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Full Length Research Paper

Ecological Assessment of Home Garden Flora and Canopy Structure in São Luís, Maranhão, Brazil

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Tropical home-gardens are widely recognized as a repository of biodiversity of domesticated and wild plant, and animal species that need to be developed to meet livelihood needs and for purpose of their conservation. Despite being the oldest form of agroforestry, this system is still poorly studied and understood. This study investigates the pattern of indigenous and exotic flora in the home-gardens managed by urban dwellers in São Luis city, Maranhão, Brazil. Forty home-gardens were randomly selected from ten locations and studied for their species richness and diversity, floristic distribution and canopy structure. The species were categorized as exotic and indigenous to Brazil. The home-gardens were species-rich, with 186 plant species in total. Of the species recorded, 62% produced edible fruit and nut trees, 17% were food crops, 7.5% were condiments, 7.5% were of medicinal value and 6.4% were timber species. Nearly 60% of all species were indigenous. Differences in species composition determined differences in vertical canopy structure. The floristic composition and high abundance of indigenous and exotic species managed or retained in the home-gardens demonstrates high degree of biodiversity conserved by urban dwellers in São Luís.

Key words: Homegardens, canopy structure, floristic composition, São Luis.

INTRODUCTION

Home-gardens are the oldest forms of managed land use systems, now called agroforestry, and are considered to be the epitome of sustainability (Kang and Akinnifesi, 2000; Kumar and Nair, 2004). In Brazil, home-gardens are traditionally known as “Quintais”, “Pomares domestics” or “Quintal agroforestal”, and constitute an important niche for indigenous fruit trees. Historically, indigenous fruit trees were the earliest source of food known to mankind and their harvesting predated hunting and settled agriculture, with strong links with culture and religion (Akinnifesi et al., 2006, 2008 a). They now represent unique assets that could be developed, domes-ticated and owned by farmers. Brazilian home-gardens are known to be floristically variable and biodiverse
(Akinnifesi et al., 2009; Albuquerque et al., 2005), and thus are considered a model of sustainable resource management where human and nature meets (Akinnifesi et al., 2009).

Although, urbanization is generally believed to displace indigenous species diversity by replacing them with exotics leading to the loss of native biodiversity (McKinney, 2002; Thompson et al., 2003; von der Lippe and Kowarik, 2008), but the urban home-gardens of São Luis Island, Brazil provides a uniquely greater richness of native species (Akinnifesi et al., 2009). The home-gardens in urban centers is mainly for meeting various subsistence and livelihood needs of the household, such as food, spices, wood, ornamental and medicine. They also help to maintain greenness and biodiversity in the urban areas, thereby providing important ecosystem services such as shade, pollination, wind-breaks and aesthetic and other values to the urban dwellers (Niemelä, 1999; WinklerPrins and de Souza, 2005). The
home-gardens also provide important habitat for managing and conserving biodiversity (Akinnifessi et

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al., 2009).

Despite their importance to livelihoods of urban dwellers and the enormous biodiversity they contain, home-gardens in cities have not been systematically studied in Brazil (Albuquerque et al., 2005). Such a study would yield important information necessary for understanding the potential for domestication, improved utilization and conservation of the biodiversity in homegardens. Akinnifesi et al. (2009) showed models describing the diversity of wild, semi-wild and cultivated plant and animal species at family scale in the home-gardens of São Luis. They concluded that there is high abundance and mix of indigenous and exotic plant and animal species, and confirmed that city dwellers in São Luís value biodiversity as an important component of their livelihoods. The present paper follows on from this work to document the floristic composition and vertical structure of the homegardens, with a list of species and their categories of use. Knowledge of the floristic composition and structure of home-gardens is critical to understanding the dynamics of urban flora and fauna, and prescribe management practices.

The objective of this paper is to describe the floristic composition and vertical canopy distribution, and growth status of both native and exotic species in the home-gardens São Luís, Brazil. Akinnifesi et al. (2009) reported on the biodiversity distribution of plant and animals in the homegardens. Its main objective was to test whether urbanization displaces native biodiversity of plants and animals housed in the homegardens, using series of ecological models including patterns of their rank abundance and diversity indices.

The study rejected the hypothesis that urbanization generally displaces native species. The current paper builds on this effort by focusing on the detailed plant flora distribution in terms of floristic composition, vertical canopy structure and growth stages. The study is hoped to provide insight that is crucial not only for understanding the role of the home-gardens as repository of biodiversity but also helpful in formulating appropriate strategies for their conservation, management and improvement in the urban setting.

MATERIALS AND METHODS

Study site, data collection and analysis

The study was undertaken in the city of São Luís (2.51° S, 44.29° W), Maranhão, North-East Brazil. Within the pool of available residences in São Luís, 40 domestic gardens that satisfied a set of criteria were randomly selected from ten areas in the urban and suburban areas of São Luís city. For the purpose of this study, a homegarden was defined as a multi-strata combination of various trees and crops, sometimes in association with animals, around homesteads (Kumar and Nair, 2004). The criteria for selection of home-gardens were as follows: 1) The homegarden must have been more than 20 years old, and is managed as a dwelling. In that case, managed fruit tree orchards and communal lands were not selected. 2) Each homegarden must be at least 50 m apart and sites at least 2 km apart; 3) A multiple access to the homegarden was granted. Home-gardens that were locked or restricted access to information gathering were eliminated in the selection. 4) Open agroforerests where there was no demarcation between homegarden and forests where not selected. The study sites were Panaquatira, Sao Jose de Ribamar, Santa Barbara, Forquilla, Turu, Ipem São Cristovão, Olho D'agua, Cohafuma, Juçatuba and Monte Castelo, which are suburbs of the city. Four ‘quintais’ (hereafter referred to as homegardens) were randomly sampled in each study site, ensuring a minimum distance of 50 m between homegardens. The study sites ranged from 5 to 30 km apart. The map of the study sites is shown in Figure 1.

The homegarden was surveyed intensively using a checklist and semi-structured questionnaires. In each sample area, the type of dwelling and location were noted. Linear dimensions of the residence, area occupied by the house, and the various microhabitats (vegetable garden, tree orchard, play ground) were recorded. A list of all vascular plant taxa, and animals present in the garden was recorded in a checklist. The number of each individual species is recorded according to their user categories.

The frequency of occurrence of each species was calculated as the percentage of home-gardens where a species was present. Mean abundance of each species was also calculated as the average of the counts across homegardens. Plant species present were categorized according to their use as crops, fruit trees, timber and shade trees, medicinal plants, aromatic and ornamental plants. The home-gardens owner usually provides information on the use of the species, and those not known are further identified by ethno-botanists in the team. The flora of Brazil and Maranhão were also consulted. The species were also differentiated into exotic and native species.

The height and basal diameter of all mature trees found in each homegarden were also measured. Mature trees referred to those that have reached reproductive stage of growth. Tree heights were measured using measuring poles, while basal diameter was measured using girth diameter tapes. Trees were categorized into five height classes: emergent canopy (>15 m), dominant (11 - 15 m), co-dominant (5 - 10 m), under-storey (2 - 4 m) and sapling/seedling (<2 m). Woody tree species were further grouped into age classes (old, mature, juvenile, sapling and seedling) based on visual assessment of their silvicultural growth stages for each species (Nyland, 1996). Those grouped as old were those that appeared to have reached the stage of senescence due to age and are no longer actively growing or reproducing. The matured trees were those that have reached reproductive stage or physiologically matured stage and have stabilized in their growth. The juvenile were trees that were still actively growing and have not reached reproductive stage. The saplings were plants that have just passed seedling stage and actively growing. Seedlings were those planted recently and establishing in the gardens. We have combined data from juvenile, saplings and seedlings categories together in this paper.

The occurrence of species was calculated as the percentage of home-gardens where a species is present. Mean abundance of a species was calculated as the average of the counts per home garden.

The species were also differentiated into exotic (introduced) and native species of Brazil base on their origin. Attempts were made to trace the origin of native species and their association with the major biomes of Brazil (Amazon, Cerrado, Caatinga, Atlantic rainforest, Pantanal and the subtropical forest) based on published literature on flora of Brazil (Castro et al., 1999; Oliveira-Filho and Fontes, 2000; Silva and Tassara, 2005). Plant species present were categorized according to their use as crop plants, fruit, timber and shade trees, medicinal, aromatic, ornamental plants etc, also based on literature and information from home-garden dwellers.

