9 Kandyan home gardens

A time-tested good practice from Sri Lanka for conserving tropical fruit tree diversity

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Introduction

In Sri Lanka, home gardens (HGs) have been identified as an integral part of the landscape and culture for centuries and remain today one of the major and oldest forms of land use in the country (Mahawansa, undated; De Silva, 1981; Jacob and Alles, 1987; FSMP, 1995; MFE, 1999; Pushpakumara *et al.*, 2010). Although the term Kandyan home garden (KHG), as a subset of HGs in Sri Lanka, is commonly used in literature, the term has several definitions (see Jacob and Alles, 1987; Perera and Rajapakshe, 1991). In this study KHG is defined, based on the historical Kandyan Kingdom, to include HGs in Kandy and adjacent districts, such as Badulla, Kegalle, Kurunegala, Matale, Nuwara Eliya and Rathnapura. This area largely falls in the wet zone of Sri Lanka but occasionally in the intermediate zone, where the climate and edaphic environment support luxurious growth of perennial trees. The area consists of deep soil (i.e. reddish brown latasolic, immature brown loam and red yellow podzolic soils). The rainfall is year-round, sufficient to meet the evaporation demand of the atmosphere, with a distinct dry spell of one to two weeks that triggers the flowering of perennial species (personal communication, B.V.R. Punyawardena, Department of Agriculture, Sri Lanka).

KHGs are considered a result of farmers' conception, investment and long-term planning. Through generations, KHGs in Sri Lanka have evolved to satisfy households' food and other needs while countering the resource constraints resulting from population pressure and shortage of arable lands and capital. The composition and structure of the plant and animal species found in KHGs are a result of a combination of farmers' selection, natural evolution, environmental suitability and occasional recommendations by researchers and extension workers and subsequent co-adaptation. They form a complex to suit

context and environment. Thus, KHGs blend characteristics to suit the socio-economic, cultural and ecological needs of the area's diverse communities and landscapes. About 70 per cent of the households in Kandy and the adjacent districts have long-standing KHGs.

KHGs are managed through family labour as smallholdings with an average land area of 0.4 ha (range from 0.05 to 2.5 ha; Pushpakumara *et al.*, 2012). Despite their small average size, they are characterized by dense, multi-storeyed arrangements with a combination of mixed but compatible species. HGs and KHGs are tree-based systems where many of the trees (40%–50%) are tropical fruit trees (Ariyadasa, 2002; Heenkenda, 2014). As a result, HGs in Sri Lanka are a major contributor to fruit production in the country. Different canopy and root configurations and different requirements for light, nutrients, water and space maximize the resource use in the system. The layered structure and the composition of the KHGs are dynamic and change according to uses and cropping seasons, while largely maintaining their overall structure and functions. The dynamic nature of the system is illustrated by the age classes of tree species, which include seedlings, saplings and mature trees in production. Annuals are cultivated based on the season and land suitability throughout the year (McConnell and Dharmapala, 1973; Jacob and Alles, 1987; Wickramasinghe, 1995; Pushpakumara *et al.*, 2010; 2012).

A good practice for maintaining diversity (GPD) has been defined as a practice in a system, organization or process that over time and space maintains, enhances and creates crop genetic diversity and ensures its availability to and from farmers and other actors for improved livelihoods on a sustainable basis (Sthapit *et al.*, 2004). KHGs at a landscape level represent a land use system that over time and space maintains and, in some instances, enhances and creates crop genetic diversity (Wickramasinghe, 1995; Pushpakumara *et al.*, 2012) and so represents a GPD. As a result of the good practice, the system provides a wide range of products year-round (Figure 9.1). The combination of trees, crops and livestock with different production cycles and rhythms provides a relatively uninterrupted supply of food products, which helps to increase the self-reliance of households. In some instances, KHGs are used to develop new business ventures as a means of value addition to either the home gardens themselves or their products (Pushpakumara *et al.*, 2010). KHGs also provide many ecosystem services: provisioning (Jacob and Alles, 1987; Perera and Rajapakse, 1991; Mohri *et al.*, 2013), regulating (Krishnarajah and Sumanarathne, 1988; Raheem *et al.*, 2008; MENR, 2009; Dela, 2011; Kudavidanage *et al.*, 2012; Pushapakumara *et al.*, 2012; Mattsson *et al.*, 2013), cultural services and support services (Siddique *et al.*, 2007). They also reduce pressure on fragmented natural forests by connecting them with a biodiversity-friendly land use system. Hence, KHGs are crucially important in Sri Lanka, and in particular in the Kandy and adjacent districts, as they provide products and services and an attractive living environment for household members (Wickramasinghe, 1995; Pushpakumara *et al.*, 2010; 2012).

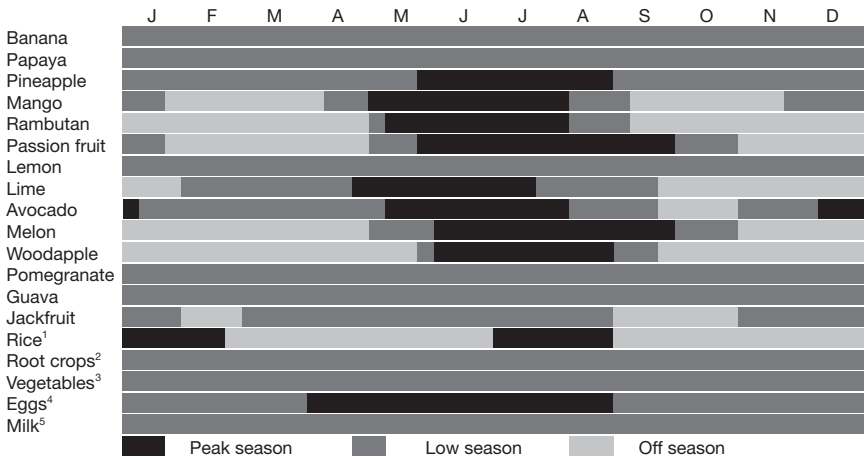

Figure 9.1 Availability and seasonality of fruit, rice, root and vegetable crop production and egg and milk production in Sri Lanka.

Sources: 1–3 derived from available information; 4 and 5 from Silva, G.L.L.P (an author of this chapter); all others extracted and prepared from SCS (2011).
Note: Fruit is widely grown in home gardens. Root crops and vegetables are also substantially grown in home gardens. Rice is mainly grown in other agricultural lands.

The historical introduction of a large number of well adapted, economically important exotic species and the country's agro-ecological diversity, biogeography, geographical location and cultural diversity, coupled with antiquity and dual agriculture (small *vs* large and subsistence *vs* commercial), and the long existence of a unique hydraulic civilization (one that has an agricultural system that is dependent on large-scale government waterworks or irrigation systems) have played a role in the evolution of today's agrobiodiversity in Sri Lanka (Pushpakumara and Silva, 2008). Despite the rich diversity including tropical fruit trees and thriving systems such as KHGs, concern has been growing over the last two decades about the loss of genetic diversity of field crops, fruit and vegetables, livestock and poultry, in the agricultural landscape (MFE, 1999; Pushpakumara and Silva, 2008). In Sri Lanka, HGs constitute the most significant production system for fruit (Heenkenda, 2014). Despite their thriving nature as a GPD, some KHGs have been subjected to fragmentation due to population pressure and recent replacement of low-yielding genetic resources of tropical fruit and vegetable crops by high-yielding varieties of such crops. This leads to loss of genetic resources (MFE, 1999; Dela, 2011; Pushpakumara *et al.*, 2012), although the extent has not yet been properly assessed (Pushpakumara and Silva, 2008).

