

Characteristics and functions of traditional homegardens: a review

Huyin HUAI (✉)¹, Alan HAMILTON²

¹ College of Bioscience and Biotechnology, Yangzhou University, Yangzhou 225009, China
² Plantlife International, 14 Rolleston Street, Salisbury, Wiltshire SP1 1DX, UK

© Higher Education Press and Springer-Verlag 2008

Abstract Traditional agroecosystems play an important role in the conservation of biodiversity and in sustainable development. As a typical type of traditional agroecosystem, traditional homegardens have been receiving increasing attention from scientists, especially ethnobotanists. They are considered as germplasm banks for many crops and other economic plants. They are also a key site for domestication of wild plants. Current ethnobotanical studies on homegardens focus on their structures, floristic composition, and contributions to their owners. Traditional homegardens often show complicated structures, diverse floristic compositions, multiple functions, low input (including labor and money), and ecological and socio-economic sustainability. The characteristics and functions of traditional homegardens are closely related to many factors, such as their geographic location and the cultural backgrounds and socioeconomic conditions of their owners. Many researches on homegardens are conducted in the tropics. There are few studies on the dynamics of traditional homegardens, especially those located in temperate, arid and semi-arid zones. The dynamics of homegardens and the factors affecting these processes will be a fruitful field for future research.

Keywords traditional agroecosystem, homegarden, ethnobotany, conservation of biodiversity

1 Introduction

Traditional agroecosystems have not only provided indigenous people with subsistence, such as foods, fruits, medicine, and cash income, but have played an important role in biodiversity conservation, especially for conservation of local crop varieties and species germplasm

(Plucknett et al., 1983; Le et al., 1999; Levasseur and Olivier, 2000). They have contributed greatly to modern agricultural science as they provide genetic material for breeding programs. It is estimated that 96% of genetic materials in modern agriculture come from traditional agro-ecosystems in developing countries (Primack and Ji, 2000).

Traditional agroecosystems all over the world often contain a high diversity of crop varieties. Arora (1997) reported that 320 crop cultivars are cultivated in traditional agriculture systems by indigenous groups in a small mountainous area in India. In South America, the Andean peoples grow thousands of different potato cultivars in their farmlands (Primack and Ji, 2000). The indigenous people of Apo Kayan, Kalimantan, grow about 50 varieties of rice (Browning, 1991). In fact, most crop germplasm resources have been conserved effectively by indigenous people through their traditional practices (Plucknett et al., 1983; Le et al., 1999; Elias et al., 2004; Major et al., 2005). These crop varieties contain abundant genetic diversities of huge value to modern crop breeding. In a sense, traditional agroecosystems can be regarded as a kind of reservoir for storing crop and other economic plant diversity for use in the future (Niñez, 1987; Blanckaert et al., 2004; Das and Das, 2005).

However, along with the loss of traditional life-styles and changes in the socioeconomy, the continuing existence of traditional agroecosystems has now become questionable. The characteristics and functions of traditional agroecosystems all over the world are under great change (Dash and Mishra, 2001; Trinh et al., 2003; Soini, 2005; Peyre et al., 2006). In some parts of the world, many species once commonly cultivated in traditional agroecosystems are becoming lost and, along with this, related knowledge about their management is also being lost (Lamont et al., 1999; Kumar and Nair, 2004). For example, Rhoades (1991) reported that farmers in Sri Lanka cultivated 2000 landraces in their traditional agricultural

systems before 1950, but only 5 varieties still remain. Many varieties of crops cultivated in slash-and-burn agriculture in southwest China are vanishing due to the gradual disappearance of this practice (Pei, 1997). Thus, there are compelling, urgent reasons for scientists to systematically study these valuable traditional agroecosystems before they completely disappear.

