads of households with regard to their garden. Using a 2x2 factorial experimental design, the male and female household labor inputs were analyzed for interactions within size categories and within gender (Table 4-10). Multi factor analysis of variance (ANOVA) indicated that there were no interactions between the size of garden, gender of decision-maker and number of daily

hours of household labor input by the male and female members. It has to be noted that the labor hours as estimated did not include time spent (mainly by the female) on livestock related activities, cottage industries, food harvesting, cooking, and tasks associated with processing food for home use. Besides these tasks, the women also spent significant amounts of time in actual labor, including watering, collecting fruits and nuts for market, plowing, weeding, and planting. Women primarily tended to vegetables, while men tended to the trees and other plants requiring hard manual labor.

Table 4-10 Daily input of household labor by female and male family members into 75 homegardens in Thrissur district, Kerala, India.

Size of garden	Male labor hours/day	Female labor hours/day
Small	1.9	2.3
Medium	3.5	2.0
Large	6.1	3.0
Commercial	5.8	5.40

A majority of the homegardens surveyed also reported that the male and female heads of household participated equally in the economic decision-making processes of the garden.

Economic Alternatives to Homegardens

Two possible alternatives to homegarden cultivation were considered when comparing the economic rationale behind homegarden cultivation to other forms of investment. The first alternative for a farmer would be to sell the land, with the house and all associated crops and benefits, invest the capital in a bank at 6% compound interest rate and to live in a comparable neighborhood with a similar quality of life. The second alternative would be to lease the land and all associated benefits to other farmers. Both alternatives with their profit values at the end of the investment year are considered in Tables 4-11, 4-12, 4-13 and 4-14. The non-monetary benefits were not quantified. The

values listed are all estimated from the homegarden of mean size in the corresponding size category. Lease value is based on existing rent rate of Rs.12,350 per hectare.

Living expenses were estimated based on a two-month survey of four urban and rural households with no attached homegardens. All household expenses, not including meat, staple food such as rice, potatoes, salt, and other goods not normally realized from the garden, were estimated to be an average minimum of Rs. 20000 per year per household. Homegarden costs were the average costs from each size category of garden.

Table 4-11 Comparison of an average small homegarden to two alternate forms of economic investment, in Thrissur District, Kerala, India.

Variables (a)	Garden	Lease	Bank
Land	0	1086	22012
Labor	0	7250	7250
Living expense	0	(20000)	(20000)
Rent	0	0	(15000)
Transportation	0	(500)	(500)
Incidentals	0	(800)	(800)
HG Costs	(7548)	0	0
Benefits	65519	0	0
	57971	(12964)	(7038)

Note: n=24, small ≤ 0.26 ha

Table 4-12 Comparison of an average medium homegarden to two alternate forms of economic investment, in Thrissur District, Kerala, India.

Variables (b)	Garden	Lease	Bank
Land	0	2552	61329
Labor	0	14914	14914
Living expense	0	(22000)	(20000)
Rent	0	0	(15000)
Transportation	0	(500)	(500)
Incidentals	0	(800)	(800)
HG Costs	(12399)	0	0
Benefits	174912	0	0
	162513	(5834)	39943

Note: n=14, 0.26 ha < medium ≤ 0.52 ha

Table 4-13 Comparison of an average large homegarden to two alternate forms of economic investment, in Thrissur District, Kerala, India.

Variables (c)	Garden	Lease	Bank
Land	0	4240	101760
Labor	0	11880	11880
Living expense	0	(22000)	(20000)
Rent	0	0	(15000)
Transportation	0	(500)	(500)
Incidentals	0	(800)	(800)
HG Costs	(12307)	0	0
Benefits	237158	0	0
	224851	(7180)	77340

Note: n=10, 0.52 ha < large ≤ 0.78 ha

Table 4-14 Comparison of an average commercial homegarden to two alternate forms of economic investment, in Thrissur District, Kerala, India.

Variables (d)	Garden	Lease	Bank
Land	0	8250	201370
Labor	0	17862	17862
Living expense	0	(24000)	(20000)
Rent	0	0	(15000)
Transportation	0	(500)	(500)
Incidentals	0	(800)	(800)
HG Costs	(17302)	0	0
Benefits	275524	0	0
	258222	812	182932

Note: n=27, 0.78 ha < commercial ≤ 1.0 ha.

These tables indicate that homegardens are the most efficient economic rationale for farmers as opposed to leasing or selling the land. Selling the garden becomes a reasonable yet not comparable alternative, with the large and commercial gardens. Small farmers would be best served if they retained their homegardens. Leasing was not an economically viable option for the small, medium or large gardens, and just broke even in the commercial category.

Discussion

All surveyed homegardens generated profit at steady state, thus justifying their need to be considered on par with other mainstream agriculture by policy makers. This study

reported the existing financial value (Benefits-Costs during the year of study) of the surveyed gardens (Table 4-3). The profit generated per unit area was highest in the small gardens (Table 4-4), and lowest in the commercial gardens thus perhaps implying that farmers are adept at adaptive management techniques. Land being a constraint, farmers intensify cultivation on available land in order to attain desired goals and objectives. It could also follow that commercial farmers are not devoting land to production of economically important crops but to intangible benefits such as aesthetics and ornamentation. Future studies could assess whether this difference in profit generation equals the opportunity cost incurred by those commercial farmers who do not intensify production.

Coconut, arecanut and bananas were the three most economically important crops (Appendix C). Although arecanut was responsible for a significant portion of the profits in many of the gardens, the farmers recognized that this transient crop could be utilized for only as many years as demand persisted, and that arecanut palms were not integral parts of the homegarden culture. It was noted that although economic demands were extremely important in determining garden use, small gardens devoted more than 50% of their garden profit to household subsistence uses, such as vegetables, fruit and firewood. This implies that the larger and commercial gardens might possess more liquid cash than the small or medium farmers, with which to buy these household products from the local market, thus being able to devote homegarden space to commercially viable crops such as arecanuts and spice trees. A majority of the farmers (more than 80% in all sizes of homegardens) reported that more than 75% of their household needs were met by their gardens.

The sensitivity analyses (Table 4-5) reaffirmed the hypothesis that these systems are economically stable, not dependent on any one crop or factor, and that the farmers followed an age-old adaptive approach to farming. Harvests were staggered so as to retain food crops such as cassava, for times of the year when staple food crops such as rice were not readily available. It was also evident that none of these crops formed a focal point of the garden. For example, arecanut crop had been sustaining high market values during the 1990s, but their market values have suffered a drastic reduction during the past few years (2001, 2002) and many farmers would have sustained heavy losses if their gardens consisted of sole stands of arecanut palms. In the complex and varied homegardens, a lag in the prices of arecanut did not cause a significant reduction in overall profit.

After considering two potential alternatives to homegardening (Tables 4.11-4.14), it was estimated that retaining homegardens was more profitable than leasing or selling the land. The estimated values for the homegarden did not consider the additional benefits attained from intangible benefits such as aesthetics, nutritional security, and improved quality of food. Plantation farming was not considered as an alternative because many of the gardens surveyed were deemed to be too small in area to be fit for plantation agriculture. The household labor associated with homegardening was an important component of the alternatives because it was assumed that if the land were no longer available to farmers, they would earn money by providing hired labor to neighboring farms. This is another debatable point, however, because many of the farmers reported that they were not equipped to perform any skilled work, nor did they desire to perform farm labor outside their properties. Furthermore, many of the farmers

were older, and cherished the relative freedom they enjoyed in their fields, and in their ability to set their own times. It was, therefore, obvious that farmers with no alternative employment options except hired field labor, preferred working in their own fields and this preference would account for some level of dissatisfaction with the other economic alternatives.

The combined results indicate that homegarden systems generate economic profit, while simultaneously providing certain non-market benefits. These non-market benefits, while not necessarily economically viable, are nevertheless important to the farmer. This provides scope for future studies that can evaluate the opportunity costs of these intangible benefits. Until then, homegardens remain a better economic alternative than selling the land, or leasing to another farmer

CHAPTER 5
ECOLOGICAL OVERVIEW OF HOMEGARDENS

Introduction

Much of the existing homegarden literature is highly descriptive with tables of species names, and descriptions of the systems as a whole. These descriptions, although highly informative, do not represent the true ecological rationale behind the functioning of these homegardens, nor do they provide the reasons behind the farmers' decisions to plant or retain certain species in their gardens. For example, homegardens are regarded as an ideal system for in situ conservation of genetic resources (Esquivel and Hammer, 1992; Gajaseni and Gajaseni, 1999; Watson and Eyzaguirre, 2002). But the biophysical aspects behind this conservation effect and other ecological phenomena in homegardens have not been adequately understood. Farming and food production is a system. This system has several properties that cannot be fully understood as a sum of their parts, but rather how they interact together to form a complete whole. This chapter attempts to provide an understanding of the diversity of these systems, and how certain selected species interact to form a complete, functioning ecosystem.

The underlying concept is that natural ecosystems are sustainable barring major disturbances, and therefore provide a basis of comparison for assessing ecosystem attributes such as soil fertility (Ewel, 1999). Although managed systems differ in that they endure repeated harvests and biomass removals, the same biological processes of production, decomposition, and plant-organism interactions are prevalent in natural and managed systems. The concepts of agricultural ecology and biodiversity in

agroecosystems are prevalent in the research done in many forms of agriculture. The premise behind this line of study is that there might be some way to preserve certain attributes of sustainability such as diversity, while using it to produce agricultural crops (Collins and Hawtin, 1999). Homegardens are somewhat similar to natural tropical ecosystems in structure, and agricultural ecosystems in function, and yet these systems prove to be the continuous and often primary subsistence source for thousands of farmers and landowners. Although these systems might not attain diversity levels of natural forests, they can be considered the systems with the highest diversity and complexity among man-made agroecosystems (Swift and Anderson, 1993), and the species that make up the diversity of these systems are often not assembled as in natural forests, but are carefully chosen with their utility value as the main criterion. Initially created out of natural forests, they are now restricted to a defined assemblage of crop plants, livestock, trees, and the associated pests, diseases, and weeds, still undergoing the basic renewable ecological processes such as competition between plants for sunlight and water, consumption of plants by livestock, and pests, and predation of pests by their natural enemies (Soemarwoto and Conway, 1992). These processes are regulated by agricultural practices such as cultivation, control of water, pests and diseases, and harvesting. And these agricultural practices are in turn regulated by economic and social decisions.

This chapter focuses on the following major questions:

- What are the patterns of similarity in species selection across homegardens?
- What are the patterns of biodiversity across homegardens? Do these patterns depend on certain factors such as size of garden or years in cultivation?
- What, if any, are patterns that remain unchanged regardless of garden size and other socioeconomic characteristics?

- What are the various useful species found in the surveyed gardens? What are the importance values of the major crops? What are the other uses, if any, of the medicinal varieties?
- Would homegardens be sustainable alternatives to monocropping and loss of biodiversity?

Agroecology is based on the premise that there are several factors interacting to form an agro-ecosystem. These factors work together to form a functioning and living system. One of the steps toward a sustainable agroecosystem seems to be increasing biodiversity. Homegardens are often diverse and complex with many plant and animal species interacting in the same land. In order to understand the rationale behind the seeming (although man-made) sustainability of these systems, a variety of factors would have to be explored. One of these relevant factors would be the species diversity and similarities across gardens.

Methodology

All 75 gardens used in this study were inventoried for their plants. All species, including seedlings and saplings, that were deemed useful to the farmer were listed, and the number of individuals of each species per garden were noted. Some species, whose identification proved taxonomically difficult (such as medicinal plants) were identified with the help of an officer from the local farm office, and with help from a scientist at the Kerala Agricultural University. Seedlings and saplings were defined as non-herbaceous plants that were less that 1.0 m in height; they were not included in calculating the economic productivity of the system. All herbaceous plants were included in the study. Sorenson's Index of Similarity (Sorenson, 1948) was used (details are given in the following sections) to assess the levels of similarity in species selection across different size categories of gardens. Diversity was estimated using two methods: Margalef Index

(to assess species richness) (Margalef, 1958), and Shannon-Wiener Index (Krebs, 1985) to assess both richness and evenness. Overall species density (number of species/unit area) and tree species density (number of tree species/unit area), and importance values of various species were also determined. The details of each procedure are given in the following sections.

Similarity among Homegardens

Sorenson's Index of Similarity was used to compare the vegetative composition (not including abundance of species) of homegardens of different sizes, taking into account both the herbaceous and woody components of the garden. All similarity indices are expressed in percentages in order to make the comparisons easier to read.

Sorensen's index represents the number of common species between two sites (Say Garden A and Garden B). The equation for this measure of similarity is as follows

Sorensen's Index is shown in Equation 5-1

$$S_S = \left(\frac{\text{Number of Common Species}}{(S_a + S_b)/2}\right) * 100 \qquad (5\text{-}1)$$

S_s = Sorenson's Index

S_a = The number of species in community A

S_b = The number of species in community B

In this study, homegardens were categorized into one of four community sizes: small, medium, large and commercial. The gardens included in the study were divided into four groups, based on median increments of 0.26 ha: Small (≤ 0.26 ha); medium (0.27 – 0.52 ha); large (0.53 - 0.78 ha); and commercial (0.79 – 1.0 ha). The Sorenson index values were calculated for all combinations of homegardens, then averaged for

each category and these values were compared to the average value from each of the other size categories.

Diversity

Diversity Indices are used to assess the level of biodiversity in systems. Diversity can be expressed as a function of scale, where α-diversity represents diversity within a single community or ecosystem (such as homegarden) and β-diversity represents the diversity among communities along an environmental gradient such as ecosystems of Kerala.

Diversity in any vegetated system is a product of its richness and evenness. Richness is simply the presence or absence of species, without regard to abundance. Evenness refers to the balance between the numbers of individual members of species. To measure evenness in a system, the index needs to be relatively insensitive to the occurrence of rare species. Many studies have attempted to assess the biological diversity of tropical forests, and to understand the many factors that affect the existing genetic, species, and ecosystem diversity (e.g. Krebs, 1985; Gimaret-Carpenter et al., 1998; Margurran, 1988; Ricklefs and Schluter, 1993; Huston, 1994). Standard ecological references use many different techniques to estimate the diversity of a given vegetated site. The Shannon-Weiner Index is the most commonly used diversity indicator in plant communities, and it takes a value of zero when there is only one species in a community, and a maximum value when all species are present in equal abundance. The following equation from Krebs (1985), which was used for this study, looks at the diversity of those species in the garden that are grown on an annual or perennial basis.

$$H = -\sum_{i=1}^{s} p_i \ln p_i \qquad (5\text{-}2)$$

Where H is the Shannon-Weiner Diversity Index, the proportion of species i relative to the total number of species is calculated and multiplied by the natural logarithm of this proportion. The resulting product is summed across species and multiplied by –1.

Example is provided in Appendix E

Species Richness

The Margalef richness index adjusts the number of species sampled in an area by the log of the total number of individuals sampled, summed over species. The higher the Margalef index, the richer would be the species diversity of the population.

$$\text{Margalef Index} = (S-1) / \ln(N), \qquad (5\text{-}3)$$

Where s is the number of species, and N is the total number of individuals in the sample.

