Homegardens as Sustainable Urban Agroforestry Systems to Promote Household Well-Being in Kandy, Sri Lanka

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Sachini Kavinda Jayakody and Mrittika Basu

Abstract

Accessibility to green space is vital for physical and mental well-being and homegardens in urban areas present space to connect with nature and derive benefits. Homegardens, whether small scale or large scale, represent sustainable agroforestry systems as spaces for physical exercise and mental health and also are a repository of a wide range of biological diversity that provides multiple benefits including provisioning, regulatory and supporting services. With increasing urbanization, urban hinterlands and rural areas are often encroached, threatening the ecosystem sustainability. Homegardens in Sri Lanka boast of age-old traditional knowledge and hold distinctive and multifunctional characteristics. They have been an integral part of Sri Lankan culture and a source of household food security. Though no immediate dangers to the homegardens in Sri Lanka are witnessed, the urbanization impacts are becoming evident and the future sustainability of homegardens is questionable. This chapter attempts to summarize the existing literature on homegardens in Sri Lanka, especially Kandyan homegardens, their characteristics, significance and threats. Due to the distinctive features of Kandyan homegardens and their benefits to the local community, they are an ideal example of agroforestry systems and provide instances that can be downscaled or upscaled for effective implementation in other parts of the world. This chapter explains the threats to homegardens and urban green policies/programmes in Sri Lanka as an opportunity to identify the challenges faced in mainstreaming policies and/or programmes on homegardens. This chapter

S. K. Jayakody · M. Basu (✉)
Laboratory of Sustainable Rural Development, Graduate School of Global Environmental Studies, Kyoto University, Kyoto, Japan
e-mail: basu.mrittika.4r@kyoto-u.ac.jp

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discusses future urban planning strategies for inclusion of homegardens in rural as well as urban areas of Sri Lanka.

Keywords

Homegardens · Urban green spaces · Agroforestry systems · Kandy · Sri Lanka

10.1 Introduction

Urbanization results in physical and socioeconomic changes including changes in land use as well as lifestyle of people (Madsen et al. 2010). Urban green spaces (UGS) present important solutions to these impacts that arise from the unsustainable activities that include not only environmental impacts but also social and economic impacts (Rostami et al. 2015). UGS are natural or man-made vegetated areas that are private or open to and accessible by the public in urban areas, allowing urban dwellers to be close to nature and for biodiversity within the urban area to be conserved. They have the ability to enhance air and water quality, reduce noise pollution, provide a barrier for extreme events, as well as provide health benefits for people, such as improving social interactions and reducing stress (Rostami et al. 2015; World Health Organization 2017). A study by Dobbs et al. (2017) studied 100 cities from 6 continents to evaluate the principal factors behind the global patterns of the landscape structure of urban vegetation. They determined that the main factors driving these global urban vegetation patterns were population and Gini index (a measure of income inequality within societies). Consequently, as population increased, green cover was observed to decrease and vegetation fragmentation to increase (Dobbs et al. 2017; Basu et al. 2020). Furthermore, cities with a higher level of income inequality were observed to have more fragmented vegetation (Dobbs et al. 2017). There is also some differences in participation between lower income households and higher income households of urban areas as those with lower income may not have a property with an area to grow food (Ranasinghe and Hemakumara 2018; Jayasinghe et al. 2021). They determined these findings to be supported by several other studies that have been conducted at the local and regional scale. When developing UGS, it is important to ensure that the different spaces, such as parks and forests, are interconnected using links, such as green corridors, to enable the flow of ecosystems (Benedict and McMahon 2002; Lafortezza et al. 2013; Semeraro et al. 2021). The percentage of urban area that has been allocated for green spaces from the total extent of the urban area can be used to assess the environmental sustainability of a city (Chiesura 2004). Various organizations suggested different standards with the aim of assessing the ecological sustainability of cities. One such method is determining the per capita green space extent of a city (Laghai and Bahmanpour 2012). This value represents the extent of green space in square meters (m^2) per individual. UN has expressed that the per capita green space should be more than 30 m^2 and such cities are named as sustainable cities, while the European Union (EU) stated the minimum value as 26 m^2 (Khalil 2014). The World

Health Organization (WHO) has defined that an area of 9 m^2 of green space should be maintained for each person in an urban area to provide a better quality life (Khalil 2014). Sometimes, developed countries have their own per capita green space values, for example, 50 m^2 in the USA, 30–60 m^2 in Germany and 50–60 m^2 in Switzerland (Hosseini et al. 2015). Major cities, too, in developed countries have defined individual values, for example, 154 m^2 by Los Angeles and 47 m^2 by New York (Hosseini et al. 2015).

As the urban green spaces are under immense pressure from urbanization and are rapidly vanishing, and access to green spaces at a distance becomes troublesome, homegardens and/or community gardens are considered as potential UGS that help to reconnect people to nature in an urban space (Teuber et al. 2019). This connection contributes to the resilience in cities, as it fosters ecosystem services on local to regional scales (Ernstson et al. 2010). Especially, the direct human-environment interaction of gardening might increase the resilience of the urban social-ecological system, as gardens provide ecosystem services like food and habitat provision or local climate regulation (Cabral et al. 2017; Speak et al. 2015). The provision of food by homegardens can also play a vital role in alleviating food insecurity. Food insecurity is already a major problem faced by many parts of the world, and with the increment of the world's population and rapid urbanization, this may become a crisis for both developed and developing countries, more so for developing countries (Lal 2020). It was recently intensified by the COVID-19 pandemic from interferences to food supply chains (Lal 2020; Sofo and Sofo 2020). People resorted to growing food at home for various reasons such as to avoid going outside to crowded places, a solution to food shortages and increase in food prices, as well as to fill the day with outside activity during lockdown (Chenarides et al. 2021). Apart from food security during the pandemic, homegardens are reported to significantly contribute to physical and mental well-being by helping them to connect to nature as well as providing them a space for physical exercise (Corley et al. 2021). Despite all the importance and services provided by homegardens, they are not extensively studied in a comprehensive manner and often ignored as potential urban green spaces (Calvet-Mir et al. 2012; Mohri et al. 2013).

