

**HOMEGARDENS AS A SOURCE OF MICRONUTRIENTS: AN  
ANALYSIS OF FOOD HARVESTED FROM HOMEGARDENS IN  
KANDY, KURUNEGALA AND BATTICALOA DISTRICTS  
IN SRI LANKA**

J. WEERAHEWA<sup>1</sup>, B. WIJERATHNE<sup>2</sup> AND D.K.N.G. PUSHPAKUMARA<sup>3</sup>

<sup>1</sup>Department of Agricultural Economics and Business Management, <sup>2</sup>Postgraduate Institute of Agriculture, <sup>3</sup>Department of Crop Science, Faculty of Agriculture, University of Peradeniya.

**ABSTRACT**

**Micronutrient malnutrition has been identified as one of the serious health problems in Sri Lanka. This study investigates the potential of homegardens in fulfilling micronutrient requirement of the household through provision of a range of vegetables and fruits. The specific objectives are to: (i) identify species composition in homegardens, (ii) calculate the per person consumption of vitamins A and C, calcium and iron from the harvested products from the homegarden and (iii) analyze the factors affecting intake of above micronutrients by the households using an econometric approach. Data gathered from a primary survey conducted in 643 homegardens in Kandy, Kurunegala and Batticaloa districts, was used for the analysis. The results show that on average, a homegarden provides 63%, 73% and 4% of the vitamin C requirement in Kandy, Kurunegala and Batticaloa, districts, respectively and the provision of other nutrients is less than 15% of their respective requirements in all 3 districts. The food species diversity is highest in Kandy district followed by Kurunegala and Batticaloa districts. The results also reveal that the amounts of vitamins A and C, calcium and iron obtained from homegardens are higher in Kurunegala due to higher abundance and productivity of micronutrient rich food species such as nelli, guava, lime, mango and papaya. The results of the econometric estimations show that smaller families, those who are engaged in farming, those who manage the gardens well and those who reside in Kandy and Kurunegala districts tend to obtain more micronutrients from the homegardens. Moreover, the higher the fruit species diversity, the greater the levels of micronutrients obtained from homegardens. Improvements in the structure, composition and management of homegardens are recommended as potential strategies to increase obtaining of micronutrients from the homegardens.**

**KEYWORDS:** Species diversity, Homegardens, Micronutrients, Sri Lanka

## INTRODUCTION

The global toll of people affected by micronutrient deficiencies is estimated to be much higher than the people with low energy intakes. Iodine, vitamin A and iron are the most important micronutrients in global public health terms, as their inadequacy represents a major threat to the health and development of populations, particularly children and pregnant women in low-income countries. Nearly 37% of the world population suffers from anaemia and it is mainly due to iron deficiency. According to the World Health Organization, 45 and 122 countries have vitamin A deficiency of public health significance based on the prevalence of (i) night blindness and (ii) biochemical vitamin A deficiency (serum retinol concentration  $<0.70 \mu\text{mol/l}$ ), respectively, in preschool-age children during the period 1995-2005 (WHO, 2011).

The three key micronutrient deficiencies found in Sri Lanka include iron deficiency anaemia (IDA), vitamin A deficiency (VAD), and iodine deficiency disorders (ACC/SCN, 2001; Hettiarachchi *et al.*, 2006; MRI, 1998a; 1998b). According to the demographic and health survey of the Department of Census and Statistics of Sri Lanka, the prevalence of anaemia among children aged 6-59 months, pregnant and non-pregnant women aged 15-49 years are 36%, 39% and 34%, respectively (DCS, 2006/07). Micronutrient deficiencies are most prevalent when the diet lacks variety. When people cannot afford to supplement their diets with adequate amounts of fruits, vegetables or animal-source foods that contain large amounts of micronutrients, deficiencies are inevitable. In this regard, homegardens can play a vital role as they are abundant sources of fruits and vegetables (Pushpakumara and Silva, 2008; Pushpakumara *et al.*, 2010; 2011; Ruel and Levin, 2002).

A homegarden is a supplementary food production system managed and controlled by household members. A portion of the production of homegarden is consumed by the producers and the rest is either sold or shared with neighbours. However, homegarden products are often not the household's primary source of food or income (Soleri *et al.*, 1991), but it may be a supplementary source. Homegardens provide food to households throughout the year at a lower cost and it helps in increasing quality and quantity of food consumed (Caron, 1995; Marsh, 1998; Mendez *et al.*, 2001; Ndaeyo, 2007; Pushpakumara *et al.*, 2010; Soemarweto, 1987). It has also been reported that households with gardens typically provide

more than 50% of vegetables, fruits, medicinal plants and herbs requirement of the household (Soleri *et al.*, 1991; Marsh and Talukder, 1994; UNDP, 1996 in Marsh, 1998). According to Kabeya and Paulus (1997), by promoting household food production more than 30% of the families have improved the quantity and quality of their weekly intake of food in Kinshasa, Zaire. A recent study done in some countries in Asia (Bangladesh, Cambodia, Nepal and the Philippines) by Talukder *et al.* (2010) showed that household food consumption can be improved through promotion of homegardens along with provision of education on nutrition. It was estimated that homegardens in Sri Lanka produce 50-60% of leafy vegetables and 20% of all vegetables consumed by the household (Ensing *et al.*, 1985; Kumari, 2009).

Even though there is ample empirical evidence to highlight the contribution of homegardens as a source of food, there is a dearth of studies that quantified the contribution of homegardens in providing micronutrients. It has been found that homegardens in villages in Lawang, East Java produce a daily average of 398.4 calories, 22.8 g protein, 16.4 g fat, 185 g carbohydrate, 818.4 mg calcium, 555 mg phosphorous, 14 mg iron, 8,362 IU vitamin A, 1,181.2 mg vitamin B and 305 mg vitamin C (Hayadi, 1975). According to Marsh and Talukder (1994) even a very small mixed vegetable garden can provide a significant percentage of the recommended dietary requirement of protein, iron, calcium, vitamin A and vitamin C. According to Iannotti *et al.* (2009) Homestead Food Production (HFP) program in Bangladesh improved diet quality and intake of micronutrient-rich foods for nearly 5 million vulnerable people. Gopalan and Tamber (2003) also provided the scientific and policy implications for food based approaches to prevent and control micronutrient malnutrition.