Example is provided in Appendix D

Species Density

Density of species (number of species / unit area of homegarden) was calculated in order to determine the effect, if any, of decreasing land size on diversity and number of species. Species density is also indicative of the planting and cultivation patterns of the farmer and would serve to assess whether land constraints inhibit species diversity.

Agroecological Importance Values

Importance values are utilized by ecologists to assess the ecological composition of a forest community based on three criteria: How commonly a species occurs across the entire site (frequency), the total number of individuals of that species (density), and the area occupied by that species (dominance) (Burns and Honkala, 1990). These values are usually ascertained from values obtained from sampling sites that are equal in area.

However, in the case of homegardens, where the communities differ in size, the importance values are calculated using relative rather than absolute values. Extrapolating the values on a basis of unit area might not be applicable to homegardens because these systems display marked changes in intensity of cultivation with increasing land size.

$$\text{Importance Value} = \text{Relative frequency} + \text{Relative Density} + \text{Relative Dominance} \quad (5\text{-}4)$$

Relative frequency is the number of occurrences of a species, as a percentage of the total occurrences of all species; *relative density* is the number of individuals of a species as a percentage of the total number of individuals of all species in that area; and *relative dominance* is the total area occupied by one species as a percentage of the total area occupied by all the species in the sampled site.

Dominance was calculated by estimating the space occupied by each species in each sampled garden based on information from Kerala Agricultural University's Crop publications (2002). For example, a coconut tree was estimated to occupy an area of $12m^2$, and fully-grown mango trees were estimated to occupy an average area of $16m^2$.

Analysis and Results

Diversity, Species Richness and Density

Species diversity and richness measures were estimated for all 75 gardens. Medicinal plants were included in the diversity indices. Weeds and ornamental plants were merely noted in species count, and not included in the species diversity calculations because the presence of weeds and ornamentals are highly transitory and hard to count. Shannon-Wiener indices were calculated for all annual, perennial, and medicinal species in homegarden (Appendix E) and Margalef indices were calculated for all species,

including weeds, ornamentals, and medicinal plants (Appendix D). Means of diversity estimations and species densities are listed in Table 5-1

Table 5-1 Ecological characteristics of 75 homegardens in Thrissur district, Kerala, India.

		Small (n=24)	Medium (n=14)	Large (n=10)	Commercial (n=27)
1	Total no. of observed species	128	109	121	118
2	Mean no. of species/garden	34	32	38	38
3	Mean species density (no. of species /100m^2)	4.9a	1.66b	1.06c	0.5b
4	Mean tree species density (no. of trees /100m^2)	0.7a	0.2b	0.14c	0.08d
5	Mean Margalef Index	6.42	5.61	6.01	5.43
6	Mean Shannon-Weiner Index	1.15	1.27	1.42	1.39

Note: a,b,or c following the mean value indicates a statistically significant difference (at $\alpha = 0.05$) between means using t tests assuming unequal variances

There was a statistically significant difference in mean species density per100m^2 area, across garden size classes (with $P \leq 0.05$). Farmers listed 94 useful species (excluding medicinals, weeds and pure ornamentals); and a total of 153 species including medicinals were found, and taxonomically identified. All medicinals observed in the surveyed homegardens and a list of their uses as reported by farmers are listed in Appendix F. The average number of species in a garden was estimated to be 36.

Similarity among Homegardens

Sorenson's Index was calculated for all species in the 75 homegardens. The homegardens were again divided into four communities: small, medium, large and commercial. Table 5-2 shows the percentage of similarities in overall species richness and tree species richness across the four homegarden sizes. The similarities among communities were fairly consistent. The percentages of similarity across homegardens

sizes were all fairly high, with the highest overall species similarity observed between the medium and large gardens (90.9%)

These values indicate that land sizes did not restrict species composition in a homegarden. Farmers might instead reduce the number of individuals of certain species, to accommodate all the species they required in their homestead.

Table 5-2 Percentage of similarity of overall species richness and tree species richness using Sorenson's index of similarity across four size categories of homegardens in Thrissur District, Kerala, India.

	Small (S)	Medium (M)		Large (L)		Commercial (C)	
		O	T	O	T	O	T
S	---	81.3	88.1	82.3	81.3	85.9	84.2
M	---	---		90.9	81.4	78.7	76.0
L	---	---		---		77.5	76.0

Note: The gardens included in the study were divided into four groups: Small ≤ 0.26 ha; 0.26 ha < medium ≤ 0.52 ha; 0.52ha < large ≤ 0.78 ha; 0.78 ha < commercial ≤ 1.0 ha. Refer to Results section in Chapter 4.

O = Overall Species Richness
T= Tree Species Richness

Agroecological Importance Values

The agroecological importance values were estimated (Table 5-3) using an aggregate of the relative frequency, relative density, and relative dominance (Burns and Honkala, 1990; Curtis and McIntosh, 1951). Nine major categories were found to be ecologically prevalent in the gardens. The V (vegetable) — M (medicinal) — O (ornamental) category was found to be overwhelmingly important in the small gardens, while the spice trees were relatively more important in the large and commercial area categories than in the small and medium gardens.

Table 5-3 Agroecological Importance Values of homegarden species, based on frequency, density and dominance patterns in 75 homegardens of Thrissur district, Kerala, India

Importance of crop category	Small (n=24)	Medium (n=14)	Large (n=10)	Commercial (n=27)
1	V, M, O (100)	Tree fruit (57.4)	Coconut (51.4)	Coconut (46.9)
2	Tree fruit (44.8)	Coconut (52.8)	Tree fruit (45.5)	Banana (43.2)
3	Arecanut (35.3)	V, M, O (43.9)	V, M, O (45.4)	Arecanut (37.9)
4	Banana (34.3)	Banana (34.3)	Arecanut (42.6)	Tree fruit (32.1)
5	Coconut (33.7)	Black pepper (29.9)	Banana (35.1)	Spice trees (26.8)
6	Black pepper (26.7)	Arecanut (18.4)	Cashew (30.5)	V, M, O (24.3)
7	Rubber (6.3)	Rubber (4.6)	Spice trees (9.3)	Black pepper (18.2)
8	Cashew (3.7)	Cashew (2.2)	Black pepper (2.8)	Rubber (7.2)
9	Spice trees (1.7)	Spice trees (1.2)	--	Cashew (3.5)

Note: Importance Values are given in parentheses. V,M,O = Vegetables excluding cassava, medicinal plants and ornamentals. Rubber was not found to be a significant presence in the large homegardens.

Species Inventory

Tables 5-5 and 5-6 indicate the useful woody species found in the gardens, some of which have been retained, not necessarily planted. Herbaceous species are listed in tables 5-4 and 5-7. The number of useful species (excluding ornamentals, weeds, useful grasses, and medicinals) was fairly consistent throughout homegardens, at an average of 20.9 species per homegarden. All homegardens deemed medicinals as useful and essential, but not economically important. This is an arguable point, however, because if these medicinal species were not available, farmers would have had to spend money on homeopathic medicines, including cold and cough treatments.

The farmers were asked to assign all their homegarden species a value of primary, secondary, or tertiary. Primary implied a species that was essential to the household, secondary implied a species that was not absolutely essential but without which the household would suffer nutritional deficiencies and reduced quality of life, and tertiary implied a plant species that was merely designed to improve quality of life of the householder, such as ornamental plants. Tables 5-4 and 5-6 were all considered to be 'primary species', while most farmers listed the species in tables 5-6 and 5-7 as those of secondary importance. Medicinals could be accurately classified in one of these categories because their presence is highly arbitrary and rare, and dependant on the individual needs of the particular respondent. However, the medicinals, although not of economic value by themselves, (i.e. the medicines would require time and energy to prepare and might not be useful in plant form), were generally considered to be vital parts of the homegarden.

Table 5-4 Herbaceous species that are of economic importance to the household, as reported by respondents in 75 homegardens in Thrissur district, Kerala, India.

Local/Common Name	Scientific Name
Banana	*Musa* spp.
Black pepper	*Piper nigrum*
Ginger	*Zingiber officinale*
Turmeric	*Curcuma longa*
Arrowroot	*Maranta arundinacea*
Taro	*Colocasia esculenta*
Elephant foot yam	*Amorphophallus campanulatus*
Greater yam	*Dioscorea alata*
Bitter gourd	*Momordica charantia*
Ash gourd	*Benincasa hispida*
Spinach	*Amaranthus spp.*
Snake gourd	*Trichosanthes anguina*
Beans	*Vigna unguilicata*
Vanilla	*Vanilla planifolia*
Pineapple	*Ananas comosus*
Mango ginger	*Curcuma amada*
Pigeon pea	*Cajanus cajan*

Table 5-5 Tree and shrub species encountered in sampled homegardens, assessed as economically important by respondents from 75 surveyed homegardens in Thrissur district, Kerala, India.

Local/Common Name	Scientific Name	Family	Uses
Coconut	*Cocos nucifera*	Arecaceae	a, c, f
Arecanut	*Areca catechu*	Arecaceae	a, f
Mango	*Mangifera indica L.*	Anacardiaceae	d, b
Jackfruit	*Artocarpus heterophyllus*	Moraceae	d, b
Cassava	*Manihot esculenta*	Euphorbiaceae	e
Rubber	*Hevea brasiliensis*	Euphorbiaceae	c, f
Coffee	*Coffea arabica*	Rubiaceae	d
Nutmeg/Mace	*Myristica fragrans*	Myristicaceae	a
Clove	*Syzygium aromaticum*	Myrtaceae	a
Tamarind	*Tamarindus indica*	Caesalpiniaceae	d
Matti	*Ailanthus triphysa1*	Simaroubaceae	b
Teak	*Tectona grandis*	Verbenaceae	b
Maridu	*Terminalia termentosa*	Combretaceae	b
Veeti (Rosewood)	*Dalbergia latifolia*	Papilionaceae	b
Kodampuli	*Garcinia cambogia*	Clusiaceae	d, c
Kaini	*Briclilia rectusa*	Euphorbiaceae	b
Mahogany	*Swietennia macrophylla*	Meliaceae	b
Cashew	*Anacardium occidentale*	Anacardiaceae	d,b,a
Poomaram	*Delonix regia1*	Leguminoseae	b
Irumullu	*Xylia xylocarpa*	Mimisoideae	b,c
Venga	*Tirocarpus marsupium*	Leguminoseae	b
chadchi (Grewia)	*Grewia tiliifolia*	Tiliaceae	b
Mulberry	*Morus alba*	Moraceae	c,f
Venga (IndianKino)	*Pterocarpus marsupium*	Leguminoseae	b
Sandalwood	*Santalum album*	Santalaceae	f
Asoka maram	*Saraca indica*	Caesalpiniaceae	b,c
Poola	*Bombax ceiba*	Bombacaceae	b,f
Kaatu chembakam	*Michelia champaca*	Magnoliaceae	b,c,g
Aini	*Artocarpus hirsutus*	Moraceae	b,c
pana (palmyra palm)	*Borassus flabellifer*	Palmae	f,e
Talipot palm	*Corypha umbraculifera*	Palmae	f
Fish-tail palm	*Caryota urens*	Palmae	f
Thippili	*Alstonia venenata*	Apocynaceae	g,b
Pali	*Palaquium ellipticum*	Sapotaceae	b,g
Rubber tree	*Hevea braziliensis*	Euphorbiaceae	f

Note: Local names are in italics.

Table 5-6 Trees and shrubs of secondary economic utility, mainly for household uses, as reported by respondents from 75 homegardens in Thrissur district, Kerala, India.

Local/Common Name	Scientific name	Family	Uses
Breadfruit	*Artocarpus altilis*	Moraceae	d
Guava	*Psidium guajava*	Myrtaceae	b,c,d
Louvi-Louvi	*Flacourtia inermis*	Flacourtiaceae	b,c,d
Papaya	*Carica papaya*	Caricaceae	d,
Cherunarakam	*Citrus limon*	Rutaceae	d,c
Irimbampuli	*Auroia bilimbi*	Oxalidaceae	d,c
Cacao	*Theobroma cacao*	Sterculiaceae	f,a
Cinnamon	*Cinnamomum zeylanicum*	Lauraceae	e,c
Rose apple	*Syzygium jambolanum*	Myrtaceae	d,b
Sapota (sapodilla)	*Achras zapota*	Sapotaceae	d,b,c
Indian almond	*Terminalia catappa*	Combretaceae	e,c
Neem	*Azadirachta indica*	Meliaceae	g
Indian gooseberry	*Emblica officinalis*	Euphorbiaceae	d,g
Kattaadi	*Casuarina equisetifolia*	Casuarinaceae	f,h
Custard apple	*Anona squamosa*	Annonaceae	d,b,c
Camphor	*Cinnamomum camphora*	Lauraceae	f,g
Ylang Ylang	*Cananga odorata*	Annonaceae	f,g
Curry leaf tree	*Murraya koenigii*	Rutaceae	e,c
Allspice	*Pimenta dioica*	Myrtaceae	e,g
Bablus	*Punica granatum*	Punicaceae	d
Eggfruit	*Pouteria campechiana*	Sapotaceae	d

a = nuts, b = timber, c = fuelwood, d = fruits, e = leaves, bark and other parts of plant used as food, f = leaves, bark and other parts of plant used for other purposes, g = ornamental or medicinal purpose, h=shade

Local names are reported in vernacular Malayalam wherever appropriate, and are given in italics.

Table 5-7. Herbaceous species reported to be of secondary economic importance by respondents from 75 homegardens in Thrissur district, Kerala state, India

Local/Common Name	Scientific name
Red pumpkin	*Cucurbita moschata*
Chillies	*Capsicum frutescens*
Eggplant	*Solanum melongena*
Ivy gourd	*Coccinia cordifolia*
Okra	*Abelmoschus esculentus*
Snow pea	*Dolichos limon*
kaavath (kaachal)	*Dioscorea alata*
Vellarikka	*Cucumis sativus*
Veliya chembu	*Xanthosoma sagitofolia*
Cheru kazhungu	*Dioscorea esculenta*
Pigeon pea	*Cajanus cajan*
Pichinga	*Luffa acutangula*
Indian Pennywort	*Centella asiatica*
Koorka	*Coleus parviflorus*
Tulsi	*Ocimum sanctum*
Jasmine	*Jasminum sambac*
Vettla	*Piper betle*

Importance Values and Plant Selection

Tables 5-8, 5-9, 5-10 and 5-11 compare the agroecological importance values of homegarden crops, to their economic importance based on the percentage of the garden profits devoted to that crop, and to their cultural importance based on farmer preferences in the four size categories used in this study. Farmer preferences were obtained by ranking the top nine crops, based on survey respondents in the 75 homegardens used in the study. The agroecological importance values are based on the relative frequency, relative density and relative dominance (Table 5-3). The economic importance values of the plant categories are based on the percentage of contribution to homegarden profit (Appendix C).