Ex situ conservation of traditional varieties, landraces and underutilized fruit crops is limited in scope in Sri Lanka. So, it is generally agreed that *in situ* conservation of genetic resources is an indispensable complementary tool (UN,

1992). *In situ* conservation encompasses the maintenance of species in biotic environments that they belong to either as uncultivated plant communities or in farmers' fields (on-farm conservation). On-farm conservation seeks to maintain the process of evolution and adaptation of existing species to their environments and calls for active participation by farmers (Jarvis *et al.*, 1997). Although KHGs are important to maintain the unique agricultural biodiversity of Sri Lanka, few scientific studies on their role in the conservation of agricultural biodiversity have been carried out (Pushpakumara *et al.*, 2012). The study described in this chapter was conducted to investigate the role of KHGs in the conservation and use of fruit crop diversity in Sri Lanka as a GPD.

Materials and methods

The present chapter evaluated the existing scientific data regarding KHGs to identify their role in and contribution to the conservation and use of fruit crop genetic resources in Sri Lanka. The land extent of KHGs was obtained from HG areas of Kandy and adjacent districts of Badulla, Kegalle, Kurunegala, Matale, Nuwara Eliya and Rathnapura. Total land area, population density, forest cover and HG cover were obtained from the Forestry Sector Master Plan (FSMP) (FSMP, 1995) and IUCN and MENR (2007). The HG extent of all selected districts was compared with the national average. The tree cover was calculated by considering forest cover and HG cover of each district. The information on the species diversity of fruit crops in Sri Lanka was obtained from Dassanayake and Fosberg (1980–1991), Dassanayake *et al.* (1994), Dassanayake and Clayton (1995–2000), Ashton *et al.* (1997) and Pushpakumara and Silva (2008). The information on varietal diversity of fruit crop species was extracted from Mankotte (2011) and Heenkenda (2014). The occurrence or presence of fruit crop species and their varieties in KHGs was obtained from the literature related to KHGs, and also by the authors while conducting field surveys in each selected district. Custodian farmers – those farmers who maintain, adapt and disseminate unique fruit crop species and their varieties over time and space, with knowledge needed for their use and cultivation (Sthapit *et al.*, 2013) – were also recorded. Focus group discussions were also held with custodian farmers to identify reasons for use of local varieties of fruit crops.

Results and discussion

Land extent of Kandyan home gardens (KHGs)

The extent of HGs in Sri Lanka was reported as 858,100 ha in 1995, which represents 13.1 per cent of the total land area of the country (FSMP, 1995). The total land extent of the Kandy, Badulla, Kegalle, Kurunegala, Matale, Nuwara Eliya and Rathnapura districts represent 28 per cent total land area of the country; 17 per cent of this area is covered by KHGs. The average population density in the study areas is higher than that of the national average except in the

Kurunegala, Badulla and Matale districts (Table 9.1). Apart from the Matale and Nuwara Eliya districts, the forest cover in all the districts studied is lower than that of the national average, whereas the KHG cover is higher than that of the national average (Table 9.1). In the study area, the total tree canopy cover is similar to the national average tree cover. The data presented in this section indicate that KHGs are a dominant form of land use in these districts.

Diversity of fruit crop species and their production

The species diversity of fruit in Sri Lanka is represented by about 196 species belonging to 46 plant families. This species diversity is composed of 18 per cent endemic, 41 per cent indigenous and 41 per cent exotic fruit species. Of the 196 species, 56 species are considered wild relatives of fruit species (Tables 9.2 and 9.3).The main fruit species grown in Sri Lanka in terms of land extent are banana (*Musa* spp.), pineapple (*Ananas comosus*), papaya (*Carica papaya*), mango (*Mangifera indica*), avocado (*Persea americana*) and rambutan (*Nephelium lappaceum*) (Heenkenda, 2014). Besides the major fruit species, there are a large number of minor, underutilized fruit species (at least 50 species) grown in various parts of the country, which recently have begun to gain popularity at the national scale (Pushpakumara *et al.*, 2007; 2011). The majority of fruit plants in HGs have originated from seedlings (Weerakkody, 2004; Pushpakumara *et al.*, 2007; Heenkenda, 2014). Planting material dissemination of improved fruit plants is from recommended sources such as nurseries by the Department of Agriculture. Many farmers visit research stations and their demonstration sites to collect improved planting material. However, farmer-to-farmer exchange of planting material is also common in KHGs (Plate 7).

Table 9.1 Land area, population density, forest cover and home garden (HG) area of administrative districts where Kandyan home gardens (KHGs) exist more widely in Sri Lanka

District	*Area (km^2)*	*Population density (per km^2)*	*Forest cover (%)*	*Home garden cover (%)*⋆	*Tree canopy cover (%)*⋆⋆
Badulla	2,803	294	19.0	17.7	36.7
Kandy	1,906	704	17.0	30.4	47.4
Kegalle	1,693	468	9.5	23.2	32.7
Kurunegala	4,813	311	5.0	15.1	20.1
Matale	1,993	233	40.5	11.7	52.2
Nuwara Eliya	1,720	423	24.5	5.3	29.8
Rathnapura	3,255	325	20.0	15.8	35.8
All KHGs	18,183	394	19.0	17.0	36.0
Sri Lanka	65,610	314	23.5	13.1	36.6

Note: ⋆⋆ Tree canopy cover is defined to include forest and HG areas.
Sources: IUCN and MENR (2007) and ⋆ based on FSMP (1995).

Until the early 1990s, only seedlings were used as planting material of many fruit species. Thereafter vegetatively propagated improved material has been introduced and used for selected fruit species. Except for a few fruit species, such as mango and rambutan, usually both improved vegetatively propagated material and seedlings are used as planting material.

Conservation and use of fruit crop species diversity in KHGs

KHGs conserve about 50 per cent of the species diversity of fruit crops in Sri Lanka, of which 6 per cent are endemic, 34 per cent are indigenous and 60 per cent are of exotic origin. This suggests that the majority of fruit species conserved in KHGs are well-adapted species of exotic origin (Tables 9.2 and 9.3). Hence, KHGs, as a good practice for diversity (GPD), provide an important option for on-farm conservation of species diversity of naturalized exotic fruit crops. In addition, KHGs add value to the conservation of endemic and indigenous fruit species in the country by providing the option of a field genebank because they have natural populations in forests. Based on frequency of occurrence, the most common fruit tree species in Sri Lankan HGs are jackfruit (10.437 million trees), mango (5.607 million trees), cashew (3.001 million trees), citrus (2.484 million trees), guava (1.790 million trees), sweet orange (1.468 million trees), rambutan (1.178 million trees) and avocado (0.986 million trees), of which 57 per cent, 48 per cent, 47 per cent, 35 per cent, 43 per cent, 49 per cent, 46 per cent and 90 per cent of their populations, respectively, are recorded in the KHGs (Ariyadasa, 2002).

On average, one KHG conserves 10 to 20 fruit crop species. Fruit crops are perennials and usually require more space than herbaceous plants. Only one or two individual trees per species may be sufficient to provide fruit for family consumption. Therefore, their representation may be limited to one or two individuals of each species in each KHG. Although individual populations of species in KHGs may be small, at a landscape level they are a vital refuge for species that are neither grown in the wider agro-ecosystems nor found in the wild. The average density of trees in the KHGs of Sri Lanka is around 200 trees/ha (with a range from 20 to 475 trees/ha) of which 40–50 per cent are fruit trees (Ariyadasa, 2002).