RESULTS

Edible fruit-and-nut bearing trees

A total of the 186 plant species were recorded in the homegardens, of which 61.8% were fruit tree species, 16.7% were edible crops including vegetables, cereals, legumes and condiments, 7.5% were medicinal plants, 6.4% were timber trees and the remaining 7.7% were plants of miscellaneous use (Figure 2). A total of 63 species of fruit tree were recorded and were found in home-gardens (Table 1). Nearly 60 of all species found were native to Brazil. The native species were significantly more than exotics for fruit trees, medicinal and timber species. In terms of frequency of occurrence, fruit tree species were the most common (Table 2). Native fruit tree species originating from the various biomes of Brazil were found in the homegardens. A few exotic species were also frequently observed (>70% of the homes).

Native species that frequently occurred were 90% of the home-gardens for cashew (*Anacardium occidentale*), 73% for guava (*Psidium guajava*). The species that occurred in 25 - 52% of the homes were all native except papaya (*Carica papaya*) (Table 1). Only 13 species occurred in 10 - 17% of the homegardens, and the remaining 23 of the fruit bearing species occurred in less than 2.5 - 7.5% of the gardens (Table 1). A number of native fruit tree species occurred in nearly half of the homegardens. Mangoes (*Mangifera indica*), coconut (*Cocos nucifera*), cashew (*A. occidentale*), avocado (*Persea americana*), jack fruit (*Artocarpus integrifolia*), carambola (*Averrhoa carambola*), guava, 'babasu' (*Attalea speciosa*), 'pitomba' (*Talisia esculenta*) and açãi (*Euterpe oleracea*) were the top ten most frequent fruit species. Banana was the most frequent with 139 plants per garden whereas it only occurred in half of the 40 homegardens. Cashew and guava were found in over a third of the home-gardens in this study.

Cultivated food crops

Several cultivated food crops were found in the homegardens, including vegetables, condiments, leguminous and cereal food crops (Table 2). The food crops were generally grown as a monoculture or intercropped in the open cultivated fields (roças) and separated from tree canopies in most cases. In the majority (71%) of homegardens, exotic food crops were predominantly planted and managed. The five most frequent species occurred in the homegardens, and these were mainly condiments: 30% for *Coriandrum sativum*, 27.5% for *Capsicum annuum*, 22.5% for *Allium schoenoprasum*, 20% for both *Capsicum frutescens* and *M. esculenta* (Table 2). Most vegetables, root crops and cereals occurred in 10 - 17.5% of the homegardens, including 17.5% for *Abelmoscus esculenta, Cucumis anguria, Cucumis sativus, Lactuca sativa*, and *Lycopersicon esculentum*; also 15% for *Citrullus vulgaris*. Both *Brassica oleracea* and *Ipomoea batatas* occurred in 12.5% of the homegardens; *Cucurbita pepo*, *Manihot utilissima* and *Zea mays* were cultivated in 10% of the home-gardens (Table 2). In total, 16 species occurred in less than 10% of the gardens. *Z. mays* was the most abundant in terms of number of plants.

Medicinal species

A number of indigenous medicinal plants including trees, shrubs and herbs were recorded in the domestic gardens (Table 3). Over 59% of these species were native to Brazil. None of the medicinal species was found in more than 15% of the home-gardens (Table 3). These were found in 17.5% of home-gardens for *Bixa orellana*, 15% for *Coleus barbatus* and *Cymbopogon citrates*, 12.5% for *Andropogon nardus*, *Jatropha gossypiifolia*, *Virola sebifera* and *Cecropia sciadophylla*. Whereas, *Chenopodium ambrosioides* and *Lippia alba* were 10%. The remaining twelve medicinal plant species occurred in less than 5% of the homegardens.

Timber species

The most frequent timber species included *Tabebuia chrysotricha, Eucalyptus sp., Caesalpinia echinata, Mimosa caesalpiniifolia, Simarouba amara, Tabebuia impetiginosa, Nectandra nitidula, Cedrela odorata*, *Myracrodruon urundeuva, Swietenia macrophylla* and*Tabebuia sp.* These occurred in 10 - 17% of the home-gardens (Table 4). Except for Eucalyptus sp., all the other timber tree species were native to Brazil.

Ornamental species

Ornamental species occurred in less than 20% of the domestic gardens. Most (55%) of these species were exotic (Table 5). The most commonly species were found in 20% of the home-gardens for *Roystonea oleracea*, 17.5% *Rhamnidium elaeocarpus*, 10% for *Delonix regia* and *Senna siamea*. The rest of the species occurred in less than 10% of the homegardens.

Canopy structure

Over 10 tree species constituted the emergent canopy (>14 m height) (Table 6). In the canopy, *C. nucifera, A. integrifolia, Cecropia sp., Attalea speciosa, T. esculenta, R. oleracea, Caryocar brasiliensis, Platonia insignis, Eugenia jambos* and *Theobroma cacao* dominated. *C. nucifera* (coconut) and *M. indica* (mangoes) also occurred in the dominant and co-dominant canopies

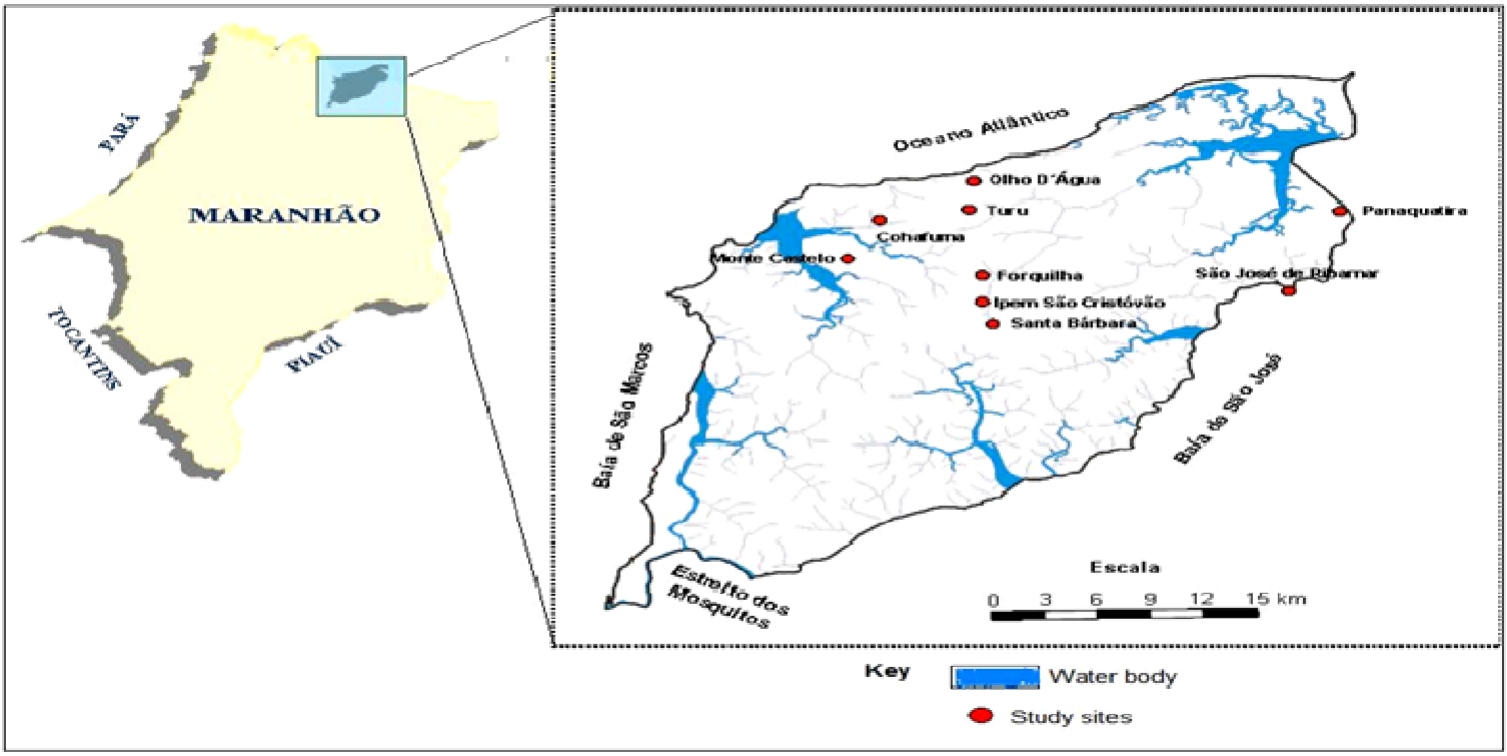

Figure 1. Map of the Island of Sao Luis indicating the selected sites (Akinnifesi et al., 2009).