Table 5-8 Importance value index (IVI) of nine plant categories in 24 small homegardens in Thrissur district, Kerala, India

Crop	Agroecological	Economic	Cultural
Vegetables, ornamental plants, medicinals	100	51.5	1
Coconut	33.7	18.3	2
Banana	34.3	05.3	3
Tree fruit	44.8	03.5	4
Arecanut	35.3	11.2	5
Black pepper	26.7	-	6
Cashew	03.7	0.7	7
Spice trees	01.7	0.2	8
Rubber	06.3	-	9

Note: Rubber was found predominantly in 2 of the 24 sites inventoried, and was not found to provide a significant economic nor cultural value to a majority of the surveyed gardens.

Agroecological importance values are based on relative density, relative frequency, and relative dominance. The cultural importance values are based on farmer rankings. The economic importance values are based on the percentage of economic contribution to the homegarden profit.

Table 5-9 Importance value index (IVI) of nine plant categories in 14 medium homegardens in Thrissur district, Kerala, India

Crop	Agroecological	Economic	Cultural
Coconut	43.9	37.9	1
Vegetables, ornamental plants, medicinals	52.8	19.3	2
Arecanut	57.4	23.4	3
Banana	34.3	04.7	4
Black pepper	18.4	-	5
Tree fruit	29.9	04.1	6
Cashew	02.2	0.6	7
Rubber	01.8	-	8
Spice trees	04.6	1.2	9

Note: 1. Black pepper, although important both in terms of ecological presence and cultural value, did not provide significant economic value in the surveyed year due to the prevalence of the quick wilt disease.

2. Agroecological importance values are based in relative density, relative frequency, and relative dominance. The cultural importance values are based on farmer rankings. The economic importance values are based on the percentage of economic contribution to the homegarden profit.

Table 5-10 Importance value index (IVI) of nine plant categories in 10 large homegardens in Thrissur district, Kerala, India.

Crop	Agroecological	Economic	Cultural
Coconut	45.4	36.4	1
Arecanut	45.5	33.4	2
Banana	35.1	10.6	3
Black pepper	42.6	-	4
Vegetables, ornamental plants, medicinals	51.4	14.4	5
Cashew	02.7	03.0	6
Tree fruit	30.5	0.3	7
Spice trees	09.3	01.9	8
Rubber	-	-	-

Note: Agroecological importance values are based in relative density, relative frequency, and relative dominance. The cultural importance values are based on farmer rankings. The economic importance values are based on the percentage of economic contribution to the homegarden profit.

Table 5-11 Importance value index (IVI) of nine plant categories in 27 commercial homegardens in Thrissur district, Kerala, India

Crop	Agroecological	Economic	Cultural
Coconut	24.2	18.8	1
Arecanut	46.9	37.7	2
Banana	32.1	13.9	3
Black pepper	37.9	-	4
Rubber	18.2	04.1	5
Spice trees	03.5	00.6	6
Vegetables, ornamental plants, medicinals	43.2	14.2	7
Tree fruit	26.7	04.0	8
Cashew	07.2	04.9	9

Note: Agroecological importance values are based in relative density, relative frequency, and relative dominance. The cultural importance values are based on farmer rankings. The economic importance values are based on the percentage of economic contribution to the homegarden profit

The crop categories that were estimated to be most economically important were also been shown to be agroecologically predominant. This similarity is somewhat different from the social rankings. For example, arecanut was a commercially viable crop occupying a significant portion of the ecology of these gardens; but they were, especially in the small gardens, not considered to be of high cultural value. One of the reasons for this was that the farmers recognized arecanut to be a transient crop, to be phased out

when the demand for the nuts eventually disappeared. Furthermore, many of the farmers who planted the arecanut in place of the more traditional fruit and timber species such as jackfruit, had already started the process of replanting their gardens with timber species that had more long-term economic potential.

All garden categories displayed a high ecological importance for herbaceous species including vegetables, ornamental plants, and medicinal crops. While some of these vegetables in a few of the largest gardens were grown for commercial production, a majority of these species were grown primarily for household consumption. These tables, or data such as these, could be used in the formulation of agricultural policies and in technical support. The nine categories that have been found to be important in all 75 homegardens and farmer preferences should be considered when decision-makers are attempting to provide farmers with agricultural support.

Do Diversity and Species Richness Affect Homegarden Financial Value?

Multivariate regression analyses (using *Statistica* programs) were conducted to assess whether diversity and species richness interacted with land size and age of garden to affect the financial worth of these systems.

Table 5-12 Land size, number of years in cultivation, and species richness as predictors of homegarden economic worth in Thrissur district in Kerala, India, as indicated by multivariate regression analysis

	B	Standard error of B	P values
Intercept	5.17	0.265	0.000
Land Size (sq m)	$0.57*10^{-4}$	0.001	0.002
Age of garden	0.003	0.001	0.017
Species Richness	- 0.09	0.043	0.030

Note: $r^2 = 0.50$, Adj. $r^2 = 0.45$, , B is the intercept value

The Shannon-Weiner Index was also included in the analysis, but was found to have no predictive relationship to financial worth of garden

Species richness, as estimated using Margalef Index, causes a slight reduction in financial value. The equation is modeled as follows:

Financial Value of Homegarden =

$$\mathbf{5.17 + 0.57.10^{-4}\,(x_1) + 0.003\,(x_2) - 0.09\,(x_3)}$$

Where x_1 = land size in sq.m

x_2 = number of years in cultivation

x_3 = species richness (as indicated by Margalef's Index)

Discussion

Homegardeners cultivate a diverse variety of plants for many different reasons. The farmer motivations behind species selection would have to be further evaluated in order to better understand species selection criteria. For example, it has been found that some species such as *Prosopis juliflora* and *Delonix elata* are deliberately grown in the agricultural fields of Tamil Nadu, the state neighboring Kerala, in order to ameliorate saline soils and render them capable of growing annual crops (Jambulingam and Fernandes, 1986). Scientists are often aware of such practices only because there is a 'before and after' effect. The land becomes degraded, the farmer uses an adaptive management technique, and the effect is documented. With homegardens, where farmers have been following traditional adaptive management technologies for centuries, such studies have been neglected because the land has not attained a level of degradation at which the farmers have suffered massive losses.

As reported by respondents, the major constraint to increasing abundance of individuals of various species seemed to be land size, yet, species selection is not

hindered by land limitations, as all gardens were found to be fairly consistent in the number of useful species (including medicinals) that are retained or planted. The commercial and large gardens retain a higher number of ornamentals and wild plants. This implies that although these large gardens are utilized for commercial purposes to a large extent, commercial production is not the primary goal. All farmers grew subsistence crops, and 95% of the respondents reported that they used their garden for primary supplies of all household foods excluding rice, potatoes, onions, salt, and non-plant products such as fish and meat. Several farmers also listed chilli peppers as a necessary food that they were forced to purchase, because the chilli plants were not producing well the season this study was conducted.

Although species diversities in terms of richness were fairly similar among homegardens, the differences among species densities were statistically significant. The smallest gardens showed a density of nearly 5 (species)/100m^2, while the medium (1.63 /100m^2), large (1.14 /100m^2) and commercial (0.5 /100m^2) had lower species densities. These densities do not include abundance measures, and merely indicate presence or absence of species. This implies that the farmers who own and manage small gardens intensify their planting patterns to adapt to their land constraints. People might cultivate plants to fulfill household needs, rather than for market sale. Thus, in the smaller gardens, the planting has to be intensified, while in the larger gardens, the planting is less dense but abundance remains similar. It also implies that the presence of certain selected species is important to the farmer, regardless of their minimal value in the economic market. There are only a few crops that would fetch significant profits, and instead of

concentrating the limited land space to grow those crops, the farmers are opting for diversified use of the available land space.

The fact that there was no difference in Margalef indices of the homegardens across categories of homegardens implies that the species richness is not affected by homegarden size. In fact, the Margalef indices reported in this study (Appendix D) were fairly close to the 7.07 index reported from the wet evergreen forests of the southern Western Ghats mountains of Kerala (Varghese and Balasubramanyan, 1998). This further establishes our conjecture that homegardens are agricultural systems that might differ from natural forests in function, but are close to natural forests in species diversity.

The seasonal vegetables were not included in the Shannon-Weiner diversity tests, because they would not present an accurate estimate of the diversity index for the entire year. The smallest homegardens had a mean index with 1.15, but they were not significantly different from the indices reported for the medium, large and commercial gardens (1.27, 1.42, and 1.39 respectively). In a research report on Kerala homegardens (Sankar and Chandrashekara, 2002), the authors found that the smallest gardens had the highest Shannon-Weiner index, with the medium and large gardens at 0.97 and 0.81. This observation might be explained by the fact that the authors did not include medicinals in their estimations. If they had been included, it might have resulted in higher values for the large and commercial gardens because the larger gardens maintain higher numbers of medicinals than the small gardens. The larger gardens are also less likely to be concerned about loss of production due to the presence of weeds. Furthermore, their 'large' gardens were significantly larger than the 'large' gardens in this study, and included stands of commercial crops such as rubber. We presume that any homegarden with land size more

than 1.0 ha is more an agricultural field or plantation, and therefore will have lower species richness and diversity.

Another study conducted in Kerala yielded Shannon-Weiner diversity indices comparable to this study, ranging from 1.12 to 3.0 (Mohan Kumar et al., 1994), which were close to the values yielded from a government owned forest in the same area. Gajaseni and Gajaseni (1999) also conducted Shannon tests in the homegardens of Thailand, and found ranges from 1.9 to 2.7, which are also fairly comparable to the results from this study. Their values were fairly close to the species diversity indices of a dipterocarp forest ecosystem in northeastern Thailand, again reaffirming that the diversity of managed homegardens are close to, although not as high as, those of natural ecosystems, even though homegardens are not naturally occurring assemblies of plants.

Constraints of Using Proposed Methods in Homegardens

The major drawback in using the Shannon-Wiener index to account for diversity in a homegarden is that, while it considers both the species richness and evenness, it cannot account for the consistent variability in the number and individual count of homegarden species. Some of the herbaceous components, such as ornamentals, weeds and grasses, and some seasonal vegetable crops observed in the homegardens, can only be expressed in terms of presence or absence of number of species, not in terms of number of individuals because the farmers themselves are unsure as to the number of individual plants in their gardens. The usefulness of Margalef's index is also limited to the extent that it cannot distinguish between individuals of different species (Gliessman, 2000), and merely looks at total number of individuals.

The species density measure serves to understand whether species composition is affected by land-size, however, a species density measure is not an indication of the

species abundance or evenness, i.e. it would not be able to reveal whether the species contained 1 individual or 10.

The research associated with agricultural ecology ranges over a wide variety of subjects, including soil conservation with and without using chemical fertilizers, integrated pest management techniques, and maximum production with minimum environmental damage. If homegardens were considered individual landscapes, and their biophysical interactions further investigated, we would find that these sites have undergone more disturbances than forests, and other naturally undisturbed or conserved landscapes, yet have not undergone the dramatic transformation usually seen in an agricultural landscape such as a rice or maize field. For example, some of the main sources of land disturbances in traditional agriculture are tilling, weeding by tillage, use of fertilizers and pesticides, and harvesting. Many of the homegardens surveyed in this study have never undergone any tillage, there was minimal disturbance due to manual weeding, organic fertilizers are used, and harvesting is never done on a mass scale. There is continuous use and renewal of both plant and soil resources. Homegardens seem to be close mimics of close mimics of naturally biodiverse systems, which also provide economic benefits (see Chapter 4) and are the great hope of sustainable agriculture.The sustainability of any agricultural system should be assessed beyond the levels of quantity, economics and use. The definition must be expanded to include the consistent production with continuous cultivation and use, and biological diversity of these systems.

Conclusions

This chapter estimated the ecological diversity of the surveyed homegardens based on two indicators – the Shannon-Weiner Index, and the Margalef Index. Both indices need to be used in conjunction with each other in order to establish a satisfactory

estimate of the diversity of these systems. The homegardens were fairly similar to each other in terms of species composition, thus indicating that all gardens retained certain species that the farmers considered to be important, regardless of the economic value. The number of individuals of species per unit area of land increases with increase in land area, but the density of species is highest in the smallest gardens. This implies that although increasing species richness leads to a decrease in financial value, farmers do not sacrifice species diversity in favor of increasing production of a particular crop.

CHAPTER 6
SYNTHESIS AND CONCLUSIONS

Synthesis

This research uses existing scientific methodology to develop a method of quantification of some of the benefits provided by tropical homegardens. Numerous studies have investigated the costs and benefits derived from agroforestry ventures, especially in the Caribbean and the Central American countries (Current et al., 1995), but field studies pertaining to homegardens are limited. The reasons for this lack are that homegardens are extremely diverse and traditional economic models might not accurately represent the worth of these systems. Furthermore, field studies in homegardens are extremely time-intensive, and often not generalizable to other homegardens.

Many studies point to biodiversity as an indicator of sustainability. But unlike natural forested systems, the man-made homegardens often serve very specific purposes to the farmer, indicating that the biodiversity in homegardens is planned and managed. Biodiversity, although difficult to estimate, can be quantified using species diversity calculations and other indicators of vegetation presence or absence.

Mercer and Miller (1998) called for more socioeconomic research in agroforestry, which can produce more generalizable results. Their attempt to understand knowledge gaps in socioeconomic research revealed that several of the gaps listed by their respondents were crucial areas for improving cost benefit analyses. These include valuation of non-market goods and service, risk, and market analysis. This research examines the economic benefits provided by homegardens in some detail, and provides

guidelines for analysis. These guidelines call for estimating the financial values based on homegarden inventory and market prices of products used in the household, conducting sensitivity analyses to ascertain economic resilience of these systems, comparing the financial values to those obtained from alternative uses of the land, and finally, developing an economic index of the most important crop and plant categories to the farmer. These guidelines can be used in homegardens in different geographic regions, with suitable modifications as necessary, and depending on the location. It has to be noted, however, that these steps would still entail a considerable amount of data collection because the homegardens themselves are so diverse and are highly dissimilar in terms of species composition, species use, and are mainly based on the needs of the individual farmer and family.

Based on the study findings, the inputs and outputs that comprise the financial management of a homegarden have been listed (Table 4-1). If these inputs and outputs are quantified, according to the existing rates and conditions of the geographic location being analyzed, it is possible to calculate the financial value of the homegarden. A complete evaluation would further require sensitivity analyses in order to assess the response of these systems to factors such as labor or price fluctuations. Upon determination of the major constraints or risks to production, these sensitivity analyses would have to analyze the level and extent of risk presented by these constraints.

Productivity of homegarden species can be estimated according to both farmer surveys and established information on productivity and crop yields. The productivity of minor crops, such as vegetables and tuber crops that are grown by the farmer for purposes of household consumption would have to be estimated according to farmers responses

based on intensity and frequency of use. Although market prices fluctuate based on supply and demand, it is possible to estimate an average price for most plant products available on the market.