Fruit species represent all layers of KHGs. In the understorey layer below 3 m, pineapple is the most common species, whereas in the lower stratum (3–10 m) banana, cacao, passion fruit, lime and lemon are common. In the middle stratum (10–15 m), papaya, avocado, mangosteen, bread fruit and some citrus species commonly occur. In the upper middle stratum, over 15 m, jackfruit, mango, durian, wild bread fruit and bread fruit are the dominant fruit crop species. Perera and Rajapakse (1991) reported that out of 39 fruit species recorded in KHGs, 32 species were lesser known. Hitinayake and Ekanayake (1999) also reported that out of 39 fruit species recorded in KHGs, 20 species are underutilized. However, in neither case were attempts made to intensify the garden's productivity by replacing these with improved or

Table 9.2 Species diversity of fruit crops in Sri Lanka and their endemic, indigenous and exotic status and occurrence in Kandyan home gardens (KHGs)

Category	*In Sri Lanka*		*In KHGs*		
	Number	*% [a]*	*Number*	*% [b]*	*% [c]*
Fruit species recorded	196		98	50	–
Plant families of fruit species	46		36	78	–
Wild relatives of fruits	54	29	11	20	–
Endemic fruit species	35	18	6	17	6
Indigenous fruit species	81	41	33	41	34
Exotic fruit species	80	41	59	74	60

Note: [a] = percentage out of total fruit species; [b] = percentage of species recorded in KHGs out of total fruit species in each category; [c] = percentage out of total fruit species recorded in KHGs.

vegetatively propagated more productive plants. In terms of *ex situ* conservation, out of 12,333 accessions over 125 plant species at the Plant Genetic Resources Centre of Sri Lanka, only 163 accessions are of fruit species. The fruit germplasm collection at the Horticultural Crop Research and Development Institute consists of 670 samples of 20 fruit species, but details of varieties are not available (Chithral, 2011). These examples clearly indicate the potential for KHGs to act as an already existing good practice for conservation and use of fruit crop species.

Conservation of fruit crop varietal diversity (intraspecific) in KHGs

A field survey with farmers revealed that the majority of known fruit crop varieties are recorded in KHGs (Table 9.4), indicating the conservation of a high level of genetic diversity of fruit crops in KHGs. However, few studies have been carried out on their genetic diversity. An assessment of morphological and genetic diversity of jackfruit using RAPD markers revealed that much of the genetic variation of the species is conserved in KHGs (Pushpakumara and Harris, 2007). This is mainly due to the seedling origin of most of the fruit crops in KHGs, which are highly heterogeneous as a result of the outcrossing nature of the species (Pushpakumara *et al.*, 1997). Confirming this, a wide range of variation has also been observed for the jackfruit population in the Kandy district in terms of fruiting season, fruit shape, number of fruit per tree, fruit weight, flesh thickness and hardness, flesh texture, aroma, colour and juiciness, and latex quantity. Although there has been no comprehensive analysis of genetic diversity of mango in Sri Lanka, the country has a large number of mango morphotypes. The distribution of mango morphotypes such as *gira amba* and *mee amba* in the KHGs of the Matale and Kandy districts, respectively (personal communication, Mr Leel Randeniya, Ministry of Environment and Renewable Energy, Sri Lanka), suggests that the bulk of the genetic diversity of many perennial fruit crop species is conserved through

Table 9.3 Species diversity of fruit in Sri Lanka and their occurrence in Kandyan home gardens

Family	*Botanical name*	*Common names*
Anacardiaceae (9, 5, 3/1, 2/1, 4/3)	***Anacardium occidentale* L.**	Cashew nut
	***Buchanania axillaris* (Desr.) Ramamoorthy+**	Kiri palu
	***Mangifera indica* L.**	Mango
	Mangifera pseudoindica Kosterm.★•	–
	***Mangifera zeylanica* (Blume) Hook.f.★•**	Atemba, Wal amba
	Semecarpus subpeltata Thw.★	Maha badulla
	***Spondias dulcis* Sol. ex Parkinson**	Amberella
	Spondias mombin L.	Hog plum tree
	Spondias pinnta (L.f.) Kurz+•	Hog plum, Ambarella
Annonaceae (8, 4, 1/0, 1/0, 6/4)	***Annona cherimola* Miller**	Cherimoyer
	Annona glabra L.	Wel artha
	***Annona muricata* L.**	Soursop
	***Annona reticulata* L.**	Bullock's heart, Weli artha
	***Annona squamosa* L.**	Custard apple, Seeni artha
	Enicosanthum acuminata (Thw.) Airy Shaw★	Mal laulu
	Polyalthia korinti (Dunal) Thw.+•	Ul kenda
	Uvaria grandiflora Roxb.	–
Apocynaceae (4, 3, 0/0, 2/2, 2/1)	***Carissa carandas* L.+•**	Maha karamba
	***Carissa grandiflora* A. DC.**	Damson
	Carissa inermis Vahl•	–
	***Carissa spinarum* L.+•**	Heen karamba
Arecaceae (8, 2, 1/1, 3/1, 4/0)	*Borassus flabellifer* L.	Palmyrah
	Calamus rotang L.+	Heen wewel
	Corypha umbraculifera L.	Talipot plant
	***Loxococcus rupicola* (Thw.) H. Wendl. & Drude★•**	Dothalu
	Nypa fruticans Wurmb+	Water coconut
	Phoenix dactylifera L.	Date palm
	***Phoenix pusilla* Gaertn.+•**	Indi
	Phoenix sylvestris (L.) Roxb.	Indi
Berberidaceae (3, 1, 1/1, 2/0, 0/0)	***Berberis ceylanica* Schneider★**	Barberry
	Berberis tinctoria Leschen.+•	Barberry
	Berberis wightiana Schneider+•	Barberry
Bombacaceae (4, 2, 2/0, 0/0, 2/2)	***Adansonia digitata* L.**	Baobab
	Cullenia ceylanica (Gardner) K. Schum.★•	Kataboda
	Cullenia rosayroana Kosterm.★•	Kataboda
	***Durio zibethinus* Murr.**	Durian
Boraginaceae (2, 0, 0/0, 1/0, 1/0)	*Cordia dichotama* Forst. f.	Lolu
	Cordia myxa L.	Lolu
Bromeliaceae (1, 1, 0/0, 0/0, 1/1)	***Ananas comosus* (L.) Murr.**	Pineapple
Burseraceae (2, 0, 1/0, 1/0, 0/0)	*Canarium zeylanicum* (Retz.) Blume★	Kekuna
	Scutinanthe brunnea Thw.	Maha bulumora