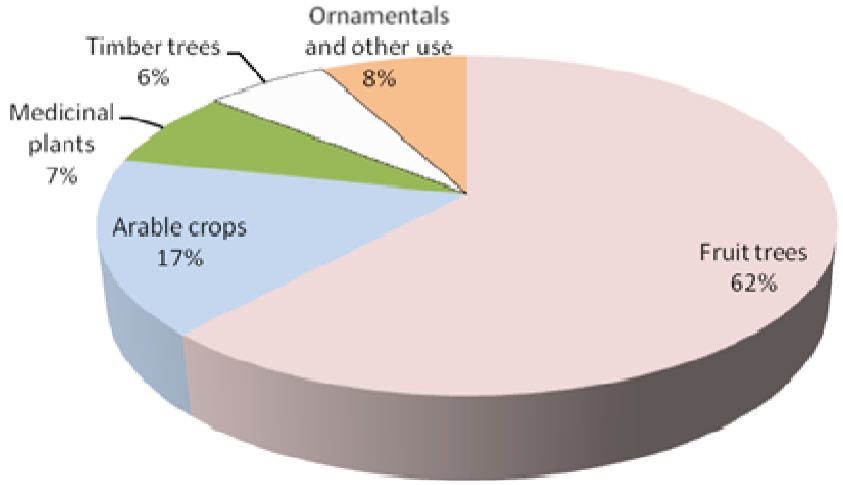

Figure 2. Percentage distribution of plant taxa and use categories in Sao Luis homegardens, Brazil.

(Table 1). Approximately 29% of the *C. nucifera* occupied the emergent canopy class, and 24% of mangoes (M. indica) occupies the dominant class.

Ten species occurred in the emergent canopy class (>15 m), including 29.2% for *C. nucifera*, 12.5% for both *A. integrifolia* and *C. sciadophylla*. Also, three species represented 8.3% of the species found at the emergent canopy class, including *A. speciosa, T. esculenta* and *R. oleracea*. Four species represented 4.2% of the emergent canopy class including *P. insignis, E. jambos* and *T. cacao* (Table 6). Similarly, the dominant canopy (10 - 15 m) was mainly dominated by *M. indica* representing 23% of all species found there. The frequency of all the remaining 34 species found in the

Table 1. Fruit and nut bearing species, their local name, family, origin, frequency of occurrence (FO%) and abundance (AB), that is mean number of individuals per garden averaged over 40 homegardens.

Scientific name	Local name	Family	Origin	FO (%)	AB
Mangifera indica L.	Mangueira	Anacardiaceae	Exotic	95.0	6.6
Cocos nucifera L.	Coqueiro da Praia	Arecaceae	Exotic	92.5	6.5
Anacardium occidentale L.	Cajui	Anacardiaceae	Native	90.0	4.4
Persea americana Mill.	Abacate	Lauraceae	Exotic	87.5	2.8
Artocarpus integrifolia L	Jaca	Moraceae	Exotic	72.5	3.7
Averrhoa carambola L.	Carambola	Oxalidaceae	Exotic	72.5	2.6
Psidium guajava L.	Goiabeira	Myrtaceae	Native	72.5	4.7
Attalea speciosa Mart.	Babaçu	Arecaceae	Native	52.5	4.5
Talisia esculenta (Hill) Radlk	Pitomba	Sapindaceae	Native	42.5	1.7
Euterpe oleracea Mart.	Açaí	Arecaceae	Native	40.0	15.3
Carica papaya L.	Mamao	Caricaceae	Exotic	37.5	8.3
Byrsonima crassifolia (L.) Rich	Murici	Malphigiaceae	Native	37.5	2.8
Platonia insignis Mart	Bacuri	Clusiaceae	Native	37.5	5.7
Spondias dulcis Parkinson	Cajá do Pará	Anacardiaceae	Native	35.0	3.1
Annona squamosa L.	Ata	Annonaceae	Native	32.5	2.9
Manilkara zapota (L.) Royen	Sapoti	Sapotaceae	Native	32.5	2.3
Annona muricata L.	Graviola	Annonaceae	Native	30.0	2.5
Theobroma grandiflorum Schum	Cupuaçu	Sterculiaceae	Native	30.0	6.3
Genipa americana L.	Jenipapo	Rubiaceae	Native	27.5	2.1
Caryocar villosum (Aubl.) Pers	Pequi	Caryocaceae	Native	25.0	2.3
Theobroma cacao L.	Cacau	Sterculiaceae	Native	25.0	2.7
Tamarindus indica L.	Tamarindo	Caesalpinaceae	Exotic	22.5	3.4
Mammea americana (L.) Jacq.	Abricó	Clusiaceae	Exotic	20.0	1.5
Eugenia uniflora L	Pitanga	Myrtaceae	Native	20.0	2.5
Musa paradisiaca L.	Banana	Musaceae	Exotic	20.0	138.7
Inga edulis Mart	Ingá cipó	Mimosaceae	Native	17.5	2.1
Spondias lutea L.	Cajazeira	Anacardiaceae	Native	17.5	1.7
Amygdalus communis L.	Amendoeira	Rosaceae	Exotic	15.0	2.5
Ananas comosus (L.) Merrill.	Abacaxi	Bromeliaceae	Native	15.0	19.3
Pouteria caimito (Ruz and Pav.)	Abiu	Sapotaceae	Native	12.5	1.6
Myrciaria cauliflora (Mart.)	Jaboticaba	Myrtaceae	Native	12.5	6.4
Annona marcgravii Mart.	Araticum	Annonaceae	Exotic	10.0	2.5
Caryocar brasiliensis Cambess	Pequi	Caryocaceae	Native	10.0	1.3
Bactris gasipaes Kunth	Pupunha	Arecaceae	Native	10.0	8.5
Artocarpus heterophyllus	Fruta-pão	Moraceae	Exotic	10.0	3.7
Astrocaryum aculeatissimum (Schott)	Tucum	Arecaceae	Native	10.0	2.3
Spondias purpurea L.	Siriguela	Anacardiaceae	Native	7.5	1.7
Spondias tuberosa Aruda	Umbu	Anacardiaceae	Native	7.5	1.0
Garcinia mangostana L.	Mangustao	Clusiaceae	Exotic	5.0	1.0
Lichi chinensis Sonn	Lichia	Sapindaceae	Exotic	5.0	1.5
Manilkara huberu Adans	Macaranduba	Sapotaceae	Native	5.0	2.5
Citrus limon (L.) Burn	Limão	Rutaceae	Exotic	5.0	1.5
Cocos vagans L.	Anini	Arecaceae	Native	5.0	8.0
Diospynos brasiliensis Mart.	Mabolo	Ebenaceae	Native	5.0	1.0
Olea europeae L.	Azeitona preta	Oleandraceae	Exotic	5.0	1.0
Acrocomia aculeata (Jacq.)	Macauba	Arecaceae	Native	2.5	--*
Duguetia lanceolata Hill	Ameju	Annonaceae	Native	2.5	--
Rollinia mucosa (Jacq.) Baill.	Condessa	Annonaceae	Exotic	2.5	--

Table 1. Contd.

Morus alba L.	Amora	Moraceae	Exotic	2.5	--
Anacardium humile Hil.	Caju	Anacardiaceae	Native	2.5	--
Chysobalanus icaco L.	Guajuru rosa	Chrysobalanaceae	Native	2.5	--
Citrus aurantium L.	Laranja Lima	Rutaceae	Exotic	2.5	--
Citrus mobilis L.	Mexerica	Rutaceae	Exotic	2.5	--
Diospynos kaki L	Caejui	Ebenaceae	Exotic	2.5	--
Hymenaea courbaril L.	Jatoba	Caesalpiniaceae	Native	2.5	--
Psidium sp.	Guajuru branco	Myrtaceae	Native	2.5	--
Punica granatum L.	Romã	Rosaceae	Exotic	2.5	--
Lecythis pisonis Cambess	Sapucaia	Lecythydaceae	Native	2.5	--
Ficus sp.	Ficus	Moraceae	Exotic	2.5	--

*Species occurred in only one garden. So Means were not calculated.

Table 2. Food crop species, their local name, family, origin, frequency of occurrence (FO %) and abundance (AB) that is mean number of individuals per garden averaged over 40 homegardens.

