Plant Diversity in Home Gardens and Its Contribution to Household Economy in Suburban Areas in Sri Lanka

ความหลากหลายของพันธุ์พืชในสวนรอบบ้านและประโยชน์ที่มีต่อเศรษฐกิจครัวเรือนในพื้นที่ชุมชนชานเมืองประเทศศรีลังกา

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Abstract

Plant diversity is threatened by rapid and unplanned urbanization, which increases environmental problems such as heating, pollution, loss of habitats and ecosystem disruption. Tropical home gardens have played a significant role in conserving plant diversity while providing substantial benefits to households. This research aimed to understand the relationship between household characteristics and plant diversity in suburban home gardens and the contributions of plants to the household economy. Plant diversity and different uses of plants were studied in a random sample of 106 suburban home gardens in the Thimbirigaskatuwa suburban area, Katana Divisional Secretariat Division, western Sri Lanka, based on complete garden inventories followed by household surveys on socio-economic status during 2008. A total of 289 species of plants were observed, of which 51% were ornamental plants, 36% food plants, and 12% medicinal plants. Of these 6% were sold commercially to produce income. Coconuts, bananas, and other fruits produced in excess, anthurium, orchids, and dracaenas were used and sold commercially. Home gardens contributed the equivalent of 5% of total annual household income in terms of food and commercial sales. Multiple regression analysis showed that education, time spent in gardening, land for cultivation, household expenses, primary conservation practices, and uses of special techniques explained 65% of the total plant diversity. Food, medicinal and commercial plant species had significant positive relationships with time spent gardening and land area for gardening. Education and conservation practices significantly affected food and medicinal plant diversity. Special techniques used in gardening showed significant positive relations with ornamental and commercial plants. Reassessments in different suburban and urban home gardens and proper documentation using same methodology is essential to build a firm policy for enhancing plant diversity and related values to households and surroundings.

Key words: Plant diversity / urbanization / suburban home gardens / garden inventories / Sri Lanka.

บทคัดย่อ

ความหลากหลายของพันธุ์พืชถูกคุกคามจากการกลายเป็นเมืองอย่างรวดเร็วและขาดการวางแผน ส่งผลให้เกิดปัญหาสิ่งแวดล้อมตามมาเพิ่มมากขึ้น เช่น ภาวะอุณหภูมิที่สูงขึ้น มลพิษต่างๆ การสูญเสียที่อยู่อาศัยของสิ่งมีชีวิตและระบบนิเวศที่ถูกทำลาย การปลูกพืชพันธุ์ในสวนรอบบ้านในพื้นที่เขตร้อนมีบทบาทสำคัญในการอนุรักษ์

ความหลากหลายของพันธุ์พืช ในขณะเดียวกันได้ให้ประโยชน์มากมายสำหรับครัวเรือน งานวิจัยนี้มุ่งที่จะเข้าใจความสัมพันธ์ระหว่างลักษณะครัวเรือน และความหลากหลายของพันธุ์พืชที่ปลูกในสวนรอบบ้าน รวมทั้งประโยชน์ในเชิงเศรษฐกิจที่ครัวเรือนได้รับจากพันธุ์พืชต่างๆ การศึกษาประกอบด้วยการสำรวจความหลากหลายของพันธุ์พืชและการใช้ประโยชน์พันธุ์พืชในรูปแบบต่างๆ โดยศึกษาจากจำนวน 106 ครัวเรือนในพื้นที่ชานเมืองทิมบีลี่คัสกาตั้ว ฝั่งตะวันตกของประเทศศรีลังกาในปี 2008 ผลการศึกษาพบพันธุ์พืชจำนวน 289 ชนิด 51% ของพันธุ์พืชที่พบเป็นไม้ดอกไม้ประดับ 36% เป็นพืชอาหาร และ 12% เป็นพืชสมุนไพร จากพันธุ์พืชที่พบทั้งหมด มีจำนวน 6% ที่ถูกขายเป็นรายได้ของครัวเรือน พืชที่ปลูกเพื่อทั้งใช้ในครัวเรือนและขายประกอบด้วยมะพร้าว กล้วย ผลไม้ พืชสกุลหน้าวัวใบ กล้วยไม้ และวาสนา ประโยชน์ในเชิงเศรษฐกิจของพันธุ์พืชจากสวนรอบบ้านมีมูลค่าเท่ากับ 5% ของรายได้รวมประจำปีของครัวเรือน จากการวิเคราะห์ความถดถอยเชิงพหุพบว่าปัจจัยด้านระดับการศึกษา เวลาในการทำสวน ขนาดที่ดินของสวนรอบบ้าน ค่าใช้จ่ายของครัวเรือน วิธีการอนุรักษ์ และเทคนิคพิเศษที่ใช้ สามารถอธิบายความแตกต่างของความหลากหลายของพันธุ์พืชในสวนรอบบ้านได้ 65% พืชอาหาร พืชสมุนไพร และพืชเชิงพาณิชย์มีความสัมพันธ์เชิงบวกอย่างมีนัยสำคัญทางสถิติกับเวลาในการทำสวนและขนาดพื้นที่ของสวนรอบบ้าน ระดับการศึกษาและวิธีการอนุรักษ์ส่งผลต่อความหลากหลายของพืชอาหารและพืชสมุนไพรอย่างมีนัยสำคัญ สำหรับเทคนิคพิเศษที่ใช้ในการทำสวนมีความสัมพันธ์เชิงบวกกับพืชประดับและพืชเชิงพาณิชย์ การประเมินความหลากหลายของพันธุ์พืชในสวนรอบบ้านในเขตชานเมืองและในเขตเมืองรวมทั้งการบันทึกข้อมูลอย่างเหมาะสมด้วยวิธีการศึกษาแบบเดียวกันจะช่วยในการกำหนดนโยบายในการเสริมสร้างความหลากหลายของพันธุ์พืชและเอื้อต่อประโยชน์ที่มีต่อครัวเรือนและพื้นที่โดยรอบ

คำสำคัญ: ความหลากหลายของพันธุ์พืช / การกลายเป็นเมือง / สวนรอบบ้านชานเมือง / รายการพันธุ์พืชในสวน

1. Introduction

Plant diversity is often used as a measure of health of the biological system (Naeem, 2002). It is threatened by the agricultural expansion, deforestation, and development activities including rapid urban expansion (Ricketts and Imhoff, 2003). Urbanization is one of the recent important issues in the enormous reduction of plant diversity. Currently the world urban population (3.2 billion) exceeds the number living in rural areas. People create rapid demands for food, settlements, jobs, waste management, and all basic needs for living (Rizvi, 2007). Dense settlements, traffic congestion, air and soil pollution, and waste dumps, reduce the space for plants, especially natural domestic plants (Mckinney, 2002). Although urbanization is a global phenomenon, its magnitude differs widely among regions (Reid, 1998). Hence addressing the global problem of reversing plant diversity in urban areas requires multiple innovative ways. Urban and suburban home gardens play a major role in providing food, breeding sites and shelter for animals and plants and also modifying microclimate (Smith et al, 2006).