Cactaceae (1, 1, 0/0, 0/0, 1/1)	***Hylocereus undatus* (Haw.) Britt & Ross.**	Dragon fruit
Caricaceae (1, 1, 0/0, 0/0, 1/1)	***Carica papaya* L.**	Papaya
Clusiaceae (7, 5, 4/2, 1/1, 2/2)	*Calophyllum calaba* L.★	Heen keena
	***Garcinia quaesita* Pierre.★**	Goraka
	***Garcinia zeylanica* Roxb.★•**	Ela goraka
	***Garcinia mangostana* L.**	Mangosteen
	***Garcinia morella* (Gaertn.) Desr.+•**	Gamboge
	Garcinia terpnophylla (Thw.) Thw.★•	–
	***Garcinia xanthochymus* Hook. f.**	Rata goraka
Combretaceae (1, 1, 0/0, 0/0, 1/1)	*Terminalia catappa* **L.**	Kotamba
Cucurbitaceae (1, 1, 0/0, 0/0, 1/1)	***Citrullus lantanus* (Thunb.) Matsum & Nakai**	Melon
Elaeagnaceae (1, 0, 0/0, 1/0, 0/0)	*Elaegnus latifolia* L.+•	Katu embilla
Elaeocarpaceae (4, 1, 3/0, 1/1, 0/0)	*Elaeocarpus amoenus* Thw.★•	Titta weralu
	Elaeocarpus glandulifer (Hook.) Masters★•	Gal weralu
	***Elaeocarpus serratus* L.**	Indian olive, Weralu
	Elaeocarpus subvillosus Arn.★•	Gal weralu
Erythroxylaceae (1, 1, 0/0, 1/1, 0/0)	***Erythroxylum moonii* Hochur.**	Bata kirilla
Euphorbiaceae (13, 5, 3/0, 8/3, 2/2)	*Antidesma alexiteria* L.+•	Heen embilla
	***Antidesma bunius* (L.) Spreng.+**	Karawala kebella
	Antidesma ghaesembilla Gaertn.+•	Bu embilla
	Antidesma thwaitesianum Muell. Arg.+•	Karawala kebella
	Aporusa cardiosperma (Gaertn.) Merr.+	Kampottu
	Aporusa lanceolata (Tul.) Thw.★	Heen kebella
	Aporusa lindleyana (Wight) Baill.+	Kebella
	***Baccaurea motleyana* Mull.-Arg.**	Gaduguda
	Drypetes gardneri (Thw.) Pax & Hoffm.•	Eta wira
	***Drypetes sepiaria* (Wight & Arn.) Pax & Hoffm.**	Wira
	***Phyllanthus acidus* (L.) Skeels**	Rata nelli
	***Phyllanthus emblica* L.+**	Amla, Nelli
	Ptychopyxis thwaitesii (Baill.) Croizat★	Wal rambutan
Fabaceae (7, 3, 2/0, 2/1, 3/2)	*Adenanthera bicolor* Moon★	Mas mora
	Castanospermum australe Cunn. & Fraser ex W.J. Hook.	Australian chestnut
	***Cynometra cauliflora* L.**	Nam nam
	Dialium ovoideum Thw.★	Velvet tamarind
	***Pongamia pinnata* (L.) Pierre+**	Gal karanda
	Tadehagi triquetrum (L.) Ohashi+	Baloliya
	***Tamarindus indica* L.**	Tamarind

Table 9.3 continued

Family	*Botanical name*	*Common names*
Flacourtiaceae (6, 2, 3/0, 1/1, 2/1)	*Dovyalis hebecarpa* (Gardner) Warb.★	Ceylon gooseberry
	***Flacourtia indica* (Burm. f.) Merr.+**	Uguressa
	***Flacourtia inermis* Roxb.**	Lovi
	Flacourtia jangomas (Lour.) Rausch.	Rata uguressa
	Hydnocarpus octandra Thw.★•	Wal divul
	Trichadenia zeylanica Thw.★	Tolol
Hippocrateaceae (2, 0, 0/0, 2/0, 0/0)	*Salacia chinensis* L.+	Heen himbutuwel
	Salacia oblonga Wall. Ex Wight & Arn.+•	Chundan
Lauraceae (4, 1, 1/0, 2/0, 1/1)	*Crtptocarya membranaceae* Thw.★	Galmora
	Crtptocarya wightiana Thw.+	Galmora
	***Persea americana* Miller.**	Avacardo
	Persea macrantha (Nees) Kosterm.+	Ululu
Melastomataceae (1, 1, 0/0, 1/1, 0/0)	***Melastoma malabathricum* L.**	Bowitiya
Meliaceae (2, 1, 0/0, 1/0, 1/1)	***Sandoricum koetjape* (Brum. f.) Merr.**	Donga
	Walsura trifoliolata (A. Juss.) Harms+	Kirikon
Moraceae (6, 5, 1/1, 2/1, 3/3)	***Artocapus heterophyllus* Lam.**	Jackfruit
	***Artocarpus incisus* L.f.**	Breadfruit
	***Artocarpus nobilis* Thw.★•**	Waldel
	***Ficus racemosa* L.+**	Attikka
	***Morus alba* L.**	Mulberry
	Streblus asper Lour.+	Getanitul
Musaceae (3, 1, 0/0, 3/1, 0/0)	*Musa acuminata* Colla+•	Unel
	Musa bulbicianan Colla+•	Atikesel
	***Musa* spp. L.**	Kesel
Myrsinaceae (4, 1, 1/0, 3/1, 0/0)	***Ardisia elliptica* Thunb.+**	Baludan
	Ardisia solanaceae Roxb.+	Baludan
	Ardisia willisii Mez★	Baludan
	Embelia ribes Burm. f.+	Wel embilla
Myrtaceae (14, 8, 3/0, 6/5, 5/3)	*Cleistocalyx nervosum* (DC.) Kosterm.★	Batadamba
	Eugenia uniflora L.	Brazilian cherry
	***Psidium guajava* L.**	Guava
	***Psidium guineense* Sw.•**	Cheena pera
	Psidium montane Sw.	Embulpera
	***Rhodomyrtus tomentosa* (Ait.) Hassk.+**	Wild guava
	Syzygium aqueum (Burm. f.) Alston+•	Wal jambo
	***Syzygium caryophyllatum* (L.) Alston+**	Heen dan
	Syzygium cordifolium Walp.★•	Wal jambu
	***Syzygium cumini* Skeels+**	Madan, Jamun
	***Syzygium jambos* (L.) Alston+**	Rose apple
	***Syzygium malaccense* (L.) Merr. & Perry+**	Jambu
	***Syzygium samarangense* (Blume) Merr. & Perry**	Pini jambu
	Syzygium umbrosum Thw.★•	Heen damba