Scientific name	Local name	Family	Origin	FO (%)	AB
Mangifera indica L.	Mangueira	Anacardiaceae	Exotic	95.0	6.6
Cocos nucifera L.	Coqueiro da Praia	Arecaceae	Exotic	92.5	6.5
Anacardium occidentale L.	Cajui	Anacardiaceae	Native	90.0	4.4
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Averrhoa carambola L.	Carambola	Oxalidaceae	Exotic	72.5	2.6
Psidium guajava L.	Goiabeira	Myrtaceae	Native	72.5	4.7
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Euterpe oleracea Mart.	Açaí	Arecaceae	Native	40.0	15.3
Carica papaya L.	Mamao	Caricaceae	Exotic	37.5	8.3
Byrsonima crassifolia (L.) Rich	Murici	Malphigiaceae	Native	37.5	2.8
Platonia insignis Mart	Bacuri	Clusiaceae	Native	37.5	5.7
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Eugenia uniflora L	Pitanga	Myrtaceae	Native	20.0	2.5
Musa paradisiaca L.	Banana	Musaceae	Exotic	20.0	138.7
Inga edulis Mart	Ingá cipó	Mimosaceae	Native	17.5	2.1
Spondias lutea L.	Cajazeira	Anacardiaceae	Native	17.5	1.7
Amygdalus communis L.	Amendoeira	Rosaceae	Exotic	15.0	2.5
Ananas comosus (L.) Merrill.	Abacaxi	Bromeliaceae	Native	15.0	19.3
Pouteria caimito (Ruz and Pav.)	Abiu	Sapotaceae	Native	12.5	1.6
Myrciaria cauliflora (Mart.)	Jaboticaba	Myrtaceae	Native	12.5	6.4
Annona marcgravii Mart.	Araticum	Annonaceae	Exotic	10.0	2.5

Table 2. Contd.

Caryocar brasiliensis Cambess	Pequi	Caryocaceae	Native	10.0	1.3
Bactris gasipaes Kunth	Pupunha	Arecaceae	Native	10.0	8.5
Artocarpus heterophyllus	Fruta-pão	Moraceae	Exotic	10.0	3.7
Astrocaryum aculeatissimum (Schott)	Tucum	Arecaceae	Native	10.0	2.3
Spondias purpurea L.	Siriguela	Anacardiaceae	Native	7.5	1.7
Spondias tuberosa Aruda	Umbu	Anacardiaceae	Native	7.5	1.0
Garcinia mangostana L.	Mangustao	Clusiaceae	Exotic	5.0	1.0
Lichi chinensis Sonn	Lichia	Sapindaceae	Exotic	5.0	1.5
Manilkara huberu Adans	Macaranduba	Sapotaceae	Native	5.0	2.5
Citrus limon (L.) Burn	Limão	Rutaceae	Exotic	5.0	1.5
Cocos vagans L.	Anini	Arecaceae	Native	5.0	8.0
Diospynos brasiliensis Mart.	Mabolo	Ebenaceae	Native	5.0	1.0
Olea europeae L.	Azeitona preta	Oleandraceae	Exotic	5.0	1.0
Acrocomia aculeata (Jacq.)	Macauba	Arecaceae	Native	2.5	--*
Duguetia lanceolata Hill	Ameju	Annonaceae	Native	2.5	--
Rollinia mucosa (Jacq.) Baill.	Condessa	Annonaceae	Exotic	2.5	--
Morus alba L.	Amora	Moraceae	Exotic	2.5	--
Anacardium humile Hil.	Caju	Anacardiaceae	Native	2.5	--
Chysobalanus icaco L.	Guajuru rosa	Chrysobalanaceae	Native	2.5	--
Citrus aurantium L.	Laranja Lima	Rutaceae	Exotic	2.5	--
Citrus mobilis L.	Mexerica	Rutaceae	Exotic	2.5	--
Diospynos kaki L	Caejui	Ebenaceae	Exotic	2.5	--
Hymenaea courbaril L.	Jatoba	Caesalpiniaceae	Native	2.5	--
Psidium sp.	Guajuru branco	Myrtaceae	Native	2.5	--
Punica granatum L.	Romã	Rosaceae	Exotic	2.5	--
Lecythis pisonis Cambess	Sapucaia	Lecythydaceae	Native	2.5	--
Ficus sp.	Ficus	Moraceae	Exotic	2.5	--

dominant canopy was less than 10%. Of the 39 species found in the co-dominant canopy class, only five were more than 5%, including *C. nucifera* (13.0%), *M. indica* (12.6%), *P. guajava* (10.5%), *P. americana* (8.9%) and *T. esculenta* (6.9%).

Most of the dwellings had, on average, two or more trees of these species: *Annona sp., Citrus sp. Malphigia glabra* and *P. guajava* occurred predominantly in the under-storey or as seedlings (Table 6). The majority (>66%) of species were trees, thus giving the home-gardens vertical structuring. Cecropia sp. are fast growing trees and occurred entirely in the emergent and dominant canopy, but only in <25% of the home-gardens and in smaller abundances (mean <1.0 per homegarden). The vertical structure observed in the home-gardens of São Luís was similar to those reported in other parts of Brazil (Albuquerque et al., 2005).

Figures 3 - 6 shows the distribution of individual plants according to maturity class for each species. Fruit, timber and other trees occurred in all maturity classes, ranging from senescent trees to saplings and seedlings. Nine fruit and nut species also had >50% as seedlings or juvenile growth stage (Figure 3). Only 12 out of 63 fruit tree species did not have juvenile/seedlings plant. Two medicinal species (*Cercropia peltata* and *J. gossypiifolia*) were 100% juvenile (Figure 4). Two ornamental species (*Senna occidentalis* and *Leucaena leucocephala*) (Figure 5); Seven of ornamentals and two for medicinal and timber species had no juvenile phase (Figures 4 and 5). Also, we estimated that 100% of two timber species (*C. odorata and Cupressus sempervirense*) were juvenile or seedlings (Figure 6).

DISCUSSION

The results of this study suggest that home-gardens are biodiversed and vertically structured in multi-strata pattern, and regeneration dynamic was indicative. The observation of 186 different plant species managed in the homegardens, of which 61.8% were fruit tree species, 16.7% were edible crops including vegetables, cereals, legumes and condiments, 7.5% were medicinal plants, 6.4% were timber trees and the remaining 7.7% were plants of miscellaneous use, indicate high biodiversity conservation. Genetic diversity is a fundamental component of biodiversity, forming the basis for species and ecosystem diversity (Atta-Krah et al., 2004). It is evident

Table 3. Medicinal plant species, their local name, family, origin, frequency of occurrence (FO %) and abundance (AB) that is mean number of individuals per garden averaged over 40 homegardens.

Scientific name	Local name	Family	Origin	FO (%)	AB
Bixa orellana L.	Urucum	Bixaceae	Native	17.5	4.1
Coleus barbatus Bentha	Boldo	Lamiaceae	Exotic	15.0	0.59
Cymbopogon citratus (DC) Staf.	Capim limão	Poaceae	Exotic	15.0	10.4
Andropagon nardus L.	Cidreira	Poaceae	Exotic	12.5	22.0
Jatropha gossypiifolia L.	Picão roxo	Euphorbiaceae	Native	12.5	5.4
Virola sebifera Aubl.	Bicuiba	Myristicaceae	Native	12.5	1.4
Cecropia sciadophylla C. Martius	Embaúba	Cecropiaceae	Native	12.5	4.5
Chenopodium ambrosioides L.	Matruço	Chenopodiaceae	Exotic	10.0	4.8
Lippia alba Brown	Erva-cidreira	Verbenaceae	Native	10.0	1.5
Bauhinia forficata Link	Pata-de-vaca	Caesalpinaceae	Native	5.0	6.5
Dimorphandra gardneriana Tul.	Fava d'anta	Caesalpinaceae	Native	5.0	5.5
Kyllinga odorata Rottb.	Capim cidreira	Cyperaceae	Native	5.0	26.5
Aloe vera L.	Babosa	Liliaceae	Exotic	5.0	2.5
Gossypium arborium L.	Algodoeiro arbóreo	Malvaceae	Exotic	5.0	5.5
Mentha villosa Huds.	Hortelã miúda	Lamiaceae	Exotic	5.0	21.0
Mentha piperita L.	Hortelã	Lamiaceae	Exotic	2.5	--*
Operculina macrocarpa (L.)	Batata de purgo	Convolvulaceae	Native	2.5	--
Ricinus communis L.	Mamona	Euphorbiaceae	Native	2.5	--
Artemisia verlotorum	Anador	Asteraceae	Native	2.5	--
Sambucus nigra L.	Sabugueiro	Adoxaceae	Exotic	2.5	--
Bryophyllum pinnatum Kurz	Erva Santa	Crassulaceae	Exotic	2.5	--
Canna desnudata Rosc.	Cana-da-india	Cannaceae	Exotic	2.5	--
Lilium candidum L.	Lírio	Liliaceae	Exotic	2.5	--
Mirabilis sp.	Maravilha	Nyctaginaceae	Exotic	2.5	--
Zingiber officinale (Willd.) Roscoe	Gengibre	Zingiberaceae	Exotic	2.5	--
Pogostemon heyneanus Benth	Oriza	Lamiaceae	Exotic	2.5	--
Anadenanthera falcata (Benth.) Speg	Angiqueiro	Mimosaceae	Native	2.5	--

*Species occurred in only one garden. So means were not calculated.