Homegardens (otherwise known as backyard gardens, kitchen gardens, dooryard gardens, and household gardens) are a typical type of traditional agroecosystem, being intensively managed lands close to human dwellings (Niñez, 1987; Hamilton and Hamilton, 2006; Peyre et al., 2006). They are generally marked by obvious boundaries of bamboos, shrubs or other materials (Gobin et al., 2001; Kehlenbeck and Mass, 2004), and are characterized as a type of agroecosystem of high biodiversity, with multiple functions and roles, complex structures, and ecological and socioeconomic sustainability (Rico et al., 1990; Padoch and De Jong, 1991; Lamont et al., 1999; Zaldivar et al., 2002; Hamilton and Hamilton, 2006; Peyre et al., 2006). Homegardens are also regarded as a type of agroecosystem with high levels of production and relatively low labor, cash or other input (Niñez, 1987; Kehlenbeck and Maass, 2004). Because of their great contribution to indigenous people's livelihoods, biodiversity conservation, ecological and economic functions, and modern agrosience, homegardens have been receiving increasing attention from scientists, especially ethnobotanists, but are still under-researched. The purpose of the current paper is to review studies on the structural characteristics, functions, and dynamics of traditional homegardens.

2 Definition and types of traditional homegardens

2.1 Definition of traditional homegardens

Scholars vary in their understanding of traditional homegardens. However, most researchers consider homegardens those that are located close to dwellings, contain diverse species with different life forms and uses, and are managed for multiple purposes and ecological sustainability (Fernandes and Nair, 1986; Gajaseni and Gajaseni, 1999; Peyre et al., 2006). For a general definition, we cite Niñez (1987): “(a traditional homegarden is) a small-scale production system supplying plant and animal consumption and utilitarian items either not obtainable, affordable, or readily available through retail markets, field cultivation, hunting, gathering, fishing, and wage earning. Household gardens tend to be located close to dwellings for security, convenience, and special care. They occupy land marginal to field production and labor marginal to major household economic activities. Featuring ecologically adapted and

complementary species, household gardens are marked by low capital input and simple technology”. Two basic components of traditional homegardens are indicated by this definition, i.e. proximity to houses and a diversity of plants, the latter well adapted to the local environment and serving multiple purposes.

2.2 Types of traditional homegardens

There are many types of traditional homegardens, varying in their layouts and types of species grown, and associated with different geographical areas or ethnic groups (Hamilton and Hamilton, 2006). Size, structure, socioeconomic value, or dominant species have all been used as criteria in classifying homegardens (Kehlenbeck and Mass, 2004). There are many systems of classification, but no universally accepted current scheme, especially for tropical homegardens for which many types are reported (Kehlenbeck and Mass, 2004). Niñez (1987) classified traditional homegardens into two ecological types, tropical and temperate, each marked by particular features in terms of structure and species composition. Tropical homegardens tend to have complex vertical structures and many species with many life-forms. In contrast, temperate homegardens have simple vertical structures with all the plants unshaded and dominated by annual species. Niñez has further proposed an alternative way of classifying traditional homegardens according to their contributions to household economies: subsistence and budget gardens. The former is mainly devoted to providing households with food, fruit and other daily produce, and the latter mainly to providing financial income (Niñez, 1987). In Vietnam, Trinh et al. (2003) classified traditional homegardens into four types according to their main functions and main species, that is, “homegardens with fruit trees”, “homegardens with pond and covered livestock area”, “homegardens with vegetables”, and “homegardens with forest trees”. The classification of homegardens is predicted to be a fruitful field for future research.

3 Structure of traditional homegardens

3.1 Vertical structure of the vegetation

Traditional homegardens often have complicated vertical structures. They vary in their vertical structure according to their location (e.g. more complex in the tropics), floristic composition, age and size (Kehlenbeck and Maass, 2004). De Clerck and Negrreos-Castillo (2000) reported five vertical layers for one type of homegarden in Mexico (Table 1). In the Chao Phraya Basin of Thailand, Gajaseni and Gajaseni (1999) reported on traditional homegardens with four vertical layers (Table 2), similar in this way to a dry dipterocarp forest except that each layer is lower in

height. Even in arid regions in the tropics, vertical profiles can be complex. For example, the homegardens in northeastern Brazil have three strata (Albuquerque et al., 2005) (Table 3).