Sri Lanka has a population of 21 million people, with approximately 18% residing in urban areas, of these about 15% of urban dwellers live in Colombo (Li 2017). The land use land cover map of Sri Lanka (Fig. 10.1) provides some insight into the vegetated and built-up areas in Sri Lanka. As clearly illustrated, the highest built-up area is in Colombo which is situated on the western coast of Sri Lanka. When analysing urbanization and UGS in Sri Lanka, the city of Colombo is the most studied area being the commercial capital that has observed a rapidly increasing migration from other parts of Sri Lanka. Maintaining or increasing green spaces in urban areas proves to be difficult due to more space being required to accommodate the growing population as well as increased urbanization. The study by Li (2017) on Colombo meeting UGS standards showed that the 83.1% of green space in Colombo in 1980 dropped to 13.5% by 2015, with a 20.7% increment in population by 2015 compared to 1980. It can also be observed that Sri Lanka consists of significant areas of homesteads/homegardens which was determined by

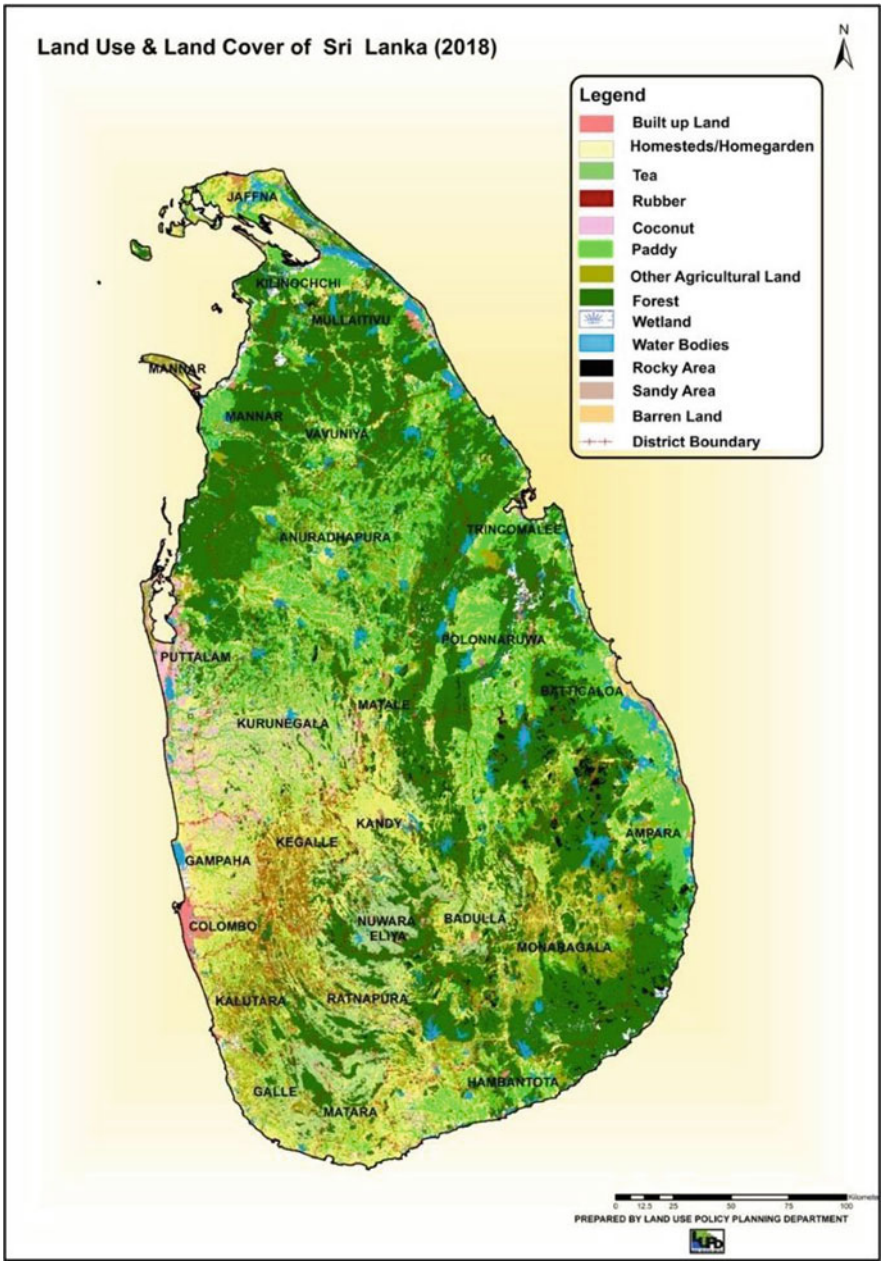

Fig. 10.1 Land use and land cover of Sri Lanka. (Source: Land Use Policy and Planning Department 2021)

the Land Use and Policy Planning Department to be 18.18% of all land in 2018. In Sri Lanka, the Kandyan area, which is in the mid-country region, is renowned for homegardens. They come from ancient and traditional ways of sustainable production that comprises of a wide variety of plant species with multiple uses and sometimes include livestock (Pushpakumara et al. 2010; Mohri et al. 2013). Their importance come from their ability to act similar to natural forests and provide food, an income and an aesthetically pleasing environment for home owners (Pushpakumara et al. 2010). It should be noted that the availability of UGS in Sri Lanka depends on whether settlements are planned and unplanned (Senanayake et al. 2013) and on the perception of the residents (Ranasinghe and Hemakumara 2018; Jayasinghe et al. 2021). With the pressures experienced by public UGS in Sri Lanka, gardens that are privately maintained may provide a solution to fulfilling the UGS requirement.

The homegardens of Sri Lanka are well known for their expanse and varied composition and multiple ecosystem services. However, with increasing threats from urbanization and other anthropogenic factors, homegardens in Sri Lanka have also become vulnerable. With the understanding of the importance of UGS and the threats they face, this chapter aims to explore the homegardens in Sri Lanka, especially Kandy, and to identify its role as important small-scale green spaces in Sri Lanka that can support urban sustainability. The findings will provide an understanding about the characteristics of homegardens and their role in improving urban socio-ecological resilience.

10.2 Literature Review

10.2.1 Urban Green Space Policy in Sri Lanka: Initiatives and Strategies

As previously explained, most literature on UGS in Sri Lanka focusses on Colombo. Colombo has seen a 83.8% drop in green space between 1980 and 2015 (Li 2017). The availability of UGS in Colombo may depend on planned and unplanned settlements such as the differences in UGS observed in the Southern Colombo Municipal Council (CMC) area (planned) and north-central CMC area (unplanned), where planned settlements had more access to UGS (Senanayake et al. 2013). As per two studies conducted in the city of Galle and a town in Matara in Sri Lanka, availability of residential gardens can depend on various factors such as land area, land ownership, residents' orientation towards nature, time availability to maintain a residential garden and perception of advantages and disadvantages of having a residential garden (Ranasinghe and Hemakumara 2018; Jayasinghe et al. 2021). Because there are a variety of factors that affect the presence of green spaces, it is important that proper policies and strategies are in place to ensure that current UGS are protected and sustainably utilized.