Nelumbonaceae (1, 0, 0/0, 1/0, 0/0)	*Nelumbo nucifera* Gaertn.+	Lotus
Oxalidaceae (2, 2, 0/0, 0/0, 2/2)	***Averrhoa carambola* L.**	Star fruit
	***Averrhoa bilimbi* L.**	Biling
Passifloraceae (4, 1, 0/0, 0/0, 4/1)	***Passiflora edulis* Sims**	Passion fruit
	Passiflora laurifolia L.	Water melon
	Passiflora mollissima (HBK) Bailey•	Banana passion fruit
	Passiflora quadrangularis L.	Desi puhul
Punicaceae (1, 1, 0/0, 0/0, 1/1)	***Punica granatum* L.**	Pomegranate
Rhamnaceae (5, 2, 2/0, 3/2, 0/0)	*Ziziphus lucida* Moon ex Thw.★•	Eraminya
	***Ziziphus mauritiana* Lam.+**	Masan
	Ziziphus napeca (L.) Willd.★•	Yak eraminiya
	Ziziphus oenoplia (L.) Miller+•	Heen eraminiya
	***Ziziphus rugosa* Lam.**	Maha eraminiya
Rosaceae (11, 4, 1/0, 3/0, 7/4)	*Duchesnea indica* (Andr.) Focke+	Indian strawberry
	***Eriobotrya japoica* (Thunb.) Lindley**	Japan batu
	***Fragaria vesca* L.**	Strawberry
	***Malus sylvestris* Miller**	Apple
	Prunus cerasoides D. Don+•	Indian cherry
	Prunus persica (L.) Batsch	Peach
	Prunus walkeri (Wight) Kalkman★•	Golumora
	***Pyrus communis* L.**	Pear
	Rubus ellipticus Smith+	False blackberry
	Rubus moluccanus L.	Blackberry
	Rubus rosifolius Smith	Wild raspberry
Rubiaceae (7, 1, 0/0, 6/0, 1/1)	*Anthocephalus chinensis* (L.) A. Rich. Ex Walp.+•	Ela bakmi
	Canthium coromandelicum (Burm. f.) Alston+•	Kara
	Ixora coccinea L.+	Ratambala
	***Ixora macrothyrsa* (Teys. & Binn.) Moore**	Ixora
	Ixora pavetta Andr.+,	Maha rathambala
	Morinda umbellata L.+	Kiri wel
	Nauclea orientails (L.) L.+•	Bakmi
Rutaceae (15, 10, 0/0, 6/1, 9/9)	***Aegle marmelos* (L.) Correa**	Baelfruit
	Atalantia ceylanica (Arn.) Oliver+•	Yakinaran
	Atalantia monophylla (Roxb.) DC.+•	Perukuruntu
	Atalantia rotundifolia (Thw.) Tanaka+•	–
	***Citrus aurantifolia* (Christm. & Panzer) Swingle**	Dehi, Lime
	***Citrus aurantium* L.**	Sour orange
	***Citrus grandis* (L.) Osbeck**	Pummelo
	***Citrus hystrix* DC.**	Gada dehi
	***Citrus limon* (L.) Burm. f.**	Lemon
	***Citrus medica* L.**	Citron
	***Citrus reticulata* Blanco**	Mandarin, Heen naran
	***Citrus sinensis* (L.) Osbeck**	Sweet orange
	Glycosmis pentaphylla (Retz.) A. DC.+•	Dodan pana
	***Limonia acidissima* L.+**	Woodapple
	Naringi crenulata (Roxb.) Nicolson+•	Wal beli

Table 9.3 continued

Family	*Botanical name*	*Common names*
Sabiaceae (1, 0, 0/0, 1/0, 0/0)	*Meliosma pinnata* (Roxb.) Maxim.+•	Wal bilin•
Sapindaceae (6, 4, 2/0, 3/3, 1/1)	*Dimocarpus gardneri* (Thw.) Leenh.⋆	Nurai
	***Dimocarpus longan* Lour**.+	Mora
	Glenniea unijuga (Thw.) Radlk⋆•	Wal mora
	***Nephelium lappaceum* L.**	Rambutan
	***Pometia pinnata* J.R. & G. Forst.+•**	Bulu mora
	***Schleichera oleosa* (Lour.) Oken**	Ceylon oak, Kon
Sapotaceae (8, 6, 0/0, 3/2, 5/4)	***Chrysophyllum cainito* L.**	Kos ata laulu
	Chrysophyllum oliviforme L.	Date plum
	***Chrysophyllum roxburghii* G. Don**	Laulu
	***Manilkara hexandra* (Roxb.) Dubard**+•	Palu
	***Manilkara zapota* (L.) P. van Royen**	Sapodilla
	***Mimusops elengi* L.+•**	Munamal
	***Pouteria campechiana* (Kunth) Baehni**	Canistel, Rata laulu
	Xantolis tomentosa (Roxb.) Raf.+	Mul makil
Solanaceae (3, 2, 0/0, 1/1, 2/1)	*Datura stramonium* L.	Thorn apple
	***Physalis micrantha* Link+**	Nalal batu
	***Physalis peruviana* L.**	Cape gooseberry
Sonneratiaceae (1, 0, 0/0, 1/0, 0/0)	*Sonneratia alba* J. Sm.	Kirala
Sterculiaceae (2, 1, 0/0, 1/0, 1/1)	*Sterculia foetida* L.+	Telabu
	***Theobroma cacao* L.**	Cocoa
Tiliaceae (4, 2, 0/0, 3/1, 1/1)	***Grewia damine* Gaertn.+**	Daminiya
	Grewia helicterifolia Wall. Ex G. Don+•	Bora daminiya
	Microcos paniculata L.+•	Keliya
	***Muntingia calabura* L.**	Jam tree
Ulmaceae (1, 0, 0/0, 1/0, 0/0)	*Holoptelea intergrifolia* (Roxb.) Planch.	Goda kirilla
Verbanaceae (3, 2, 0/0, 2/1, 1/1)	***Gmelina arborea* Roxb.+**	Athdemata
	Gmelina asiatica L.+	Asiatic beach berry
	***Lantana camara* L.**	Gandapana
Vitaceae (1, 1, 0/0, 0/0, 1/1)	***Vitis vinifera* L.**	Grape

Note: ⋆, + and • indicate endemic species, indigenous species and wild relatives of crops, respectively. Botanical names without any symbol indicate exotic species whereas botanical names in bold indicate species observed/recorded in KHGs. Values in parenthesis under each family name (1, 1, 0/0, 0/0, 1/1) represent fruit crop species recorded from the given family in Sri Lanka, number of species recorded in KHGs, endemic fruit species recorded in Sri Lanka/KHGs, indigenous fruit species recorded in Sri Lanka/KHGs, exotic species recorded in Sri Lanka/KHGs, respectively.

Source: Derived from Ashton *et al.* (1997); Dassanayake and Fosberg (1980–1991); Dassanayake *et al.* (1994); Dassanayake and Clayton (1995–2000).

Table 9.4 Varietal diversity of commonly grown fruit recorded in Sri Lanka and their presence in Kandyan home gardens (KHGs)

Species	*Varieties*
Banana	**Alukesel, Amban, Ambul kesel, Anamalu, Binkesel, Cavendish, Kolikuttu, Nethrappalan, Puwalu, Rathambala, Seenikesel, Suwadel, Wathabanga, Local types**
Papaya	**Rathna, Red lady, Local types**
Mango	**Alponso, Ambalavi,** Seedless, **Beti amba, Chembatan, Dampara, Gira amba, Karthakolomban,** Kalu kohu amba, **Kohu amba, Malwana, Mee amba, Petti amba, Piterprasand, Pol amba, Tom EJC, Velleikolomban, Villard,** Walu amba, **Local types**
Avocado	**Booth 7, Furete, Hass, Peradeniya purple, Pollock, Simonds, Tower 2, Local types**
Jackfruit	Arthur V Dies, Dahaata masya, **Fartherlong,** Ganegoda, Horana, Kalpitiya, **Kothmale, Kurukos, Kuruwita, Maharagama**, Mandoor, Pani waraka, **Rosakos/Hirosa**, Thellippalai, **Gannoruwa, Local types**
Guava	**Horana rosi, Horana sweet, Lanka giant, Red giant, Local types**
Rambutan	**Malayan red, Malwana special, Malayan yellow, Local types**
Durian	**Ambathenna, Gannoruwa, Kasun, Local types**

Note: Bold letters indicated varieties observed/occurred in KHGs.
Source: Survey data by authors (2014).

KHGs. Similar information has also been reported by Muthukuda and Wijerathne (2007) for several perennial fruit crops. Hence, as a GPD, KHGs constitute a valuable system for on-farm conservation of genetic diversity and facilitation of their gene flow.