The word biodiversity is ubiquitous with conservation. Organizations devoted to conservation and increasing biodiversity are prevalent in both developing and industrialized countries. The ecology of agricultural systems is consistently researched in the hope of finding the 'sustainable' solution to managing natural resources for economic profit while consistently attempting to conserve and protect these very same resources. This study hypothesized that homegardens fulfilled an economic need while satisfying the laws of conservation and preservation of biodiversity. In order to conduct a complete ecological analysis of homegardens, it would be necessary to estimate levels of biodiversity, carbon sequestration, soil productivity and quality, and air and water quality in individual gardens, and then compare them to other agricultural fields and natural forests. Although some of these research needs were outside the scope of this study, this study has estimated the levels of biodiversity using two different methods, and then compared them to established indices from existing natural vegetation. The Shannon-Weiner indices were calculated to measure both the species diversity and abundance and evenness of these species. The results were only slightly lower than those yielded by other homegarden studies in the area and naturally occurring Kerala forests. However, it has to be noted that these lower numbers might partly be due to the fact that our Shannon-Weiner tests excluded the herbaceous species that are seasonal, and also the rare species such as medicinal plants. Although this is an established method of analyzing vegetation diversity, it is difficult to understand the complexity of these systems without

complementing this method with another method designed to identify species richness. For this purpose, Margalef Indices were calculated and the results were similar to those of a tropical deciduous forest in the Western Ghats of southern India. These two indices, the Shannon-Weiner, and the Margalef, can be used in conjunction with each other to understand the diversity of these systems. Once these values are established and the importance of homegardens to biodiversity conservation understood, the biophysical aspects that are involved in maintaining these levels should be further studied. This study also attempted to compare the floristic similarity across homegardens, and the results indicated that the homegardens were fairly similar in species composition, regardless of garden size.

While homegardens are important in providing both economic and ecological benefits, they are also very important for the provision of social and cultural benefits to the individual farmer and to the community. Many plants were cultivated and retained for ornamentation and aesthetics, medicinal uses and in some cases for religious reasons. The farmers also considered food grown in their gardens to be of higher quality, both in terms of taste and shelf life, than produce obtained from the local commercial markets. Farmers employed methods of integrated pest management and other forms of organic management that have been passed down for generations. Conservation of indigenous knowledge is one of the benefits provided by homegardens, as proposed by this research, but only recognized by less than 50% of the surveyed farmers. Brodt (2001) looked at tree and crop cultivation in central India to examine the dynamics of knowledge system change. She suggested methods for the preservation of indigenous knowledge, and that

technical innovation might allow local indigenous knowledge to mesh more effectively with large-scale technologies.

An important cultural benefit was the availability of medicinal species. Although it was difficult to quantify the actual economic worth of the presence of these medicinal species in a garden, the farmers considered them to be of essential importance in their daily lives, and therefore these or the shadow prices of these plants should be considered while evaluating the benefits provided by homegardens. It is also essential to consider the importance of aesthetics, ornamentation and shade in the lives of these farmers. This research has indicated that farmers generally grow some species designed to enhance their aesthetic pleasure, regardless of their land constraints (data not reported). It was also evident to the researcher that women participate equally in the various processes associated with the garden, including the economic decision-making.

These benefits are exclusive to homegardens because no other single system has been found to provide all these benefits in conjunction with each other. For example, a rice field might provide many economic benefits, and some cultural benefits, but they would not provide an avenue to conserve genetic diversity of a wide variety of species.

Annual monoculture systems of cultivation are inviting habitats for pests that thrive by colonizing new, welcoming environments. In order to reduce pest numbers and insect damage, it is necessary to recognize the needs and abilities of the pest, and design a system that works against these preferences (SARE, 2000). Homegardens, being mixed stands, already possess natural insurance against pests and disease outbreaks (Michon et al., 1983). The main diseases and pests reported in these gardens were those afflicting commercial plantation crops such as arecanut, banana and black pepper, and farmers

were already employing diversified planting techniques and other forms of integrated pest management to combat these agricultural pests. These integrated pest management techniques might provide valuable insight to those researchers who are dealing with pest management issues in traditional agricultural systems. If these systems and their resilience against pests and diseases are carefully investigated, it might prove a beneficial component in the pest management efforts even in other geographic locations, and different agricultural systems.

It is important that farmers receive adequate information about planting procedures, and techniques to ensure an adequate subsistence garden, and supplement indigenous knowledge with state-of-the-art new technology. In today's agriculture, where Kerala farmers are looking to their gardens not only to fulfill their subsistence requirements, but also as a source of income by growing commercial crops for market sale, it is important to educate them about how to ensure adequate nutrition and food supply. The United State Department of Agriculture has published a manual that describes techniques and plants for a tropical subsistence farm, which is very useful for both farmers and for local agricultural officers (Martin and Ruberte, 1980). Such manuals, published in regional languages, would serve to educate the farmers about their nutritional needs and other long-term benefits that they might attain from their gardens.

Homegarden Design

The literature suggests that the criteria for designing and implementing agroforestry systems are productivity, sustainability, and adoptability (Raintree,1984). Homegarden design and choice of species can follow the same criteria with a few modifications. First of all, these systems are mainly used for subsistence purposes; therefore, productivity and economic feasibility are usually the most important criteria. However, once these needs

are met, the end result is usually a diverse mixture of trees and crops that also lend to the diversity and sustainability of the system.

Ease of adoptability is an important consideration while developing and designing a homegarden. For example, it would be fairly impossible to grow such a diverse mixture of vegetation, with varying growth, planting, pruning, and fertilizing needs, if the labor is not easily and cheaply available. Most of the homegarden labor comes from family members, and this is a significant reduction in labor costs (in monetary terms, not in terms of time spent). Furthermore, distance between the system and the house is also a consideration. Since these gardens are around the household area, it makes it easier for the women of the house to work in the gardens without having to leave household premises.

Finally, religious and other social considerations also play a part in homegarden design. Plants such as *Ocimum sanctum*, which are needed for daily religious rituals, and for medicinal reasons, are almost always found immediately next to the residential area, for easy access. Also, potted plants, and other plants designed to enhance aesthetics are found around the house for easy viewing.

In conclusion, a homegarden is designed to fulfill a wide array of functions, and provide a range of benefits. These benefits are economic, ecological, and cultural in nature. The economic benefits can be quantified using basic economic methods of costs and benefits comparison and the ecological diversity can be estimated using the Shannon-Weiner and Margalef Indices in conjunction with each other. It is difficult to ascertain whether diversity, although of established value, would be of any specific value to the individual farmer and it would be necessary to consider all the benefits, both qualitative

and quantitative, to truly understand the benefits provided by these agroforestry systems. These benefits have to be considered together, as a sum of all the individual parts, in order to understand the true value of a homegarden, and its worth to both the farmer and to society. Although different homegardens in different geographic locations might have different motivations and interests behind species selection and retention, they all provide a similar range of benefits, and encompass a similar range of interactions, albeit in varying quantities.

APPENDIX A
SURVEY ADMINISTERED TO SELECTED HOMEGARDENS

1. What is your total land size in acres/cents
2. How much area does your house occupy?

Section 1: Agronomy

1. Survey of all economically useful products in the homegarden (conducted by researcher)

2. Please classify these products into three categories: Primary importance, secondary importance, tertiary importance.

Primary: Products that are essential to your livelihood
Secondary: Products that are very important but not absolutely essential
Tertiary : Products that serve a purpose but are not essential.

3. Estimate the individualized productivity of these crops and trees in terms of numbers. For example, how many kilograms of tomatoes do you estimate that you use and or sell every week?

----Crops used on a daily basis
----Plants used on a regular (non-daily) basis
----Plants used infrequently (as according to need, for eg Medicinals)

4. Estimate the percentage of these products that are used for home consumption.

5. Do you estimate that this % varies from season to season? If so go to 6

6. Estimate an average for each season

7. Why did you select these particular plants? (Individual preferences)

8. How much did you pay to obtain these seedlings or seeds (Table)

9. Who supplies your seedlings?

10. Where do you obtain your desired variety of seedling/seed?

-----Gift -----Trade -----Krishi Bhavan ----Other (please specify)

11. Do you select the variety of the particular species you want to use in your garden? If so..go to 12

12. Do you believe that certain varieties are better than others? Why?

13. What are your preferred varieties from the list of primary species from the garden

14. What are the main factors that influence your decision to buy a particular type of seedling? Please rate the top three

----- Availability	----- Monetary reason	….Location
----- Nutritional value	----- Ease of growing	….Other
----- Market value	----- Ease of maintenance	
----- Aesthetic value	-----Nutritional security	

15. If you use livestock products for the household or for market production, what are they

----- Cattle ----- Goats ----- Chickens -----Pigs ……Other

16. What are the products that are used from these livestock?

---- Milk ---- Meat -----Eggs -----Draft labor
-----Transportation …….Other

17. How many years have you used this homegarden, or how many years has this homegarden remained in your family?

18. Has it always been this size? If not, please go to 19, If yes, go to 21

19. Is your homegarden now bigger or smaller than it used to be?

20. What are the reasons behind this change?

21. Do you use any type of fertilizer? If so, go to 22. If not, go to 29.

22. Is your fertilizer

…chemical …..animal ….household wastes (compost) …Other

23. Do you use more than one type of fertilizer?

24. Does the season affect the type of fertilizer you use?

25. Reasons for fertilizer use

……soil degradation …….high requirements of selected plant species
…….commercial production ……Other

26. If you buy fertilizer, how much do you buy at a time?

27. Do you pay for it with
…cash …trade …credit

28. Is sack size important? I.e. would you buy more or less fertilizer if it came in small bags?

29 What part of the plants do you use? how or for what?

30. Do you plant annual crops in the same place in the garden year after year? Why or why not?

31. If you save your own seed, what do you do to protect it, to make sure it will germinate when you plant it next season?

32. How do you determine what will be seed and what will be eaten or sold?

33. Do you plant certain crops the same time as your neighbors? How do you know when to plant?

34. Are there any crops which you used to grow, or your parents used to grow, that you no longer grow? If so, which ones and why?

35. Are you growing any new crops, that your parents or grandparents never grew? If so, which ones and why?

36. If you could only grow five crops, what would they be?

37. Which crops require the most care? Why?

38. Which crops are most profitable, to sell or trade? Why?

39. Have you noticed any significant ecological degradation in your homegarden in terms of the following categories?
….soil degradation …..quality of plant product ….litter quality…..…..quantity of plant product …….availability of livestock fodder …….intangible loss …….Other

40. <u>Pests and Diseases</u>
How do you decide on a particular species in order to keep common pests and diseases away from your homegarden
…..Family wisdom ……Local krishi bhavan info ……extension materials ……Other

41. <u>Planting systems</u>
What are the factors behind your placing these homegarden species in this particular order that you have chosen

…Light interception …..Plant requirements ……Commercial requirements ……Space constraints ……No particular reason …….Soil characteristics

Section 2: Input: Labor, money, time

1. How many hours of labor do you put into the garden on a daily basis?

2. How many hours of paid labor is put into the garden on a monthly basis?

3. Out of the labor input, how much time (in terms of percentage of the total labor input) is spent on the following categories?

……..Planting ……Weeding ……Maintenance ……Harvesting ….Livestock ……Cottage industries ……Other

4. How much money do you spend on fertilizers for the homegarden on a monthly basis?

5. How many seedlings do you buy on a monthly basis for purposes of planting, and other garden needs?

6. How much money do you spend on transportation to and from market, and to and from the Krishi Bhavan (the local agricultural office) in terms of Rs/week

7. How much time do you spend on transportation to and from market, and to and from the Krishi Bhavan in terms of hours/week?

8. Do you own livestock? If so, go to 9. If not, go to section 3

9. How many?

10. Do you buy feed? How much money do you spend on feed on a monthly basis?

11. Does your livestock live in the garden?

12. How much money did you spend on their facilities: barn, hay storage facility
    One time cost
    Weekly (for things that need to be done once a week)
    Monthy (once a month)
    Yearly (once a year)

Section 3 Output from garden

1. What are the main benefits from your homegarden. Please rate them in order of importance by numbering them from 1-15

----------	Household food supply	----------	Biodiversity
----------	Nutritional security	----------	Wildlife habitat
----------	Livestock housing, and shade	----------	Timber production
----------	Commercial production	----------	Fuelwood production
----------	Aesthetics and ornamentation	----------	Fruit Production
----------	Cottage industries	----------	Gender equality
----------	Site for aquaculture, pisciculture,	----------	Other (please specify)
----------	Bee keeping		

2. Estimate the total monetary worth of your garden in terms of Rs.

3. Estimate the total monetary worth of your garden
   -------- 10 years from now
   -------- 20 years from now

4. Do you plan on leaving this garden to your children?

5. Do you believe that this garden will be of economic worth to the inheritor?

6. Do you believe that this garden will be of social worth to the inheritor?

Section 4: Homegarden and its impact on lifestyles

1. Do you think this homegarden is essential to your lifestyle? If so…..please rate it's importance

------ Invaluable ------Very important ------ Somewhat important
------ Neutral ------Not very important -------Waste of space

<u>CONTINGENT VALUATION</u>

2. How much would you need to be paid to not have access to your homegarden? Please estimate in terms of percentage of your annual income?

0-2% 3-5% 6%-10% 11-20% 21%+

3. Do you think this homegarden contributes to your household economy?

4. If so, please estimate its value in terms of percentage of your income?

0-2% 3-5% 6%-10% 11-20% 21%+

5. How important is it to obtain aesthetic and ornamentation benefits from your garden?
----- Invaluable ------Very important ------ Somewhat important
------ Neutral ------Not very important

6. How much money would you need to lose the aesthetic benefit? Please estimate in terms of percentage of total income
0-2% 3-5% 6%-10% 11-20% 21%+

7. Conversely, how much money would you be willing to pay to obtain such aesthetic benefit? Please estimate in terms of percentage of total income
0-2% 3-5% 6%-10% 11-20% 21%+

8. How important is it to obtain shade for your livestock?
----- Invaluable ------Very important ------ Somewhat important
------ Neutral ------Not very important

9. How much money would you need to lose the opportunity to obtain shade for your livestock from this garden? Please estimate in terms of % of total income?
0-2% 3-5% 6%-10% 11-20% 21%+

10. Conversely, how much money would you be willing to pay to obtain shade for your livestock? Please estimate in terms of percentage of total income
0-2% 3-5% 6%-10% 11-20% 21%+

Section 5 Demographics and gender

1. How many people live in your household?

2. What are their age demographics?

3. How many people work outside of the home?

4. What is your annual income
------ Don't know ------- Rs.1.0-Rs.4999 ------- Rs. 5000-Rs.9999
------ Rs. 10000-14,999 ------- Rs. 15,000-Rs. 20,000

5. Where does your income come from? Please rate from 1-5, with 1 being the employment providing the highest income

------ Outside employment ------- Farming outside of homegarden

------ Homegarden -------Other business -------Family

6. If you were not spending work hours in the garden, what else could you be doing?
------- Income generating employment --------- Nothing
------- Household chores.