There are several policies/initiatives/plans/strategies in Sri Lanka that involve sustainable development, environmental management and land management with

regard to urban development as per the information given in Table 10.1. The documents show that governing bodies have identified the importance of maintaining and improving UGS, with many of these documents placing emphasis on protecting and increasing urban green cover. However, there is no clear directive on accomplishing this, as was also determined in the study by Asmone et al. (2016). For example, the Annual Performance Report & Accounts in 2015 by the Ministry of Mahaweli Development and Environment states that, with regard to Mission 8 of the *Haritha Lanka* Programme of 2009 (Table 10.1), "a policy has to be developed to enhance and manage urban green cover" and that it will be considered in Megapolis Planning. While the Megapolis—Western Region Master Plan of 2016 refers to certain actions that can and should be undertaken, no policy on urban green cover has been developed so far in Sri Lanka. However, a lot of focus has been given for the enhancement of homegardens through programmes such as *Haritha Lanka*, *Api Wawamu Rata Nagamu* (let us grow and uplift the nation) and *Divi Neguma* (livelihood development) (Pushpakumara et al. 2012), mainly at the rural level. Irrespective of urban and rural areas, considering the important role of homegardens in food security, people are encouraged to cultivate vegetables and multipurpose tree species (food and fruits) in their own backyards for their daily consumption under the current Food Production National Programme aimed at eliminating poverty and making the country self-sufficient in food. Homegardens are also indirectly referred in Sri Lanka's Intended Nationally Determined Contributions (INDCs) to the United Nations Framework Convention on Climate Change (UNFCCC 2016) and are identified to have a prominent role in meeting climate mitigation goals under Sri Lanka's UN REDD+ Programme to sequester carbon (UN-REDD 2015). Homegardens are also recognized as a good practice to promote traditional methods of biodiversity conservation for increased crop resilience in Sri Lanka's National Adaptation Plan for Climate Change (NAP) for 2016–2025 (Ministry of Mahaweli Development and Environment 2015).

10.2.2 Homegardens in Sri Lanka

Agroecosystems provide bunch of social benefits that usually transcend from their provisioning services. Apart from food, fuel and fibre, some agroecosystems provide important regulatory, supporting and cultural services which in turn depend on the intensity of use and diversity of the ecosystems. Despite the recognition of ecosystem services provided by agroecosystems, ecosystem services and benefits provided by homegardens or homestead lands remain somewhat unexplored. Studies are available from Global North where homegardens have been identified as potential agroecosystems that significantly contribute to quality of life. However, existing knowledge on homegardens from Global South is still at an infant stage even though homegardens are common throughout the tropics and often referred to as household or homestead farms, multi-strata tree gardens, analogue forests, compound farms, backyard gardens, village forest gardens, dooryard gardens and house gardens. This demonstrates lack of knowledge about the services provided by homegardens among

Table 10.1 Policies, initiatives and strategies in Sri Lanka on UGS

Policies/initiatives/ strategies	Year	Potentially applicable principles/statements from the document	Reference to UGS
The National Environmental Policy	2003	– Traditional knowledge and practices will be respected in the development of environmental management systems – Sri Lanka's attractive landscapes—rural and urban, coastal and inland—as well as sites of archaeological, cultural and religious interest are protected – Sri Lanka's traditional knowledge on biodiversity is protected – Adopt strict planning of urban centres, allowing for the expected growth of the urban population and paying special attention to maintaining a healthy environment	No reference
National Action Plan for *Haritha Lanka* Programme	2009	Mission 8: Green cities for health and prosperity – Keep adequate lands for conservation needs in urban areas – Encourage urban biodiversity parks as part of the public outdoor recreation space network in each urban area – Declaration of wetlands and establishing city-based monitoring systems for declared wetlands – Establish landscape units and design the city incorporating greening aspects, design management and implementation, in all local authorities – Transform urban cities into green urban cities extending the green cover at all appropriate places	Some reference to ensuring urban environmental sustainability and increasing urban green cover

(continued)

Table 10.1 (continued)

Policies/initiatives/ strategies	Year	Potentially applicable principles/statements from the document	Reference to UGS
National Land Use Policy	2009	Conversion of good agricultural lands for non-agricultural uses in urban fringe areas will be discouraged	No reference
Mahinda Chinthana—Vision for the Future—Manifest regarded as a national policy	2010	Beautiful cities—"Green villages" to be launched under *Gama Neguma* Programme	No reference nor any specific actions listed for green villages
The Megapolis—Western Region Master Plan 2030	2016	– Ensure that wetland in Western region is conserved and are well integrated as public spaces in urban areas – Campuses to be designed with green buildings and open spaces – Basic recreational facilities to include public spaces and parks – Conserve the natural capital of the Western region by demarcation and protection of the environmental sensitive and ecologically important hotspots, by declaring three types of eco zones that include forests, wetlands, urban parks, green belts, buffer zones, paddy fields, etc.	Reference to public open spaces and urban parks in the Western region
National Physical Planning Policy & The Plan 2050	2019	5.2 The Urban Development Strategy: – Selection of the most appropriate lands as part of assuring environmentally sustainable and "green" developments – Minimum un-built open area requirement and space for green cover strictly regulated and maintained within urban areas as specified in respective urban development plans – An island-wide programme to shade main streets and major public	Specific reference to urban green cover and proposes preserving of 60% of agricultural lands and plantations within development corridors

(continued)

Table 10.1 (continued)

Policies/initiatives/ strategies	Year	Potentially applicable principles/statements from the document	Reference to UGS
		spaces of all urban areas with trees of endemic species, implemented by the Urban Development Authority 5.7 Agriculture and Plantations – Respective urban development plans shall evaluate the non-market-based benefits of urban agricultural land such as open public spaces – The agricultural lands and the rubber plantations within the proposed development corridors to be thoroughly evaluated for their alternative uses such as carbon sequestration if demanded for alternative developments. In general, at least 60% of these lands in urban environments are proposed to be preserved to meet the national forestry improvement targets as set by the UN REDD Programme (2016)	
Sri Lanka 2030 Vision and Strategic Path	2019	Open spaces—Present urban development schemes don't meet the general requirement of 1 ha per 1000 people – Enforcing the National Physical Planning Policy	Reference to open spaces
Draft National Policy and Strategy on Sustainable Development	2020	Policy goal 11: Cities and human settlements are made inclusive, safe, resilient and sustainable – By 2030, provide universal access to open and green public spaces, develop standards/design guidelines and introduce regulatory provisions to mandate incorporation of sufficient green and public	Specific reference to urban green spaces and increasing urban green cover