According to the best of authors' knowledge, the contribution of homegardens as a source of micronutrients has not been evaluated in the Sri Lankan context even though a variety of incentives have been provided by the Sri Lankan government to promote homegardens. The diverse agro-ecological regions exist in Sri Lanka can provide interesting empirical evidence to highlight the roles that homegardens in different biophysical environments and socio-economic settings could play in providing micronutrient requirements. Therefore, the purpose of this study is to examine the extent to which homegardens contribute to nutritional needs, with special emphasis on micronutrients requirements particularly vitamins A, C, calcium and iron of households in Kandy, Kurunegala and Batticaloa districts

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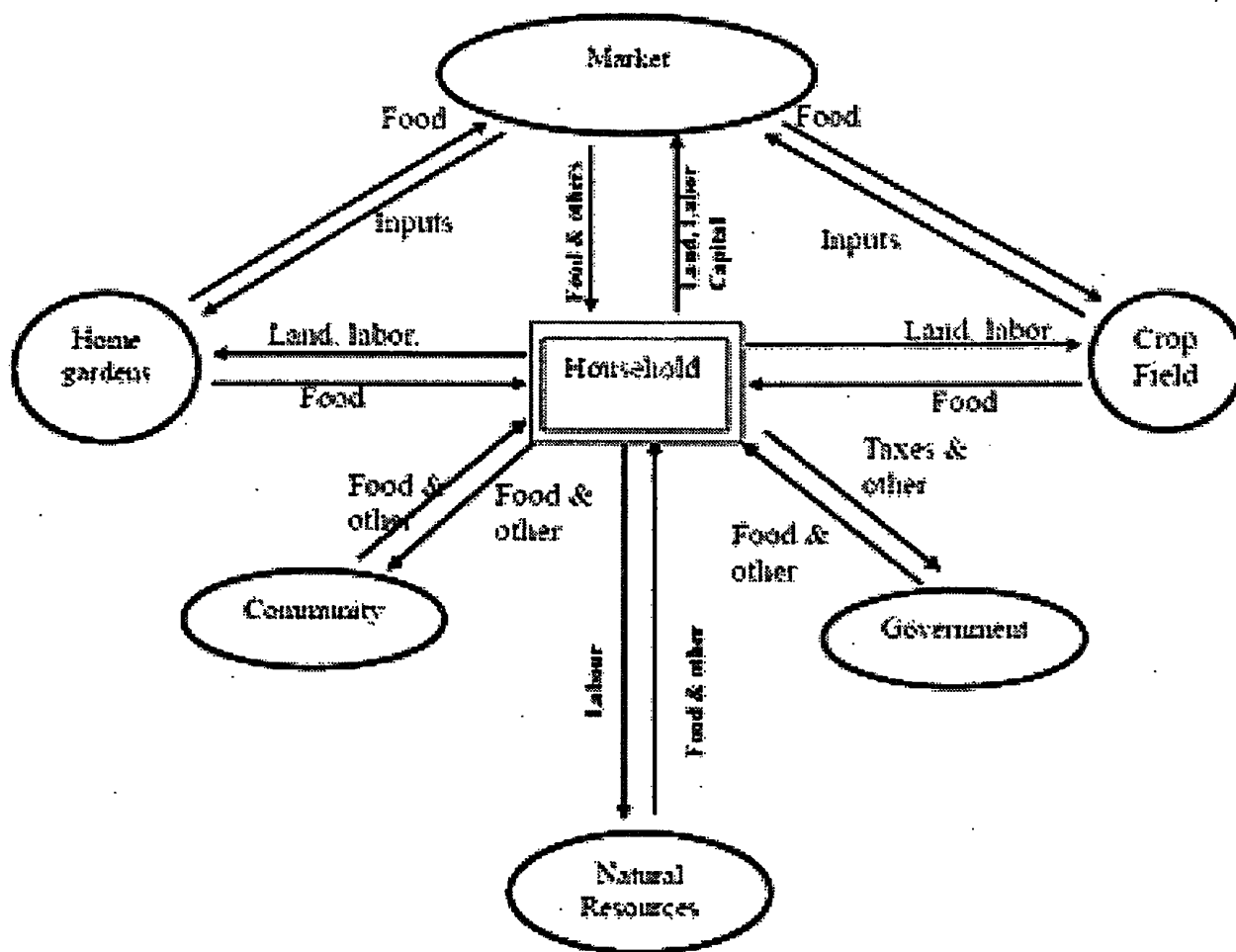
in Sri Lanka. The specific objectives of the study are: (i) identify composition of plants and trees in homegardens, (ii) calculate the per person consumption of vitamins A and C, calcium and iron harvested from the homegarden sources, and (iii) analyze the factors affecting intake of above micronutrients by the households.

### METHODOLOGY

#### A conceptual framework

Availability of the food at the household is the physical existence of food for consumption by the household. They reach the household through a number of means (i) own production in the homegarden and/or crop field, (ii) purchases from the markets, (iii) as transfers from relatives, members of the community, and/or the government, and (iv) collection from the wild (Riely *et al.*, 1995). The extent of reliance from one or more of the sources is context specific and is determined by the objectives of the household and its resource endowment. Figure 1 illustrates the linkages among different sources of food supply and how the household interacts with them.

Own agricultural production is carried out in homegardens and/or in own crop fields. The household allocates a certain level of its resources, *i.e.* land, labour and capital, for agricultural production. In return, the household obtains a supply of food and part of which is consumed at home and the rest is either sold or given away to the community as exchanges. Further, the household engages with the market in a number of ways. They include provision of skilled and unskilled labour and capital and obtaining salaries and wages and capital rents, which it uses to obtain food and non-food needs, in return. Harvest of food from the wild or common properties using labour is another activity that a household engages in. The household also receives, among other things, food in kind from the government and non-governmental agencies.



**Figure 1. Flowchart outlining sources of food supplies in a household.**

Accordingly, the availability of food at the household depends on allocation of resources among various activities (homegardens, crop fields and markets) and the surrounding environment (community, governmental and non-governmental organizations, public properties) in addition to resource endowment of the household. Intra-household allocation of food, which is determined by the strategic interactions among family members, influences food intake by individual family members. Individual characteristics, such as care for children and elderly, feeding practices and the health status of an individual determine the degree of food utilization once it is consumed.