Table 1 Vertical profiles of a homegarden in Mexico

vertical profile	height/m	species
tall tree stratum	6–12	mango, avocado, and timber trees
lower tree stratum	3–6	<i>Citrus</i> spp.
tall shrub stratum	1.5–3	bananas, papaya, and achioté
lower shrub stratum	0.5–1.5	annual & perennial herbaceous plants: tomatoes, espelon, corn, ginger, cassava, and taro
herbaceous stratum	< 0.5	herbs & creepers: basil, squash, epazote, and sweet potatoes

Table 2 Vertical profiles of a homegarden in Thailand

vertical profile	height/m	species
emergent layer	≥ 10	coconut, areca palm, bamboo, and teak
canopy layer	5–10	mango, tamarind, durian, coral tree, Indian trumpet flower, and plum mango
understory layer	< 5	diverse fruit trees with a height < 5 m
shrubs and ground cover		different species of shrubs and grasses

Table 3 Vertical profiles of a homegarden in northeastern Brazil

vertical profile	height/m	species and usage
upper stratum	7–12	fruits and timbers: <i>Schinopsis brasiliensis</i> , <i>Anacardium occidentale</i> , <i>Erythrina velutina</i> , etc.
mid-stratum	3–7	multiple uses: <i>Tabebuia</i> sp.; <i>Myracrodruon urundeuva</i> , etc.
lower stratum	1–3	medicinal plants, fruits, and forages: <i>Psidium guajava</i> , <i>Annona squamosa</i> , <i>Jatropha molissima</i> , etc.

The wide range of species of different heights and life forms found in traditional homegardens add to their ecological efficiency in terms of use of physical and chemical resources such as water, sunlight, and nutrients (Wiersum, 1982; Blanckaert et al., 2004).

3.2 Floristic composition and resource categories

Whether located in tropical or temperate regions, or in wet or arid areas, all traditional homegardens show high floristic diversities compared with other kinds of agroecosystems. Trinh et al. (2003) reported that in Vietnam the number of species in homegardens ranged from 12 to 103, with the average number of species being 0.7 to 2.7 per 100 m². In Cuba, the average number of species per homegarden varies from 18 to 24 (Wezel and Bneder, 2002). In the Gaoligong Mountains, China, homegardens are one of the major land-use types. It is reported that

species richness in homegardens managed by local farmers ranges from 14 to 85 (Dao et al., 2000).

Ecological and socioeconomic factors influence the species diversity of traditional homegardens, including the utilization of the products of homegardens (Gajaseni and Gajaseni, 1999; Trinh et al., 2003; Kehlenbeck and Maas, 2004; Coomes and Ban, 2004; Wezel and Ohl, 2005). They include geographic location, climate, water availability, garden size and history, agricultural policy, market needs, food culture and household preferences. Species diversity is higher in tropical and humid regions than in temperate and arid areas (Niñez, 1987; Blanckaert et al., 2004). Annual plants are proportionally more important in temperate areas than in the tropics (Niñez, 1987; Zaldivar et al., 2002).

Species in traditional homegardens are used for many purposes. Blanckaert et al. (2004) found at a village in an arid part of Mexico that the plants cultivated in traditional homegardens are used for three main purposes: ornamental (65.7%), edible (29.6%) and medicinal (8.6%). In northeastern Brazil, species in homegardens can be classified as medicinal (26%), food (26%), timber (16%), ornamental (12%), shade (8%), forage (3%), poisonous (3.75%), soap substitutes (1%) and magical (1%) (Albuquerque et al., 2005). In Xishuangbanna, China, Cui et al. (2000) reported that species of plants in traditional homegardens provided the following types of products: medicines (23% of species), vegetables (21%), fruits (19%), ornamentals (9%), and spices (7%). In the Eastern Ghats of Orissa, India, provision of vegetables and spices is the main purpose for growing plants in traditional homegardens (Dash and Misra, 2001). In Costa Rica, food plants are the dominant species planted in homegardens, and the mean species number of edible plants per homegarden has been measured to be between 3.80 to 8.63 in Costa Rica (Zaldivar et al., 2002).

Blanckaert et al. (2004) classified plants in homegardens into three types according to the intensity of their management (Table 4). All three categories can have high value, including spared (or wild) plants. High and Shackleton (2000) reported that the average total value of plants in homegardens of a South African rural village was about US\$667 per hectare per year, with the wild plants accounting for 31%. Traditional homegardens conserve not only genetic diversity of crops and economic plants, but some wild plant resources as well (High and Shackleton, 2000; Angel-Pérez and Mendoza, 2004).