Although the number of individuals of each species is limited, the presence of even a few trees in each KHG may preserve rare alleles related to elite characteristics allowing for present use and future selection and breeding. Uninterrupted maintenance of landraces and farmers' varieties in KHGs has prevented the erosion or extinction of most economically important varieties of fruit and other crop species in Sri Lanka. It was observed that custodian farmers safeguarded specific fruit crop varieties for several reasons (Table 9.5). Similar observations were made in focus group discussions with farmers, where it was revealed that some farmers appreciated certain quality characteristics for local food preparations, for example local jackfruit types (*pani waraka*, a sweet hard-fleshed type of which the immature fruit is used in the preparation of polos curry). Other qualities appreciated were medicinal properties (nelli, bael and pomegranate), premium marketability (hard-fleshed durian type), cultural reasons (use in New Year festivals) and lack of pest and disease problems (local jackfruit, mango and guava types).

Table 9.5 Custodian farmers with local varieties and landraces of fruit crop in Kandyan Home Gardens (KHGs) and reasons for maintaining such diversity

Custodian farmers of KHGs	*Fruit species and their diversity used in KHGs*	*Reason(s) for maintaining diversity*
D. Werake, Kundalagama, Kundasale	Local types of mango, passion fruit, guava and annona	1, 2, 3, 4, 5
K.M. Gunathilaka, Walawwaththa, Hondiyadeniya	Local types of mangosteen, guava, durian, passion fruit, mango, lime, mandarin, jackfruit (waraka), avocado	1, 2, 3, 4
A. Dharmakerthi, Mahaweli Uyana, Kundasale	Local types of mango, jackfruit (waraka), sweet orange, passion fruit, nelli (*Phyllanthus emblica*)	1, 2, 3, 4, 5
B.M. Perera, Teekawatta, Thannekumbura	Local types of rambutan, mango, sweet orange, mandarin, jackfruit (waraka), avocado, pummelo, jambu (*Syzygium malaccense*), uguressa (*Flacourtia indica*)	1, 2, 3, 4, 5
M.M. Kerthirathne, Malgammana, Nugawela	Local types of jackfruit (waraka), uguressa, annona, avocado, mango, banana	1, 2, 3, 4, 5
R.K. Wickramarathne, Yatihalagala, Katugastota	Local types of mango, jackfruit (waraka), avocado, mandarin, jambu, banana	1, 2, 3, 4
M. Heenkenda, Araliyawa, Arangala, Nattranpota	Local types of mango, jackfruit (waraka), avocado, mandarin, jambu, banana	1, 2, 3, 4
G. Wijewardena, Padiwatta, Kundasale	Local types of mango, jackfruit (waraka), avocado, mandarin, jambu, banana	1, 2, 3, 4, 5
G. Hennkenda, Karaththamada Road, Naththaranpotha	Local types of durian, avocado, breadfruit, mango, jackfruit (waraka), banana, annona, mangosteen, jambu, uguressa, cocoa	1, 2, 3, 4
G. Rathnayake, Gadaladeniya Road, Pilimathalawa	Local types of mango, jackfruit, guava, sweet orange, mandarin, banana, jambu, uguressa, avocado	1, 2, 3, 4, 5

Source: Survey data by authors (2014).
Note: 1 = believed that the quality (flavour, flesh character, medicinal value etc.) of local fruit varieties is superior to improved varieties; 2 = under dense canopy of HGs, improved varieties do not perform well but local varieties adapt to conditions; 3 = local varieties need low levels of technical and management input (pruning and training); 4 = in most local varieties fruit ripening is not synchronous and is thus supportive of a longer production period; 5 = less susceptible to pest and disease and to extreme conditions. All the custodian farmers listed are men because they are the owners of the KHGs. In Sri Lanka, while, in theory, women may own land, in practice, land ownership documents must be signed by the 'head of household' and this is usually deemed to be the man (Gomez and Tran, 2012).

Until the early 1960s, farmers were the custodians of the complete range of genetic diversity available in the landraces of the traditional cultivars of the majority of crops and fruits in Sri Lanka (Ganashan *et al.*, 1996; Jayasuriya and Rajapakse, 2004). By the late 1980s and early 1990s, especially with regard to landraces of some vegetatively propagated fruit crops, some landraces and local cultivars had been replaced with introduced or improved cultivars. At the same time, the survey revealed, some varieties of fruit crops had almost been wiped out from the KHGs as the result of: the use of improved varieties of grafted planting material (i.e. local cultivars of durian, rambutan and mango); lack of attention and care (bullock's heart or *weli anoda*, and *koholla laulu*, *laulu*); fragmented HGs due to population pressure (i.e. large trees of durian, mango and jackfruit) and damage by animals such as monkeys (many fruit species). However, still a large number of KHGs at a landscape level help to safeguard local varieties and landraces of many fruit species (Tables 9.3–9.5).

KHGs and sustainable landscape management

The KHG network in Sri Lanka provides a complementary resource base acting as a kind of field genebank for conservation of fruit crop genetic resources. The network also acts as a complementary option to mediate the *in situ–ex situ* gap through on-farm conservation and as a platform for continuation from natural vegetation to monoculture fields. Thus, KHGs can be used to conserve other crops, tree, livestock and poultry species as well as fruit crops in the landscape. The presence of KHGs provides environmental conservation, such as easing pressure on natural forests, increased multi-layered vegetation cover leading to a pleasant living environment, control of erosion and pollution, and fertility replenishment, in addition to food and nutritional security and biodiversity conservation with associated ecosystem services. The systems also bolster cultural identity, as traditional systems based on indigenous knowledge and species are part of the cultural patterns of the communities. Trees, which are the main structural feature of KHGs, have a positive effect on the global carbon balance (Mattsson *et al.*, 2013) and are climate resilient (Marambe *et al.*, 2012; Weerahewa *et al.*, 2012). Thus, it is a land use system that can produce goods and services while protecting and connecting environments in fragmented areas and is useful in the management of landscapes in Sri Lanka.

In order to protect the multi-storeyed and multispecies nature of KHGs under increasing intensification of land use practices, it will be increasingly important to find ways to increase the profitability of KHG systems while maintaining, as much as possible, their biodiversity benefits. This consideration is key to ensuring the sustainability of this system. It will also be important to increase the level of technology used in KHGs. Comparatively low levels of technology and crop management techniques are practised by KHG owners and their attention is also variable. As a result, the yield and quality of KHG fruit are comparatively low (Weerakkody, 2004; Heenkenda, 2014). Introduction of technology packages, for example induction of flowering and proper

pruning of fruit trees to enhance productivity through rejuvenation, is essential for the conservation and sustainability of the system.

During the survey, many farmers indicated that they did not receive any incentives for on-farm conservation of genetic resources, although some farmers had received awards, certificates and cash prizes for management of KHGs with high diversity in the context of family food and nutrition security. The importance of HGs for genetic resource conservation is not yet widely recognized outside scientific circles, and little work has been done on custodian farmers in Sri Lanka with respect to reasons for maintaining unique genetic resources of fruit species.

KHG policy environment

Over the years, the number and total area of KHGs and HGs have increased annually, despite little policy support. During the last two decades the number of species and structure of HGs has remained constant because HGs and KHGs are now increasingly recognized as examples of traditionally developed agroforestry systems with excellent promise for facing present and future challenges. Having realized the importance of HGs, the national development policy framework of the government of Sri Lanka now includes strategies to expand and improve food and timber production in these landscapes (NCSD, 2009). In addition, the National Agriculture Policy of 2007 (MADAS, 2007) also highlights the need to promote HGs, especially focusing on the urban sector and the role played by women in HGs. Improvement of HGs in Sri Lanka has been the priority of many development programmes implemented over the past five to seven years, after development of 375,000 HGs was targeted under the "*Api Wawamu Rata Nagamu*" (Let us grow and uplift the nation) programme launched in 2007. The strengthening of 1.5 million HGs is the target of the "*Divi Neguma*" (Livelihood development) programme in order to achieve self-sufficiency in vegetable production leading to reduction in vegetable prices to make them affordable for all (Government of Sri Lanka, 2011).