Home gardens are frequently identified as traditional agroforestry systems with complex structure and multiple functions. They may also help to conserve plants, both wild and domesticated, because of their uses to the households (Abdoellah et.al., 2006). Thus, home gardens have gathered much research attention during the past few decades, for several reasons. They are an attractive model for research and the design of sustainable agroecosystems (Das and Das, 2005). The realization that this 'home garden' system is also a vital reservoir of unique genetic diversity has recently led to more careful study this system in order to obtain a better understanding of the role of home gardens in the management and conservation of genetic diversity *in situ* (IPGRI, 2002).

Sri Lanka is an island with tropical climate, and is one of the biodiversity hot spots of the world (IUCN/ UNEP/ WWF, 1980). The home garden is often the traditional life supporting system in rural areas as in many other countries (Engels, 2002). Recently, there is a trend to establish home gardens in urban and suburban areas, especially with government intervention (Ranasinghe, 2005). Department of Agriculture maintains demonstration plots of home garden and extension services for promoting both urban and rural home gardens in its Horticultural Research and Development Unit (Hein, 2007). Provincial Agricultural Sector (Western) in Sri Lanka has also been encouraging urban people to maintain their gardens sustainably, using the concept of family business gardens (Ranasinghe, 2005). Under the government program launched in 2007, "Let us grow, and uplift the nation," urban and rural home gardens were recognized as a means to achieve national goals (Yatawara, 2008). They can enhance food security, reduce living costs and imports of food products, expand suitable new technologies, and maintain environmentally friendly-traditional agriculture methods.

This study was done with two major objectives: identifying the internal and external household factors related to plant diversity in suburban home gardens, and understanding its contribution to the household economy.

2. Research design

2.1 Study site

Thimbirigaskatuwa, where the study was conducted, is a suburban area situated in the Katana Divisional Secretariat 2 km away from the coastal town of Negombo, Western Province. Thimbirigaskauwa is on the eastern margin of Negombo. It is in wet zone of Sri Lanka (7° 25′ N latitude and 79° 75′ E longitude) and experiences a warm humid climate with a mean of above 2,500 mm annual rainfall. Average temperature ranges from 27 to 31°C. This area covers 2.5 km^2 and has 1,160 households with a total population of 5,042. Ethnically the population is 99.5% Sinhalese; there are only three families of Sri Lankan Moors.

2.2 Sampling procedure and data collection

Sample size was determined by the method proposed by Bartlett *et al*. (2001). A sample of 106 households was randomly selected from a list of 1160 households provided by the village headman for study. Data collection was carried out using three methods: 1) Plant inventory survey of sampled home gardens to record plant diversity; 2) Household survey of socioeconomic characteristics; and 3) In-depth interviews for further understanding of home garden activities.

2.2.1 Plant inventory survey

The plant inventory survey was performed by using a structured format which included common and botanical names of plants, number, and types of plants, uses of plants, average values of plants, sources of planting material, conservation of planting material, access to plant sources, and choices of plants. The survey was carried out with participatory observations, plants identifications with local names, and photographs needed for further identification.

2.2.2 Household survey and interviews

Structured questionnaires were used to collect socio-economic information on the selected households. They contained some key questions regarding gardening activity other than the general household factors, such as the persons involved in gardening, time spent gardening, garden area, special techniques used in gardening, sharing of planting material, conservation methods, attitudes towards government extension services, access to markets, and access to planting material. In addition, three key informants selected by the village headman were interviewed for additional information about home gardening. Two of them were elderly persons who had a thorough understanding of the area and the history of home gardening and settlements during last few decades. The third informant was an agriculture instructor responsible for agricultural activities in the area. The analysis was done with multiple regressions using SPSS statistical package for social sciences.

3. Results and discussion

3.1 Households' characteristics and home gardening

The mean garden size was 221 m^2 (range 3 to 2000 m^2). The household with the lowest area possessed 60 plant species which were maintained on the rooftop, in a fashion of typical urban garden. The garden with highest land area maintained a similar diversity, with 74 species, but included more plants with high commercial value such as coconuts. Mean household income was 21,957 Rupees and mean expenses were 19,896 Rupees. The settlement period of 60% of respondents was less than 15 years which represents a relatively young population that had dramatically increased during the last two decades. The respondents' mean age was 44 years (range 16–87). The sample population was relatively well-educated, with a mean of 11 years of schooling (range 5 –16).

The average time spent in gardening was 8 hours per week and this was closely related to plant diversity. Most people in the area (85% of households) processed seeds or planting material for continuous use in their own gardens. In this practice they mainly used easily available local varieties or shared planting materials instead of buying new improved varieties which consume more inputs and give higher yield. As the area was experiencing the southeast monsoon in May, the data collection period in September was near the end of the season of some crops. But respondents have still maintained some crops and preserved some seeds, dried pods, or nurseries for next crop. This characteristic tended to conserve planting materials. Special techniques were identified as innovative methods for raising plants in order to use space, sunlight, water, and media efficiently using locally available materials. Different type of vertical farming techniques (air-scapes), rooftop gardening (roof scapes), cultivation towers, and hydroponics systems are examples. These techniques are low input accessible methods often followed by creative gardeners (16%).

Among total respondents, 87% were favorable towards the government's positive promotion of home gardening. A majority of households (83%) however were unsatisfied with the agriculture extension services for home garden activities in the area. Agriculture extension services mainly concentrated on rural gardening and agricultural activities and other support services.