7. Do you believe that you could be using this space occupied by the homegarden for other purposes that would generate more money?
Yes No

8. If yes, what are the other income generating activities
Industry setting Selling space to developer Setting up some other business Other

9. Who spends more time in the garden
……Father ……Mother ….Child …..Other

10. Who does most of the cooking in the household
…..Father …..Mother …..Other

11. Do you conduct any businesses from the garden? If yes, go to 12. If not, go to 13

12. What are they?
…Cottage industries …..Apiculture ……Sericulture …….Aquaculture ……Tourism ……Other

13. Who do you believe is chiefly responsible for homegarden activities and maintenance?
…..Man's enterprise …..Equally divided …….Woman's enterprise

14. Do you believe that the homegarden contributes to the whole idea of Kerala being a state where women have comparatively literacy rates, and are considered more empowered?

15. Do you believe that homegardens contribute to the empowerment of women? If yes, go to 16. If not, go to 17.

16. How so?

17. Who is responsible for the economics of the homegarden? I.e. who is responsible for the economics of the homegarden?

Section 6: Nutrition and food availability

1. How much of your daily food intake comes from the garden? Estimate in terms of % of total household nutrition

------0-20% 21-40% 41-60% 61-80% 81-100%

2. Do you buy food from the market?

3. If you did not have some of these products, for example, jackfruit, mango, tamarind, would you buy them from the market?

4. Would you buy the same quantities that you obtain from the garden?

5. How much produce do you sell to the market
----daily ----monthly

6. Do you believe that your family nutritional requirements are being met?

7. If so, what part does your garden play in meeting that requirement?
……100% ….75%…..50% ……25% ……0%

8. Do you grow crops/trees specifically to meet nutritional requirements?

9. Do you grow crops/trees specifically to obtain nutritional security for the household…

10. If so, what are they?

11. Do you grow flowers in your garden?

12. If so, what function do these flowers/leaves play?
------- Aesthetics,
------- Personal ornamentation
------- Ritualistic reasons.
------- Income
-------Other

13. If you did not have these flowers in your garden would you buy them from the market?

14. How much do you estimate these flowers contribute to the quality of your life?

15. If you were paid the monetary value for all these homegarden products and their sources, would you use some of the money generated to buy these products from the

market? For example, if you were paid a significant amount of money for your mango tree, would you use some of this money to buy mangoes, and fuelwood?

16. If so, how much
------- All of it (100%)
------- Most of it (~75%)
------- Half of it (~50%)
------- Some of it (~25%)
------- None of it (0%)

17. What would you do with the money generated from selling your homegarden?

18. Would you consider selling the garden?

19. If yes, please estimate the total amount that you would sell it for

20. If you did not have a garden on your land, what else could you do with this property?

21. Are you satisfied with the size of your house?

22. Would you increase the size of your house, and reduce the size of your garden?

23. Do you think they will obtain the same benefits as you do? -- yes --- no

24. Do you think the value of your garden will increase as the years go by?—yes --- no

25. In terms of pure economics, do you think the garden is economically profitable.

Section 7:

1. Do the source agencies offer subsidies toward these purchases?

2. Would you like to see more government help toward the development and advancement of your homegarden?

3.Do you see your homegarden as an investment for the future?

APPENDIX B
ECONOMIC VALUES OF HOMEGARDEN OUTPUTS AND INPUTS

Table B-1 Net financial value of 75 homegardens surveyed in Thrissur District, Kerala, India.

Area of homegarden (ha)	Total income excluding opportunity costs	Income incl. Opportunity costs	Income excluding household labor
1.0	88000	45700	77250
0.99	511000	452080	478780
0.99	458000	411460	441710
0.91	209800	163870	203920
0.80	419740	370440	402040
0.80	528000	7100	520900
0.79	305150	252580	280430
0.79	509200	455600	494200
0.78	228400	193050	212400
0.78	340350	283700	322250
0.76	184000	130355	140005
0.68	320400	259220	295120
0.60	92400	52148	89448
0.60	307000	268740	297840
0.59	288400	239040	272890
0.59	102200	68600	95200
0.59	227500	185750	221900
0.58	214300	200850	208200
0.57	342100	311550	321200
0.54	108800	75310	89560
0.42	374200	227400	262900
0.40	204000	168820	192120
0.40	104000	91620	103820
0.40	410000	382890	407090
0.39	254000	227400	251600
0.39	132675	121345	130995
0.38	187500	155650	185700
0.38	223600	194000	205950
0.37	47500	19170	23920
0.37	257340	224540	248340
0.34	270600	243090	261740
0.34	306000	277750	282000
0.33	238000	223580	232480

Table B-1. Continued

Area of homegarden (ha)	Total income excluding opportunity costs	Income incl. Opportunity costs	Income excluding household labor
0.29	401600	377680	393280
0.28	165800	126236	158536
0.27	335200	262200	323200
0.24	274050	199050	206850
0.23	89500	69775	78700
0.22	233000	219475	224625
0.22	203310	180262	202212
0.22	273000	256990	269340
0.19	34200	5450	34200
0.19	160000	121350	133300
0.19	154700	135310	148460
0.18	145680	125860	132960
0.18	192080	168660	178160
0.18	212500	184480	210780
0.18	66300	37790	59240
0.15	75250	64010	73160
0.12	91775	90175	91775
0.12	25740	13310	25660
0.12	134520	112295	128195
0.12	96900	63200	82700
0.10	75600	66650	69800
0.10	136120	120520	129020
0.10	48450	44600	48300
0.10	64900	62900	64800
0.10	171500	93050	113500
0.10	108300	67635	87960
0.09	110420	107405	108530
0.09	87000	69100	87000
0.08	36600	23550	36600
0.08	62450	50850	55200
0.06	23400	21770	22420
0.05	12000	2578	7940
0.04	37800	35930	37680
0.04	18500	14400	18500
0.04	24000	15805	23505
0.04	13600	4120	13420
0.03	118200	55050	72200
0.028	12900	12150	12400
0.02	13600	9750	13600
0.02	24000	21325	23975
0.01	37780	22870	30070

Financial values measured in Rupees (1.00 $US ~ Rs. 47, October, 2003).

Table B-2 Economic values representing the finances of homegardens.

Ha	Coco	Areca	Musa	Trees	Spice	Pepp	Rubb	Cassa	Cashe	Other	Milk	Other livesto	Househ	BEN	COSTS
1	18000	0	30000	0	0	4000				12000			24000	88000	10750
0.9	90000	360000	0	5000	0	5000					27000		24000	511000	32220
0.9	112500	180000	12000	10000	9000	1500	85000				24000		24000	458000	16290
0.9	15000	0	24000	16000	0	0			120000		10800		24000	209800	5880
0.8	150000	150000	43200	0	8000	140		30000			14400		24000	419740	17700
0.8	100000	400000	0	0	0	4000							24000	528000	7100
0.7	90000	25000	52000	2000	0	1350	34000		12000		64800		24000	305150	24720
0.7	45000	360000	0	5000	0	2600	51000				21600		24000	509200	15000
0.7	60000	100000	16000	7500	0	1500		5000			14400		24000	228400	16000
0.7	12000	270000	0	3000	0	2700			11250	3000	14400		24000	340350	18100
0.7	35000	0	60000	0	0	0				5000	60000		24000	184000	43995
0.7	100000	0	16000	150500	0	1500		6000	5000	3000	14400		24000	320400	15280
0.6	44000	0	0	6000	0	0			36000	4800	21600		24000	136400	2952
0.6	90000	90000	18000	15000	0	2000	68000						24000	307000	9160
0.6	60000	100000	36000	36000	0	4000			6800		21600		24000	288400	15510
0.5	8000	6000	12000	12000	0	3000			1200			36000	24000	102200	7000
0.5	90000	100000	0	1000	6000	4000				2500			24000	227500	5600
0.5	67500	81000	15000	0	0	200		200	12000		14400		24000	214300	6100
0.5	100000	180000	0	6000	0	2000				2000	14400	13700	24000	342100	20900
0.5	10000	3000	60000	0	6000	1000				4800			24000	108800	19240
0.5	20000	200000	0	0	0	2500	51000		1700	3000	72000		24000	374200	111300
0.4	34500	0	2E+05	0	0	0							24000	238500	11880

Table B-2.. Continued

Ha	Coco	Areca	Musa	Trees	Spice	Pepp	Rubb	Cassa	Cashe	Other	Milk	Other livesto	Househ	BEN	COSTS
0.4	15000	50000	15000	0	0	0							24000	104000	180
0.4	9000	360000	6000	0	7000	4000							24000	410000	2910
0.4	60000	135000	25000	0	0	4000		6000					24000	254000	2400
0.3	10000	80000	18000	0	0	675							24000	132675	1680
0.3	30000	100000	0	0	1000	2500			30000				24000	187500	1800
0.3	150000	0	40000	0	9000	600							24000	223600	17650
0.3	16500	5000	0	0	1000	1000							24000	47500	23580
0.3	102000	36000	90000	0	0	300				5040			24000	257340	9000
0.3	67500	27000	7500	0	0	600						1E+05	24000	270600	8860
0.3	90000	160000	30000	0	0	2000							24000	306000	24000
0.3	3000	180000	28000	0	0	2000				1000			24000	238000	5520
0.3	90000	160000	30000	0	0	1350				1000	14400		24000	320750	6880
0.2	150000	120000	60000	0	45000	2000						600	24000	401600	8320
0.2	15000	90000	0	0	0	800			36000				24000	165800	7264
0.2	150000	54000	0	10000	0	1200			24000		72000		24000	335200	12000
0.2	95550	3000	22500	48000	0	0					81000		24000	274050	67200
0.2	45000	5000	9000	6000	0	500							24000	89500	10800
0.2	125000	80000	0	0	0	2000				2000			24000	233000	8375
0.2	75000	90000	0	0	0	1350					12960		24000	203310	1098
0.2	37500	180000	30000	0	0	1500							24000	273000	3660
0.2	8000	0	800	0	0	0							4800	13600	0
0.1	3000	0	3000	1000	0	0	0		3200				24000	34200	0
0.1	19500	90000	0	0	0	0	6800				14400		24000	154700	6240
0.1	86000	3000	0	9000	2000	2000		480		4800	14400		24000	145680	12720

Table B-2.. Continued

Ha	Coco	Areca	Musa	Trees	Spice	Pepp	Rubb	Cassa	Cashe	Other	Milk	Other livesto	Househ	BEN	COSTS
0.1	12000	45000	0	0	3000	80					1E+05		24000	192080	13920
0.1	73500	105000	9000	0	0	0						1000	24000	212500	1720
0.1	9000	3000	5000	10000	0	900					14400		24000	66300	7060
0.1	37500	9000	3750	0	0	1000							24000	75250	2090
0.1	33000	0	31250	0	0	200				3325			24000	91775	
0.1	48000	0	0	0	0	540			1200				24000	73740	80
0.1	30000	60000	0	3000	0	2400					15120		24000	134520	6325
0.1	4500	45000	0	8000	0	1000					14400		24000	96900	14200
0.1	9000	0	5400	1000	0	0	17000				19200		24000	75600	5800
0.1	30000	60000	1400	1200	0	900				1340	17280		24000	136120	7100
0.1	19500	2700	0	0	0	2250							24000	48450	150
0.1	22500	18000	0	0	0	400							24000	64900	100
0.1	55000	7500	60000	0	0	0				25000			24000	171500	58000
0.09	4500	0	1000	0	0	400	0	0	0	1E+05			2400	108300	20340
0.09	14000	40000	1140	30000	1000	280							24000	110420	1890
0.08	22500	0	1000	35000	0	2000			2500				24000	87000	0
0.08	9000	0	0	0	0	0			3600				24000	36600	0
0.06	3000	15000	5400	0	0	650					14400		24000	62450	7250
0.05	Homeu	0	0	0	1000	0				20000			2400	23400	980
0.04	Homeus	0	0	0	0	0							12000	12000	4060
0.04	7500	6300	0	0	0	0							24000	37800	120
0.03	4500	0	0	0	0								12000	16500	0

Table B-2.. Continued

Ha	Coco	Areca	Musa	Trees	Spice	Pepp	Rubb	Cassa	Cashe	Other	Milk	Other livesto	Househ	BEN	COSTS
0.02	3000	0	180	0	0	0	0			7800	86400		2400	99780	46000
0.02	6000	0	0	500	0	0	0					6000	6000	18500	0
0.02	10500	0	0	0	0	0							2400	12900	500
0.02	Homeus	0	0	0	0	0							24000	24000	25
0.01	Homeus	0	2500	0	0	0					17280		18000	37780	7560

Table B-3 Economic values of annual inputs into typical homegardens in steady state

Ha	Chem. fert	Ani fert	Lit+ med	Man lab	Wom lab	Man wage	Fem wage	Feed	One time	Rent	Cost
1	360						7200	7200		150	7560
0.995	25						2400			250	25
0.991									500	250	500
0.910						14400	2400	36000	10000	350	46000
0.809	180					4800	0			4500	180
0.809	360	135				4800	2400			500	495
0.797	0						3600			500	0
0.793		100				600	600		20	550	120
0.789		810		2500	750	4800				562.5	4060
0.789	180							500	300	650	980
0.781				450		2400	1200	4800	2000	750	7250
0.769						4800	7200			1050	0
0.688						12000	4800			1100	0
0.607	90			1800						1125	1890
0.603	360	0			17280	9600	9600		2700	1125	20340
0.599	1000	600	1000	3000	2400	19200			50000	1250	58000
0.595		100					600			1300	100
0.595	200	0	0	1500	600	4800	2400	4800		1300	7100
0.587	0			150		1200	1200			1300	150
0.570	1000	0	0	0	0	1200	600	4800		1350	5800
0.542				625		7200	7200	5700		1500	6325
0.429	100			4500	4800	12000	6000	4800		1500	14200
0.404		80				7200	3600			1550	80
0.404									7875	1600	
0.404	540			1350		4800	2400		200	1950	2090
0.392						19200		7060		2250	7060
0.392	720					19200	4800	1000		2300	1720
0.384				900		4800	2400	7020	6000	2300	13920
0.384	0	0	0	0	0	4800		10920	1800	2300	12720
0.372				240		7200	3600	6000		2350	6240
0.344	0					19200	7200			2350	0
0.344	200	400		22500	3600	9600				2350	26700
0.331				1875	1500		2400		5000	2750	8375
0.303						9600	9600	78	1020	2750	1098
0.291	360	1400		1400		9600			500	2750	3660
0.283	360			5400		4800	1200	4800	240	2925	10800
0.275	6000			7200		4800	0	54000		3000	67200
0.246				12000		38400	19200			3400	12000
0.236	1000					19200	9600		6264	3500	7264
0.222		1820			6000	12000			500	3600	8320
0.222	360	270		6250		4800	2400			3750	6880
0.222		3000		1120		4800			1400	4100	5520
0.190	360		1000	1500		14400	0		6000	4250	8860