Table 4. Timber tree species, their local name, family, origin, frequency of occurrence (FO %) and abundance (AB) that is mean number of individuals per garden averaged over 40 homegardens.

Scientific name	Local name	Family	Origin	FO (%)	AB
Tabebuia chrysotricha L.	Ipê anardo	Bignoniaceae	Native	17.5	2.7
Eucalyptus sp.	Eucalipto	Anacardiaceae	Exotic	15.0	3.2
Caesalpinia echinata Lam	Pau-brasil	Caesalpinaceae	Native	15.0	4.8
Mimosa caesalpiniifolia Benth	Sabiá	Mimosaceae	Native	12.5	8.8
Simarouba amara Aubl.	Paparaúba	Simaroubaceae	Native	12.5	9.6
Tabebuia serratifolia (Vahl) Nicholson	Pau d'arco	Bignoniaceae	Native	12.5	6.6
Cedrela odorata L	Cedro	Meliaceae	Native	10.0	1.8
Myracrodruon urundeuva Alemao	Aroeira	Anacardiaceae	Native	10.0	1.3
Nectandra nitidula Nees	Canda	Lauraceae	Native	10.0	1.2
Swietenia macrophylla Jacq.	Mogno	Meliaceae	Native	10.0	5.8
Tabebuia impetiginosa (Mart) Standley	Pau D'arco amarelo	Bignoniaceae	Native	7.5	3.0
Caesalpinia mimosoida(Mart.)	Sabiá	Caesalpinaceae	Native	5.0	5.0
Banara sp.	Cabelo de cutia	Flacourtiaceae	Native	5.0	3.0
Carapa guianensis Aubl.	Andiroba	Meliaceae	Native	5.0	2.5
Parkia pendula (Willd.) Benth.	Visgueiro	Mimosaceae	Native	5.0	2.0

Table 4. Contd.

Tabebuia heptaphyla L.	Pau D'arco Roxo	Bignoniaceae	Native	5.0	2.7
Vismia guianensis (Aubl.) Choisy.	Lacre do mato	Clusiaceae	Native	5.0	21.0
Pinus elliotti Engelm.	Pinheiro	Pinaceae	exotic	2.5	--*
Araucaria brasiliensis L.	Pinheiro	Araucaryaceae	Native	2.5	--
Cariniana estrellensis (Raddi) Kuntze	Cachimbeiro	Lecythidaceae	Native	2.5	--
Ceiba pentandra (L.) Gaertn.	Barrigudeira	Bombacaceae	Native	2.5	--
Cupressus sempervirens L.	Cipreste	Cupressaceae	Exotic	2.5	--
Dalbergia miscolobium Benth.	Jacarandá	Fabaceae	Native	2.5	--
Mouriri guianensis Aub.	Criviri	Melastomataceae	Native	2.5	--
Nectandra puberula (Schott) Ness	Canela	Lauraceae	Native	2.5	--
Ocotea porosa Nees	Imbuia	Lauraceae	Native	2.5	--
Paquira aquatica Aubl.	Castanha do Maranhão	Bombacaceae	Exotic	2.5	--
Sacoglottis guianensis Benth	Oiticica	Humiriaceae	Native	2.5	--
Simarouba sp.	Paparauba	Simaroubaceae	Native	2.5	--
Tabebuia caraiba (Mart.) Bur.	Ipê	Bignoniaceae	Native	2.5	--
Zollernia paraensis Huber	Pau santo	Caesalpinaceae	Native	2.5	--

*Species occurred in only one garden. So means were not calculated.

evident that homeowners in these generally fenced-in home-gardens value and manage diversity, not as deliberate effort to conserve biodiversity but in their diversification of species and adaptation and resource management to meet diverse livelihood needs. Fruit tree species in particular, dominate the biodiversity found in the homegardens, accounting for a total of 63 of all the species. Nearly 60 of all species found were native to Brazil, and indigenous were significantly more than exotics for fruit trees, medicinal and timber species. Several fruits and nuts found in the home-gardens are commonly found in the Brazilian tropical regions, and are inextricable part of the Amazon or Savanna landscapes. Management of biodiversity and genetic diversity in the home-gardens in this way ensures their availability for the present and potential to combine both *in situ* (maintenance of natural population) and *circa situ* (maintenance while in agricultural use) conservation for future use (Atta-Krah et al., 2004).

The management of exotics which represented 40% of all species and found in 70% home-gardens may have reflected response of home-owners to market opportunities and availability of planting material. Also, several exotic fruit trees have been cultivated in Brazil for a long time. For instance, the cultivation of orange and mango from Asia and their uses are dated after Christopher Columbus in 1493 and were brought to Brazil by the Portuguese. Brazil is the largest producer of oranges with produces 831,000 ha under production, and 18.5 million fruit produced (Silva and Tassara, 2006), and orange adapted so well in Brazil many had thought it was native.

The crop diversity found in the home-gardens probably reflected the specific needs (including food requirements and household dietary priorities and preferences), nutritional complementarity with major food sources, as opposed to economic, ecological and social factors (Kumar and Nair, 2004). As in other regions, most of the homegarden owners appeared to constantly introduce new plant species. This is indicated by the occurrence of plants of different stages, such as seedlings, saplings and juvenile, mature and old trees (Akinnifesi et al., 2009).

Although 27 medicinal species were recorded in the study ranging from 17.5% for *Bixa orellana*, to 15% for *C. barbatus* and *C. citrates*, 12.5% for *A. nardus, J. gossypiifolia, Virola sebifera* and *C. sciadophylla*. Whereas, *C. ambrosioides* and *L. alba* were only found in 10% of homegardens. In addition, several plants classified as fruit, timber and crops also have medicinal uses, e.g. Açai (*E. oleraceae*) and Araticum (*Annona muricata*), which are a nut and fruit respectively (Neto, 1997). The Bignonaceae family was the most common medicinal group represented by up to five different species.

Exotic medicinal plants have also been naturalized and used by local people in the state of Maranhao. Some, such as lemongrass (*Cymbopogon citratus* (D.C.) Stapf., *C. barbatus* Benth, Aloe sp., are cultivated in home-gardens. Others, such as mastruço (*C. ambrosioides* L.), are well documented (Vieira, 1999). In addition, C. barbatus, introduced from Africa, is clonally propagated in Brazil. Jack fruit (*A. integrifolia*) adapted very easily to the Brazilian climate and is used in traditional Brazilian medicine to combat diarrhea.

Gonçalves et al. (2005) showed that at non-cytotoxic concentrations, the extracts from *A. integrifolia* bark and *Spondias lutea* can be useful in the treatment of human

Table 5. Ornamental plants, their local name, family, origin, frequency of occurrence (FO %) and abundance (AB) that is mean number of individuals per garden averaged over 40 homegardens.