3.2 Plant diversity in suburban home gardens

A total of 289 species were observed and identified, including 105 food plant species, 34 medicinal plant species and 148 ornamental species. A few trees grown for timber were also found in large gardens. The average diversity per household was 45 plant species, ranging from 14 to 95 throughout the home gardens. Even though land area had a positive relationship with plant diversity (number of species), high numbers of species and individual plants were also observed in home gardens with low area, which adopted their own creative techniques.

Across the gardens, 93 plant families were observed. The most common families included Fabaceae, Araceae, Euphorbiaceae, Apocynaceae, Solanaceae, Rutaceae, Orchidaceae, and Cucurbitaceae. Araceae contained the highest number of ornamental species (11) with 3 food species, while Rutaceae had the most food plant species (9) with 1 ornamental species. Euphorbiaceae, Apocynaceae, Orchidaceae, and Acanthaceae possessed high numbers of ornamental species. Fabaceae, Cucurbitaceae, and Solanaceae all had mostly food plant species. Medicinal plants were equally distributed among several families, with 4 species found in Fabaceae.

Most home garden species were perennials (85%) while 14% were annuals and 1% biennials. According to habit, 142 species (49 %) were herbs, 61 (21 %) were shrubs, 53 (18 %) were trees, 19 (6%) were herbaceous vines, and 14 (4%) were woody vines.

Figure 1 shows frequency (number of home gardens which a particular species was found) and abundance (number of plants per species) of home garden plant diversity. The most abundant plant species which can be clearly recognized in Table 1, *Centella asiatica*, *Alternanthera triandra*, and *Ipomea aquatica*, are herbaceous leafy vegetables. As they are small herbs, high numbers of plants were maintained in 1-3 m^2 plots, hanging pots or ground containers. Anthurium, dracaena, poliscias, dendrobium, rhoeo were common ornamental plant species and musa, coconut, capsicum, and brinjal were other common food plant species.

There were a few plant species which could be considered as rare (low frequency and abundance) among the least available plant species in suburban home gardens (figure 1). Cinnamon was the major crop in the area a few decades ago in cultivation. It is a native plant in sandy loam soils and offers high quality products. But cinnamon was limited to only 13 households. Some medicinal plants, including *Cassia auriculata*, *Cassia pistula, Risinus communis, Ocimum tenuiflorum, Plectranthus zeylanicus, Lawsonia inermis, Cissus quadrangularis, Acorus calamus,* and some ornamental plants such as *Merigold tagetes, Gardenia jasminoides, Hibiscus mutabilis, Cannas* spp. *Gomphrena globosa*, and *Celosia argenta*, were also restricted to less than 10 home gardens. These species were worth conserving in the area. Suburban home gardens showed the capability of preserving these valuable species while the owners are using them.

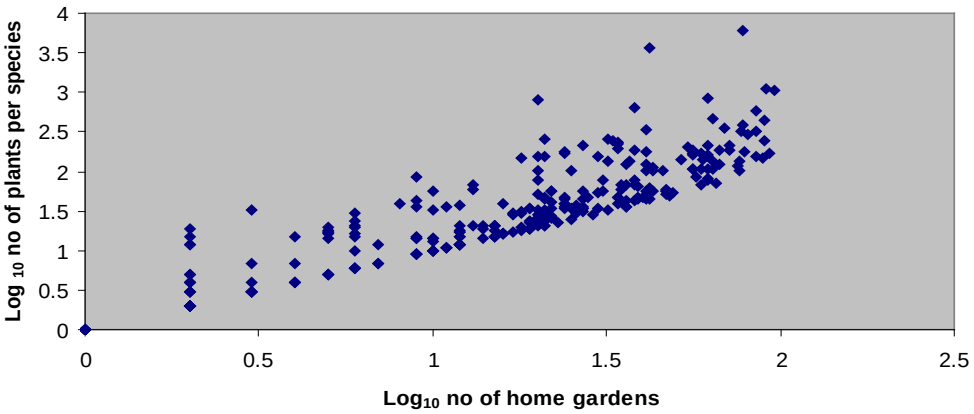

Figure 1 The frequency and abundance of total plant species in home gardens

While most food plants were well maintained, *Carica papaya*, normally a common fruit was reported in only 5 gardens. A recent epidemic caused by mealy bug has damaged a large number of plant species, including papaya. However, more than 60 home gardens maintained at least some of these crops essential for their daily needs, including curry leaves, pandanus, chilies, banana, lime, and coconut. One motivating feature of these home gardens was respondents' effort to maintain some species/varieties which were not so available in the area, such as *Canavalia ensiformis, Vanilla fragrance, Santalum album, Mimusops elengi,* and *Murraya paniculata*. Many of food and spice

plants found in suburban home gardens which possessed medicinal values, and medicinal plants were identified as a high priority by respondents.

A total of 289 species were identified across 106 suburban home gardens. This high number included 105 food plant species 148 ornamental species and 34 medicinal species. Average plant diversity per home garden was 45 species (range 14–95 plant species), of which 85% were perennials. Wezel and Bender, 2003 studied plant diversity in Cuban home gardens. In total, 101 different plant species were found with an average number of 18 to 24 species per homegarden for the three villages. In total 120 plant species were recorded in the home garden systems of Sidama (Abebe, 2005). The total number of species encountered in the homegardens in Assam, was 122 (Das and Das, 2005). However this does not compare to the entire urban garden flora that contained 1,166 species in 61 gardens in Sheffield, UK (Smith et al, 2006), which included all weedy and wild species.