### **Study area and data**

Homegardens in three districts, Kandy, Kurunagala and Batticaloa, representing three different agro-ecological zones within the country, were selected for the analysis. There exist unique bio-physical characteristics in each location, which together with household characteristics had determined the composition of vegetation in the homegardens and crop fields. Kandy district belongs to the mid country wet zone region and receives relatively high mean annual rainfall over 2,500 mm without pronounced dry periods. Kurunegala and Batticaloa districts are in the low country intermediate and dry zones, respectively. The intermediate zone receives a mean annual rainfall between 1,750 to 2,500 mm with a short and less prominent dry season. The mean annual rainfall of less than 1,750 mm with a distinct dry season from May to September is the characteristic feature in the dry zone. The major land uses in Kandy district are tea, spices and paddy. Coconut and paddy are predominant in Kurunegala district. Paddy and rainfed upland crops are the major land use in Batticaloa district (DOA, 2011).

Data used for the analysis was gathered from a comprehensive survey conducted by the World Agroforestry Centre-Sri Lanka program. The total sample consists of 643 households with 218, 219 and 206 from Kandy, Kurunegala and Batticaloa districts, respectively. Samples were drawn from three Divisional Secretariats (DS) in each district and ten Grama Niladhari (GN) divisions from each DS division. The survey was conducted from November 2009 to April 2010 using a structured questionnaire among households having homegardens.

The homegardens were selected based on the definition and key characteristics provided in Department of Census and Statistics (DCS, 2002) which is as follows; a piece of land which has a dwelling house and having some form of cultivation was defined to be a homegarden, if the total area of that piece of land is twenty or less than twenty perches. Further, total area of which is more than twenty perches was also considered as homegarden, if it has a dwelling house and the produce of the cultivated land is largely for home consumption. "Having some form of cultivation" was meant any cultivation for agriculture production. This will include even one coconut palm or one arecanut tree or couple of chilly plants and it was treated as homegarden, if the above conditions are satisfied. In this study, an upper limit on the land size was not considered.

Among the data gathered: (i) socio-economic information including family size, household income, education level, current activities of the household members, sources of additional income and expenditure pattern of the household, (ii) tree and crop inventory in the garden with their growth stages, annual production, number of harvest per year, distribution of the harvest (as amount consumed at the household, amount sold, amount given as gifts), and (iii) management of the homegarden, i.e., planting decisions, seeds and planting material, fertilizing the homegarden, labour for homegardening were used in the analysis.

## Methods and data analysis

### *Assessment of plant diversity*

Richness and evenness are the two aspects of plant diversity in a system. While richness expresses the total number of different species found in a given system the relative abundance of plant species is explained by the term evenness. Although there are numerous indices that are used to measure the plant diversity, this study uses three indices which are extensively found in literature: Richness index, Shannon-Wiener index and Simpson's index (Magurran, 1988). Richness Index is simply the count of the total number of crops that the household reports planting over the season of interest. However, this index does not indicate the relative proportion or abundance of a particular species in the farm. Shannon-Wiener Index (I) expresses the proportional abundance or evenness, accounting for the land shares allocated to each crop as well as the number of crops. The Shannon-Wiener index is higher when the relative abundance of the different species in the sample is even, and is low when few species are more abundant than the others.

$$I = -\sum_{i=1}^{m(\epsilon)} P_i \ln P_i$$

I = Shannon-Wiener Index

$P_i$  = Probability of the  $i$  th species

$M_e$  = Total number of species

Simpson index (S) provides the probability that two randomly selected plants belong to the same species. When this probability is high, diversity is low (Magurran, 1988). The value of Simpson index ranges from 0 to 1. While values closer to zero denote high diversity in the homegarden, value of 1 reflects monocropping.

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$$S = \sum_{i=1}^{m(\epsilon)} P_i^2$$

- $S$  = Simpson index  
 $P$  = Probability of the  $i$  th investigation object such as species

### *Measurement of nutrient intake:*

The levels of micronutrients harvested from the homegarden products were calculated using the following equation:

$$N = \sum_{i=1}^m \left[ V_i * e_i * cf_i \right]$$

$N$  = Nutrient intake

$V_i$  = Volume of  $i^{\text{th}}$  plant product harvested from the homegarden for consumption

$e_i$  = Edible portion of the  $i^{\text{th}}$  plant product

$cf_i$  = Nutrient conversion factor of the  $i^{\text{th}}$  plant product

Following Marsh and Talukder (1994), vitamin A and vitamin C, calcium, iron were selected to assess the contribution of homegarden plant and tree products to the micronutrient requirements of households. Data on food consumption from mature plants and trees gathered from the household survey was converted into four micronutrients, vitamin A retinol equivalent, mg of vitamin C, mg of calcium and iron per adult equivalent (AE), for the edible portion, using locally available food composition table of the Medical Research Institute (MRI) (Perera *et al.*, 1979). Some food items were not included in the local tables, hence, USDA/ARS (2010) and food composition table for use in East Asia were used (FAO, 1972).

In calculation of the micronutrient supply, the following assumptions were used: (i) all fruits and vegetables of a particular species were considered to be uniform in size even though it may have varied with variety, agro-ecological region and various other factors. Therefore, specific conversion factors were applied to each species to translate the quantity in to gram weight. The conversion factors used for weight in this study are given in Appendix 1, (ii) the selected nutrients contained in the different foods were considered to be fully bio-available.

*Assessment of determinants of micronutrient intake*

The levels of nutrients harvested from the homegarden, for consumption, was hypothesised to be dependent upon the characteristics of the homegarden (number and abundance of food trees, structure and size), characteristics of the members of the household (whether they are employed or not, their educational levels, sources and levels of income and other socio-economic characteristics) and extraneous factors such as agro-ecological factors. Accordingly, the following econometric model was specified to establish the relationship between the per capita micronutrient consumption obtained from the homegarden produce with its determinants.

$$I = \beta_0 + \beta_1 X + \beta_2 Y + \beta_3 Z$$

Where,

$I$	=	Per capita intake of micronutrient
$X$	=	Vector of socio-economic characteristics of the household
$Y$	=	Vector of characteristics of homegardens
$Z$	=	Vector of extraneous factors

Four regression equations were specified for four micronutrients and estimated as a Seemingly Unrelated System (SUR) to accommodate for the likely correlation among error terms of the four equations.