(continued)

Table 10.1 (continued)

Policies/initiatives/ strategies	Year	Potentially applicable principles/statements from the document	Reference to UGS
		spaces in city planning Policy goal 15: Sustainable use and conservation of terrestrial ecosystems are ensured – By 2022, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation—increase the tree cover wherever appropriate covering both urban and rural areas	
National Agriculture Policy	2021	Policy statement 1: Improve production and productivity of food and feed crops through a well-organized agricultural production system while harnessing the agroecological potential and strengthening the food system – Promote and support systematic home gardening – Promote different production technologies (e.g., vertical farming, family farming, rooftop gardening, community gardens), especially focussing on urban and peri-urban food systems and metro agriculture	References to homegardens and farming/gardening in urban and peri-urban areas

Global South population which is also leading to the degradation of these agroecosystems along with other factors like increasing population, urbanization, climate change, etc.

Though there is no established definition of homegardens yet, a homegarden can be generally defined as "a farming system that combines physical, social and economic functions on the area of land around the family home" (Landon-Lane 2004). Homegardens are an agroforestry system that can be found in both rural and urban areas, providing food, herbs and medicine, and sometimes livestock, for home

Table 10.2 Common traits of homegardens

Trait	Description
Species density	High
Species type	Stable, vegetable, fruit (cultural)
Main production objective	Home consumption
Labour source	Family (female, elderly, children)
Labour requirements	Part time
Water requirements type	High irrigation
Harvest frequency	Daily, seasonal
Size of unit	Small (relative)
Space utilization	Horizontal, vertical
Fencing	Frequent
Location	Close to dwelling
Cropping patterns	Irregular, row
Economic role	Supplementary
Technology	Simple hand tool
Inputs—cost	Low
Geographical distribution	Rural and urban
Skills	Gardening—Horticulture
Government assistance	None or minor

Source: Niñez (1984)

use, but it can also be an additional source of income if extra food is produced (Galhena et al. 2013). The study by Calvet-Mir et al. (2012) in Spain identified that while the most important and obvious service provided by homegardens is quality food for consumption, there are many other less recognized services that are highly valuable. These include services such as habitat services (maintenance of landraces) and cultural services (heritage value, enjoyment of homegardens, etc.). Mazumdar and Mazumdar (2012), in their study on homegardens in the houses of immigrants from different countries, reported that homegardens represent a space for religious, cultural and ecological socialization, and it helps them to continue their identity. Since homegardens can vary based on cultural, ecological and socioeconomic factors, Niñez (1984) determined common traits to help identify homegardens as mentioned in Table 10.2.

Homegardens in Sri Lanka have been studied for a long time (Perera and Rajapakse 1991; Weerahewa et al. 2012; Galhena et al. 2013; De Zoysa and Inoue 2014; Mattsson et al. 2013, 2018; Marambe et al. 2018; deHaan et al. 2020; Herath et al. 2021; Jayasinghe et al. 2021; Melvani et al. 2020; Mohri et al. 2013, 2018; Pushpakumara et al. 2010, 2012, 2016). Homegardens, often a traditional life supporting system, cover a significant land area (18.18%) of the country and was estimated to increase at an extent of 1% per year until 2020 (FAO 2009). Homegardens in Sri Lanka are often characterized as a piece of land, which has a dwelling house and some form of cultivation on a total area of between 0.05 and 2.5 ha (mean 0.4 ha) (Pushpakumara et al. 2010). These gardens are mostly privately

owned and are managed through family labour using indigenous technologies that rely on rich local knowledge systems (Pushpakumara et al. 2010, 2012). In Sri Lanka, homegardens represent complex sustainable land use system that combines multiple farming components, such as annual and perennial crops, livestock and occasionally fish, which provides environmental services, resources for household needs as well as employment and income generation opportunities (Weerahewa et al. 2012; deHaan et al. 2020; Jayasinghe et al. 2021). Apart from the provisioning services like supply of food, the role of Sri Lankan homegardens in providing regulating and supporting ecosystem services like maintaining carbon stock, pollination, water retention, soil retention, etc. is well evident. Apart from this, cultural services like aesthetic and ornamental preferences and social relations through homegarden product sharing are found to be quite prominent (Saito et al. 2013).

The composition of Sri Lankan homegardens is reported to be different based on the different climatic zones of the country (Mattsson et al. 2013). Dry zone (with annual rainfall $\leq$1750 mm) homegardens have lower tree density when compared to wet zone (with annual rainfall $\geq$2500 mm) homegardens and are often larger in size. The biomass production in dry zone homegardens is often limited by moisture, leading to a weaker capacity to replenish soil fertility by organic matter inputs than wet zone homegardens (Sangakkara and Frossard 2014). Wet zone homegardens are characterized by higher level of plant diversity and a denser canopy structure than dry zone homegardens due to climatic conditions favourable for high growth (FAO 2009; Pushpakumara et al. 2010; Ali and Mattsson 2016). Wet zone of the country also records a high population density, higher urbanization, low land availability, a developed infrastructure and high opportunity for off-farm jobs. An estimation reported more than 400 different woody species in Sri Lankan homegardens (Ariyadasa 2002) with a total of 153,493 million trees across 20 districts. The average density of trees in homegardens of Sri Lanka is varying from 20 to 475 trees per hectare.

10.3 Homegardens in Kandy

10.3.1 Kandy District: A Glimpse

The district of Kandy, with an area of 1940 km^2 of which land and an internal reservoir take up 98.04% and 1.96%, respectively (DCS 2020a), is located in the Central Province of Sri Lanka, as shown in Fig. 10.2. Its administrative capital is Kandy city which was named by UNESCO as a World Heritage Site, and it is well known as the last kingdom of medieval Sri Lanka (Priyantha and Harankahawa 2018) where the last monarch was betrayed by his own ministers to the British.