Table 1 List of plants observed in suburban home gardens with their characteristics

	Family	**Species**	**Uses[1]**	**Habits[2]**	**Season[3]**	**No of gardens**	**No of plants**
1	Acanthaceae	*Fitonia* spp.	O	H	P	56	108
2		*Crossandra infundibuliformis*	O	H	P	16	39
3		*Odontonema strictum*	O	H	P	25	25
4		*Pachystachys lutea*	O	H	P	24	39
5		*Pseuderanthemum laxiflorum*	O	S	P	23	23
6		*Pseuderanthemum reticulatum*	O	S	P	2	5
7		*Sanchezia speciosa*	O	S	P	15	21
8	Agavaceae	*Cordyline terminalis*	O	H	P	56	187
9		*Cordyline australis*	O	H	P	35	67
10		*Yucca* spp.	O	H	P	18	30
11		*Agave* spp.	O	H	P	56	107
12		*Sansevieria trifoliatus*	O	H	P	24	167
13	Amaryllidaceae	*Pancratium longiflorum*	O	H	P	19	19
14	Amaranthaceae	*Alternanthera ficoidea*	O	H	P	21	260
15		*Gomphrena globosa*	O	H	A	5	17
16		*Celosia argenta*	O	H	A	3	7
17		*Alternanthera dentata*	O	H	P	33	240
18		*Alternanthera triandra*	Fv	H	P	42	3630
19		*Achyranthes aspera*	M	H	P	2	15
20		*Aerva lanata*	M	H	P	37	134
21	Anacardiaceae	*Mangifera indica*	Ff	T	P	75	117
22		*Spondias dulcis*	Ff	S	P	65	72
23		*Anacardium oxidentale*	Ff	T	P	6	10
24	Annonaceae	*Annona muricata*	Ff	T	P	16	16
25		*Annona squamosa*	Ff	T	P	15	15
26		*Anonna reticulata*	Ff	T	P	10	10
27	Apocynaceae	*Plumeria alba*	O	T	P	19	24
28		*Plumeria rubra*	O	T	P	22	27
29		*Allamanda blanchetii*	O	S	P	47	58
30		*Allamanda cathartica*	O	S	P	20	77

Table 1 (Cont.)

	Family	Species	Uses[1]	Habits[2]	Season[3]	No of gardens	No of plants
31		*Plumeria acuminata*	O	S	P	24	45
32		*Nerium oleander*	O	S	P	26	30
33		*Trachelospermum jasminoides*	O	S	P	49	55
34		*Ervatamia divaricata*	O	S	P	34	47
35		*Adenium obesum*	O	H	P	39	45
36		*Catharanthus roseus*	M	H	P	9	36
37		*Carissa congesta*	Ff/O	S	P	9	9
38	Apiaceae	*Centella asiatica*	Fv	H	P	78	6120
39	Araceae	*Lasia spinosa*	Fv	H	P	27	210
40		*Amophophallus commutatus*	Fr	H	A	2	2
41		*Colocasia esculanta*	Fr	H	A	20	52
42		*Anthurium andraeanum*	O	H	P	91	1121
43		*Anthurium hookeri*	O	H	P	62	109
44		*Anthurium cristallinum*	O	H	P	59	105
45		*Diffenbachia spp.*	O	H	P	62	213
46	Araceae	*Monstera spp.*	O	H	P	20	29
47		*Philodendron spp.*	O	H	P	85	154
48		*Spathiphyllum* spp.	O	H	P	19	34
49		*Syngonium* spp.	O	H	P	24	39
50		*Alocasia* spp.	O	H	P	52	139
51		*Caladium* spp.	O	H	P	27	45
52		*Aglonima*	O	H	P	54	205
53	Araliaceae.	*Poliscias balfouriana*	Fv	S	P	62	846
54		*Schefflera* spp.	O	H	P	36	42
55	Arecaceae	*Cyrtostachys renda*	O	T	P	38	78
56		*Pritchardia beccariana*	O	T	P	22	34
57		*Chamaedorea siefritzii*	O	T	P	12	18
58		*Dypsis letescens*	O	T	P	21	30
59		*Chrysalidocarpus lutescens*	O	T	P	71	217
60		*Areca catechu*	Fs	T	P	20	32
61	Aristolochiaceae	*Aristolochia bractelolecta*	M	HV	P	3	3
62	Asteraceae	*Gerbera jamesonii*	O	H	P	38	187
63		*Merigold tagetes* spp.	O	H	P	10	32
64		*Chrysanthemum* spp.	O	H	P	36	68
65		*Zinnia elegans*	O	H	A	21	154
66		*Oclemena nemoralis*	O	H	P	20	26
67		*Senecio macroglossus*	O	H	P	10	14
68		*Senecio confusus*	O	H	P	27	34
69	Asclepiadaceae	*Dregea volubilis*	Fv	WV	P	20	26
70		*Wattakaka volubilis*	Fv	WV	P	21	21
71		*Hemidemus indicus*	M	HV	P	13	67
72		*Hoya carnosa*	O	H	P	21	32
73	Asphodelaceae	*Aloe vera*	M	H	P	76	102
74		*Aloe deltoideodonta*	M/O	H	P	1	1
75	Aspleniaceae	*Asplenium spp*	O	H	P	79	176
76	Balsaminaceae	*Impatiens balsamina*	O	H	A	22	57
77		*Impatiens hawkeri*	O	H	P	57	86

Table 1 (Cont.)