## RESULTS

### Demographic characteristics of the households:

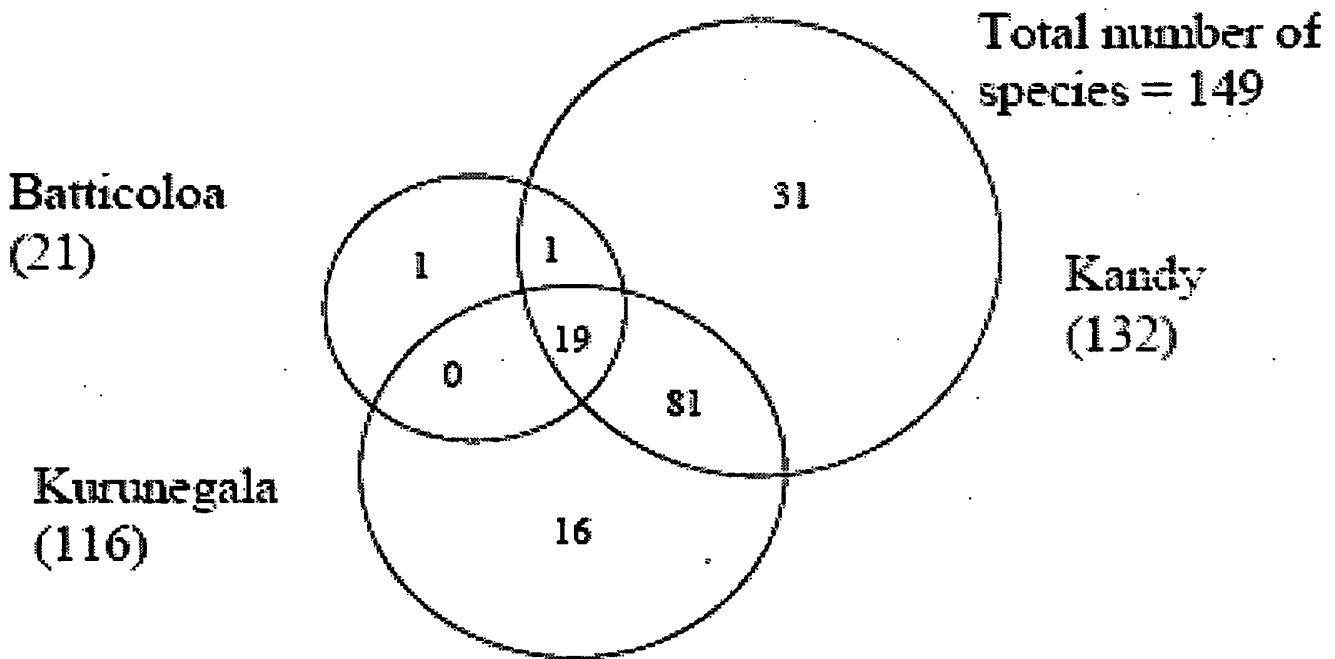
An average household consists of around 4 members in all 3 districts. The mean monthly income levels of sampled household are Rs. 19,712/=, Rs. 22,164/= and Rs. 17,723/= in Kandy, Kurunagala and Batticaloa districts, respectively. The majority of the respondents are educated up to GCE (Ordinary Level), i.e., around 10 years of schooling and are over 40 years. The average size of a homegarden is 0.14, 0.27 and 0.05 ha in Kandy, Kurunegala and Batticaloa districts, respectively. Average household characteristics and distribution of different categories in sampled area are given in Table 1.

116 **Table 1. Average household characteristics and distribution of different categories in sampled householders and their distribution.**

Selected Characteristics /Districts	Observed values (mean±standard deviation and range in parenthesis)			Categories	Distribution (%)		
	Kan	K'gala	Batti		Kan	K'gala	Batti
	Age (years)	47.5±11.46 (24-77)	49.3±12.7 (25-78)		47.5±11.6 (27-73)	Less than 25	1
Education (years)	10.5±3.04 (0-13)	10.5±2.7 (0-13)	10.4±2.09 (0-13)	25 to 39	23	29	29
				40 and above	76	69	71
				No education	4	0	0
				Primary (1 to 5)	5	8	0
				Secondary (up to O/L)	35	54	54
				Higher education (above A/L)	43	31	24
Family size (number)	4±1.3 (1-9)	4±1.4 (1-9)	4±1.6 (2-8)	Small (1 to3)	27	36	34
				Medium (4 to 6)	68	59	54
				Large (7 to 9)	5	5	9
Total income (Rs./month)	19,712±12,909 (3,000-100,000)	22,164±13,922 (2,000-80,000)	17,723±9,771 (1,500-40,000)	Low (3,000-15,000)	49	32	59
				Middle (15,000-30,000)	38	37	30
				High (more than 30,000)	12	18	11
Size of the Homegarden (ha)	0.14±0.151 (0.025-0.809)	0.274±0.276 (0.051-1.619)	0.054±0.197 (0.02-0.10)	Small (0.025 to0.050)	30	0	47
				Medium (0.050 to 0.126)	38	41	53
				Large(0.126 to 0.303)	21	24	0
				Very large (0.303 to 0.809)	11	34	0

**Diversity of Plant species in Home Gardens**

A total of 283 species were identified from Kandy, Kurunegala and Batticaloa districts and among them 53% are food related plant species. Figure 2 illustrates the distribution of food related species in three districts whereas Appendix 2 shows the list of species common to two and three districts and unique species to each district.



**Figure 2. Distribution of food related plant species in homegardens in three districts.**

The diversity indices calculated for homegardens are given in Table 2. The Shannon-Wiener Indices indicate that species diversity is higher in Kandy and Kurunegala districts compared to Batticaloa district. Simpson and Richness Indices also confirm that the homegardens in Batticaloa district are less diverse than other two districts (Table 2).

A categorization of trees and plants in homegardens into different groups reveals that fruit trees are predominant in homegardens in all districts. Vegetables are the second most significant category in Kandy and Kurunegala. Coconut and Palmyra are the second and third largest categories of food species in a

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homegarden in Batticaloa and in Kurunegala districts, respectively. Spices are the next important category in Kandy and Kurunegala districts. Yams, beverage crops and leafy vegetables are also present in Kandy and Kurunegala.

**Table 2. Diversity indices for food species in homegardens by district.**

<b>Plant Diversity Index</b>	<b>Kandy</b>	<b>Kurunegala</b>	<b>Batticaloa</b>
Richness Index	18.25 (6.45)	12.28 (5.82)	1.72 (0.90)
Shannon-Wiener Index	2.38 (0.45)	1.75 (0.60)	0.40 (0.40)
Simpson Index	0.15 (0.09)	0.29 (0.16)	0.74 (0.25)

Numbers in parenthesis show standard deviations.