Located in the transition between wet and intermediate zone, Kandy district is mountainous and boasts much greenery. In 2019, forests and homegardens contributed to 33.03% and 35.03% of Kandy, respectively, and the built-up area covered only 1.53% of the district's land area (DCS 2020a). With an annual rainfall of about 1840 mm (Statistics Division Kandy 2020), the highest rainfall in 2019 was

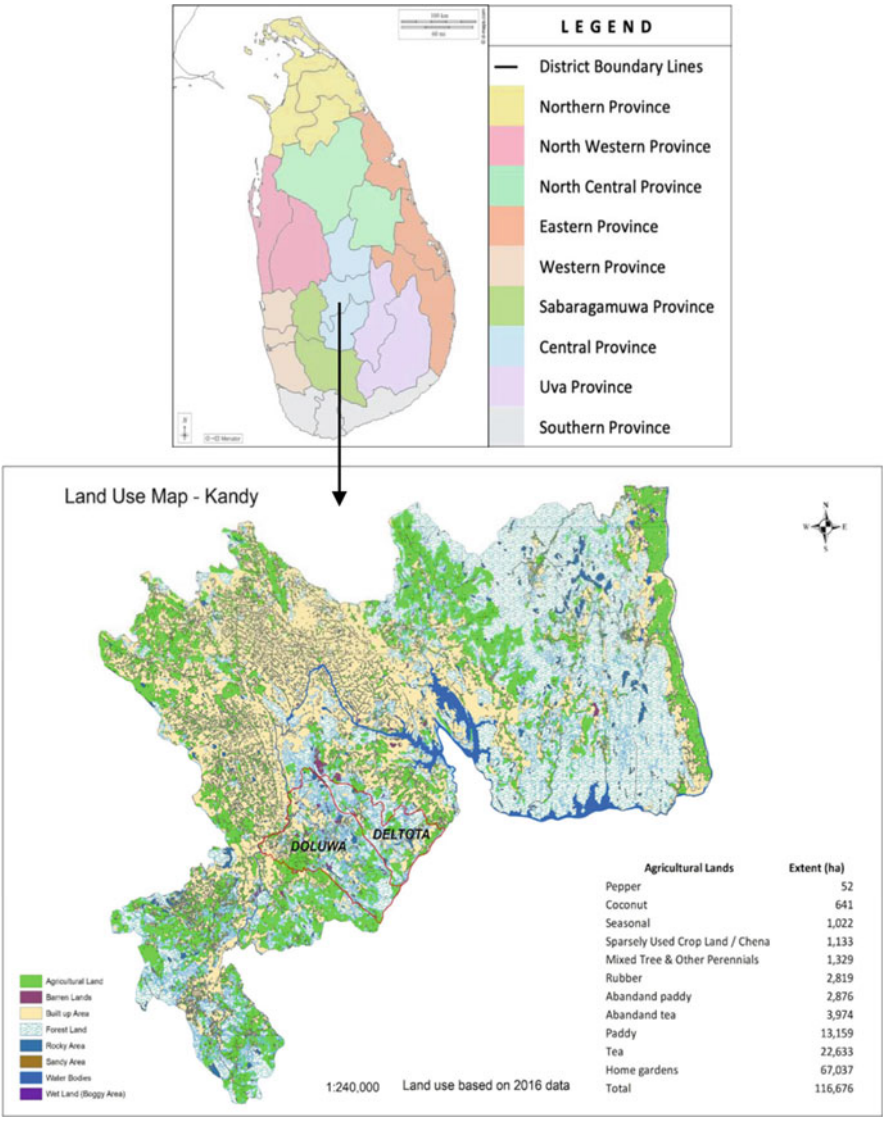

Fig. 10.2 Land use map of Kandy district based on data from 2016. (*Source*: SriCAT 2019)

in October while the lowest was recorded in January, and the observed temperature varied between 18.5 °C and 33.2 °C (DCS 2020a). The socio-demographic characteristics of Kandy district are given in Table 10.3. Kandy is sustained by the Mahaweli River, the longest river in Sri Lanka, which flows around Kandy city keeping it hydrated and luscious (UDA 2019). The river is fed by many streams, some of which are nourished by Udawatta and Wakarewatta forests that surround

Table 10.3 Socio-demographic characteristics of Kandy district of 2019

Indicator		Value
Area (in km^2)		1940.0
Population		1,475,627
Population density (per sq. km)		761
Urban population		182,974
Rural population		1,200,796
Gender	Male	703,588
	Female	772,039
Employment	Total	513,443
	Male	334,311
	Female	179,132
Literacy rate *(for the year 2012, in %)*		95.4

Source: DCS (2020a, b)

Kandy city (UDA 2019), but the water for the river is mainly obtained from the summits of the Knuckles mountain range (Statistics Division Kandy 2020).

10.3.2 Kandyan Homegardens and Their Characteristics

Homegardens in Kandy district are often called as Kandyan Homegardens (KHGs) or Kandyan forest gardens. While primarily found in Kandy district, KHGs can also be found in the other mid-country areas of Kegalle, Rathnapura, Matale and Kurunegala districts (Pushpakumara et al. 2010). Land use changes, in the form of deforestation for coffee and tea plantations, occurred under the British rule. The indigenous people had to adapt to losing forest resources; thus homegardens became even more important, especially in terms of conserving a wide variety of species (Wickramasinghe 1995). Kandy district was reported to have nearly 82,563 homegardens that covered about 32 per cent of its land area and are attached to about 70 per cent of households (FAO 2009; Mohri et al. 2013). Only the urban households were reported to either have no homegardens or they share homegardens with relatives in neighbouring households (Landreth and Saito 2014).

The composition of homegardens can differ from home to home in addition to the differences observed across regions and agroecological zones in Sri Lanka (Wickramasinghe 1995), depending on the physical characteristics of the area, the expected outputs as well as how much time the homeowners spend to tend to the plants. For example, if the homeowner has more time to spend in the garden, then plants that need more tending to may be available in the homegarden. Consequently, KHGs are uniquely diverse within the district and can consist of both agri-silvicultural systems and agro-silvopastoral systems (Wickramasinghe 1995; Pushpakumara et al. 2010).