Table 4 Plant types in homegardens based on plant management

plant types	management practices
cultivated	under intensive management
protected or encouraged	spontaneously growing or transplanted from elsewhere, the owner taking measures to protect or encourage them
spared	spontaneously growing, left unweeded

3.3 Management

There is certainly a close relationship between the management and functions of traditional homegardens (Schroth et al., 2004), but actually there have been very few studies specifically on management. Typically, homegardens are associated with abundant knowledge on how to manage plants and their sustainable use, as, for example, in the case of the Maya who are very knowledgeable about the propagation of many plants (Lamont et al., 1999). Traditional management of homegardens is characterized by low input and simple technology (Niñez, 1987), with, in many cases, human labor being the only input (Dash and Misra, 2001). However, many traditional management practices are fading as traditional lifestyles disappear (Gillespie et al., 2004). Different genders often play different roles in the management of homegardens. For example, women and children are the main labor forces in traditional homegarden management in Bangladesh (Ali, 2005), but in Yemen, children work less in homegardens (Ceccolini, 2002). In the Wola communities of Papua New Guinea highlands, *Eleocharis cf dubia* and *Ipomoea batatas* are cultivated only by women and *Musa* and *Saccharum officinarum* only by men (Sillitoe, 2003).

3.4 Changes in traditional homegardens with modernity

Presently, many traditional homegardens show a trend of shift from subsistence-oriented agriculture to market economy (Peyre et al., 2006). This shift is likely to threaten the characteristics of traditional homegardens, such as biodiversity, a multi-purpose nature, and ecological and socioeconomic sustainability (Peyre et al., 2006).

In some parts of the world, the species richness in traditional homegardens will change along with the vanishing of other traditional agroecosystems. For example, the Hani people in south Yunnan, China, introduced lots of wild plants (including rare and high demand species) from swidden fallows and fallow forests. These plants not only increase the species richness and initial plant domestication, but contribute greatly to households' economic income as well (Fu et al., 2003). The majority of plants in homegardens were calorie-rich and basic subsistence crops during the wars in Vietnam, and species of economic crops increased along with the new policy in land tenure issued and as markets opened (Trinh et al., 2003). In fact, the species distributed in homegardens are often determined by a combination of environmental, cultural, socio-economic factors and market demands (Fernandes and Nair, 1986; Albuquerque et al., 2005). When these factors change, the species composition in homegardens will also change.

Additionally, traditional management of homegardens is also facing challenges along with physical and socio-economic condition variations. Based on their investigation, Peyre et al. (2006) found that only 50% of

homegardens still remained traditional management practices, while 33% have incorporated modern technology.

The spatial and temporal dynamics of traditional homegardens are affected by many different factors. Actually, the dynamics of homegardens are always a result of the combination of many factors. However, there are very few studies on this issue.

4 Functions of traditional homegardens

Traditional homegardens are multi-purpose agroecosystems (Méndez et al., 2001) having economic, ecological and social functions (Angel-Pérez, Mendoza, 2004). Based on a survey of the literature, Niñez (1987) has summed up their roles in the conservation and development of plant resources as follows: (1) historically, they have served as informal experimental sites for the domestication of plant species; (2) they have been centers for informal mini-experiments for testing new varieties and exotic species before placing them into field cultivation; (3) they have served as field germplasm banks. For ease of understanding, we sum up the functions of traditional homegardens under the following headings.

4.1 Providing daily substance and economic income for the owners

A major role for homegardens is to provide households with food, fruits, vegetables, fodder, fuel, medicines and other materials for domestic use (Gillespie et al., 1993; Kumar and Nair, 2004; Hamilton and Hamilton, 2006). Traditional homegardens provide 40% of the calories, 30% of the protein and 65% of the fuel to households in some parts of Indonesia (Wilson, 2003). Homegardens in Vietnam supply more than 50% of vegetables, fruits, and herbs (Trinh et al., 2003). Although the proportions of species used for different purposes vary, in general, traditional homegardens contribute substantially towards meeting the basic subsistence needs of their owners for products and services such as food (including vegetables and fruits), medicines, forage, shade, and ornamentals (Cui et al., 2000; Blanckaert et al., 2004; Albuquerque et al., 2005). Obviously, their contributions to daily substance are different among homegardens located in different sites and held by different owners.