### **Supply of micronutrients from the homegarden**

#### *Availability, productivity and consumption of micronutrient rich species in homegardens*

The availability, productivity and consumption levels of the 10 most micronutrient rich food species (excluding spices and condiments) across the three districts are given in Appendices 3-6. The Appendices clearly depict that such species are more prevalent in Kandy and Kurunegala district compared to those of Batticaloa district. Appendix 3 depicts that mango, papaya and *naran* are the top 3 vitamin A rich species and their productivity levels are higher in Kurunegala yet relatively a higher percentage of the harvest is taken for consumption by the home gardeners in Kandy district. According to Appendix 3, mango is found to be the best source of vitamin A and in an average homegarden in Kandy district, one mango tree is available at the bearing stage and importantly 67% of its harvest is home consumed. An average homegarden in Kurunegala district consists of two mango trees in bearing stage of which 60% of the total harvest is home consumed. Guava, drumstick and bittergourd are the species that are rich in vitamin C and their productivity levels are relatively higher in Kurunegala. Calcium is mainly obtained from artichok, *thibbatu* and *elabatu* while iron is obtained from cashew, drumstick and *thibbatu* by the home gardeners in the three districts (Appendices 4-6).

*Contribution of homegardens to micronutrient requirement*

Table 3 presents the average levels of micronutrients derived from the homegardens in the three districts by the type of food species. The results clearly show that out of total harvest used for consumption from the homegarden, over 75% of the vitamin A is from mango and over 20% of vitamin C requirement is from guava in all 3 districts. Interestingly, around 30% of iron and calcium are obtained from wingbean and jackfruit in Kandy district. Coconut supplies 17%, 45% and 84% of iron and 6%, 18% and 67% of calcium in Kandy, Kurunagala and Batticaloa districts, respectively. It should however be noted that the levels of harvest, in absolute terms, are much lower in Batticaloa district compared to those in Kandy and Kurunagala districts, due to poor development of homegardens.

Table 4 shows the daily micronutrient supply by the homegarden to the household. The results show that homegardens are good sources of vitamin C which provide 61% and 53% of the requirement in Kandy and Kurunagala districts, respectively. The contributions of homegardens as sources of vitamin A, calcium and iron are in the range of 5%-15% in Kandy and Kurunagala districts. Homegardens in Batticaloa do not make significant contributions to the micronutrient requirements of the household.

**The econometric estimation**

Tables 5 and 6 present the descriptive statistics of the variables used in the econometric estimation and the results of the Seemingly Unrelated Regression (SUR) estimates, respectively. The correlation coefficients among the independent variables used in the estimation indicate that there are no considerable correlations among the variables. The models were specified in log-log form and coefficient estimates show elasticity estimates with respect to various continuous variables specified in log form. The models were corrected for heteroskedasticity using the robust procedure in STATA. It is clear from the results presented that most of the co-efficient are statistically significant with correlation coefficient ranging from 37 to 61%.

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**Table 3. Average level of micronutrients derived from homegardens in three districts by the top 8 species.**

Type of Micro nutrients	Food Item	Level of collection			Amount from the total collection (%)		
		Kan	K'gala	Batti	Kan	K'gala	Batti
<b>Vitamin A</b>	Mango	29.807	72.572	3.650	78.1	84.5	75.1
	Papaw	1.907	1.497	0.000	5.0	1.7	0.0
	Kathurumurunga	1.824	1.745	0.004	4.8	2.0	0.1
	Guava	1.047	0.644	0.041	2.7	0.8	0.9
	Banana	0.785	1.247	0.288	2.1	1.5	5.9
	Avocado	0.573	0.151	0.000	1.5	0.2	0.0
	Coconut	0.512	1.431	0.759	1.3	1.7	15.6
	Orange	0.410	0.444	0.028	1.1	0.5	0.6
<b>Vitamin C</b>	Guava	7.714	4.743	0.305	31.5	22.3	23.6
	Jackfruit	5.401	3.094	0.168	22.0	14.6	12.9
	Mango	2.086	5.080	0.255	8.5	23.9	19.7
	Papaw	1.958	1.537	0.000	8.0	7.2	0.0
	Anoda	1.031	0.085	0.011	4.2	0.4	0.9
	Jambola	0.883	0.103	0.000	3.6	0.5	0.0
	Banana	0.846	1.343	0.310	3.5	6.3	24.0
	Avocado	0.818	0.215	0.000	3.3	1.0	0.0
<b>Iron</b>	Wingbean	0.657	0.004	0.000	29.3	0.2	0.0
	Jackfruit	0.656	0.376	0.020	29.2	15.8	3.0
	Coconut	0.387	1.082	0.573	17.3	45.5	83.6
	Mango	0.170	0.413	0.021	7.6	17.4	3.0
	Banana	0.109	0.173	0.040	4.8	7.3	5.8
	Avocado	0.045	0.012	0.000	2.0	0.5	0.0
	Anoda	0.042	0.003	0.000	1.9	0.1	0.1
	Jambola	0.027	0.003	0.000	1.2	0.1	0.0
<b>Calcium</b>	Jackfruit	11.573	6.630	0.359	28.5	18.6	7.1
	Wingbean	11.423	0.072	0.000	28.1	0.2	0.0
	Kathurumurunga	4.581	4.382	0.009	11.3	12.3	0.2
	Coconut	2.277	6.362	3.373	5.6	17.8	66.7

Banana	2.054	3.262	0.753	5.1	9.1	14.9
Mango	1.826	4.445	0.224	4.5	12.4	4.4
Avocado	0.982	0.258	0.000	2.4	0.7	0.0
Guava	0.608	0.374	0.024	1.5	1.0	0.5

It was hypothesized that per person consumption of micronutrients harvested from the homegarden does not depend on the size of households. However, the results of the econometric estimation show that larger households less likely to consume micronutrients harvested from homegardens and the effect is highly significant. This result indicates that the level of harvesting does not vary with the size of households when the effects of the other factors are controlled. The results further indicate that total food expenditure does not have a significant effect on food harvested from homegardens.

**Table 4. Daily micronutrient supply per person (adult equivalent) per day from products harvested from homegardens by district\***

	Kandy	Kurunegala	Batticaloa	RDA <sup>a</sup>
<b>Vitamin A supply (mcg RAE)</b>	38.0 (6.3)	85.9 (14.3)	4.9 (0.8)	600
<b>Vitamin C (mg)</b>	24.5 (61.3)	21.3 (53.1)	1.3 (3.2)	40
<b>Calcium (mg)</b>	40.6 (10.1)	35.7 (8.9)	5.1 (1.3)	400
<b>Iron (mg)</b>	2.2 (13.2)	2.9 (14.0)	0.7 (4.0)	17

Notes: <sup>a</sup>The values given in parenthesis are the percentage contribution of each micronutrients derived from the homegarden to a RDA of an adult recommended by the MRI, Sri Lanka.