The Sri Lankan policy framework includes establishing 'fruit villages' based on strengthening HGs in order to improve fruit production, and promoting fruit production activities at village level as a mean of ensuring village empowerment. To achieve this, planting material of identified species (jackfruit, durian, rambutan) and their varieties has been distributed to villages so that they can develop their own mechanisms to promote planting material production and marketing; and collection of fruit has been organized by villagers in the Kandy, Matale and Kurunegala districts. As yet, impacts of the fruit village concept and HG improvement programmes are yet to be identified and researched. Further production enhancement, genetic conservation, dissemination and exchange of old and new germplasm to farmers, fruit crop mating systems and selection, and effects of change of socio-economic status of householders on genetic diversity of fruits are also to be identified. These are priority research areas to understand the impacts on conservation of fruit crops in KHGs.

Conclusion and way forward

Sri Lankan HGs in Kandy and adjacent districts, such as Badulla, Kegalle, Kurunegala, Matale, Nuwara Eliya and Rathnapura, are defined and popularly known as Kandyan home gardens (KHGs) or Kandyan forest gardens. KHGs represent a scattered but important human-made land use system that increases the tree cover of this area of Sri Lanka. Out of 196 fruit species recorded in Sri Lanka, more than half of the species are recorded from 17 per cent of the area of the above districts. The KHGs, therefore, are an important land use system for Sri Lanka in terms of the percentage of land area occupied, conservation of fruit crop species and their genetic diversity, and provision of other environmental services, while helping to generate income and food and nutrition security of households. This study shows that KHGs represent a land use system that, over time and space, in most instances maintains and in some instances enhances and creates crop genetic diversity; hence they can be regarded as a good practice for maintaining diversity (GPD). Year-round production of a wide range of products required by householders, new business ventures through value addition, provision of many ecosystem services and easing pressure on natural forests have been identified as key elements of KHGs. Having said that, relatively little attention has been paid to assessing the ecosystem services and dynamics of KHGs under the influence of rural transformation to commercialization, land degradation and the impact of fragmentation of KHGs on social, cultural and ecological sustainability. Hence, a community-based long-term, multidisciplinary and participatory research programme is needed to understand the dynamics of conservation and use of species and genetic diversity of fruits. On-farm assessment of genetic diversity using temporal quantitative data against the changing social dimensions in society brings inferences at the level of individual KHGs as well as the level of the landscape on the ecosystem services of KHGs.

References

Ariyadasa, K.P. (2002) *Assessment of Tree Resources in the Home Gardens of Sri Lanka*, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand

Ashton, M., Gunatilleke, S., de Soyza, N., Dassanayaka, M.D., Gunatilleke, N., and Wijesundara, S. (1997) *A Field Guide to the Common Trees and Shrubs of Sri Lanka*, WHT Publication (Pvt) Ltd., Colombo, Sri Lanka

Chithral, G.M.W. (2011) 'Quality seed in Sri Lanka: Production, processing, legal and quality control and marketing system', in N. Huda and I. Saiyed (eds), *Quality Seed in SAARC Countries: Production, Processing, Legal and Quality Control and Marketing System*, SAARC Agriculture Centre, Bangladesh, pp. 303–454

Dassanayake, M.D. and Clayton, W.D. (1995–2000) *A Revised Handbook to the Flora of Ceylon*, vols 10–14, Oxford & IBH Publishing Company Private Limited, New Delhi, India

Dassanayake, M.D. and Fosberg, F.R. (1980–1991) *A Revised Handbook to the Flora of Ceylon*, vols 1–7, Amerind Publishing Company Private Limited, New Delhi, India

Dassanayake, M.D., Fosberg, F.R., and Clayton, W.D. (1994) *A Revised Handbook to the Flora of Ceylon*, vols 8–9, Oxford & IBH Publishing Company Private Limited, New Delhi, India

Dela, J.D.S. (2011) 'Impact of monkey–human relationships and habitat change on *Semnopithecus vetulus nestor* in human modified habitats', *Journal of the National Science Foundation of Sri Lanka*, vol 39, no 4, pp. 365–382

De Silva, K.M. (1981) *A History of Sri Lanka*, C. Hurst & Company, London

FSMP (1995) *Sri Lanka Forestry Sector Master Plan*, Forestry Planning Unit, Forest Department, Ministry of Agriculture, Lands and Forestry, Colombo, Sri Lanka

Ganashan, P., Balendira, S., and Dassanayake, M.D. (1996) *Sri Lanka: Country Report to the FAO International Technical Conference on Plant Genetic Resources (Leipzig)*, Department of Agriculture, Peradeniya, Sri Lanka

Government of Sri Lanka (2011) 'Improving family nutrition, a main objective of *Divi Neguma* Programme'; http://www.priu.gov.lk/news_update/Current_Affairs/ca201107/20110713improving_family_nutrition.htm, accessed on 10 May 2012

Heenkenda, H.M.S. (2014) *Better Future Through Fruit Crop Research*, Fruit Research and Development Institute, Horana, Sri Lanka

Hitinayake, H.M.G.S.B. and Ekanayake, U. (1999) 'Utilization of underutilized fruit tree species grown in Kandyan home gardens', in H.P.M. Gunasena (ed.), *Proceedings of the Tenth National Workshop on Multipurpose Trees: Fruit for the Future, Kandy, Sri Lanka*, 5 November 1999, pp. 186–212

IUCN and MENR (2007) *The 2007 Red List of Threatened Fauna and Flora of Sri Lanka*, IUCN and Ministry of Environment and Natural Resources, Colombo, Sri Lanka

Jacob, V.J. and Alles, W.S. (1987) 'The Kandyan gardens of Sri Lanka', *Agroforestry Systems*, vol 5, pp. 123–137

Jarvis, D., Hodgkin, T., Eyzaguirre, P., Ayad, G., Sthapit, B.R., and Guarino, L. (1997) 'Farmer selection, natural selection and crop genetic diversity: The need for a basic dataset', in D. Jarvis and T. Hodgkin (eds), *Strengthening the Scientific Basis of In Situ Conservation of Agricultural Biodiversity On-farm: Options for Data Collecting and Analysis*, Proceedings of a Workshop to Develop Tools and Procedures for *In Situ* Conservation On-farm, International Plant Genetic Resources Institute, Rome, Italy

Jayasuriya, A.H.M. and Rajapakse, R.M.T. (2004) 'Plant genetic resources activities in Sri Lanka', in Bhag Mal, P.N. Mathur, V. Ramanatha Rao, and A.H.M. Jayasuriya (eds), *Proceedings of the Sixth Meeting of South Asia Network on Plant Genetic Resources (SANPGR)*, held at PGRC, Peradeniya, Sri Lanka, 9–11 December 2002; IPGRI South Asia Office, New Delhi, India, pp. 22–38

Krishnarajah, P.S. and Sumanarathne, H.D. (1988) 'Magnitude and extent of soil erosion under different landuse in the mid country region of Sri Lanka', *Krushi*, vol 11, no 1, pp. 18–21

Kudavidanage, E.P., Wanger, T.C., de Alwis, C., Sanjeewa, S., and Kotagama, S.W. (2012) 'Amphibian and butterfly diversity across a tropical land-use gradient in Sri Lanka: implications for conservation decision making', *Animal Conservation*, vol 15, no 3, pp. 253–265