	Family	Species	Uses[1]	Habits[2]	Season[3]	No of gardens	No of plants
78	Basellaceae	*Basella rubra*	Fv	HV	P	62	160
79	Bignoniaceae	*Cydista aequinoctialis*	O	WV	P	11	11
80		*Tecoma stans*	O	S	P	16	16
81		*Podranea brycei*	O	WV	P	12	12
82	Begoniaceae	*Begonia* spp.	O	H	P	85	320
83	Brassicaceae	*Brassica caulorapa*	Fv	H	A	2	12
84		*Raphanus sativus*	Fv	H	A	20	156
85		*Brassica oleracea*	Fv	H	A	41	180
86	Bromeliaceae	*Guzmania spp.*	O	H	P	39	64
87		*Ananas cosmosus*	Ff	H	A	6	30
88		*Bromeliad spp.*	O	H	P	46	103
89	Cactaceae	*Cactus spp.*	O	H	P	71	187
90	Cannaceae	*Cannas spp.*	O	H	A	6	24
91	Caricaceae	*Carica papaya*	Ff	S	P	5	5
92	Clusiaceae	*Garcinia mangostana*	Ff	T	P	2	2
93	Combretaceae	*Quisqualis indica*	O	WV	P	11	11
94		*Terminalia glabra*	O	T	P	1	1
95	Commelinaceae	*Rhoeo* spp.	O	H	P	38	650
96		*Tradescantia pallida*	O	H	P	22	56
97		*Tradescantia zebrina*	O	H	P	24	36
98		*Commelina diffusa*	Fv	H	A	6	20
99	Convolvulaceae	*Ipomea batata*	Fr	H	A	18	150
100		*Ipomea aquatica*	Fv	H	A	20	820
101		*Ipomoea horsfalliae*	O	WV	P	14	14
102	Costaceae	*Costus speciosus*	Fv	H	P	22	40
103	Crassulaceae	*Bryophyllum pinnatum*	M	H	P	8	39
104		*Sedum morganianum*	O	H	P	36	36
105	Cucurbitaceae	*Citratus lanatus*	Ff	HV	A	3	3
106		*Luffa acutangula*	Fv	HV	A	41	121
107		*Cucurbita maxima*	Fv	HV	A	20	24
108		*Momordica charantia*	Fv	HV	A	30	55
109		*Trichosanthes cucumerina*	Fv	HV	A	15	21
110		*Benincasa hispida*	Fv	HV	A	2	3
111		*Cucumis sativus*	Fv	HV	A	14	19
112		*Coccinea grandis*	Fv	HV	A	15	21
114	Cycadaceae	*Cycus rumphii*	Fv/O	T	P	15	15
115		*Cycas revoluta*	O	H	P	7	7
116	Cyperaceae	*Cypress* spp.	O	H	P	64	134
117	Dioscoreaceae	*Dioscorea alata*	Fr	HV	A	17	28
118	Ebenaceae	*Diospyros sativa*	Fr	H	A	6	15
119	Elaeocarpaceae	*Elaeocarpus serratus*	Ff	T	P	16	16
120		*Muntingia calabura*	Ff /O	T	P	12	12
121	Euphorbiaceae	*Risinus communis*	M	S	P	7	12
122		*Croton* spp.	O	S	P	56	167
123		*Acalypha wilkesiana*	O	S	P	25	102
124		*Acalypha godseffiana*	O	S	P	34	238
125		*Acalypha hispida*	O	S	P	12	12
126		*Acalypha chamaedrifolia*	O	S	P	9	15

Table 1 (Cont.)

	Family	Species	Uses[1]	Habits[2]	Season[3]	No of gardens	No of plants
127		*Euphobia tirucalli*	O	H	P	27	35
128		*Euphobia milli*	O	H	P	67	122
129		*Pedilanthus tithymalodes*	O	H	P	24	178
130		*Jatropha spp.*	O	H	P	47	56
131		*Jatropha integerrima*	O	S	P	41	57
132		*Phyllanthus emblica*	Ff	T	P	11	11
133		*Manihot esculanta*	Fr	H	A	30	152
134	Fabaceae	*Cynometra cauliflora*	Ff	S	P	4	4
135		*Sesbania grandiflora*	Fv	S	P	40	48
136	Fabaceae	*Psopocarpus tetragonolobus*	Fv	HV	B	60	143
137		*Vigna unguiculata*	Fv	HV	A	31	56
138		*Canavalia ensiformis*	Fv	WV	P	6	6
139		*Phaseolus vulgaris*	Fv	HV	A	2	19
140		*Pongamia glabra*	M	T	P	2	2
141		*Clitoria terenata*	O	HV	P	24	34
142		*Gliricidia makulata*	O/Fw	T	P	18	31
143		*Tamarindus indica*	Ff	T	P	3	3
144		*Cassia tora*	Fv	H	A	10	56
145		*Cassia auriculata*	M	T	P	7	7
146		*Cassia fistula*	M	T	P	6	6
147		*Cassia didymobotria*	M	H	P	2	2
148		*Bauhinia acuminata*	O	S	P	5	5
149		*Bauhinia purpurea*	O	T	P	10	10
150		*Caesalpinia pulcherrima*	O	S	P	26	31
151		*Calliandra emarginata*	O	S	P	6	21
152	Flacourtiaceae	*Flacourtia incrimis*	Ff	T	P	9	9
153		*Flacourtia indica*	Ff	T	P	10	10
154	Gesneriaceae	*Episcia* spp.	O	H	P	62	77
155		*Aeschynanthus lobbianus*	O	H	P	12	15
156	Gramineae	*Vetiveria zizanioides*	M	H	P	12	12
157	Grassulaceae	*Kalanchoe daigremontiana*	O	H	P	26	37
158	Heliconiaceae	*Heliconia rostrata*	O	H	P	11	36
159	Hydrangeaceae	*Hydrangea macrophylla*	O	S	P	14	21
160	Lamiaceae	*Coleus ambouinicus*	M	H	P	5	17
161		*Ocimum tenuiflorum*	M	H	P	3	3
162		*Plectranthus zeylanicus*	M	H	P	6	16
163		*Coleus* spp.	O	H	P	34	190
164		*Coleus rotundifolius*	Fr	H	A	12	37
165	Lauraceae	*Persea americana*	Ff	T	P	22	26
166		*Cinnamomum zelanicum*	Fs	T	P	13	21
167	Liliaceae	*Asparagus falcatus/racemosus*	M	WV	P	47	56
168		*Gloriosa superba*	M	H	P	2	4
169		*Dracaena spp.*	O	H	P	96	1041
170		*Sansevieria cylindrica*	O	H	P	34	218
171		*Chlorophytum spp.*	O	H	P	43	102
172	Lythraceae	*Lawsonia inermis*	M	S	P	9	9
173		*Lagerstroemia indica*	O	S	P	39	47

Table 1 (Cont.)