Providing cash income is another important role of traditional homegardens (Niñez, 1987). Many ethnobotanical studies have focused on the actual or potential contributions of traditional homegardens to the local economy and social development (Kehlenbeck and Maass, 2004). *Dacryodes edulis*, an important economic plant in southeastern Nigeria, is commonly cultivated by local farmers, with 51.4% of the production coming from trees planted in homegardens (Aiyelaagbe et al., 1998). Questions have been raised about whether increasing the

contribution of traditional homegardens to the cash economy will influence the nutritional status of the household. An answer has been provided, at least for people in lowland Papua New Guinea, where a quantitative study has shown no decline in nutritional status (Shack et al., 1990).

4.2 Ecological functions

Traditional homegardens have been shown to be ecologically sustainable (Torquebiau, 1992; Jose and Shanmugaratnam, 1993; Kehlenbeck and Maass, 2004). Their benefits include maintenance of soil fertility and soil structure and maintaining nutrient cycling (Schroth et al., 2001). The complex vertical structures and high floristic diversity of tropical homegardens ensures an efficient use of sunlight, water, and nutrients. Even in tropical areas of low rainfall, shallow soils and low agricultural potential, homegardens have been shown to be agriculturally productive (Benjamin et al., 2001).

Traditional homegardens contribute greatly to agrobiodiversity conservation (Trinh et al., 2003), including helping to maintain or increase both the phenotypic and genotypic diversities of cultivated plants (Casas et al., 2005; Carmona and Casas, 2005). They can also play an important role in the conservation of indigenous and endemic plants, since such plants can be major components of homegardens in some cases (Albuquerque et al., 2005; Hemp, 2005).

4.3 Contributing to cultural use

Some traditional homegardens play a vital role in cultural festivals or religious activities. They provide their owners with culturally important materials, and can serve as sites for festivals and religious rituals. Some plants found in homegardens have no other value apart from a cultural one (Huai et al., 1998). In some cases, every component of the homegarden has special cultural meaning and value (Trinh et al., 2003). For example, in Vietnam, *Musa* spp., *Citrofortunella microcarpa*, *Citrus* spp., *C. grandis*, *Capsicum* sp., and *Pyrus pyrifolia* (all common in homegardens) serve as symbols of the five elements of Vietnamese Buddhism, and are used in shrines during the Vietnamese New Year festivals (Trinh et al., 2003). Hmong people who have migrated to the USA still cultivate certain plants in their gardens because of their cultural importance in their homelands (Corlett et al., 2003).

4.4 Domestication sites of wild plants

Historically, traditional homegardens have served as major centers for the domestication of wild plants (Niñez, 1987; Blanckaert et al., 2004; Das and Das, 2005), a function which persists even to this day. For instance, many fruit trees and shrubs, such as *Diospyros lotus*, *Ficus carica*,

Malus orientalis, and *Prunus cerasifera*, are still collected from the wild in northern Iran for cultivation in homegardens (Khoshbakht and Hammer, 2005). Homegardens have played a very important role in the domestication of *Dacryodes edulis*, a traditional fruit tree with many usages in West and Central Africa (Anegbeh et al., 2005).

Although traditional homegardens are today being affected by many factors, some of their basic functions remain unchanged, as has been demonstrated, for example, in Vietnam (Trinh et al., 2003). The basic function of a traditional homegarden anywhere in the world is still to provide the subsistence needs of households, even as the modern world changes so fast socially and physically.

5 Discussion and suggestions

Although many studies have been conducted on traditional homegardens, there are still few comparing their economic, ecological, and socio-cultural significance (Nair, 2001). It is expected that ethnobotanists will play an important role in future endeavors. More research should be undertaken on traditional management practices and also on the ways in which homegardens are changing in the modern world, which is changing socially and economically. More attention should be paid to the spatial (compared with the temporal) dynamics of homegardens.

There are many homegardens distributed in temperate regions, but we have little knowledge about them. They have been almost neglected completely by the scientific world, at least in China. Homegardens in temperate areas have their special species composition and management practices. Research into their characteristics will be useful for guiding local resource use and biodiversity conservation, and the genetic diversity that they contain could benefit crop breeding.