\*Excluding spices and condiments.

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**Table 5. Descriptive statistics of the variables used in econometric estimation.**

<b>Variable and units</b>	<b>Mean</b>	<b>Standard Deviation</b>
Vitamin A (mcg RAE/day/person)	41.6	88.4
Vitamin C (mg/day/person)	15.6	28.2
Calcium (mg/day/person)	27.0	98.8
Iron (mg/day/person)	1.8	5.7
Household size (number/adult equivalent)	4	1.4
Household total expenditure on food (Rs./week)	7,583	3,488
Time allocated in homegarden activities (hours/week/ household)	30	39
Homegarden size (ha)	4.3	1.44
Diversity of food species (number/homegarden)	4.6	3.7

A categorical variable on employment status of the household head was included in the regression models to assess whether the behaviour of farmers in terms of food harvested from the homegarden differs from those who are employed in government or private sectors or self employed. The results reveal that latter extract lower levels of vitamin A and calcium from the homegardens compared to that by the farmers. Furthermore, those who work in the government sectors are less likely to harvest/use vitamin C and iron from their homegarden than those farmers whereas there are no statistically different effects among private sector employees, self employed and farmers in terms of vitamin C and iron consumed from the harvested products from the homegardens.

Time allocated in homegarden activities by the household members, which is a proxy for managerial input provided was expected to have a significant and positive relationship with per capita intake of micronutrients. However, such effects were statistically significant only for calcium and iron derived from homegardens.

**Table 6. Results of the estimation and the seemingly unrelated regression model**

Variable	Vitamin A (mcg)	Vitamin C (mg)	Calcium (mg)	Iron (mg)
Constant	0.71 (0.40)	0.99 (0.73)	3.61*** (3.24)	2.14* (1.84)
Household size (adult equivalent)	-1.29*** (-4.9)	-0.95*** (-4.7)	-0.915*** (-5.59)	-0.87*** (-5.07)
Total expenditure on food (Rs./week)	0.21 (1.06)	-0.03 (-0.19)	-0.10 (-0.79)	-0.17 (-1.28)
Type of employment of head of the HH	-0.6584** (-2.11)	-0.3997* (-1.67)	-0.5960** (-3.04)	-0.4334** (-2.11)
Government sector	-0.8724*** (-3.32)	-0.3185 (-1.58)	-0.3188* (-1.93)	-0.1701 (-0.98)
Private sector				
Self employed	-0.4980** (-1.99)	-0.3103 (-1.62)	-0.3821** (-2.43)	-0.2014 (-1.22)
Time allocated in homegarden activities (hours/week)	0.1675 (1.47)	0.1168 (1.34)	0.1706** (2.38)	0.1439* (1.92)
Homegarden size (ha)	0.1338 (1.14)	-0.0534 (-0.59)	0.1707** (2.31)	0.2423** (3.14)
Diversity of fruit species (number)	1.3246*** (7.02)	1.1175*** (7.71)	0.6199*** (5.22)	0.4201*** (3.38)
Agro ecological zone				
Kandy	0.3520 (0.67)	1.3104*** (3.25)	0.9548*** (2.89)	0.4949 (1.43)
Batticaloa	0.5337 (1.23)	0.9429** (2.83)	0.7887*** (2.89)	0.5338* (1.87)
Adjusted R2	0.47	0.61	0.53	0.37
No of observations	302	302	302	302

Notes: \*, \*\*, \*\*\* statistically significant at the 10%, 5% and 1% levels, respectively. z statistics are given in the parenthesis

As expected, fruit species diversity has a significant positive effect on the intake of four micronutrients derived from homegardens. Even though the levels of extraction of all four micronutrients is quite smaller in Baticoloa district, compared to those of Kandy and Kurunagala districts, as shown in Table 4, the results of the econometric estimation reveal that the levels of extraction in Kandy and Baticoloa districts are statistically higher than those of Kurunagala. This result is due to the fact that in a regression analysis, the co-efficient depict the effect of the factor under consideration when other factors are held at constant levels.

### DISCUSSION

It is known that if properly planned and implemented, homegardens can enhance food security through direct access to a diversity of nutritionally rich foods, increased purchasing power from savings on food bills and income from garden products, and fall-back food provision during periods of temporary food scarcity (Montagnini, 2006; Pushpakumara *et al.*, 2010). This study too shows that homegarden food production has the potential to increase micronutrient intake and hence improve the health and nutritional status of households, particularly the groups nutritionally at-risk and children. It is also evident that the homegardens can also be used as one of the cost effective mechanisms to alleviate micronutrient related problems of rural communities especially when individuals own their homegardens. There exists evidence from Bangladesh that homegarden food production has improved food security for nearly 5 million vulnerable people in diverse agroecological zones which has been achieved through, increased production and consumption of micronutrient-rich foods; increased income from gardens and expenditures on micronutrient-rich foods; women's empowerment; enhanced partner capacity; and community development (Iannotti *et al.*, 2009). The results of the present study also confirm that homegardens, if properly established and adequate quantities of different species are harvested, can increase the dietary diversity of households because they can provide various products throughout the year.

For increase of food security and availability of micronutrients in Sri Lankan homegardens, four woody interventions can be used to increase production in these systems (Pushpakumara *et al.*, 2011). They are (i) replacement (harvest

existing old or less productive tree/crop species and replace with improved (or same level) once of the same species); (ii) substitution (harvest existing tree/crop species and replace with different species); (iii) expansion (increase individuals of the same species or number of different species); and (iv) management (better management of the existing and new trees (spacing, thinning, pruning, harvesting). Similarly, micronutrient and fibre rich annual vegetable and leafy vegetable species can also be introduced as a short term strategy to increase production. In this respect it is essential to prioritize species for utilization in different areas according to severity of nutritional related problems. Then, four strategies and inclusion of correct fruit and vegetable species can be used to increase production within the homegarden ecosystem, which improve/increase availability of micronutrients to households. Nutritional education coupled with higher production can alleviate the micronutrient related problem in Sri Lanka which will be cost effective and environmentally sustainable mechanism.