	Family	Species	Uses[1]	Habits[2]	Season[3]	No of gardens	No of plants
174	Malpighiaceae	*Tristellatera australasiae*	O	WV	P	21	21
175		*Malpighia glabra*	Ff/O	S	P	5	5
176	Maranthaceae	*Phrynium zeylanicum*	Fr	H	A	9	42
177		*Calathea spp.*	O	H	P	56	163
178		*Marantha spp.*	O	H	P	27	34
179	Malvaceae	*Hibiscus spp.*	O	S	P	12	21
180		*Hibiscus mutabilis*	O	S	P	1	1
181	Malveseae	*Abelmoschus esculantus*	Fv	H	A	41	343
182	Meliaceae	*Swietenia mahogany*	Ti	T	P	2	4
183		*Azadirachta indica*	M	T	P	41	45
184	Menispermaceae	*Tinospora cordifloria*	M	H	P	3	3
185	Menyanthaceae	*Nymphoides indica*	O	H	P	4	15
186	Moraceae	*Morus alba*	Ff	S	P	1	1
187		*Artocarpus heterophyllus*	Ff	T	P	30	34
188		*Artocarpus altilis*	Ff	T	P	15	15
189		*Ficus benjamina*	O	S	P	76	136
190	Moringaceae	*Moringa oleifera*	Fv	S	P	27	31
191	Musaceae	*Musa* spp.	Ff	H	P	90	435
192	Myristicaceaec	*Eugenia caryophyllata*	Fs	T	P	2	4
193	Myrtaceae	*Psidium guajava*	Ff	T	P	59	67
194		*Psidium cattleianum*	Ff	S	P	12	15
195		*Syzygium jambos*	Ff	T	P	16	16
196		*Syzygium samarangense*	Ff	S	P	29	29
197		*Zyzygium cumini*	Ff	T	P	1	1
198	Nelumbonaceae	*Nelumbo nucifera*	O	H	P	1	1
199	Nephrolepidaceae	*Nephrolepis* falcata	O	H	P	90	239
200	Nyctaginaceae	*Pisonia grandis*	Fv	S	P	1	1
201		*Bougainvillia*	O	S	P	77	326
202		*Mirabilis jalapa*	O	H	A	5	18
203	Nymphaeaceae	*Nymphaea stellata*	O	H	P	5	5
204		*Nymphaea lotus*	O	H	P	2	12
205	Oleaceae	*Jasminum sambac*	M	S	P	34	39
206		*Jasminum polyanthum*	M	H	P	42	62
207		*Nyctanthes arbor-tristis*	O	S	P	4	4
208	Orchidaceae	*Dendrobium* spp.	O	H	P	85	572
209		*Vanda* spp.	O	H	P	36	122
210		*Oncidium* spp.	O	H	P	89	151
211		*Cattleya* spp.	O	H	P	27	56
212		*Phalaenopsis* spp.	O	H	P	43	112
213		*Spathoglottis plicata*	O	H	P	21	44
214		*Ludisia discolor*	O	H	P	15	18
215		*Vanilla fragrance*	Fs	HV	P	3	3
216	Oxalidaceae	*Oxalis* latifolia.	O	H	P	38	67
217		*Averrhoa carambola*	Ff	T	P	20	21
218		*Averrhoa bilimbi*	Ff	S	P	18	18
219	Palmae	*Cocos nucifera*	Ff	T	P	69	349
220	Pandanaceae	*Pandanus latifolius*	Fc	H	P	62	83

Table 1 (Cont.)

	Family	Species	Uses[1]	Habits[2]	Season[3]	No of gardens	No of plants
221	Passifloraceae	*Passiflora edulis*	Ff	WV	P	22	26
222	Piperaceae	*Piper nigram*	Fs	WV	P	17	30
223		*Piper betle*	Fs	WV	P	32	132
224		*Peperomia* spp.	O	H	P	41	102
225	Plumbaginaceae	*Plumbago auriculata*	O	H	P	28	46
226	Poaceae	*Cymbopogan citratus*	Fc	H	P	10	13
227		*Saccharum officinarum*	M	H	P	2	5
228		*Bambusa* spp.	O	S	P	21	24
229	Polygonaceae	*Muehlenlenbeckia platyclada*	M	H	P	4	4
230		*Platycerium bifurcatum*	O	T	P	64	107
231	Portulacaceae	*Portulaca grandiflora*	O	H	A	9	86
232	Punicaceae	*Punica granatum*	Ff	S	P	47	51
233	Rosaceae	*Prunus americana*	Ff	S	P	2	3
234		*Rosa* spp.	O	H	P	67	185
235	Rubiaceae	*Coffea arabica*	Fb	S	P	25	34
236		*Hedyotis nitida*	Fv	H	P	20	102
237		*Gardenia jasminoides*	O	S	P	2	2
238		*Ixora* spp.	O	H	P	78	380
239		*Pentas lanceolata*	O	H	P	43	56
240		*Mussaenda frondosa*	O	S	P	9	14
241		*Mussaenda erythophylla*	O	S	P	16	16
242	Rutaceae	*Citrus aurantifolia*	Ff	S	P	42	45
243		*Citrus sinensis*	Ff	T	P	19	19
244		*Citrus maxima*	Ff	T	P	10	10
245		*Citrus reticulata*	Ff	S	P	36	36
246		*Citrus limon*	Ff	S	P	48	50
247		*Citrus grandis*	Ff	T	P	12	12
248		*Limonia acidissima*	Ff	T	P	6	6
249		*Aegle marmelos*	Ff	T	P	9	9
250		*Murraya koenigi*	Fc	S	P	93	167
251		*Murraya paniculata*	O	S	P	12	12
252	Santalaceae	*Santalum album*	M	T	P	2	2
253	Sapindaceae	*Nephelium lappaceum*	Ff	T	P	38	42
254		*Filicium decipiens*	O	T	P	22	27
255		*Cardiospermum helicacabrum*	M	HV	P	24	47
256	Sapotaceae	*Mimusops elengi*	M	T	P	1	1
257		*Manilkara sapota*	Ff	T	P	6	6
258		*Pouteria campechiana*	Ff	T	P	1	1
259	Scrophulariaceae	*Torenia fournieri*	O	H	P	5	20
260		*Leucophyllum frutescens*	O	S	P	32	32
261		*Otacanthus caeruleus*	O	H	P	19	19
262		*Russelia equisetiformis*	O	S	P	12	17
263	Selaginellaceae.	*Selaginella spp.*	O	H	P	3	32
264	Solanaceae	*Solanum melongena*	Fv	H	B	32	253
265		*Solanum xanthocarpun*	Fv	H	B	31	76
266		*Solanum indicum*	Fv	H	B	19	34
267		*Capsicum annum*	Fv	H	A	81	290

Table 1 (Cont.)