Traditional ecological knowledge and traditional resource management have played a crucial role historically in resource sustainability and management (Ticktin and Johns, 2002; Los et al., 2003; Drew, 2005; Miller and Nair, 2005). Along with changes in traditional lifestyles and environments, traditional knowledge on homegardens is fading (Gillespie et al., 2004). So it is necessary and urgent to conduct ethnobotanical studies on traditional management practices in homegardens, to document traditional knowledge of homegarden management, and to explore their scientific meanings.

Acknowledgement This research was supported by the National Natural Science Foundation of China (Grant No. 30770220).

References

- Aiyelaagbe I O O, Adeola A O, Popoola L, Obisesan K O (1998). Agroforestry potential of *Dacryodes edulis* in the oil palm-cassava

- belt of southeastern Nigeria. *Agroforestry Systems*, 40: 263–274
- Albuquerque U P, Andrade L H C, Caballero J (2005). Structure and floristics of homegardens in Northeastern Brazil. *Journal of Arid Environments*, 62: 491–506
- Ali A M S (2005). Homegardens in smallholder farming systems: examples from Bangladesh. *Human Ecology*, 33(2): 245–270
- Anebe P O, Ukafor V, Usoro C, Tchoundjeu Z, Leakey R R B, Schreckenber K (2005). Domestication of *Dacryodes edulis*: 1. Phenotypic variation of fruit traits from 100 trees in southeast Nigeria. *New Forests*, 29: 149–160
- Angel-Pérez A L D, Mendoza M A (2004). Totonac homegardens and natural resources in Veracruz, Mexico. *Agriculture and Human Values*, 21: 329–346
- Arora R K (1997). Ethnobotany and its role in the conservation and use of plant genetic resources in India. *Ethnobotany*, 9: 6–15
- Benjamin T J, Montañez P L, Jiménez J J M, Gillespie A R (2001). Carbon, water and nutrient flux in Maya homegardens in the Yucatan peninsula of México. *Agroforestry Systems*, 53: 103–111
- Blanckaert I, Swennen R L, Flores P M, Lopez R I, Saade R L (2004). Floristic composition, plant uses and management practices in homegardens of San Rafael Coxcatlan, valley of Tehuacan-Cuicatlan, Mexico. *Journal of Arid Environments*, 57: 39–62
- Browning J A (1991). Conserving crop plant-pathogen coevolutionary processes in situ. In: Oldfield M L, Alcorn J B, eds. *Biodiversity Culture, Conservation and Ecocodevelopment*. Boulder, CO: Westview Press, 59–85
- Carmona A, Casas A (2005). Management, phenotypic patterns and domestication of *Polaskia chichipe* (Cactaceae) in the Tehuacán Valley, Central Mexico. *Journal of Arid Environments*, 60: 115–132
- Casas A, Cruse-Sanders J, Morales E, Otero-Araiz A, Valiente-Banuet A (2005). Maintenance of phenotypic and genotypic diversity in managed populations of *Stenocereus stellatus* (Cactaceae) by indigenous peoples in Central Mexico. *Biodiversity and Conservation*, DOI 10.1007/s10531-004-2934-7
- Ceccolini L (2002). The homegardens of Soqotra island, Yemen: an example of agroforestry approach to multiple land-use in an isolated location. *Agroforestry Systems*, 56: 107–115
- Coomes O T, Ban N (2004). Cultivated plant species diversity in home gardens of an Amazonian peasant village in Northeastern Peru. *Economic Botany*, 58: 420–434
- Corlett J L, Dean E N, Grvetti L E (2003). Hmong gardens: botanical diversity in an urban setting. *Economic Botany*, 57: 365–379
- Cui J Y, Fu Y N, Guo H J, Chen A G (2000). Study on household-based agrobiodiversity assessment (HHABA) of homegarden in Daka, Xishuangbanna, Yunnan. *Acta Botanica Yunnanica*, Supp. XII: 81–90 (in Chinese)