Table B-3. Continued

Ha	Chem. fert	Ani fert	Lit+ med	Man lab	Wom lab	Man wage	Fem wage	Feed	One time	Rent	Cost
0.190		7000		7000				10000	x	4250	24000
0.190	3000			3000		19200			3000	4600	9000
0.186	2400	1550		9000	4000	4800	2400		700	4750	17650
0.186	1080			12500	10000					4750	23580
0.186		1800				19200	6000			4850	1800
0.182	180			1500			4800			4850	1680
0.157				2400		19200				5000	2400
0.129	360	300		2250		19200				5000	2910
0.125	180					7200				5000	180
0.121	180	2430		4950		14400	3600	4320		5300	11880
0.121	3600			1500	1200	19200	9600	1E+05		6700	1E+05
0.109		800		10000	7500	0	7200		940	7050	19240
0.105	4000			12000	0	0	2400	4800	100	7250	20900
0.105	100			1200				4800		7350	6100
0.105	5000			600		19200	9600			7350	5600
0.101							19200	6000	1000	7400	7000
0.091	360			3750	3000	19200	7200	8400		7450	15510
0.091	1000		300	7500	360	19200	2400			7500	9160
0.089	360			0	0	19200	9600	2592		8500	2952
0.085	1000	0	500	3750		19200	7200	10030	10000	9500	25280
0.060	0	0	0	14400	11520	0	0	18000	75	9650	43995
0.052	900			1440	1200	19200	9600	11560	3000	9750	18100
0.045		5000		8750	2250		9600			9750	16000
0.044	1080			600	360	19200	9600	12960	chicke ns	9800	15000
0.040	720					12000	6000	24000		9850	24720
0.040	2200		500	4500	3000	14400	7200	7000	500	10000	17700
0.036		5000		2100		19200		?	x	10000	7100
0.028	1080					19200	9600	4800		11250	5880
0.020	3150			4500		12000	6000	8640		12250	16290
0.020				11700	14040	9600	4800	6480		12300	32220
0.012	3000	1750		6000		19200				12350	10750

APPENDIX C
PERCENTAGE OF CONTRIBUTION OF DIFFERENT PLANT AND LIVESTOCK CATEGORIES TO THE FINANCIAL PROFIT OF HOMEGARDENS

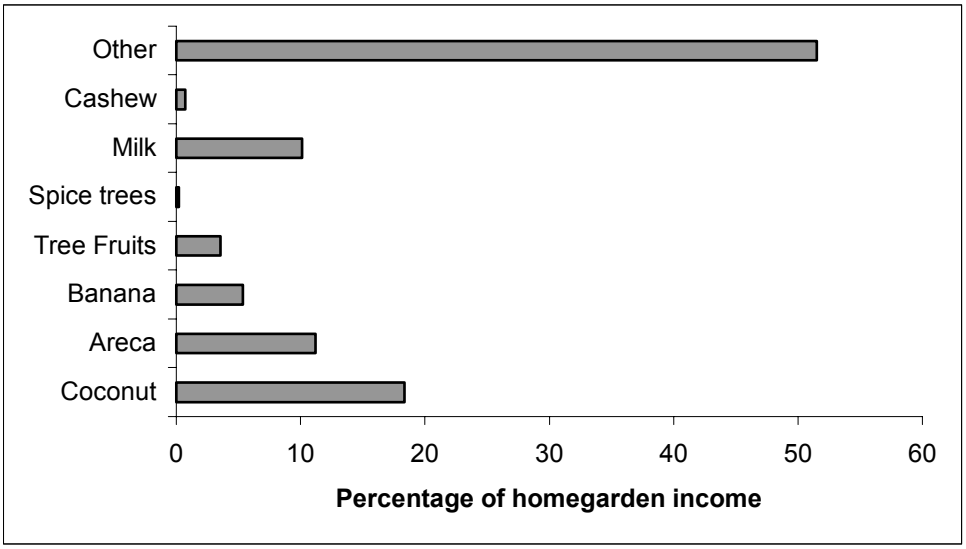

Figure C-1 Percentage of contribution of categories to the total income earned from small (less that 0.26 ha size) homegardens.

Note: 'Other' includes household food use, and firewood use

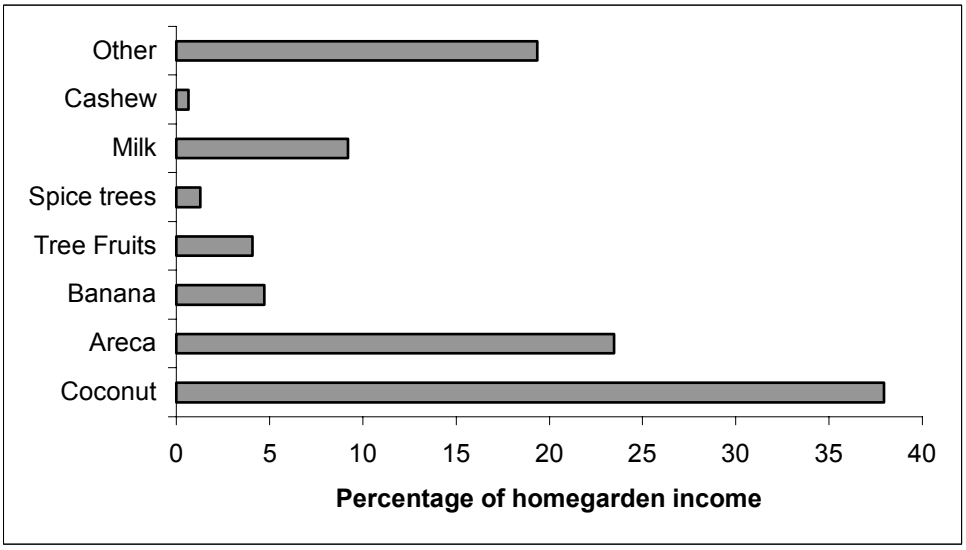

Figure C-2 Contribution of different crops to the total income earned from medium homegardens.

Figure C-3 Contribution of different crops to the total income earned from large homegardens.

Figure C-4 Contribution of different crops to the total income earned from commercial homegardens.

APPENDIX D
MARGALEF INDICES OF SPECIES RICHNESS

Example Calculations of Margalef Index

Example: Homegarden # X
Land size: 850.08 sq. m

Species Composition of garden:

Coconut	9
Black pepper	3
Papaya	2
Cashew	5
Jackfruit	2
Teak	2
Ginger	3
Turmeric	4
Taro	5
Yam	4
Moringa	1
Rose	2
Holy basil	1
Hibiscus	2
Ornamental1	2
Ornamental2	2
Medicinal1	1
Medicinal2	1
Medicinal3	1
Medicinal4	1
Total number of species	20
Total number of individuals	53
Ln (53)	3.97

Margalef Index = (Total number of species – 1)/LN (Total # of individuals) = 19/3.97 = 4.78

Table D-1 Margalef Indices of 75 surveyed homegardens in Thrissur district, Kerala, India

Area (sq.m)	Total #species	No. of individuals	Margalef Index
121.44	27	41	7.00134521
202.4	28	45	7.092827397
202.4	23	36	6.139216892
202.4	16	29	4.454613066
202.4	23	36	6.139216892
283.36	20	31	5.532926848
364.32	29	35	7.875459594
404.8	29	60	6.838701427
445.28	25	36	6.697327519
455.4	30	89	6.460759485
607.2	32	109	6.607909023
850.08	24	40	6.234955706
890.56	34	134	6.737664225
910.8	24	65	5.509790662
910.8	37	100	7.817300674
1012	34	372	5.575366076
1052.48	26	1511	3.415054699
1052.48	30	49	7.451525964
1052.48	32	93	6.839342423
1092.96	26	136	5.088898077
1214.4	30	222	5.367708999
1214.4	43	108	8.970273998
1254.88	33	59	7.847873978
1295.36	30	161	5.707083695
1578.72	33	229	5.889149275
1821.6	34	244	6.0030908
1862.08	35	3124	4.225245601
1862.08	35	369	5.752185712
1862.08	19	264	3.228149983
1902.56	30	90	6.444717027
1902.56	35	190	6.479863544
1902.56	32	208	5.807921093
2226.4	28	226	4.981058143
2226.4	38	191	7.044568511
2226.4	34	352	5.627911956
2368.08	33	149	6.394952712
2428.8	31	366	5.082477312
2752.64	39	243	6.917818122
2833.6	34	234	6.049139785
2914.56	34	172	6.410885946

Table D-1. Continued

Area (sq.m)	Total #species	No. of individuals	Margalef Index
3036	33	407	5.325510881
3319.36	33	361	5.43397235
3440.8	32	143	6.246417591
3440.8	37	233	6.604246201
3724.16	32	512	4.969282919
3845.6	34	365	5.59331765
3845.6	38	284	6.549861699
3926.56	35	339	5.835907891
3926.56	40	314	6.783324795
4048	37	235	6.593907158
4048	39	556	6.011927385
4048	41	639	6.192042047
4290.88	30	549	4.597264971
5424.32	34	708	5.028614268
5707.68	34	309	5.755805979
5869.6	34	559	5.216443295
5950.56	34	251	5.972361065
5950.56	33	265	5.735044706
5991.04	34	362	5.601152889
6031.52	32	720	4.71178239
6072	34	507	5.298216537
6881.6	27	107	5.564081399
7691.2	35	314	5.91366777
7812.64	31	1132	4.266368584
7893.6	40	475	6.327763751
7893.6	29	840	4.158373501
7934.08	35	690	5.201408005
7974.56	35	870	5.023274596
8096	40	665	6.000196584
8096	30	341	4.972665364
9108	33	638	4.954834912
9917.6	32	716	4.715775519
9958.08	36	557	5.535727774
9998.56	34	1017	4.7656097

APPENDIX E
SHANNON-WEINER INDEX OF DIVERSITY IN ANNUAL AND PERENNIAL SPECIES

Calculations of Shannon-Weiner Index

Example: Homegarden # X
Land size: 850.08 sq. m
Species Composition of garden:

Coconut	9
Black pepper	3
Papaya	2
Cashew	5
Jackfruit	2
Teak	2
Ginger	3
Turmeric	4
Taro	5
Yam	4
Moringa	1
Rose	2
Holy basil	1
Hibiscus	2
Ornamental1	2
Ornamental2	2
Medicinal1	1
Medicinal2	1
Medicinal3	1
Medicinal4	1
Total number of species	20
Total number of individuals	53

Table E-1 Shannon-Weiner Index Step –Wise calculation for Homegarden # X

	Step 1	Step 2	Step 3	Step 4
Plant	Number of individuals	Step 1 / Total number of individuals	Ln (Step 2)	Step 2 * Step 3
coconut	9	0.169811	-1.77307	-0.30109
bl pepp	3	0.056604	-2.87168	-0.16255
papaya	2	0.037736	-3.27714	-0.12367
cashew	5	0.09434	-2.36085	-0.22272
jack	2	0.037736	-3.27714	-0.12367
teak	2	0.037736	-3.27714	-0.12367
ginger	3	0.056604	-2.87168	-0.16255
turneric	4	0.075472	-2.584	-0.19502
taro	5	0.09434	-2.36085	-0.22272
yam	4	0.075472	-2.584	-0.19502
moringa	1	0.018868	-3.97029	-0.07491
rose	2	0.037736	-3.27714	-0.12367
basil	1	0.018868	-3.97029	-0.07491
hibiscus	2	0.037736	-3.27714	-0.12367
ornam	2	0.037736	-3.27714	-0.12367
orname	2	0.037736	-3.27714	-0.12367
medicinal	1	0.018868	-3.97029	-0.07491
medicinal	1	0.018868	-3.97029	-0.07491
medicinal	1	0.018868	-3.97029	-0.07491
medicinal	1	0.018868	-3.97029	-0.07491

Shannon Weiner Index = - (Sum of all values in Step 4) = 2.77

Table E-2 Shannon-Weiner Indices for 75 surveyed homegardens in Thrissur district, Kerala, India

Sq.m	Shannon-Weiner Index	Total #species	Individual #
121.44	0.736522723	7	41
202.4	1.408330212	10	45
202.4	0.952262446	10	36
202.4	0.549504348	7	29
202.4	0.668478843	10	36
283.36	1.150421681	13	31
364.32	1.035435995	13	37
404.8	1.319613351	13	60
445.28	1.104197076	10	36
455.4	1.121657171	13	89
607.2	0.845317532	13	109
850.08	1.414819856	13	40
890.56	2.209995097	13	134
910.8	0.503800404	13	65
910.8	2.005203108	13	100
1012	1.40001057	13	372
1052.5	0.477456642	7	1511
1052.5	1.228576493	13	49
1052.5	0.632742718	13	93
1093	1.449432871	13	136
1214.4	1.331258701	13	222
1214.4	1.863523923	13	108
1254.9	1.138297082	13	59
1295.4	0.993943848	13	161
1578.7	1.366883005	13	229
1821.6	1.085646637	13	244
1862.1	0.260869541	9	3124
1862.1	1.001949503	13	369
1862.1	1.290745583	14	264
1902.6	1.447424988	14	90
1902.6	1.48699607	14	190
1902.6	1.657143763	14	208
2226.4	1.079357833	14	226
2226.4	1.445497417	14	191
2226.4	1.330635843	14	352
2368.1	1.80873591	14	149
2428.8	1.64	14	366
2752.6	1.74484169	14	243
2833.6	1.45	14	234
2914.6	1.621969896	14	172
3036	1.075324265	14	407
3319.4	1.438683941	14	361
3440.8	0.027496366	14	143

Table E-2. Continued

Sq.m	Shannon-Weiner Index	Total #species	Individual #
3440.8	1.612772614	14	233
3724.2	1.82	14	512
3845.6	1.44635471	14	365
3845.6	1.987210158	14	284
3926.6	1.689444029	14	339
3926.6	0.865251024	14	314
4048	1.838484499	14	235
4048	0.712644383	14	556
4048	1.66071495	14	639
4290.9	0.217680089	14	549
5424.3	1.386927857	14	708
5707.7	1.665768859	14	309
5869.6	1.721871353	14	559
5950.6	1.88604945	14	251
5950.6	1.584543051	14	265
5991	1.444621995	14	362
6031.5	1.299374476	14	720
6072	1.620484426	14	507
6881.6	1.135220372	14	107
7691.2	1.635308411	14	314
7812.6	0.874634538	14	1132
7893.6	1.544236751	14	475
7893.6	1.706478509	14	840
7934.1	1.245432215	14	690
7974.6	1.69153576	14	870
8096	1.498928245	14	665
8096	0.489298763	14	341
9108	1.472423392	14	638
9917.6	1.942290967	14	716
9958.1	0.93767312	14	557
9998.6	1.955601331	14	1017

APPENDIX F
MEDICINAL PLANTS FOUND IN KERALA HOMEGARDENS, AND THEIR USES AS DESCRIBED BY FARMERS

Table F-1 Medicinal plants observed in 75 homegardens in Thrissur district, Kerala, India.