	Family	Species	Uses[1]	Habits[2]	Season[3]	No of gardens	No of plants
268		*Lycopersicom esculentum*	Fv	H	A	21	48
269		*Mentha viridis*	Fv	H	A	4	7
270		*Vithania somnifera*	M	H	P	1	1
271	Solanaceae	*Brugmansia*	O	H	P	3	4
272		*Brunfelsia calycina*	O	S	P	19	23
273		*Brunfelsia americana*	O	S	P	21	24
274	Sterculiaceae	*Theabroma cacao*	Fb	S	P	2	2
275	Urticaceae	*Pilea cadierei*	O	H	P	34	46
276	Verbenaceae	*Duranthas Sheena's Gold*	O	S	P	64	463
277		*Lantana montevidensis*	O	H	P	18	20
278		*Clerodendrum thomsoniae*	O	Wv	P	12	17
279		*Tectona grandis*	Ti	T	P	1	1
280		*Vitex negundo*	M	S	P	17	17
281	Vitaceae	*Vitis vinifera*	Ff	WV	P	10	14
282		*Cissus quadrangularis*	M	HV	P	1	1
283	Zamiaceae	*Zamioculcas zamiifolia*	O	H	P	9	14
284	Zingiberaceae	*Zingiber officinale*	Fc/M	H	A	59	167
285		*Curcuma longa*	Fc	H	A	35	60
286		*Acorus calamus*	M	H	A	2	2
287		*Kaempferia galaga*	M	H	P	5	14
288		*Alpinia purpurata*	O	H	P	13	60
289		*Alpinia zerumbet*	O	H	P	5	16

Use[1]: Ff; fruits, Fv; vegetables, Fc; culinary crops, Fs; Spices, Fb; beverage crops
Habit[2]: T; tree, S; shrubs, H; herbs, HV; herbaceous vine, WV; woody vine
Season[3]: P; perennial, A; annual, B; biennial

3.3 Factors affecting plant diversity in home gardens

3.*3.1 Total plant diversity (TPD)*

Plant diversity in this study was considered as different plant species found in home gardens across the area. Thus, the unit of plant diversity meant the number of plant species. Different types of plant diversity were regressed on internal and external household factors and results were illustrated in table 2. Total plant diversity (TPD) of suburban home gardens was predicted with the first equation in the table (model 1). Education level (years of schooling), time spent in gardening (hours/week), land area for gardening (m^2), household expenses, and conservation practices played significant roles in explaining total plant diversity in the first model. Each additional year of schooling increased total plant diversity by 5 units. People who followed the conservation practices maintained 13 additional units of diversity per unit of conservation practice. Each hour of additional care of plants or gardening tended to increase total plant diversity by about 2 units. The interaction between land area and special techniques in gardening was also highly significant ($p < 0.01$) in predicting total plant diversity. With higher cost of living, people also tended to grow more plant species in the gardens. This demonstrated

the economic importance of plant species in the household. However, this effect could be simply due to more affluent people with higher living costs engaged in raising plants as a hobby.

Table 2 Total, food, ornamental, medicinal, and commercial plant diversity in home gardens regressed on internal and external household factors, with significant variables and interactions are listed under each model

	Total plant diversity		Food plant diversity		Ornamental plant diversity		Medicinal plant diversity		Commercial plant diversity	
	Model 1		Model 2		Model 3		Model 4		Model 5	
Independent variables	*b*	*Beta*	*b*	*Beta*	*b*	*Beta*	*b*	*Beta*	*b*	*Beta*
Education	5.351** (*1.616*)	0.214	0.711** (*0.295*)	0.197			0.440** (*0.126*)	0.325		
Time spent gardening	1.896** (*0.331*)	0.378	0.853** (0.182)	0.354	1.014** (0.250)	0.350			0.241** (0.074)	0.287
Land area	0.009** (*0.003*)	0.194	0.006** (*0.002*)	0.266	0.005* (*0.003*)	0.190			0.002** (*0.001*)	0.299
Household income					0.000* (*0.000*)	0.196				
Household - expenses	0.000** (*0.000*)	0.187								
Settlement period					- 0.175** (*0.063*)	-0.251	0.062** (*0.020*)	0.284		
Extension service) (Agriculture)	-6.269* (*2.606*)	-0.151								
Access to planting -material			2.573* (*1.028*)	0.168						
Conservation	13.591** (*2.786*)	0.312	7.611** (*1.584*)	0.364			1.959** (*0.698*)	0.249		
Special techniques in gardening					6.125** (*2.122*)	0.250			1.818** (0.629)	0.255
Land* Special techniques	0.105** (*0.023*)	0.303								
No.of observations	106									
R^2	0.653		0.501		0.318		0.200		0.266	

Note: *b* = regression coefficients for independent variables followed by standard error in parentheses
Beta = standardized regression coefficient for independent variables.
*p < 0.05 level. **p < 0.01 level.

Extension service was negatively related to total plant diversity, indicating its lack of importance in maintaining plant diversity in the suburban area. Conversely, the standardized coefficient (beta) in the table showed that the time spent in gardening had the highest effect on plant diversity ahead of

conservation practices, while extension services had a minute effect on TPD. The combined effects of all significant variables explained 65% of the variability in total plant diversity.

3.3.2 Food plant diversity (FPD)

Model 2 in the table illustrated that conservation of planting material had a significant positive effect ($p < 0.01$) on FPD. Time spent in gardening, education and land area also had highly significant positive relationships with food plant diversity ($p < 0.01$). The data shows that additional years of schooling and one hour of gardening tended to increase food plant diversity by one unit, whereas a 1000 m^2 increase in land contributed 6 units to food plant diversity. Access to planting materials also had significant effects ($p < 0.05$) on food plant diversity. Nevertheless these five independent variables in model 2 explained 50% of the variation of food plant diversity.

3.3.3 Ornamental plant diversity (OPD)

Model 3 analyzed effects on ornamental plant diversity. Special techniques in gardening played a considerable role in increasing ornamental plant diversity. Uses of different methods such as vertical farming, hydroponics, and rooftop farming were considered as special techniques. Time spent in gardening also showed the highly positive relationship with ornamental plant diversity, and one unit increase in ornamental plant diversity resulted from one further hour of gardening. Land area and household income had positive relationships with OPD ($p < 0.05$). Settlement period had a negative relationship with ornamental plant diversity; new residents had higher interest in ornamental plants than long-term inhabitants in the area. Standardized coefficients (beta) showed that time spent in gardening had a stronger effect on ornamental plant diversity than settlement period.