- Dao Z L, Chen W S, Guo H J, Duan H L, Duan J G (2000). Household-based agrobiodiversity assessment (HH-ABA) of house garden in Hanlong village of Baosha, east slope of Gaoligong Mountains. *Acta Botanica Yunnanica*, (Suppl. XII): 102–112 (in Chinese)
- Das T, Das A K (2005). Inventorying plants biodiversity in homegardens: a case study in Barak valley, Assam, Northeast India. *Current Science*, 89(1): 155–163
- Dash S S, Misra M K (2001). Studies on 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, Negrreos-Castillo P (2000). Plant species of traditional Mayan homegardens of Mexico as analogs for multistrata agroforests. *Agroforestry Systems*, 48: 303–317
- Drew J A (2005). Use of traditional ecological knowledge in marine conservation. *Conservation Biology*, DOI: 10.1111/j.1523-1739.2005.00158.x
- Elias M, Mühlen G S, McKey D, Roa A C, Tohme J (2004). Genetic diversity of traditional South American landraces of cassava (*Manihot esculenta* Crantz): An analysis using microsatellites. *Economic Botany*, 58: 242–256
- Fernandes E C M, Nair P K R (1986). An evaluation of the structure and function of tropical homegardens. *Agroforestry Systems*, 21: 279–310
- Fu Y, Guo H, Chen A, Cui J, Padoch C (2003). Relocating plants from swidden fallows to gardens in Southwestern China. *Economic Botany*, 57: 389–402
- Gajasen J, Gajasen N (1999). Ecological rationalities of the traditional homegarden system in the Chao Phraya Basin, Thailand. *Agroforestry Systems*, 46: 3–23
- Gillespie A R, Bocanegra-Ferguson D M, Jimenez-Osornio J J (2004). The propagation of Ramon (*Brosimum alicastrum* Sw.; Moraceae) in Mayan homegardens of the Yucatan peninsula of Mexico. *New Forests*, 27: 25–38
- Gillespie A R, Knudson D M, Geilfus F (1993). The structure of four home gardens in the Petén, Guatemala. *Agroforestry Systems*, 24(2): 157–170
- Gobin A, Campling P, Deckers J, Feyen J (2001). Integrated land resources analysis with an application to Ikem (south-eastern Nigeria). *Landscape and Urban Planning*, 53: 95–109
- Hamilton A, Hamilton P (2006). *Plant conservation: an ecosystem approach*. London: Earthscan
- Hemp C (2005). The Chagga home gardens – relict areas for endemic *Saltatoria* species (Insecta: Orthoptera) on Mount Kilimanjaro. *Biological Conservation*, 125: 203–209
- High C, Shackleton C M (2000). The comparative value of wild and domestic plants in home gardens of a South African rural village. *Agroforestry Systems*, 48: 141–156
- Huai H, Pei S, Xu J (1998). Indigenous knowledge on “Banlangen” (*Baphicacanthus cusia*: Acanthaceae) of the Hani people. *Ethnobotany*, 10: 127–129
- Jose D, Shanmugaratnam N (1993). Traditional homegardens of Kerala: a sustainable human ecosystem. *Agroforestry Systems*, 24: 203–213
- Kehlenbeck K, Mass B L (2004). Crop diversity and classification of homegardens in Central Sulawesi, Indonesia. *Agroforestry Systems*, 63: 53–62
- Khoshbakht K, Hammer K (2005). Savadkouh (Iran) – an evolutionary centre for fruit trees and shrubs. *Genetic Resources and Crop Evolution*, DOI 10.1007/s10722-005-7467-8
- Kumar B M, Nair P K R (2004). The enigma of tropical homegardens. *Agroforestry Systems*, 61: 135–152
- Lamont S R, Esbaugh W H, Greenberg A M (1999). Species composition, diversity, and use of homegardens among three Amazonian villages. *Economic Botany*, 1999, 53: 312–326
- Le H T, Hancock J F, Ton-That T, Ho P H (1999). Germplasm resources in Vietnam: major horticultural and industrial crops. *HortScience*, 34: 175–180