As Talukder *et al.* 2010 suggested increase the production of animal food such as poultry products and milk in homegardens and their consumption will also be crucial to minimize micronutrient deficiencies in rural populations. Further, since bioavailability of micronutrients of plant based food products has been questioned (West *et al.*, 2002), the knowledge of bioavailability of micronutrient of plant based foods can be used as a selection criteria for identification of correct species to be popularize in homegarden improvement programs.

## CONCLUSIONS

The study found that there exist 149 food species out of a total of 283 species available in the homegardens in the study area. Mango, banana, coconut are found to be the predominant food species. The results reveal that homegardens are good sources of some micronutrients but weak in providing other micronutrients. Moreover, significant disparities exist in consumption of micronutrients derived from homegarden crops among the three districts. Households in Kandy and Kurunegala consume more micronutrients produced in homegardens compared to those in the Batticaloa district. Homegardens in Batticaloa district found to be poor in food species diversity and abundance. Per person intake of micronutrients derived from homegardens is affected by a number of household characteristics such as household size, employment status of the household head and time allocated for activities in homegardens by household members. The study recommends

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intensification of homegardens to improve food and nutrition security at the household level by inclusion of appropriate species rich with micronutrients, managing or replacing existing species for better yield.

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**Appendix 1: Conversion factors (gram equivalent) for fruits and vegetable species (\*\* See end of the paper for botanical names)**

Item	Weight	Item	Weight
Amberella	41.5	Lime	40
Ambulpera	7	Luffa	50
Angunakola	150	Long beans	15
Anoda	550	Lovi	10
Avacado	300	Mango	275
Banana	87.5	Mangoostin	50
Beans	15	Manioc	330
Beli	150	Mukunuvonne	150
Billin	20	Naminan	60
Bitterguard	55	Naran	150
Breadfruit	400	Nasnaran	25
Brinjal	125	Nelli	10
Cabbage	350	Okra	25
Capsicum	30	Orange	150
Cashew	10	Papaw	850
Chaw	300	Passion fruit	55
Chili	15	Pineapple	1000
Cocoa	500	Pinijambu	20
Coconut	850	Pomegrante	100
Cucumber	125	Pumkin	1000
Drumstick	250	Rambutan	30
Durian	1500	Ratabilin	10
Elabatu	40	Ratanelli	10
Gaduguda	10	Sapodilla	50
Garcenia	150	Sarana	150
Gotukola	150	Snake guard	250
Guava	200	Spinach	350
Hinnaran	40	Star fruit	60
Jack	4500	Sweet potato	65
Jambola	500	Tamarind	60
Jambu	10	Thal	500

Item	Weight	Item	Weight
Jampera	7	Thampala	350
Kankun	250	Thebu	150
Kathurumurunga	350	Tomato	50
Kingcoconut	1300	Uguressa	10
Kiriala	20	Velvet apple	75
Kiriangua	150	Veralu	7
Kochchi	0.5	Watermelon	750
Kohila	350	Welianoda	500
Lavulu	150	Wingbean	20
Lemon	100	Wood apple	125

**Appendix 2. List of homegarden species common to three districts and unique to one or two districts**

All three districts	Kandy and Kurunegala	Only in Kandy	Only in Kurunegala
Annona	<i>Amberella</i>	<i>Ambilla</i>	<i>Dothalu</i>
Cashew	Avocado	<i>Ambulpera</i>	<i>Gaduguda</i>
Coconut	<i>Beli</i>	Cherry	<i>Galsiyambala</i>
Drumsticks	<i>Billin</i>	Durian	<i>Kiripalu</i>
Guava	Breadfruit	<i>Jam pera</i>	<i>Madan</i>
Jackfruit	Clove	Loquat	<i>Nasnaran</i>
Mango	Cocoa	<i>Seenigoraka</i>	<i>Sidaran</i>
Orange	Curry Leaves		
Pomegranate	<i>Damba</i>		
Palmyra	<i>Daminna</i>		
	Garcenia		
	Jam		
	<i>Jambola</i>		
	<i>Jambu</i>		
	<i>Lovi</i>		
	<i>Kathurumurunga</i>		

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King coconut

*Kone*

*Kottamba*

Shark Tail

Mangoostin

Mora

*Naminan*

*Naran*

*Nelli*

Nutmeg

*Rambutan*

*Ranawara*

Sapodilla

Star fruit

Tamarind

*Uguressa*

Velvet apple

*Veralu*

*Welianoda*

Wood apple

### Appendix 3. Availability, consumption and productivity of vitamin A rich species

Item	Vitamin A RAE (mcg)	No of trees at bearing stage			Consumed % from total harvest			Frequency		
		Kan	K'gala	Batti	Kan	K'gala	Batti	Kan	K'gala	Batti
Mango	2.2858	1.6	1.9	1.4	67	61	50	75.6	83.6	13.6
Papaw	0.555	2.1	1.3	1.8	95	77	0	66.2	29.1	2.4
Naran	0.3875	1.4	0.9	0	81	76	0	10.3	12.7	0
Longbeans	0.35	2.3	0	0	91	0	0	0.5	0	0
Thibbatu	0.325	0.6	1.7	0	100	81	0	4.2	11.6	0
Guava	0.31	1.1	1.2	1.7	100	81	63	57.3	49.2	1.5
Tomato	0.2925	8.8	1.6	0	94	100	0	20.7	3.7	0

Cashew	0.2333	0.5	1.8	8.1	40	74	14	2.8	31.7	13.6
Snakeguard	0.08	0.3	0	2	100	0	0	1.9	0	0.5
Avacado	0.07	1.2	0.5	0	73	75	0	70.4	40.2	0

#### Appendix 4. Availability, consumption and productivity of vitamin C rich species

Item	Vitamin C (mg)	No of trees at bearing stage			Consumed % from total Harvest			Frequency		
		Kan	K'gala	Batti	Kan	K'gala	Batti	Kan	K'gala	Batti
Guava	2.283	1.1	1.2	1.7	100	81	63	57.277	49.206	1.456
Drumstics	1.2	0.5	0.2	2	74	71	100	16.901	8.995	3.398
Bitterguard	0.88	0	1.6	3	0	100	0	3.756	5.82	0.485
Papaw	0.57	2.1	1.3	1.8	95	77	0	66.197	29.101	2.427
Lemon	0.45	0	1	2	0	92	100	1.408	5.82	0.485
Naran	0.42	1.4	0.9	0	81	76	0	10.329	12.698	0
Pineapple	0.39	1.1	27.7	0	83	72	0	18.31	7.407	0
Anoda	0.37	1.1	0.7	0.7	85	74	100	39.437	16.931	1.456
Starfruit	0.344	1.2	0.6	0	48	58	0	2.347	7.407	0
Beans	0.27	3.7	0	0	100	0	0	7.042	1.058	0