Common name	Common Uses	Scientific name
Neem (aryaveppu)	Entire tree is important, stem, leaves, root, fruit, seed	*Azadirachta indica*
Tulasi Krishna (holy)	Leaves used to treat many diseases.	*Ocimum sanctum*
Rama thulasi (sweet)		*Ocimum basilicum*
Akki karya	Tooth and gum pain relief	*Spilanthes acmella*
Neelamri	Oil preparation	*Indigofera tinctoria*
Kanjunni	Hair oil	*Eclipta alba*
Ginger	Stimulant, digestive aid	*Zingiber officinale*
Karin Kurinji	Arthritis and pain, itch relief	*Strobilanthes ciliatus*
Kuvalam	Diabetes and cholesterol relief	*Aegle marmelos*
Kacholam	Carminative, expectorant	*Kaempferia galanga*
Nellikka	Psychiatric aid	*Emblica officinalis*
Brahmi	Oil and to prevent worms	*Bacopa monniera*
Vicks ela	Cold relief	*Mentha piperita*
Vayambu	Infant food	*Acorus calamus*
Long Pepper	Carminative, diuretic et al	*Piper longum*
Asoka tree bark	Bark is highly astringent, and helpful in uterine problems	*Saraca asoka*
Oong	General health	*Pongamia pinnata*
iruveli	kashayam	*Coleus vettiveroides*
Lentina	Alcohol benefits in ayurveda	*Lantana camera*
Shadavali	General health	*Asparagus racemosus*
Nitya kalyani	Oil preparation	*Vincarosea*
Poovan kurmana	Eye relief, cools the body	*Vernonia cineria*
Keezharnalli	Jaundice relief	*Phyllanthus niruri*
Muyal chaviyan	Tonsilitis relief	*Emelia sonchifolia*
Changanam basandha	Oil for hair, kashayam	*Cissus quandrangularis*
Nela panna	Kidney stones	*Acrotrema arnottanum*
Chakkarakolli	For diabetes	*Gymnema sylvestre*
Thechi	Privision of vitamins, minerals	*Ixora cocine*
Vishnukranthi	General health	*Evolvulus alsinoidea*
Cheroola	General health	*Aerva lanata*
Nambiarvattam	Eye problems	*Tabernaemontana divaricata*
Mukutti	General health	*Biophytum sensitivum*

Table F-1. Continued

Karuka		*Cynadon dactylon*
Common name	Common Uses	Scientific name
Tirutali		*Ipomoea maxima*
Koduveri/koduveli	Boil treatment, skin diseases	*Plumbago zeylanica*
aadalodakam	Cough	*Adhatoda beddomei*
ashvagandam	Blood circulation, pressure, arthritis, general tonic	*Withania somnifera*
Sarpagandha	Drug alkaloids in roots	*Rauvolfia serpentina*
chittamridu	kashayam	*Tinospora cordifolia*
karinthotti	kashayam	*Sida carpinifolia*
Pushkaramoolam	Hyperventilation	*Iris germanica*
Veshakolli	Snake bite antidote	*Andrographis paniculata*
Fever nut	Leaves as astringent, and soothing toothaches	*Caesalpinia crista*
Turmeric	Widely used.	*Curcuma longa*
Kasturi manjal	Aesthetic and antiseptic antimicrobial properties	*Ourouma aromatica*
Indian almond		*Terminalia catappa*
Valliuzhinja		*Cardiospermum lelicacabum*
Allamanda		*Allamanda cathartica*
Asokachethi		*Ixora coccinea*

LIST OF REFERENCES

Abdoellah, O.S. 1990. Homegardens in West Java and their future development. In: Landauer, K. and Brazil, M. (eds.), *Tropical homegardens*, pp 69-79. United Nations University Press, Tokyo, Japan.

Alavalapati, J.R.R. and Mercer, D.E. (eds). 2004. *Valuing Agroforestry Systems: Methods and Applications*. Advances in Agroforestry 2. Springer, Germany.

Allen, T.F.H., Hoekstra, T.W., 1992. *Toward a Unified Ecology*. Columbia University Press, New York.

Ayuk, E.T. 1997. Adoption of Agroforestry technology: The Case of Live hedges in the Central Plateau of Burkina Faso. *Agricultural Systems* 54: 189-206

Baijukya, F.P. and Piters, P. 1998. Nutrient balances and their consequences in the banana-based land use systems of Bukoba district, northwest Tanzania. *Agriculture, Ecosystems and Environment* 71: 147-158.

Benjamin, T.J., Montanez, P.I., Jimenez, J.J. and Gillespie, A.R. 2001. Carbon, water and nutrient flux in Maya homegardens in the Yucatan peninsula of Mexico. *Agroforestry Systems* 53: 103-111

Benson, J.F. 1994. Values for forest landscapes using travel costs and tokens. *Landscape Research 19*: 23-25.

Brierly, J.S.1985. West Indian kitchen gardens: a historical perspective with current insights from Grenada. *Food and Nutrition Bulletin* 7:52-60

Brodt, S.B. 2001. A systems perspective on the conservation and erosion of indigenous agricultural knowledge in Central India. *Human Ecology* 29: 99-120

Brownrigg. L. 1985. *Homegardening in International Development: What the Literature Shows*. League for International Food Education, Washington, DC.

Budowski, G. 1990. Homegardens in tropical America: a review. In: Landauer, K. and Brazil, M. (eds.), *Tropical homegardens*, pp 3-8. United Nations University Press, Tokyo, Japan.

Burns, R.M. and B.H. Honkala. 1990. Silvics of North America (Vol.2). *Hardwoods*. USDA, Forest Serv. Agric. Handbook 654.

Caron, C.M. 1995. The role of non timber tree products in household food procurement strategies: profile of a Sri Lankan village. *Agroforestry Systems* 32: 99-117

Carruthers, S.P. 1996. Agroforestry in Britain. *Tree News*. Spring 7-9.

Chacko, V.I. 1975. Employment of women in plantations. *Plant Chron*. 70: 159-160.

Chandrashekhara, U.M. 1996. *Studies on growth and architecture of tree species of homegarden agroforestry systems of Kerala*. KFRI Research Report No. 101.

Chandrashekhara, U.M. and Sankar, S. 1998. Ecology and Management of sacred groves in Kerala, India. *Forest Ecology and Management* 112: 165-177.

Christanty, L. 1990. Homegardens in tropical Asia, with special reference to Indonesia. Homegardens in tropical America: a review. In: K. Landauer, K and Brazil,M (eds.), *Tropical Homegardens*, pp 9-20. United Nations University Press, Tokyo, Japan

Cline, W.R. 1992. *The Economics of Global Warming*. Institute for International Economics, Washington DC.

Collins, W.W. and Hawtin, G.C. 1999. Conserving and using crop plant biodiversity in agroecosystems. In: Collins, W.W. and Qualset, C.O. (eds.) *Biodiversity in Agroecosystems,* pp 267-282. CRC Press, Fl, US.

Current, D., Lutz, E, and Scherr, S (eds.) 1995. *Costs, Benefits, and Farmer Adoption of Agroforestry. Project Experience in Central America and the Caribbean.* The World Bank Environment Paper 14: World Bank, Washington DC.

Curtis, J. T. and R. P. McIntosh. 1951. An upland forest continuum in the prairie-forest border region of Wisconsin. *Ecology* 32:476-496.

Dash, S.S. and Misra, M.K. 2001. Studies on the hill agro-ecosystems of three tribal villages on the Eastern Ghats of Orissa, India. *Agriculture, Ecosystems and Environment* 86: 287-302

De Clerck, F.A.J. and Negreros-Castillo, P. 2000. Plant species of traditional Mayan homegardens of Mexico as analogs for multistrata agroforests. *Agroforestry Systems* 48: 303-317.

de Jong, W. 2001. Tree and forest management in the floodplains of the Peruvian Amazon. *Forest Ecology and Management* 150: 125-134.

Delaney, M. and Roshetko, J.M. 1999. Field test of carbon monitoring methods for homegardens in Indonesia. *Field Tests of Carbon Monitoring Methods in Forestry Projects,* pp. 231-245. Winrock International, VA.

Devendra, C. and Thomas, T. 2002. Crop-animal systems in Asia: Importance of livestock and characterization of agro-ecological zones. *Agricultural Systems* 71: 5-15

Dove, M.R. 1994. Transition from native forest rubbers to *Hevea brasiliensis* (Euphorbiaceae) among tribal smallholders in Borneo. *Economic Botany* 48: 384-396.

Drescher, A.W. 1996. Management strategies in African homegardens and the need for new extension approaches. pp. 231-245. In: Heidhues, F. and Fadani, A. (eds), *Food Security and Innovations – Successes and Lessons Learned*. Peter Lang, Frankfurt.

Ehui, S.K., Kang, B.T., and Spencer, D.S.C. 1990. Economic analysis of soil erosion effects in alley cropping, no-till and bush fallow systems in South Western Nigeria. *Agricultural Systems* 34: 349-368.

Esquivel, M. and Hammer, K. 1992. The Cuban homegardens'conuco': A prospective environment for evolution and *in situ* conservation of plant genetic resources. *Genetic Resources and Crop Evolution* 39: 9-22

Ewel, J.J. 1999. Natural systems as models for the design of suitable systems of land use. *Agroforestry Systems* 54: 7-21

Fernandes, E.C.M. and Nair, P.K.R. 1986. An Evaluation of the Structure and Function of Tropical Homegardens. *Agricultural Systems* 21:279-310.

Fernandes, E.C.M., Oktingati, A., and Maghembe, J. 1984. The Chagga homegardens: a multi-story agroforestry cropping system on Mt. Kilimanjaro, Northern Tanzania. *Agroforestry Systems* 2: 73-86

Forest Survey of India, 1993. New Delhi. India.

Gajaseni, N. and Gajaseni, J. 1999. Ecological rationalities of the traditional homegarden system in the Chao Phraya Basin, Thailand. *Agroforestry Systems* 46:3-23.

Gimaret-Carpentier, C., R. Pelissier, J. Pascal, and F. Houllier. 1998. Sampling strategies for the assessment of tree species diversity. *Journal of Vegetation Science* 9: 161-172.

Gliessman, S.R. 2000. *Agroecology: Ecological Processes in Sustainable Agriculture*. CRC Press, Boca Raton, FL.

Government of India census, 2000. New Delhi, India.

Herdt, R.W. and Steiner, R.A. 1995. Agricultural Sustainability: Concepts and Conundrums. In: Barnett V., R. Payne, and R.Steiner (eds.), *Agricultural Sustainability: Economic, Environmental and Statistical Considerations* pp.1-13. Wiley, Chichester, U.K.

High, C. and Shackleton, C.M. 2000. The comparative value of wild and domestic plants in homegardens of a South African rural village. *Agroforestry Systems* 48: 141-156.

Huston, M.A. 1994. *Biological diversity: The Coexistence of Species in Changing Landscapes*. Cambridge University Press, Cambridge, UK.

Immink, M.D. 1990 Measuring food production and consumption, and the nutritional effects of tropical homegardens. In: Landauer, K. and Brazil, M. (eds.), *Tropical Homegardens*, pp 126-137. United Nations University Press, Tokyo, Japan

Jacob, V.J. and Alles, W.S. 1987. The Kandyan gardens of Sri Lanka. *Agroforestry Systems* 5: 123-137.

Jambulingam, R. and Fernandes, E.C.M. 1986. Multipurpose trees and shrubs on farmlands in Tamil Nadu State, India. *Agroforestry Systems* 4: 17-32

Jensen, M.1993. Productivity and nutrient cycling of a Javanese homegarden. *Agroforestry Systems* 24: 187-201.

Johnson, D. 1988. Palms as multipurpose cash and subsistence tree crops. In: Withington, D, MacDicken, K.G, Sastry, C.B, and Adams, N.R (eds.), *Multipurpose Tree Species for Small-Farm Use* pp. 222-236. Winrock, USA and IDRC, Canada.

Jose D. and Shanmugaratnam, N. 1993. Traditional homegardens of Kerala: a sustainable human ecosystem. *Agroforestry Systems* 24:203-213.

Karyono. 1990. Homegardens in Java: their structure and function. In: Landauer, K. and Brazil, M. (eds.), *Tropical Homegardens*, pp 138-146. United Nations University Press, Tokyo, Japan.

Kaur, M. and Sharma, M. 1991. Role of women in rural development. *Journal of Rural Studies* 7: 11-16.

Kaya, M., Kammesheidt, L., and Weidelt, H.J. 2002. The forest garden system of Saparua island, Central Maluku, Indonesia, and it's role in maintaining tree species diversity. *Agroforestry Systems* 54: 225-234.

Kerala Agricultural University. (1993). *Crops: Package of Practices Recommendations*. Directorate of Extension, Thrissur, Kerala.

Kerala Agricultural University. (1998). *Nutrition Garden*. Directorate of Extension. Thrissur, Kerala.

Krebs, C.J. 1985. *Ecology: The Experimental Analysis of Distribution and Abundance*. Harper and Row, New York.

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

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

Landis, J.N., Sanchez, J.E., Bird, G.W., Edson, C.E. Isaacs, Lehnert, R.R.H, Schilder, A.M.C and Swinton, S.M. (eds.) 2002. *Fruit Crop Ecology and Management*. Extension bulletin E-2759. Michigan State University, East Lansing, MI.

Lawrence, D.C. 1996. Trade-offs between rubber production and maintenance of diversity: the structure of rubber gardens in West Kalimantan, Indonesia. *Agroforestry Systems* 34: 83-100.

Leakey, R.R.B. 1999. Potential for novel food products from agroforestry trees: a review. *Food Chemistry* 66: 1-14.

Leakey, R.R.B. and Tomich, T.P. 1999. Domestication of tropical trees: From biology to economics and policy in agroforestry. In: Buck, L.E., Lassoie, J.P. and Fernandes, E.C.M (eds.), *Agroforestry in Sustainable Agricultural Systems* pp. 319-358. CRC Press, Boca Raton, FL

Leuschner, W.A. and Khaleque, K. 1987. Homestead agroforestry in Bangladesh. *Agroforestry Systems* 5: 139-151

Loomis, J.B and Walsh R. 1997. *Recreation Economic Decisions*. Venture Publishing, Inc., Pennsylvania.

Madaleno, I. 2000. Urban agriculture in Belem, Brazil. *Cities* 17: 73-77.

Mammen, C., Krishnankutty, C.N., and Rajan, A.R. 1993. *Socio-economic Study of Farm Forestry: A Survey of Four Villages in Kerala*. KFRI research report No.90. KFRI. Kerala, India.

Margalef, R. 1958. Information theory in ecology. *General Systematics* 3: 36-71.

Margurran, A.E. 1988. *Ecological Diversity and its Measurement*. Princeton University Press, Princeton, NJ.

Martin, F.W. and Ruberte, R.M. 1980. *Techniques and Plants for the Tropical Subsistence Farm*. U.S Department of Agriculture, Washington DC.

McGrath, D.A. 1998. *Ecological Sustainability in Amazon Agroforests: An On Farm Study of Phosphorus and Nitrogen Dynamics Following Native Forest Conversion.* Ph D Dissertation, University of Florida, Gainesville, FL.

Mendez, V.E., Lok, R. and Somarriba, E. 2001. Interdisciplinary analysis of homegardens in Nicaragua: microzonation, plant use and socioeconomic importance. *Agroforestry Systems* 51: 85-96.