The characteristics of KHGs, as reported by Pushpakumara et al. (2010), are given in Table 10.4. A study by Perera and Rajapakse (1991) determined that there were four distinct vertical canopy strata in the Kandy area, and the study by

Table 10.4 Characteristics of KHGs (Pushpakumara et al. 2010)

Characteristics	Value
Size of HG (ha)	0.05–2.5 (mean = 0.4)
Family size (numbers)	2–9
Number of vertical canopy strata	3–5
Canopy coverage (%)	45–98
Ground coverage (%)	50–90
Dominant soil type	Reddish brown latosolic to immature brown loam
Slope of land (%)	10–40
Number of species per KHG	37–143
Number of woody taxa per KHG	11–39
Tree species density per ha (over 5 cm DBH)	92–3736
Plant species density per ha (including annuals)	654–5663
Dominant natural vegetation of the area	Tropical wet evergreen forests
Land tenure	Mainly privately owned

Wickramasinghe (1995) determined that two neighbouring villages consisted of five layers, both of which are within the range stated in Table 10.4**.** In general, the most distinctive physical features of Kandyan homegardens are multi-storeyed canopy cover, high natural and cultivated species diversity and steep hillside gradients. The topmost layer of tree canopy includes valuable, mature timber species, such as sandalwood, teak, mahogany, jackfruit and coconut trees. The second layer below includes smaller fruit, ornamental, medicinal and spice trees, such as nutmeg and clove. The lowest layer consists of wild ground cover and cleared patches for cultivating annuals and vegetables. No specific arrangement is considered while planting, but there is significant correlation between crop and tree species, such as introduced *Gliricidia* trees cultivated to support pepper vines and provide high nutrient compost. In addition, as reported by Pushpakumara et al. (2010), about 15% of KHGs include livestock, principally cattle and poultry. Homegardens from the suburbs of Kandy city centre, Mapanawathura, Anniewatta and Dodamwala, as shown in Figs. 10.3, 10.4, 10.5, and 10.6 clearly demonstrate the different multi-storied layers and diversity of homegardens in Kandy. For example, the homegarden from Anniewatta (Fig. 10.4) is spread across an area of 0.18 ha and consists of a wide variety of plants and trees such as pomegranate, guava, star fruit, soursop, passion fruit vine, coconut, banana, papaya, bird chilli, governor plum, cardamom, rambutan and breadfruit as well as flowers. There is also a small apiary for beekeeping and a well which is used to water the plants using an electric motor. Similarly, a homegarden from Dodamwala (Fig. 10.6), located around 5 km from Kandy city centre, is mainly maintained as an ornamental garden with a small pond and includes various fruit-bearing and other trees like durian, wood apple, mango, red palm, mangosteen, king coconut, coconut, cashew, jackfruit, lemon, lime, curry tree, hummingbird tree, snow pea vines, neem, arecanut, guava, papaya, bird chilli,

Fig. 10.3 KHG with trees and a scattered plantation of cassava in the middle and a small stream

Fig. 10.4 KHG with diverse plants, trees and apiary in Anniewatta, Kandy

sweet orange, canereed, ivy gourd and nutmeg. The two homegardens from Mapanawathura (Figs. 10.3 and 10.5) clearly demonstrate the plant succession and tree canopy structure, one of the most distinctive characteristics of KHGs.

The different resource requirements of the different species mean that the plants can flourish in the varying KHG configurations and develop into self-sustaining systems (Wickramasinghe 1995; Pushpakumara et al. 2010). The most common

Fig. 10.5 KHG consisting of a variety of trees and plants including coconut, king coconut, fishtail palm and banana, next to an abandoned paddy field, which consists of a scattered planting of elephant ears

Fig. 10.6 KHG surrounding a house in Dodamwala, Kandy

floral species found in KHGs are stated in Table 10.5 from the study by Perera and Rajapakse (1991) which include the frequency of their occurrence as well as the uses of each species. Their results were obtained from analysing 50 randomly selected households in five sub-administrative divisions from Kandy district.

Table 10.5 Common floral species found in KHGs

Frequency of occurrence	Species	Life form	Uses	Canopy layer height (m)
90% (very common)	Jackfruit	Tree	Multipurpose	>10
	Coconut	Tree	Multipurpose	>10
	Cloves	Tree	Cash	2.5–10
	Avocado	Tree	Fruit	2.5–10
	Mango	Tree	Fruit	2.5–10
70–90% (common)	Coffee	Shrub	Cash	1–2.5
	Pepper	Climber	Cash	–
	Arecanut	Tree	Cash	2.5–10
	Gliricidia	Tree	Multipurpose	2.5–10
	Fishtail palm	Tree	Multipurpose	2.5–10
	Papaya	Tree	Fruit	1–2.5
	Alstonia	Tree	Timber	>10

Source: Perera and Rajapakse (1991)

As demonstrated in Table 10.5, the most common life forms in KHGs are tree species. While the produce from trees in KHGs are generally used for home consumption and/or sometimes sold, there may also be some sharing of extra food with neighbouring houses, relatives and friends, especially if that household with the homegarden does not require the additional income from selling the extra produce. This helps maintain social relations within communities.

It has been reported that the KHGs conserve about 50% of fruit crop species diversity in Sri Lanka (Pushpakumara et al. 2016). The diverse floral species found in KHGs also provide suitable habitats for a range of fauna to nest and feed. Pushpakumara et al. (2010) stated that the wide variety of fruit trees and low disturbance are among few reasons for the high faunal diversity observed in KHGs.

10.3.3 Importance of KHGs in Sustainability and Resilience Building

Climate change and its impacts are widely accepted around the world. As a developing country, Sri Lanka is especially vulnerable since Sri Lanka's GDP is highly dependent on the agriculture sector, which is sensitive to changes in the climate (Mendelsohn 2008). In fact, changes in rainfall patterns are already prevalent in Sri Lanka, and it has forced farmers to adapt in several ways to protect their livelihood like changing cropping patterns and adjusting sowing date (Marambe et al. 2018). The farmer is a key player in the adaptation of agroecosystems, and in developing countries, this means the farmer has to rely on his instincts and own innovation rather than new expensive technologies (Verchot et al. 2007).

Verchot et al. (2007) suggested that an agroecosystem, such as a homegarden, that is well adapted and houses high diversity is less sensitive to changes in climate and also enables the farmer (or homeowner) to quickly adapt to any changes.

Accordingly, agroforestry systems such as KHGs are sustainable systems due to the many benefits they provide. These include high biodiversity and conservation of endemic species, acting as carbon sinks, hindering soil erosion and nutrient leaching, enabling nitrogen fixing, controlling pests and diseases and connecting canopy patches (De Zoysa and Inoue 2014; Marambe et al. 2018).