Scientific name	Local name	Family	Origin	FO (%)	AB
Roystonea oleracea (Jacq.) Cook	Palmeira imperial	Arecaceae	Native	20.0	7.5
Rhamnidium elaeocarpus Reiss	Azeitona rósea	Rhamnaceae	Native	17.5	1.9
Delonix regia (Bojer) Raf.	Flamboyant	Caesalpinaceae	Exotic	10.0	6.0
Senna siamea (Lam.)	Acacia	Caesalpinaceae	Exotic	10.0	1.8
Phoenix dactylifera L.	Tâmara	Arecaceae	Exotic	7.5	2.3
Prosopis juliflora DC	Algaroba	Mimosaceae	Exotic	7.5	3.3
Caesalpinia ferrea Mart. Ex Tul	Pau-ferro	Caesalpinaceae	Native	5.0	1.5
Cycas sp.	Palmerinha	Cycaceae	Exotic	5.0	7.0
Dieffenbachia picta Schott.	Comigo ninguém pode	Araceae	Exotic	5.0	3.0
Hevea lutea (Benth.) Müll. Arg.	Seringueira	Euphorbiaceae	Native	5.0	4.5
Hibiscus rosa-sinensis L.	Hibisco	Malvaceae	Exotic	5.0	4.0
Pandorea ricasoliana Sprague	Sete léguas	Bignoniaceae	Exotic	5.0	8.5
Pariana maynensis Benth	Bambu	Poaceae	Native	5.0	29.0
Bambusa vulgaris L.	Bambu	Poaceae	Native	2.5	4.0
Bougainvillea glabra Choisy	Bouganville	Nyctaginaceae	Native	2.5	--*
Cassia occidentalis L.	Fedegoso	Caesalpinaceae	Native	2.5	--
Davallia fejeensis Hook.	Renda portuguesa	Davalliacea	Exotic	2.5	--
Leucaena leucocephala De Wit	Leucena	Caesalpinaceae	Exotic	2.5	--
Licania tomentosa Benth	Oiticica	Chrysobalanaceae	Native	2.5	--
Monstera deliciosa Liebm.	Costela de adão	Araceae	Exotic	2.5	--
Mussaenda alicia Hort.	Muzenga/Mussenda	Rubiaceae	Exotic	2.5	--
Prosopis juliflora (SW) DC	Algarobeira	Mimosaceae	Exotic	2.5	--
Rosa sp.	Roseiras(paulista)	Rosaceae	Exotic	2.5	--
Sansevieria trifasciata Hort	Espada de São Jorge	Dracaenaceae	Exotic	2.5	--
Scindapsus aureus Engl.	Jibóia	Araceae	Exotic	2.5	--
Spiraea cantoniensis Lour.	Buque de noiva	Rosaceae	Exotic	2.5	--
Nephrolelpis sp.	Samambaia	Oleandraceae	Native	2.5	--
Pteris denticulate Sw.	Samambaia	Pteridaceae	Native	2.5	--
Ixora coccicinea L.	Alfineta	Rubiaceae	Exotic	2.5	--

*Species occurred in only one garden. So means were not calculated.

Table 6. Percentage contribution of different tree species to the canopy and height classes: (A) Emergent (>15) m height; (B) dominant (10 - 15 m); (C) co-dominant (5 - 10 m); (D) understorey (2 - 5 m); and (E) seedling (<2 m).

Scientific name	Type	A	B	C	D	E
Cocus nucifera L.	Nut	29.2	7.7	13.0	1.4	2.4
Artocarpus integrifolia L	Fruit	12.5	4.5	2.8	2.0	4.8
Cecropia sciadophylla C. Martius	Medicinal	12.5	0.4	0.0	0.0	0.0
Attalea speciosa Mart.	Nut	8.3	3.6	1.2	0.0	0.0
Talisia esculenta (Hill) Radlk	Fruit	8.3	3.2	6.9	2.0	0.0
Roystonea oleracea (Jacq.) Cook	Ornamental	8.3	0.8	0.8	0.0	0.0
Caryocar brasiliensis Cambess	Fruit	8.3	0.4	0.4	0.0	0.0
Platonia insignis Mart	Fruit	4.2	8.1	1.6	0.0	4.8
Eugenia jambos L.	Fruit	4.2	2.0	4.0	2.7	2.4
Theobroma cacao L.	Fruit	4.2	0.4	0.0	0.7	0.0
Mangifera indica L.	Fruit	0.0	23.9		5.4	2.4
Anacardium occidentale L.	Fruit	0.0	5.3	4.5	1.4	0.0
Psidium guajava L.	Fruit	0.0	4.9	10.5	10.1	7.1

Table 6. Contd.

Anacardium occidentale L.	Fruit	0.0	5.3	4.5	1.4	0.0
Psidium guajava L.	Fruit	0.0	4.9	10.5	10.1	7.1
Persea americana Mill.	Fruit	0.0	4.5	8.9	5.4	0.0
Anacardium humile A. St. Hil.	Fruit	0.0	4.0	2.4	0.0	4.8
Spondias dulcis Parkinson	Fruit	0.0	2.8	0.8	0.7	0.0
Byrsonima crassifolia (L.) Rich	Fruit	0.0	2.4	0.8	2.0	2.4
Averrhoa carambola L.	Fruit	0.0	2.4	1.2	0.7	0.0
Carica papaya L.	Fruit	0.0	2.0	1.2	2.7	0.0
Haevia lutia (Benth) Mull. Arg	Ornamental	0.0	2.0	0.0	2.7	0.0
Olea europeia L.	Fruit	0.0	1.6	2.0	2.0	0.0
Genipa americana L.	Fruit	0.0	1.6	1.6	0.7	0.0
Annona muricata L.	Fruit	0.0	1.6	2.0	0.0	11.9
Manilkara zapota (L.) van Royen.	Fruit	0.0	1.2	0.4	3.4	0.0
Annona squamosa L.	Fruit	0.0	0.8	1.2	4.7	0.0
Amygedalus communis L.	Condiment	0.0	0.8	0.4	0.7	4.8
Inga edulis Mart	Fruit	0.0	0.8	0.4	0.7	0.0
Cariniana estrellensis (Raddi)	Timber	0.0	0.8	0.8	0.0	0.0
Tamarindus indica L.	Fruit	0.0	0.8	0.8	0.0	0.0
Astrocaryum aculeatissimum (Schott)	Fruit	0.0	0.8	0.4	0.0	0.0
Banara sp.	Timber	0.0	0.8	0.0	0.0	0.0
Mauritia vinifera L.	Fruit	0.0	0.4	0.8	0.0	0.0
Eucalyptus citriodora L.	Timber	0.0	0.4	0.4	0.0	0.0
Eugenia uniflora L	Fruit	0.0	0.4	0.4	0.0	0.0
Tabebuia caraiba (Mart.) Bur.	Timber	0.0	0.4	0.4	0.0	0.0
Coffea arabica L.	Seed	0.0	0.4	0.0	0.0	0.0
Malphigia glabra L.	Fruit	0.0	0.0	0.0	20.3	19.0
Citrus aurantium L.	Fruit	0.0	0.0	3.6	12.2	9.5
Citrus limon (L.) Burn	Fruit	0.0	0.0	5.3	6.8	19.1
Mammea americana (L.) Jacq.	Fruit	0.0	0.0	0.8	0.7	0.0
Elaeis guineensis Jacq.	Nut	0.0	0.0	0.4	0.7	0.0
Diospyos discolor Wild.	Fruit	0.0	0.0	0.0	0.7	0.0
Theobroma grandiflorum (Wild)	Fruit	0.0	0.0	1.2	0.0	2.4
Citrus mobilis L.	Fruit	0.0	0.0	0.4	0.0	0.0
Lichi chinensis Sonn.	Fruit	0.0	0.0	0.4	0.0	2.4
Bactris gasipaes Kunth	Nut	0.0	0.0	0.4	0.0	0.0
Cycas sp.	Ornamental	0.0	0.0	0.4	0.0	0.0

diarrhea. A few timber species were found in the home-gardens including *T. chrysotricha*, *Eucalyptus* sp., *C. echinata, M. caesalpinifolia, S. amara, T. impetiginoso, C. odorata, N. nitidula, M. urundeuva, S. macrophylla* and *Tabebuia* sp. These occurred in 10 - 17% of the homegardens. Apart from Eucalyptus sp., all the other timber tree species were native to Brazil. This observation is important considering the high rate of deforestation and extinction of native timber species in the forests. This homegarden based timber species are important for wood, fuel wood, wood products and non-wood products.

The occurrence of ornamental species in less than 20% of the domestic gardens, of which most (55%) of these species were exotics, is not a reflection of low value of ornamentals, but this reinforces the fact most species in the home-gardens play an ornamental role as well. People grow the ornamentals for purpose of improving the shade function, improved aesthetics of household dwellings, and other personal interests. According to Blanckaert et al. (2004), ornamentals dominated the plants cultivated in home-gardens of San Rafael Coxcatlan, valley of Tehuacan-Cuicatlan, Mexico, representing as much as 65.7%, while edible plants and medicinal were only 29.6 and 8.6% respectively.