#### Appendix 5. Availability consumption and productivity of calcium rich species

Item	Calcium (mg)	No of trees at bearing stage			Consumed % from total Harvest			Frequency		
		Kan	K'gala	Batti	Kan	K'gala	Batti	Kan	K'gala	Batti
Artichok	1.2	25	0	0	100	0	0	0.469	0	0
Thibbatu	1.04	0.6	1.7	0	100	81	0	4.225	11.64	0
Elabatu	1	0.5	2.6	0	100	80	0	7.042	3.175	0
Beli	0.85	1.4	1.1	0	78	69	0	2.817	11.111	0
Okra	0.81	0	4	0	0	100	11	0.939	4.762	0.485
Cashew	0.66	0.5	1.8	8.1	40	74	14	2.817	31.746	13.592
Beans	0.5	3.7	0	0	100	0	0	7.042	1.058	0
Tomato	0.48	8.8	1.6	0	94	100	0	20.657	3.704	0
Wingbean	0.4	1.8	0.5	0	807	78	0	40.376	7.937	0
Longbeans	0.37	2.3	0	0	91	0	0	0.469	0	0

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### Appendix 6. Availability, consumption and productivity of iron rich species

Item	Iron (mg)	No of trees at bearing stage			Consumed % from total Harvest			Frequency		
		Kan	K'gala	Batti	Kan	K'gala	Batti	Kan	K'gala	Batti
Cashew	0.067	0.5	1.8	8.1	40	74	14	2.817	31.746	13.592
Drumstics	0.053	0.5	0.2	2	74	71	100	16.901	8.995	3.398
Thibbatu	0.046	0.6	1.7	0	100	81	0	4.225	11.64	0
Beans	0.026	3.7	0	0	100	0	0	7.042	1.058	0
Artichok	0.023	25	0	0	100	0	0	0.469	0	0
Wingbean	0.023	1.8	0.5	0	807	78	0	40.376	7.937	0
Passion fruit	0.02	0.1	2.3	0	100	87	0	10.329	6.878	0
Bitterguard	0.018	0	1.6	3	0	100	0	3.756	5.82	0.485
Coconut	0.017	3.7	17.6	4.4	92	56	73	82.629	93.122	70.388
Jack	0.017	3.1	1.7	0.7	43	65	66	84.977	60.317	3.398

\*\*Amberella=Spondias dulcis, Ambilla=Morus alba L., Ambulpera=Psidium guineense, Angunakola=Wattakaka volubilis, Annona=Anoda=Annona spp., Avacado=Presea americana, Banana=Musa spp., Beans=Phaseolus spp., Beli=Aegle marmelos, Correa, Billin=Ratabiling=Averrhoa bilimbi, Bitterguard=Momordica charantia, Breadfruit=Artocarpus altilis, Brinjal=Solanum melongena, Cabbage=Brassica L.var. capitata, Capsicum=Capsicum annum, Cashew=Anacardium occidentale, Chaw=Sechium edule, Sweet, Cherry=Eugenia spp., Chili=Capsicum spp., Clove=Syzygium aromaticum, Cocoa=Theobroma cacao, Coconut=Kingcoconut=Thambili=Cocos nucifera, Cucumber=Cucumis sativus, Curry Leaves=Murraya koenigii, Damba=Syzygium gardner, Daminna=Grewia damin, Dothalu=Loxococcus rupicola, Drumstick=Murunga=Moringa oleifera, Durian=Durio zebethinus, Elabatu=Solanum melongena, Gaduguda=Baccaurea motleyana, Galsiyambala= Velvet apple=Dialium ovoideum, Garcenia=Garcinia spp., Gotukola=Centella asiatica, Guava=Psidium guajava, Hinnaran=Citrus reticulate, Jack=Jackfruit=Artocarpus heterophyllus, Jam=Muntingia calabura, Jam pera=Psidium cattleyaanum, Jambola=Citrus grandis, Jambu=Syzygium aqueum, Kankun=Ipomoea aquatic, Kathurumurunga=Sesbania grandiflora, Kiriala=Xanthosoma sagittifolium, Kirianguna=Wattakaka volubilis, Kiripalu=Buchania axillaris, Kochchi=Capsicum frutescens, Kohila=Lasia spinosa, Kone=Schleichera oleosa, Kottamba=Terminalia catappa, Lavulu=Pouteria campechiana, Lemon=Citrus limon, Lime=Cirtus aurantifolia, Long beans=Vigna unguiculata, Loquat=Eriobotrya japonica, Lovi= Flacorutia inermis, Luffa=Luffa acutangula, Madan=Syzygium cumini, Mango=Mangifera indica, Mangosteen=Garcinia mangostana, Manioc=Manihot esculenta, Mora=Dimocarpus longan, Mukunuvonne=Alternanthera sessilis, Naminan=Cynometra cauliflora, Nasnaran=Citrus madurensis, Nelli= Phyllanthus emblica, Nutmeg=Myristica fragrance, Okra=Abelmoschus esculentus, Orange=Citrus sinensis, Palmyra=Thal=Borassus flabellifer, Papaw=Carica papaya, Passion fruit=Passiflora edulis, Pineapple=Ananas comosus, Pini jambu=Syzygium samarangense, Pomegranate=Delum=Punica granatum, Pumkin=Cucurbita maxima, Rambutan=Nephelium lappaceum, Ranawara=Cassia auriculata, Ratanelli=Phyllanthus acidus, Sapodilla=Manilkara zapota, Sarana=Trianthema portulacastrum, Seeni goraka=Garcinia quaesita, Sidaran=Citrus medica, Snake guard= Trichosanthes anguina, Spinach=Basella alba, Star fruit=Kamaranga=Averrhoa carambola, Sweet potato=Ipomoea batatas, Tamarind=Tamarindus indica, Thampala=Amaranthus spp., Thebu=Costus speciosus, Tomato=Lycopersicon esculentum, Uguressa=Flacorutia indica, Veralu=Elaeocarpus serratus, Watermelon=Citrullus lantanus, Welianoda=Annona reticulate, Wingbean=Psophocarpus tertagonolobus, Wood apple=Limonium acidissima