- Levasseur V, Olivier A (2000). The farming system and traditional agroforestry systems in the Maya community of San Jose, Belize. *Agroforestry Systems*, 49: 275–288
- Los M D, Torre-Cuadros A L, Islebe G A (2003). Traditional ecological knowledge and use of vegetation in southeastern Mexico: a case study from Solferino, Quintana Roo. *Biodiversity and Conservation*, 12: 2455–2476
- Major J, Clement C R, DiTommaso A (2005). Influence of market orientation on food plant diversity of farms located on Amazonian dark earth in the region of Manaus, Amazonas, Brazil. *Economic Botany*, 59: 77–86
- Méndez V E, Lok R, Somarriba E (2001). Interdisciplinary analysis of homegardens in Nicaragua: micro-zonation, plant use and socio-economic importance. *Agroforestry Systems*, 51: 85–96
- Miller R P, Nair P K R (2005). Indigenous agroforestry systems in Amazonia: from prehistory to today. *Agroforestry Systems*, DOI 10.1007/s10457-005-6074-1
- Nair P K R (2001). Do tropical homegardens elude science, or is it the other way around? *Agroforestry Systems*, 53: 239–245
- Niñez V (1987). Household gardens: Theoretical and policy considerations. *Agricultural Systems*, 23:167–186
- Padoch C, De Jong W (1991). The house gardens of Santa Rosa: diversity and variability in an Amazonian agricultural system. *Economic Botany*, 45: 166–175
- Peyre A, Guidal A, Wiersum K F, Bongers F (2006). Dynamics of homegarden structure and function in Kerala, India. *Agroforestry Systems*, 66: 101–115
- Plucknett D L, Smith N J H, Williams J T, Anishetty N M (1983). Crop germplasm conservation and developing countries. *Science*, 1983, 220: 163–169
- Primack R, Ji W Z (2000). *A Primer of Conservation Biology*. Beijing: China Forestry Publishing House
- Rhoades R E (1991). World's food supply at risk. *National Geographic*, 179 (4): 74–105
- Rico G V, Garcia-Franco J G, Chemas A, Puch A, Sima P (1990). Species composition, similarity and structure of Mayan homegardens in Tixpeual and Tixcanltuyub, Yucatan, Mexico. *Economic Botany*, 44: 470–487
- Schroth G, da Mota M S S, Lopes R, de Freitas A F (2004). Extractive use, management and in situ domestication of a weedy plant, *Astrocaryum tucuma*, in the central Amazon. *Forest Ecology and Management*, 202: 161–179.
- Schroth G, Lehmann J, Rodrigues M R L, Barros E, Macêdo J L V (2001). Plant-soil interactions in multistrata agroforestry in the humid tropics. *Agroforestry Systems*, 53: 85–102
- Shack K W, Grivetti L E, Dewey K G (1990). Cash cropping, subsistence agriculture, and nutritional status among mothers and children in lowland Papua New Guinea. *Social Science & Medicine*, 31(1): 61–68
- Sillitoe P (2003). The gender of crops in the Papua New Guinea highlands. In: Howard P L, ed. *Women and plants*. London, UK: Zed Books, 165–180
- Soini E (2005). Changing livelihoods on the slopes of Mt. Kilimanjaro, Tanzania: Challenges and opportunities in the Chagga homegarden system. *Agroforestry Systems*, 64: 157–167
- Ticktin T, Johns T (2002). Chinanteco management of *Aechmea magdalenae*: Implications for the use of TEK and TRM in management plans. *Economic Botany*, 56: 177–191
- Torquebiau E (1992). Are tropical agroforestry homegardens sustainable? *Agriculture, Ecosystems and Environment*, 41: 189–207
- Trinh L N, Watson J W, Hue N N, De N N, Minh N V, Chu P, Sthapit B R, Eyzaguirre P B (2003). Agrobiodiversity conservation and development in Vietnamese home gardens. *Agriculture, Ecosystems and Environment*, 97: 317–344
- Wezel A, Bneder S (2002). Plant species diversity of homegardens of Cuba and its significance for household food supply. *Agroforestry Systems*, 57: 37–47
- Wezel W, Ohl J (2005). Does remoteness from urban centers influence plant diversity in homegardens and swidden fields? : A case study from the Matsigenka in the Amazonian rain forest of Peru. *Agroforestry Systems*, 65: 241–251
- Wiersum K F (1982). Tree gardening and Taungya on Java: examples of agroforestry techniques in the humid tropics. *Agroforestry Systems*, 1: 53–70
- Wilson M (2003). Exchange, patriarchy and status: women's homegardens in Bangladesh. In: Howard P L, ed. *Women and plants*. London, UK: Zed Books, 211–225.
- Zaldivar M E, Rocha O J, Castro E, Barrantes R (2002). Species diversity of edible plants grown in homegardens of Chibchan Amerindians from Costa Rica. *Human Ecology*, 30(3): 301–316