3.3.4 Medicinal plant diversity (MPD)

Conservation of planting material, education, and settlement period of residents were positively related to medicinal plant diversity ($p < 0.01$). These three variables explained 20% of the variation of MPD in model 4. Education had the greatest effect on MPD according to the standardized coefficients. Results confirmed that people with long residence period and good education recognized the importance of rearing medicinal plants.

3.3.5 Commercial plant diversity (CPD)

Commercial plants were those give economic yield to the household in monetary terms. Coconut, banana, and other fruits, spices, orchids, anthurium, dracaena, pot plants, and few others fell in this category. In model 5, special techniques, time spent for gardening and land area explained 26% of the variation in commercial plant diversity. Commercial plant diversity showed a strong positive relationship with special techniques. Land area had little higher effect on CPD over other variables.

Plant diversity in urban gardens may generally reflect socio-economic, cultural, and traditional ecological concepts of inhabitants (Hope *et al*., 2003). Recently it was influenced by commercialization, urbanization, and fragmentation (Kehlenbeck et.al., 2007). Elevation, current and former land use, family income, housing age, and education level were found to be best explain the variation in plant diversity across the city gardens (Hope et al., 2003). With a closer relation in food security, household economy contributed as a factor for plant diversity (Gilimani, 2005). In European countries; garden size accounted for about a third of the variation in total species richness across gardens, but the relationship was weak. The behavior of gardener was likely to be stronger factor which influenced by education, fashion, and advices than garden size in determining plant diversity (Smith et al., 2006). Present study reflected majority of above factors played a considerable role in suburban home garden plant diversity in Sri Lanka.

3.4 Annual contribution of home garden products to household economy

The mean annual value of food plants was 7,714 Rupees per household. A majority of households gained 7,500 Rupees from food plants. This ranged from 600 to 25,250 Rupees across the households. Households with large lands and coconut trees obtained the highest income. Medicinal plants showed comparatively low values with the mean of 1,623 Rupees/household per year. Most households had at least 1,400 Rupees from medicinal plants, with the range of 150-4,500 Rupees. Commercial plants including food, medicinal, and ornamental species had a mean annual value of 3,578 Rupees, with the range of 0-35,000 Rupees. Forty percent of households didn't raise commercial plants, even though many had species with commercial value. They did share them with neighbors.

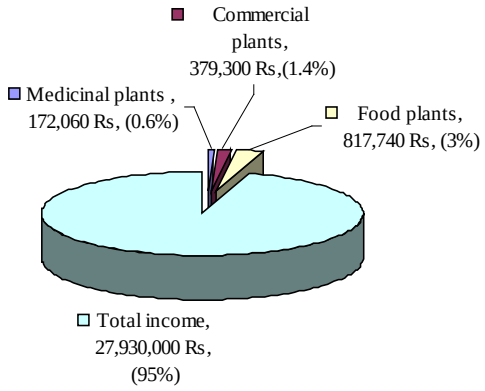

Figure 2 Percentage contributions of suburban home garden products to annual households income

In calculating total annual contribution of suburban home gardens to households, a few assumptions were made. Even though food and medicines used by households didn't represent direct income to households, it was assumed that home garden products (both used and sold) contributed to households as income. Monthly incomes and expenses of households were also gathered during the survey. The

contribution accounted for 5% of total annual income, of which 3% was from food plants, 1.4 % from commercial plants, and 0.6% from medicinal plants. Across the households, the home garden contribution ranged from 0.01% to 21% of total income. In the majority of households, the contribution of home garden products was not more than 2.8% of total income.

The value of total annual fresh food products (home garden products + market fresh products) consumed by households was equivalent to 13 % of total household expenses (range 5% to 35). Home garden fresh products provided 27% of total annual fresh products with the range of 1% to 57%. A higher percentage of contribution was frequently observed in the home gardens with coconut plants used for home consumption. Home garden fresh products consisted of fruits, vegetables, spices, and medicines. Leafy vegetables, medicinal plants, and fruits provided year round benefits to the households. More over 57% of annual vegetable species across the home gardens supplied considerable amount of fresh products with higher quality for household consumption.

A study of urban and rural households in three Russian provinces found that two-thirds of all households obtained some income from agricultural home production. In rural areas the market value of home production exceeded household labor income (Mitchell and Hanstad, 2004). In the Helen Keller International (HKI/AP 2003) pilot home garden project in Bangladesh, 54 % of households reported selling home garden products and earning the cash equivalent of 14.8% of total average monthly income (HKI/AP 2003). The present study reflects the contribution of suburban home gardens products to households. Gilimani (2005) revealed that there was very little contribution in terms of income made by home production for home consumption. Contribution of Eastern Cape Households was 12% of total income while Kwazulu–Natal households contributed 6.7% of the total income. These finding was in line with the results of present study.

The major part (73%) of fresh products consumed by suburban households came from the market. Most people in the sample shopped in the vegetable and fruit markets for fresh products rather than the supermarket. These markets were held daily or weekly and were near to the suburban area. Roadside vegetable and fruit sales were frequently used by the people in the area. Most fresh products sold were not present in most home gardens, such as carrot, beet root, bean, onion, lotus root, cabbage, pineapple, apple, grapes, water melon, and other fruits. The use of modern supermarket for fresh products was very low in the area. Cargills super market was the nearest supermarket which was situated at 1.5 km from the suburban area.

4. Conclusion

The present study shows that plant species diversity in suburban home gardens were dominated by ornamental plants (51%) followed by food plants (36%) and medicinal plants (12%). Food plant made

highest contribution to household income (3%) and annual fresh products used (27%). All the factors which significantly affected plant diversity emphasized that gardener attitudes, decisions, skills, and management heavily influenced number of plant species in the home garden.

Plant diversity is not a priority issue in the country. But national policy has already for promoted urban agriculture for household food security and environment protection. Thus it is a useful opportunity for increasing plant diversity in urban/suburban home gardens through promotion of their own benefits. Peoples' understanding about greener and cleaner environment provided a base to launch long term programs for gardening, and conservation of plants. Hence, the relevant government and nongovernmental sectors have considerable roles in promoting urban/suburban home gardens, to enhance food security, native plant diversity, and relevant issues for a better quality of life of people.

5. Acknowledgement

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