Furthermore, the presence of a high density of trees in homegardens may provide much needed resilience to climatic changes (De Zoysa and Inoue 2014). For example, the inclusion of a large number of trees provides many advantages over changing rainfall patterns; these include longer roots that are able to reach deeper into the soil for water and nutrients, higher water infiltration due to the more porous soils that also have a better cover from the canopy helping to reduce run-off and erosion, better soil aeration due to the higher evapotranspiration of trees and having trees that yield better value produce than row crops (Verchot et al. 2007; De Zoysa and Inoue 2014). While more research into the resilience that can be provided by these systems is required, it has been reported that homegardens that are diverse and dense, and also include livestock, are able to endure climatic changes (Verchot et al. 2007). This means that even with the impacts of climate change, homes with agroforestry systems such as KHGs will be able to sustain the lives of those who rely on them.

10.3.4 Threats to Homegardens

Pushpakumara et al. (2012), based on reports over the 20-year period before his 2012 study, stated that homegardens in the wet zone experienced fragmentation and urbanization, causing degradation to homegardens. This refers to the fact that the quality of ecosystem services that KHGs were once able to provide had deteriorated. In addition, farmers are increasingly choosing to replace traditional homegarden tree species with high yielding cash crops by clearing a part of their homegarden area to sustain their needs, thus converting the highly diverse homegardens into lands with mono crops and reduced vertical layers, which may lead to a loss in canopy cover, carbon stocks and genetic material (Pushpakumara et al. 2012, 2016). Despite this, the study by Herath et al. (2021) shows that the overall extent of homegardens in the Mahaweli Upper Catchment area, which includes Kandy district, have increased by 60% (approximately 32,000 ha) between 1992 and 2017 through the conversion of agricultural lands (excluding paddy) and some tea land. At the same time, the study reports that 1000 ha of homegardens were lost due to urbanization. As it was highlighted, it is extremely important to ensure and retain high biodiversity in these newly converted homegardens so that the ecosystem services provided are of high quality.

Households with homegardens often perceive the disservices from wild animals, insects and other pests, and this threatens the high biodiversity of homegardens (Mohri et al. 2018; deHaan et al. 2020). In the study by Mohri et al. (2018), macaques, boars and porcupines were observed to be the primary culprit, and the households stated that these incidents have only grown over the years. This is also

Fig. 10.7 Bitter gourd (**a**) and guava (**b**) covered with plastic bags and bottle containing methyl eugenol on namnam (*Cynometra cauliflora*) (**c**), to protect the fruits from pests and insects

confirmed by deHaan et al. (2020), who also adds rats, mice and squirrels to the list, and by Melvani et al. (2020), who further added giant squirrels, grey langurs, elephants and peacocks. Consequently, some owners abandon homegardens while others change various aspects to discourage/stop the wild animals from venturing in to cause damage. An example of this is clearing surrounding canopy so that macaques do not have a direct path to reach the homegarden (Mohri et al. 2018). People also resort to shooting at the macaques and other pests such as giant squirrels (sometimes with rubber bullets) to scare them away; however, this is a very temporary solution. In addition, when food is primarily used for domestic consumption, they are less inclined to use pesticides on the produce; thus, they will find other methods to protect their produce. Examples of this are provided in Fig. 10.7. If such methods do not work, they are likely to eliminate the species of flora that attracts the pest (Melvani et al. 2020). For example, banana plants were infested with snails at a homegarden, and the snails eventually moved to attacking the other plants in the garden; thus, the only solution for the homegarden owner was to eliminate the banana plants completely.

Wild animal incursions and attacks from insects and pests mean that households may be unable to sustain their needs and thus depend on outside markets and that households are not able to replace damaged crops with new plants as the wild animals will destroy the new plants as well (Mohri et al. 2018). Changing of the homegarden structure or composition (such as from food crops to only spices or eliminating certain species) leads to loss in biodiversity, while abandonment will lead to the formation of secondary forests that are ideal ecosystems for these very same wild animals to thrive, creating a feedback loop that is likely not beneficial for the household or the community (Mohri et al. 2018; deHaan et al. 2020). It is

therefore important to conserve remnant forest patches surrounding these areas to ensure wild animals do not feel the need to venture into homegardens (Melvani et al. 2020).

Another threat to KHGs is the succession by secondary forest which leads to the loss of agricultural diversity—without active human management, endemic plants covering the ground are often out-competed by dominant secondary forest species, including invasive coffee, or lack of sunlight in the ground because of unpruned tree canopies. KHGs provide almost a quarter of household staples, and abandonment increases vulnerability to market price fluctuations, especially expensive vegetables. Other threats include climatic changes causing unpredictable rainfall which forces homegarden owners to seek alternative income sources (Mohri et al. 2013), unavailability of labour to harvest produce from homegardens, lack of interest in younger generations to continue the gardening practises and reduction of available land to expand homegardens due to high population density and urbanization (deHaan et al. 2020). Finally, another important threat identified is the loss of the traditional and cultural knowledge that has been passed down for generations due to the structural changes being made to homegardens as well as younger generations not taking part in homegarden activities (deHaan et al. 2020).

10.3.5 How Can Homegardens Be Incorporated in Urban Planning Strategies in Kandy

Kandy city of the Kandy Municipal Council (KMC), being the second largest city in Sri Lanka, experiences major congestion and threats to the cultural heritage and environmentally sensitive sites (UDA 2019). To alleviate these issues, fostering developmental corridors between special-inclined suburban centres was proposed in the Kandy Town Development Plan from 2019 to 2030 by the UDA (2019) as illustrated in Fig. 10.8. This means that certain activities from the central business district (CBD) of Kandy will be pushed towards the surrounding towns of Katugastota, Kundasale-Digana and Peradeniya, and these will be developed further to accommodate the needs of the growing population of Kandy city. It is expected that focussing development on these areas will control/halt the unplanned development occurring in environmentally sensitive areas and landslide-prone areas. In this plan, it is also proposed that the Udawatta and Wakarewatta forest reserves are protected due their importance in terms of environmental services and scenic beauty. Furthermore, environmental sensitive zones are to be declared, and open spaces in the form of parks are to be established.

With the planned expansion into neighbouring towns, it is important to ensure that the greenery and climate that Kandy is known for are protected. The benefits provided by homegardens will greatly compliment this and, in addition, provide areas of high carbon stock compared to other open spaces. Open spaces such as parks and golf courses are seen by urban planners to be more in line with the image of urban areas (Drescher et al. 2006).