Mercer, E., Kramer, R., and Sharma, N. 1995. Rain Forest Tourism: Estimating the benefits of tourism development in a new national park in Madagascar. *Journal of Forest Economics* 1: 239-269.

Mercer, D.E. and Miller, R.P. 1998. Socioeconomic research in agroforestry: progress, prospects, priorities. *Agroforestry Systems* 38: 177-193.

Michon, G. 1983. Village forest-gardens in West Java. In: Huxley, P.A. (ed.), *Plant Research and Agroforestry*, pp. 13-24. ICRAF, Nairobi, Kenya.

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

Michon, G., Bompard, J., Hecketseiler, P., and Ducatillion, C. 1983. Tropical forest architectural analysis as applied to agroforests in the humid tropics: the example of traditional village agroforests in West Java. *Agroforestry Systems* 1: 117-129.

Millat-E-Mustafa, M.D., Hall, J.B., and Teklehaimanot, Z. 1996. Structure and floristics of Bangladesh homegardens. *Agroforestry Systems* 33: 263-280.

Mitchell, R.C. and Carson, R.T. 1989. *Using Surveys to Value Goods: the Contingent Valuation Method*. Resources for the Future, Washington DC.

Montagnini, F. and Nair, P.K.R. 2004. Carbon sequestration: An underexploited environmental benefit of agroforestry systems. *Agroforestry Systems* 61: 281-295.

Moreno-Black, G., Somnasang, P., and Thamathawan, S. 1996. Cultivating continuity and creating change: Women's home garden practices in northeastern Thailand. *Agriculture and Human Values* 13: 3-11.

Muniz-Miret, N., Vamos, R., Hiraoka, M., Montagnini, F., and Mendelsohn, R.O. 1996. The economic value of managing the acai palm (Euterpe oleracea Mart.) in the floodplains of the Amazon estuary. *Forest Ecology and Management* 87: 163-173.

Neupane, R.P and Thapa, G.B. 2001. Impact of agroforestry intervention on farm income under the subsistence farming system of the middle hills, Nepal. *Agroforestry Systems* 53: 31-37.

Nair, M.A and Sreedharan, C. 1986. Agroforestry farming systems in the homesteads of Kerala, southern India. *Agroforestry Systems* 4:339-363.

Nair, P.K.R. 2001. Do tropical homegardens elude science, or is it the other way around? *Agroforestry Systems* 53: 239-245.

Nair, P.K.R. 1993. *An Introduction to Agroforestry*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Nair, P.K.R., Buresh, R.J., Mugendi, D.N., and Latt, C.R. 1999. Nutrient cycling in tropical agroforestry systems: Myths and science.. In: Buck, L.E., Lassoie, J.P., and Fernandes, E.C.M. (eds.), *Agroforestry in Sustainable Agricultural Systems,* pp. 1-31. CRC Press, Boca Raton, FL.

Nair, P.K.R and Dagar, J.C. 1991. An approach to developing methodologies for evaluating Agroforestry systems in India. *Agroforestry Systems* 16: 55-81.

Nelson, K.C. and de Jong, B.H.J. 2003. Making global initiatives local realities; carbon mitigation projects in Chiapas, Mexice. Global Environmental Change 13: 19-30.

Ninez, V.K. 1987. Household gardens: theoretical and policy considerations. *Agricultural Systems* 23: 167-186.

Okafor J.C. and Fernandes, E.C.M. 1987. Compound farms of Southeastern Nigeria: A predominant homegarden system with crops and small livestock. *Agroforestry Systems* 5: 153-168.

Okigbo, B.N. 1990. Homegardens in Tropical Africa. In: Landauer, K. and Brazil, M (eds.), *Tropical Homegardens*, pp. 21-40. United Nations University Press, Tokyo, Japan

Oladokun, M.A. 1990. Tree crop based agroforestry in Nigeria: a checklist of crops intercropped with cacao. *Agroforestry Systems*. 11:227-241.

On, T.V., Quyen, D., Bich, L.D., Jones, B., Wunder, J., and Russel-Smith, J. 2001. A survey of medicinal plants in Ba Vi National Park, Vietnam: methodology and implications for conservation and sustainable use. *Biological Conservation* 97: 295-304.

Padoch, C. and de Jong, W. 1991. The house gardens of Santa Rosa: Diversity and variability in an Amazonian agricultural systems. *Economic Botany* 45: 166-175.

Peters, C.M., Gentry, A.H., and Mendelsohn, R.O. 1989. Valuation of an Amazonian rainforest. *Nature* 339: 655-656

Pilbeam, C.J., Tripathi, B.P., Sherchan, D.P. Gregory, P.J. and Gaunt, J. 2000. Nitrogen balances for households in the mid-hills of Nepal. *Agriculture, Ecosystem and Environment* 79: 61-72.

Pinton, F. 1985. The tropical garden as a sustainable food system: A comparison of Indians and settlers in Northern Colombia. *Food and Nutrition Bulletin* 7: 25-28.

Posey, D.A. 1985. Indigenous management of tropical forest ecosystems: The case of the Kayapo Indians of the Brazilian Amazon. *Agroforestry Systems* 3: 139-158.

Price, C. 1995. Economic evaluation of financial and non-financial costs and benefits in agroforestry development and the value of sustainability. *Agroforestry Systems* 30: 75-86.

Raintree, J.B. 1984. *Designing Agroforestry Systems for Rural Development: ICRAF's Diagnosis and Design Approach*. ICRAF, Nairobi, Kenya.

Ramamurthy, P. 2000. The cotton commodity chain, women, work and agency in India and Japan: The case for feminist agro-food systems research. *World Development* 28: 551-578.

Ranasinghe, D. 1995. Agroforestry and community forestry in Sri Lanka. *Sri Lanka Forester* 20: 45-49.

Raynolds, L.T. 2003. Wages for Wives: Renegotiating gender and production relations in contract farming in the Dominican Republic. *World Development* 30: 783-798.

Reed, D.D. and Mroz, G.D. 1997. *Resource Assessment in Forested Landscapes*. John Wiley and Sons, Inc. New York.

Renuka, C. 1999. *Palms of Kerala*. Kerala Forest Research Institute, Kerala, India.

Ricklefs, R.E. and Schluter, D. 1993. *Species Diversity in Ecological Communities*. University of Chicago Press, Chicago, IL.

Rico-Gray, V., Chemas, A., and Mandujano, S. 1991. Use of tropical deciduous forest species by the Yucatan Maya. *Agroforestry Systems* 14: 149-161

Robert, G.L. 1988. Let them eat trees: Some observations on nutrition and social forestry. In: Withington, D, MacDicken, K.G., Sastry, C.B., and Adams, N.R. (eds.), *Multipurpose Tree Species for Small-Farm Use*, pp. 175-181. Winrock, USA and IDRC, Canada

Rocheleau, D.E. 1987. The user perspective and the agroforestry research and action agenda. In: Gholz, H.G. (ed.), *Agroforestry: Realities, Possibilities, and Potentials,* pp. 59-88. Martinus Nijhoff, Dordrecht

Rugalema, G.H., Johnsen, F.H., O'ktin'ati, A., and Minjas, A. 1995. The homegarden agroforestry system of Bukoba district, North-western Tanzania. (No.3) An economic appraisal of possible solutions to falling productivity. *Agroforestry Systems* 28: 227-236.

Rugalema, G.H., O'ktin'ati, A., and Johnsen, F.H. 1993. The homegarden agroforestry system of Bukoba district, North-western Tanzania. (No.1) Farming system analysis. *Agroforestry Systems* 26: 53-64.

Rugalema, G.H., Johnsen, F.H., and Rugambisa, J. 1993. The homegarden agroforestry system of Bukoba district, North-western Tanzania. (No.2) Constraints to farm productivity. *Agroforestry Systems* 26: 205-214

Russell, A.E. 2002. Relationships between crop-species diversity and soil characteristics in southwest Indian agroecosystems. *Agriculture, Ecosystems and Environment* 92: 235-249.

Salafsky, N. 1995. Forest gardens in the Gunung Palung region of West Kalimantan, Indonesia. Defining a locally developed, market-oriented agroforestry system. *Agroforestry Systems* 28: 237-268.

Salam, M.A., Noguchi, T., and Koike, M. 2000. Understanding why farmers plant trees in the homestead agroforestry in Bangladesh. *Agroforestry Systems* 50:77-93.

Sanchez, J.E., Willson, T.C., Zoppolo, R.J., Stefanelli, D., and Bird, G.W. 2002 The soil. In: Landis, J.N., Sanchez, J.E., Bird, G.W., Edson, C.E., Isaacs, R., Lehnert, R.H., Schilder, A.M.C., and Swinton, S.M. (eds.), *Fruit Crop Ecology and Management*, pp. 21-29. Extension bulletin E-2759. Michigan State University, East Lansing, MI.

Sankar, S. and Chandrashekara, U.M. 2000. *Development and Testing of Sustainable Agroforestry Models in Different Agroclimatic Zones of Kerala with Emphasis on Socio-cultural, Economic, Technical and Institutional Factors Affecting the Sector*. KFRI Research Report No. 234. Kerala Forest Research Institute, Kerala, India.

SARE. 2000. http://www.sare.org/htdocs/docs/SANandSARE.html.

Sasidharan, N. 2000. *Forest Trees of Kerala*. Kerala Forest Research Institute Handbook No.2, KFRI, Kerala, India.

Scartezzini, P. and Speroni, E. 2000. Review on some plants of Indian traditional medicine with antioxidant activity. *Journal of Ethnopharmacology* 71: 23-43

Scherr S.J. 1992. Financial and economic analyses of agroforestry systems: An overview of the case studies. In: Sullivan, G.M., Huke, S.M., and Fox, J.M. (eds.), *Financial and Economic Analyses of Agroforestry Systems,* pp. 3-12. Nitrogen Fixing Tree Association, Paia, HI.

Schulz, B., Becker, B., and Eotsch, E. 1994. Indigenous knowledge in a 'modern' sustainable agroforestry system – a case study from eastern Brazil. *Agroforestry Systems* 25: 59-69

Semwal, R.L. and Maikhuri, R.K. 1996. Structure and functioning of traditional hill agroecosystems of Garhwal Himalaya. *Biological Agriculture and Horticulture* 13: 267-289.

Shanavas, A. and Mohan Kumar, B. 2003. Fuelwood characteristics of tree species in homegardens of Kerala, India. *Agroforestry Systems* 58: 11-24.

Smith, N.J.H. 1996. Homegardens as a springboard for agroforestry development in Amazonia. *International Tree Crops Journal* 9: 11-30.

Soemarwoto, O. 1987. Homegardens: A traditional agroforestry system with a promising future. In: Steppler, H. A. and Nair, P. K. R. (eds), *Agroforestry: A Decade of Development*, pp. 157-170. ICRAF, Nairobi, Kenya.

Soemarwoto, O. and Conway, G.R.1992. The Javanese homegarden. *Journal for Farming Systems Research-Extension* 2: 95-118.

Sorenson, T. 1948. A method of establishing groups of equal amplitude in a plant society based on similarity of species content. *K. Danske Vidensk. Selsk*. **5**: 1-34.

Sustainable Agriculture Network Bulletin. 2000. *A Whole-Farm Approach to Managing Pests*. USDA-CREES, Washington DC.

Swift, M.J. and Anderson, J.M. 1993. Biodiversity and ecosystem function in agricultural systems. In: Schulze, E.D. and Mooney, H.A. (eds.), *Biodiversity and Ecosystem Function,* pp. 15-42. Springer Verlag, Berlin.

Tajuddin, E., Anilkumar, A.S., and Prasannakumari, K.T. 1996. *Medicinal Plants*. Directorate of Extension, Kerala Agricultural University, Kerala, India.

Tejwani, K.G. 1987. Agroforestry practices and research in India. In: Gholz, H.G. (ed.), *Agroforestry: Realities, Possibilities, and Potentials*, pp. 109-136. Martinus Nijhoff, Dordrecht.

Tejwani, K.G. 1994. *Agroforestry in India*. Concept Publishing Company. New Delhi, India, pp 233 109-136

Thorne, P.J. and Tanner, J.C. 2002. Livestock and nutrient cycling in crop-animal systems in Asia. *Agricultural Systems* 71: 11-126.

Torquebiau, E.F. 2000. A renewed perspective on agroforestry concepts and classification. *Life Sciences* 323: 1009-1017.

Torquebiau, E.F. 1992. Are tropical agroforestry homegardens sustainable? *Agriculture, Ecosystems and Environment* 41: 189-207.

Trautmann, T.R. 1995 [orig 1981]. *Dravidian Kinship*. Walnut Creek, CA.: Altamira Press.

Varghese A.O. and Balasubramanyam, K. 1998. Structure, composition and diversity of the tropical wet evergreen forest of the Agasthyamalai region of Kerala, Western Ghats. *Journal of South Asian Natural History* 4: 87-98.

Vasey, D.E. 1985. Household gardens and their niche in Port Moresby, Papua New Guinea. *Food and Nutrition Bulletin* 7: 37-43

Vogl, C.R., Vogl-Lukraser, B. and Caballero, J. 2002. Homegardens of Maya Migrants in the district of Palenque, Chiapas, Mexico: Implications for sustainable rural development. pp. 1-12. In: Stepp J.R., Wyndham, F.S. and Zarger, R.K. (eds), *Ethnobiology and Biocultural Diversity*, University of Georgia Press, Athens, GA.

Watson J.W. and Eyzaguirre, PB (eds.). 2002. Homegardens and in situ conservation of plant genetic resources in farming systems. *Proceedings of the Second International Home Gardens Workshop*, 17-19 July 2001, Germany. International Plant Genetic Resources Institute (IPGRI), Rome, Italy

Wezel A. and Bender, S. 2003. Plant species diversity of homegardens of Cuba and its significance for household food supply. *Agroforestry Systems* 57: 39-49.

Wiersum, K.F. 1982. Tree gardening and taungya in Java: examples of agroforestry techniques in the humid tropics. *Agroforestry Systems* 1:53-70

Wilson, R.T. 1995. *Livestock Production Systems*. ICTA, Macmillan, UK.

Withrow-Robinson, B., Hibbs, D.E., Gypmantasiri, P., and Thomas, D. 1999. A preliminary classification of fruit-based agroforestry in a highland area of northern Thailand. *Agroforestry Systems* 42:195-205.

BIOGRAPHICAL SKETCH

Soumya Mohan was born on July 13, 1976 in Kerala India. She spent her youth in Kuwait, where studied at the Carmel School Convent. Her university experience includes undergraduate degrees in Communication Studies, and Asian Studies, from the University of Michigan in Ann Arbor. She continued her education at the University of Michigan and obtained two master's degrees, an MS in Natural Resources and Environment, and an MA in South Asian Studies. Her thesis project was carried out in Kathmandu, Nepal, following which she returned to Michigan, and was employed by ShoreBank Enterprise, Inc., a non-profit organization, as part of a project to provide affordable housing to East Detroit residents. She then moved to Florida to begin her PhD studies in 2000.

She is married to Michael Kevin Rasser, and currently resides in Texas.