The vertical structure and stratification into emergent, dominant and co-dominant and under storey canopies are typical of homegardens, making them to resemble a young secondary forest. These are fenced-in home-gardens, and the partition of cropland from tree areas

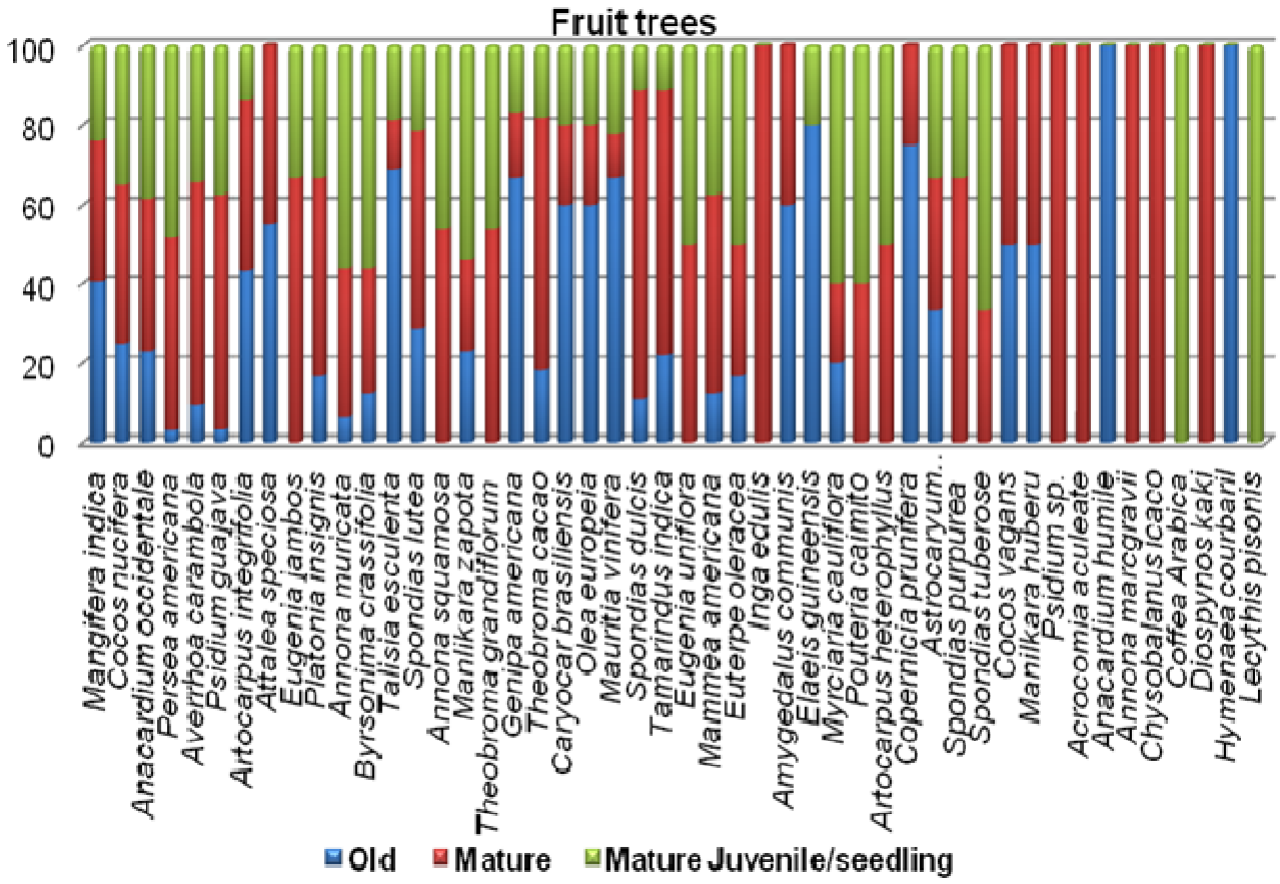

Figure 3. Distribution of fruit tree species according maturity classes: old, mature, juvenile and seedlings and saplings (Seedlings) in the homegardens.

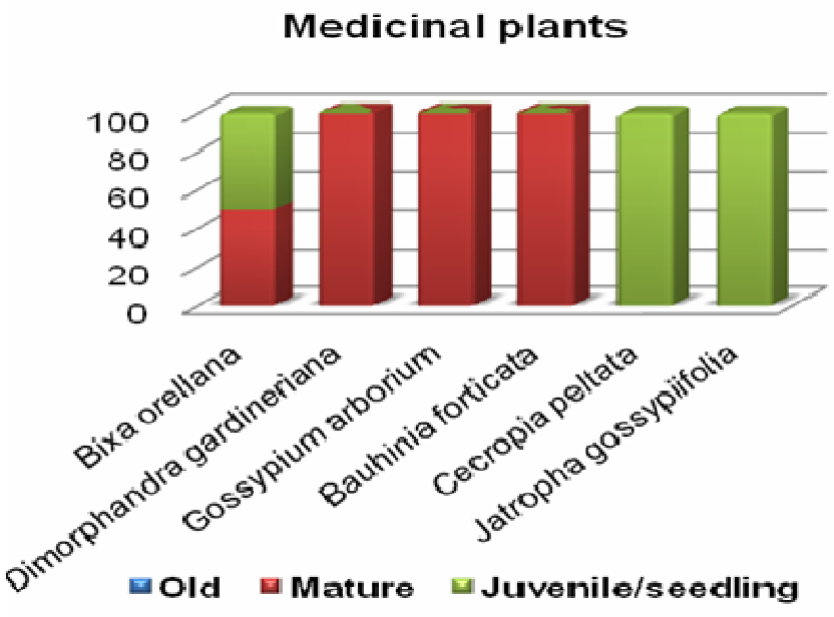

Figure 4. Distribution of medicinal tree species according maturity classes: old, mature, juvenile and seedlings and saplings (Seedlings) in the homegardens.

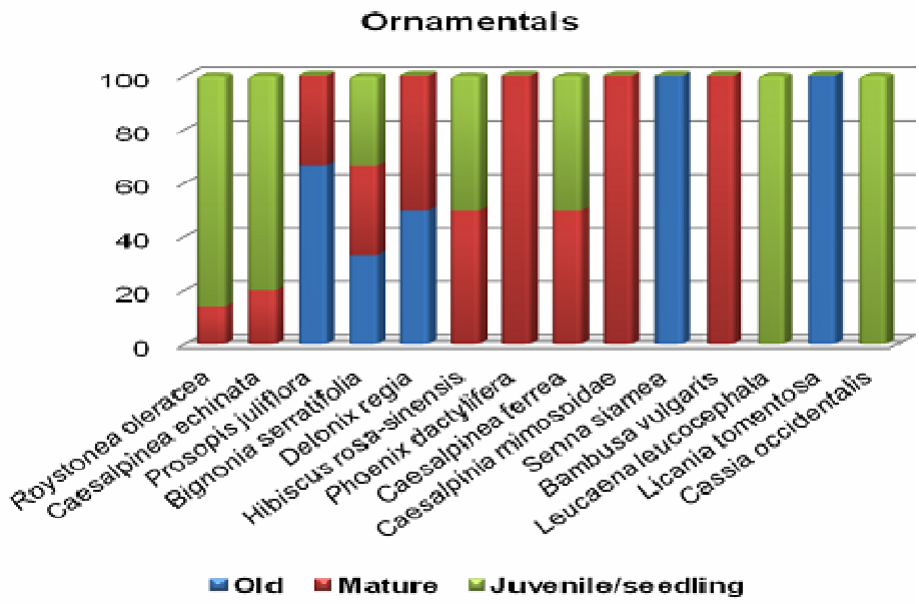

Figure 5. Distribution of ornamental tree species according maturity classes: old, mature, juvenile and seedlings and saplings (Seedlings) in the homegardens.

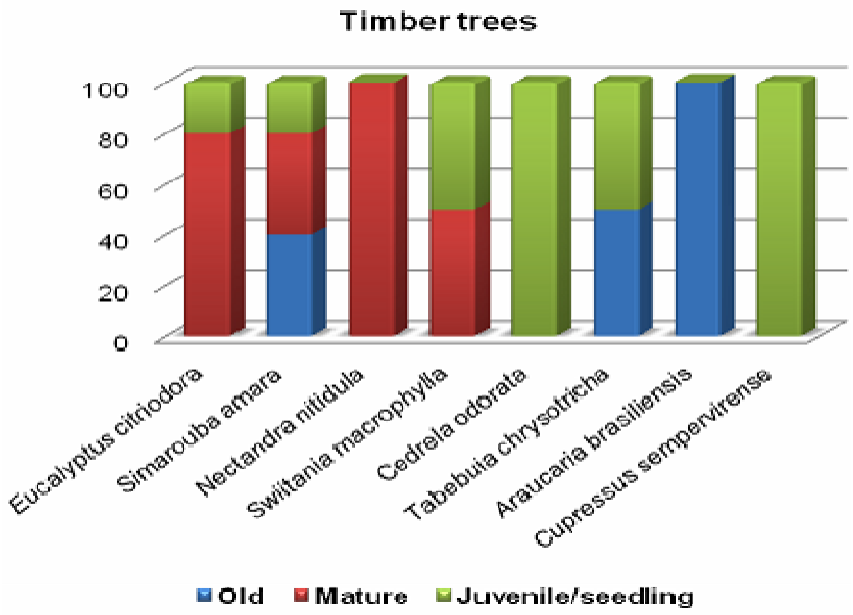

Figure 6. Distribution of timber tree species according maturity classes: old, mature, juvenile and seedlings and saplings (Seedlings) in the homegardens.

were not clear cut. There might be some inter-site variations that could not be captured in our data. Several authors have reported distinct horizontal/vertical zonation in homegardens, and that their location, size and plant species composition reflect deliberate management strategies (Kumar and Nair, 2004).