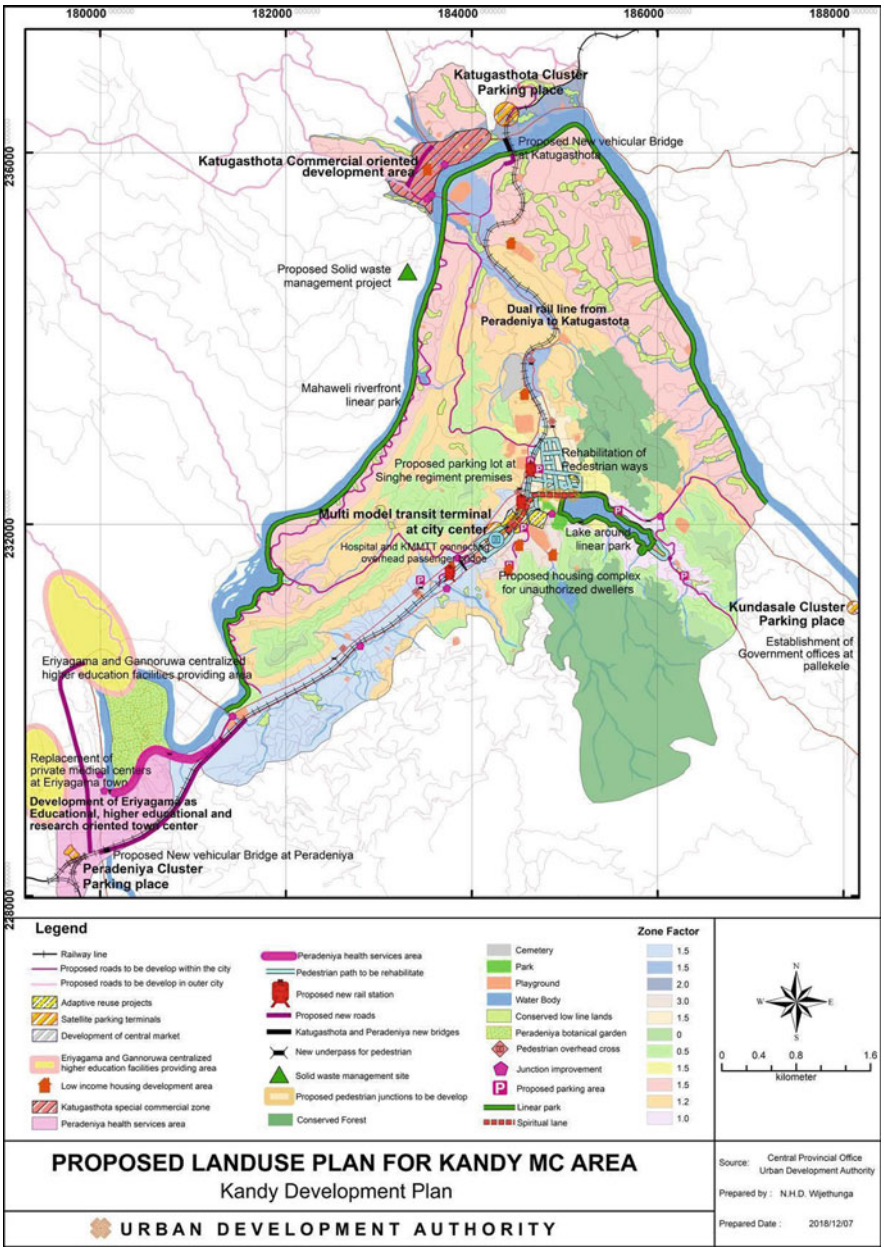

Fig. 10.8 Proposed land use plan in the Kandy Town Development Plan 2019–2030 by the UDA (2019)

Mattsson et al. (2013) proposed expanding homegardens into abandoned and degraded lands, and this can be incorporated into the planned development and expansion of Kandy city. Therefore, it is first necessary to identify any abandoned or degraded lands along these developmental corridors and in cluster towns that have the potential to be converted into homegardens. Then, owners of the lands can be incentivized to convert the lands into homegardens instead of selling the land for construction. Incentives can include, among others, promoting homegardens and highlighting their importance and benefits and providing seeds or seedlings of crops free of charge or at a low cost. However, it is also necessary to determine the cause of abandonment and propose solid strategies and provide access to new technologies to alleviate the issues faced by the homegarden owners.

It is also imperative to ensure that proper land zoning is implemented to protect surrounding forest patches from clearing for construction or other purposes so that wild animals and other pests do not need to venture into homegardens in urban areas in search of food. The establishment of these urban homegardens will also conserve the biodiversity, provide food security and improve the hydrology of the developing urban areas (Mattsson et al. 2018). Land zoning can also be used to specify the certain land areas of the planned development that can only be used to establish homegardens.

10.4 Conclusion

Demographic changes and globalization pressurize the existing traditional agroforestry systems like homegardens, with visible changes in urban areas. Commercialization is leading to oversimplification of homegardens. This leads to disappearance of homegardens and the traditional knowledge associated with it and subsequent loss of species richness, the genetic diversity it contains and the ecosystem services. The high structural and floristic diversity of Sri Lankan homegardens reflects the unique biophysical environment and sociocultural factors under which they exist. Vast and diverse number of plants around the home and in direct and constant interaction with its owners fulfils specific economic, social and cultural needs of the garden owners as well as provides biological conservation, carbon sequestration and such other intangible yet valuable benefits to the society. Kandyan homegardens present distinctive biophysical characteristics that make them multifunctional and sustainable. Irrespective of the demographic pressures and expansion of urban areas, Kandy district has still been able to maintain the homegardens as they can be considered as ecological assets of Kandy that helped to socially connect its inhabitants and sustain the community for the last 2000 years. However, the multiple existing threats like urbanization, commercialization, wildlife threats, economic changes, climatic variations, etc. endanger the existence and sustenance of Kandyan homegardens in future. In addition to the different programmes and strategies adopted by both the national and regional government, it is required to create awareness among the local people, especially the younger generation about the values of homegardens and also involve them in conservation and maintenance so that they develop a sense of

ownership towards these gardens and maintain them in future. Kandyan homegardens demonstrate ideal examples of microscale agroforestry systems that can be practiced and implemented. Hence, reinforcing and augmenting the Kandyan homegarden systems so that they continue to provide sustainable ecological habitats and other social and economic functions, and connect wild and other cultivated habitats, are important for the future adaptation of this globally important landscape.

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Sachini K. Jayakody is enrolled for Masters in Environmental Management at Kyoto University, Japan.

Mrittika Basu is an Assistant Professor in the Laboratory of Sustainable Rural Development, Graduate School of Global Environmental Studies, Kyoto University, Japan.