McConnell, D.J. and Dharmapala, K.A.E. (1973) *The Economic Structure of Kandyan Forest Garden Farms. Small Forest Garden Farms in the Kandy District of Sri Lanka*, Farm Management Diversification Report No. 7, UNDP/SF/FAO Diversification Project, Peradeniya, Sri Lanka

MADAS (2007) *National Agriculture Policy*, Ministry of Agriculture Development and Agrarian Services, Sri Lanka

Mahawamsa (undated) *The Great Chronicle of the History of Sri Lanka*; www.mahawamsa.org, accessed on 6 September 2012

Mankotte, K. (2011) *Department of Agriculture in Retrospect (1912–2011)*, Department of Agriculture, Peradeniya, Sri Lanka

Marambe, B., Weerahewa, J., Pushpakumara, G., Silva, P., Punyawardena, P., Premalal, S., Miah, G., and Roy, J. (2012) *Vulnerability of H Garden Eco-systems to Climate Change and its Impacts on Food Security in South Asia*; http://www.apn-gcr.org/resources/archive/files/3ddf57b875774091a38f95bdfee0b6c9.pdf, accessed on 25 July 2012

Mattsson, E., Ostwald, M., Nissanka, S.P., and Marambe (2013) 'Exploring the potential of home gardens as a multifunctional land-use strategy in Sri Lanka with focus on carbon sequestration', *Ambio*, vol 42, pp. 892–902

MENR (2009) *Fourth Country Report to the Convention on Biological Diversity*, in J.D.S. Dela (compiled), Ministry of Environment and Natural Resources, Sri Lanka; https://www.cbd.int/doc/world/lk/lk-nr-04-en.pdf, accessed on 7 November 2014

MFE (1999) *Biodiversity Conservation in Sri Lanka: A Framework for Action*, Ministry of Forestry and Environment, Battaramulla, Sri Lanka

Mohri, H., Lahoti, S., Saito, O., Mahalingam, A., Gunatilleke, N., Irham, Hoang, V.T., Hitinayake, G., Takeuchi, K., and Herath, S. (2013) 'Assessment of ecosystem services in home garden systems in Indonesia, Sri Lanka and Vietnam', *Ecosystem Services*, vol 5, pp. 124–136

Muthukuda Arachchi, D.H. and Wijerathne, P.M. (2007) *Country Report on the State of Plant Genetic Resources for Food and Agriculture: Sri Lanka*, FAO Government Cooperative Programme: The Status of the PGRFA in Sri Lanka, Department of Agriculture, Sri Lanka

NCSD (2009) *National Action Plan for Haritha Lanka Program*, National Council for Sustainable Development, Presidential Secretariat, Colombo 1, Sri Lanka

Perera, A.H. and Rajapakshe, R.M.N. (1991) 'A baseline study of Kandyan forest gardens of Sri Lanka: structure, composition and utilization', *Forest Ecology and Management*, vol 45, pp. 269–280

Pushpakumara, D.K.N.G., Boshier, D.H., and Harris, S.A. (1997) 'Mating system in *Artocarpus heterophyllus* Lam', *Tropical Agricultural Research*, vol 9, pp. 1–14

Pushpakumara, D.K.N.G. and Harris, S.A. (2007) 'Potential of RAPD markers for identification of fruit types of *Artocarpus heterophyllus* Lam. (jackfruit)', *Journal of National Science Foundation*, vol 35, part 3, pp. 175–179

Pushpakumara, D.K.N.G., Gunasena, H.P.M., and Singh, V.P. (eds) (2007) *Underutilized Fruit Trees in Sri Lanka,* World Agroforestry Centre, South Asia Office, New Delhi, India, vol 1

Pushpakumara, G. and Silva, P. (2008) *Agrobiodiversity in Sri Lanka*, Biodiversity Secretariat, Ministry of Environment and Natural Resources, Battaramulla, Sri Lanka

Pushpakumara, D.K.N.G., Wijesekara, A., and Hunter, D.G. (2010) 'Kandyan home gardens: A promising land management system in Sri Lanka', in C. Belair, K. Ichikawa, B.Y.L. Wong, and K.J. Mulongoy (eds), *Sustainable Use of Biological Diversity in Socio-ecological Production Landscapes: Background to the 'Satoyama Initiative for the Benefit of Biodiversity and Human Well-being*, Technical Series no 52, Secretariat of the Convention on Biological Diversity, Montreal, Canada

Pushpakumara, D.K.N.G., Gunasena, H.P.M., and Singh, V.P. (eds) (2011) *Underutilized Fruit Trees in Sri Lanka*, World Agroforestry Centre, South Asia Office, New Delhi, India, vol 2

Pushpakumara, D.K.N.G., Marambe, B., Silva, G.L.L.P., Weerahewa, J., and Punyawardena, B.V.R. (2012) 'A review of research on home gardens in Sri Lanka: The status, importance and future perspective', *Tropical Agriculturist*, vol 160, pp. 55–118

Raheem, D.C., Naggs, F., Preece, R.C., Mapatuna, Y., Kariyawasam, L., and Eggleton, P. (2008) 'Structure and conservation of Sri Lankan land-snail assemblages in fragmented lowland rainforest and village home gardens', *Journal of Applied Ecology*, vol 45, pp. 1019–1028

SCS (2011) *List of Information on Department of Agriculture Registered Fruit Nurseries*, Seed Certification Services, Department of Agriculture, Ministry of Agriculture Development and Govijanaseva, Colombo, Sri Lanka

Siddique, I., Gutjahr, C., Seneviratne, G., Breckling, B., Ranwala, S.W., and Alexander, I.J. (2007) 'Changes in soil chemistry associated with the establishment of forest gardens on eroded, acidified grassland soils in Sri Lanka', *Biology and Fertility of Soils*, vol 44, no 1, pp. 163–170

Sthapit, B.R., Sajise, P., Ramanatha Rao, V., Quek, P., de Cruz, F., and Bellon, M. (2004) 'Selection of good practices of *in situ* conservation of tropical fruit tree diversity: Methodology and key practices, Appendix K', GEF/UNEP Project document (unpublished)

Sthapit, B.R., Lamers, H., and Ramanatha Rao, V. (2013) *Custodian Farmers of Agricultural Biodiversity: Selected Profiles from South and South East Asia*, Proceedings of the Workshop on Custodian Farmers of Agricultural Biodiversity, 11–12 February 2013, New Delhi, India; Bioversity International, New Delhi, India

UN (1992) *Convention on Biological Diversity*, United Nations

Weerahewa, J., Pushpakumara, G., Silva, P., Daulagala, C., Punyawardena, R., Premalal, S., Miah, G., Roy, J., Jana, S., and Marambe, B. (2012) 'Are home garden ecosystems resilient to climate change? An analysis of the adaptation strategies of home gardeners in Sri Lanka', *APN Science Bulletin*, vol 2, pp. 22–27

Weerakkody, W.A.P. (2004) 'Horticulture in Sri Lanka', *Chronica Horticulturae*, vol 44, pp. 23–27

Wickramasinghe, A. (1995) 'The evolution of Kandyan home gardens: An indigenous strategy for conservation of biodiversity in Sri Lanka', in P. Halladay and D.A. Gilmour (eds), *Conserving Biodiversity Outside Protected Areas: The Role of Agroecosystems*, IUCN, Gland, Switzerland and Cambridge, UK, pp. 164–182