In terms of regeneration dynamics, the observation of species occurring across growth stages, old, mature and juvenile/seedlings suggests a continuous management and re-stocking. We estimated that 100% of all the plants in certain species were seedlings or at juvenile phase of growth, especially for two timber species (*C. odorata and C. sempervirense*); two ornamental species (*Senna occidentalis* and *L. leucocephala*); two medicinal species

(*Cercropia peltata and J. gossypiifolia*). Nine fruit and nut species also had >50% as seedlings or juvenile growth stage. Only 12 out of 63 fruit tree species did not have juvenile/seedlings plant, seven of ornamentals and two for medicinal and timber species had no juvenile phase. The observation of juvenile/seedling phase is an evidence of dynamics in managing biodiversity in the gardens. Homegarden owners are generally known to be perpetual 'experimenters,' constantly trying and testing new species varieties and their management (Atta-Krah et al., 2004). Most of the germplasms and products of the species are often exchange among relatives and neighbors, which may help sustain critical social networks and relationships. Introduction of new species often depend on their uses, characteristics and values while these are mostly based on personal instincts and preference. The size of the gardens and available planting area may also contribute to choice of planting or species to be retained. It has also been known that religious and cultural beliefs may influence the diversity and composition of tropical homegardens.

Conclusion

The study contributes insight into species distribution and abundance, their growth and management dynamics in the urban home-gardens of São Luis, Brazil. We conclude that the home-gardens of São Luis city are biodiversity-rich and have potential to contribute to year-round food security in terms of production and consumption of fruits, nuts, crops and vegetables and also meet diverse non-food livelihood needs of the urban dwellers. While a large proportion of the products are for domestic consumption, there is potential for commercialization in local markets. Market research needs to creating new markets and linking producers to the market. There is need for research and investment on the post-harvest storage and handling of fruits and other products to reduce the high rate of spoilage from collection to consumption.

These home-gardens continue to serve as important repositories of biodiversity including those of endangered species, and provide tree and non-tree products such as fruits, nuts, medicine etc, and ecosystem services such as shade, erosion control, and pollination source. The homegarden owners managed their home-gardens based on tradition, needs and preferences and this tradition eventually means that they include many species in their gardens. This may not be seen as a conscious effort by the homegarden owners to get as high as possible diversity in their gardens. The diversity is a consequence of the way they manage their homegarden. The home-gardens owners are constantly introducing new tree germplasms into the home-gardens as evidenced by the high abundance of juvenile plants. However, improved horticultural research and skills, soil fertility management and agronomic management will further enhance the sustainability and economic value of the homegarden systems. Systematic efforts are still needed to improve the productivity and economic returns of the homegardens. A logical follow up of the study is the detail ethnoecological study of the use of the biodiversity in the homegardens.

Deliberate effort is need for promotion of home-gardens in urban landscapes. In the tropics with similar biophysical conditions as São Luis, the sustainable landscape of the future will necessarily be tree-based, because this guarantees the achievement of the dual goals of sustainable livelihood and environment. The implications of this work for the management of the homegardens, if that conscious effort could be channeled to promote new species, and conserve the biodiversity indigenous species already domesticated by the homegarden owners, especially those that are endangered or threatened in the forest and agricultural land uses. There is need to stimulate policy recognition of the importance of home-gardens agroforestry system as a "win-win" solution in tackling both livelihoods challenges and environmental sustainability constraints in developing countries, especially with the climate change dilemma. The first step is to scale-up integrated tree-based practices, such as homegardens, using sound decision support mechanisms that build on knowledge, partnerships and capacity at all scales. Managing biodiversity of native and exotive species through domestication and sustainable utilization offers a new opportunity to mitigate over-exploitation of wild stands and loss of biodiversity (Akinnifesi et al., 2006, 2008a, b).

We recommend deliberate domestication research for development as a robust strategy to simultaneously conserve genetic diversity and achieve speedy development of elite cultivars of wild or semi-domesti-cated species. The management and cultivation of fruit tree species, in particular, will become more important as the households goal of managing the home-gardens move from subsistence to a cash-oriented economy.

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REFERENCES

Akinnifesi FK, Kwesiga FR, Mhango J, Chilanga T, Mkonda A, Kadu CAC, Kadzere I, Mithofer D, Saka JDK, Sileshi G, Ramadhani T,

Dhliwayo P (2006). Towards the development of miombo fruit trees as commercial tree crops in southern Africa. Forest. Trees Livelihood 16: 103-121.

Akinnifesi FK, Leakey RRB, Ajayi OC, Sileshi G, Tchoundjeu Z, Matakala P, Kwesiga FR (2008a). Indigenous Fruit Trees in the Tropics: Domestication, Utilization and Commercialization. World Agrofoforestry Centre: Nairobi. CAB International Publishing, Wallingford, UK pp. 438.

Akinnifesi FK, Sileshi G, Ajayi OC, Akinnifesi AI, de Moura EG, Linhares JFP, Rodrigues I (2009). Biodiversity of the urban home-gardens of São Luís city, Northern Brazil. Urban Ecosyst. 13: 129-146.

Akinnifesi FK, Sileshi G, Ajayi OC, Chirwa PW, Mngomba S, Chakeredza S, Nyoka B (2008b). Domestication and conservation of indigenous Miombo fruit trees for improving rural livelihoods in southern Africa. Biodivers. (Ottawa) 9: 72-74.

Albuquerque UP, Andrade LHC, Caballero J (2005). Structure and floristic of home-gardens in Northeastern Brazil. J. Arid Environ. 62: 491-506.

Atta-Krah K, Kindt R, Skilton JN, Amaral W (2004). Managing biological and genetic diversity in tropical agroforestry. Agroforest. Syst. 61: 183-194.

Blanckaert I, Swennen RL, Flores PM, Lopez RI, Saade RL (2004). Floristic composition, plant uses and management practices in home-gardens of San Rafael Coxcatlan, valley of Tehuacan-Cuicatlan, Mexico. J. Arid Environ. 57: 39-62.

Castro AAJF, Martins FR, Tamashiro JY, Shepherd GY (1999) How rich is the flora of Brazilian Cerrados? Annal Missouri Bot. Garden 86: 192-224.

Gonçalves JLS, Lopes RC, Oliveira DB, Costa SS, Miranda MMFS, Romanos MTV, Santos NSO, Wigg MD (2005). *In vitro* anti-rotavirus activity of some medicinal plants used in Brazil against diarrhea. J. Ethnopharm. 99: 403-407.

Kang BT, Akinnifesi FK (2000). Agroforestry as alternative land-use production systems for the tropics. Nat. Res. Forum 24: 137-151.

Kumar BM, Nair PKR (2004). The enigma of tropical homegardens. Agroforest. Syst. 61: 135-152.

McKinney LM (2002). Urbanization, biodiversity and conservation. BioScience 52: 883-890.

Neto GG (1997). A importância da flora Amazônica para uso medicinal. Palestras do 37 Congresso Brasileiro de Olericultura 15: 159-160.

Niemelä J (1999). Ecology and urban planning. Biodivers. Conserv. 8: 119-131.

Nyland RD (1996). Silviculture: concepts and applications. Mcgraw-Hill Companies, New York pp. 633.

Silva S, Tassara H (2006). Fruit in Brazil. http://www.crfg.org/pubs/bkrev/FruitInBrazil.html.

Thompson K, Austin KC, Smith RM, Warren PH, Angold PG, Gaston KJ (2003). Urban domestic gardens (I): Putting small-scale plant diversity in context. J Veg. Sci. 14: 71-78.

Vieira RF (1999). Conservation of medicinal and aromatic plants in Brazil. In: Janick J (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA. pp. 152-159.

Von der Lippe M, Kowarik I (2008). Do cities export biodiversity? Traffic as dispersal vector across urban-rural gradients. Divers. Distr. 14: 18-25.

Winklerprins AMGA, de Souza PS (2005). Surviving the city: Urban home gardens and the economy of affection in the Brazilian Amazon. J. Latin. Am. Geogr. 4: 107-126.