Ecosystem Services of Kandyan Homegarden Systems and Rural Livelihood under Climate and Ecosystem Changes in Sri Lanka

Osamu SAITO[1], Nicholas LANDRETH[1], Jintana KAWASAKI[2], Hideyuki MOHRI[1], Gamini HITINAYAKE[3], Nimal GUNATILLEKE[4]

[1] Member of JSCE, Institute for Sustainability and Peace, United Nations University
(53-70, Jingumae 5, Shibuya-ku, Tokyo, 150-8925, Japan)
Email: saito@unu.edu.au
[2]Insitute for Global Environmental Strategies
(2108-11, Kamiyamaguchi, Hayama, Kanagawa, 240-0115, Japan)
[3]Department of Crop Sciences, University of Peradeniya
(Faculty of Agriculture, University of Peradeniya, Peradeniya, 20400, Sri Lanka)
[4]Department of Botany, University of Peradeniya
(Faculty of Science, University of Peradeniya, Peradeniya, 20400, Sri Lanka)

Abstract: Kandyan homegardens or forest gardens are a widespread land use system in and around the central Kandy district of Sri Lanka that have served local communities for centuries, harmoniously blending agriculture with the natural landscape. This paper gives an overview of (1) the multiple ecosystem services identified in homegardens and their contribution to sustainable livelihoods and well-being of local communities; (2) an analysis of changes in recent land use and ecosystem services; and (3) discusses the resilience of homegarden socio-ecological systems to cope with climate and ecosystem change. The study found that homegardens contribute useful income, food sources and cultural values for villagers, although climate, environmental and socio-economic pressures are reducing their productivity. Wild animal incursion, unpredictability of water availability, and economic specialization are driving abandonment and simplified cultivation in homegardens, risking their capacity to contribute to resilient livelihoods. Key recommendations from the survey for maintaining homegarden system resilience include: 1) incorporating higher yield, locally appropriate crop varieties with lower water requirements and higher resilience to high temperatures; 2) improving irrigation governance for better allocation of water demands; 3) review legal obstructions to locally appropriate wild animal control; 4) maintaining lock-and-spill drain systems to reduce soil erosion; and 5) adapting economic models to reward more holistic ecosystem management, such as organic certification or local procurement incentives.

Key Words: *Kandyan homegardens, households, land use changes, livelihoods, resilience*

1. INTRODUCTION

Homegardens, found around Sri Lanka as well as the lowlands of India, Thailand, Malaysia, Indonesia, and Papua New Guinea, provide multiple ecosystem services including sources of food and household income, conserving traditional culture and biodiversity, regulating climate and mitigating CO_2 emission through carbon sequestration, and providing a low rate of erosion due to varied species and a multilayered canopy structure[1),2),3)]. However, climate and socio-economic changes are considered to bring significant and additional threats to homegarden systems and local livelihoods. Climate change brings changing seasonal patterns and an increasing frequency of extreme weather events, particularly floods and droughts[4)].

Concurrent socio-economic changes also create threats, such as population pressure to convert homegardens to housing and other uses, intensification of marketable crops through the use of synthetic chemical pesticide and fertilizer, and

redirection of homegarden and paddy labor to off-farm employment[5),6),7)].

The specific objectives of this paper are to 1) identify and analyze the importance of multiple ecosystem services of homegarden systems; 2) determine the contribution from homegardens to households in comparison with other income sources; and 3) explore the role of homegardens to cope with climate and socio-economic changes. This paper is divided into four sections. This introduction constitutes Section One, followed by method and materials of the study presented in Section Two. Section Three will discuss the characteristics of communities studied, ecosystem services from Kandyan homegardens, and changes in land use and ecosystem services. Section Three also includes an analysis of factors related to specific climate change resilience in Kandyan homegardens based on interviews with local farmers and key stakeholders. Section Four discusses the general resilience of homegardens to cope with climate change in the discussion and conclusions of the study.

2. METHOD AND MATERIALS

(1) Study Area

The study areas included households from two neighbouring villages located 8 kilometres drive to the north-west of Kandy in Sri Lanka's 'wet' climate zone (Kulugammuna and Haloluwe, henceforth referred to collectively as 'Kulugammuna'), and two neighbouring villages located 14km south-east of Kandy in the 'intermediate' zone (Godammuna and Talutouya, henceforth referred to collectively as 'Godammuna') (**Figure 1**). These villages lie in the mountainous Kandy District of Sri Lanka's Central Province, around 500m above sea level in the center of the island with wetter and cooler temperatures than the rest of the country. Most rain in the Kandy area falls during the yala season from May to September[8)]. The wet zone receives higher mean annual rainfall of over 2,500mm. The intermediate zone receives annual rainfall between 1,750 to 2,500mm with a short dry season. The dry zone to the north and west receives less than 1,750 mm a year, with a distinct dry season from May to September[9)].

(2) Household, focus group, and market surveys

Research entailed a questionnaire survey in 2012 of 40 farmer households in the Godammuna area and 25 farmer households in the Kulugammuna area in Kandy district, Sri Lanka. From January 6 to February 6, 2013 a follow-up

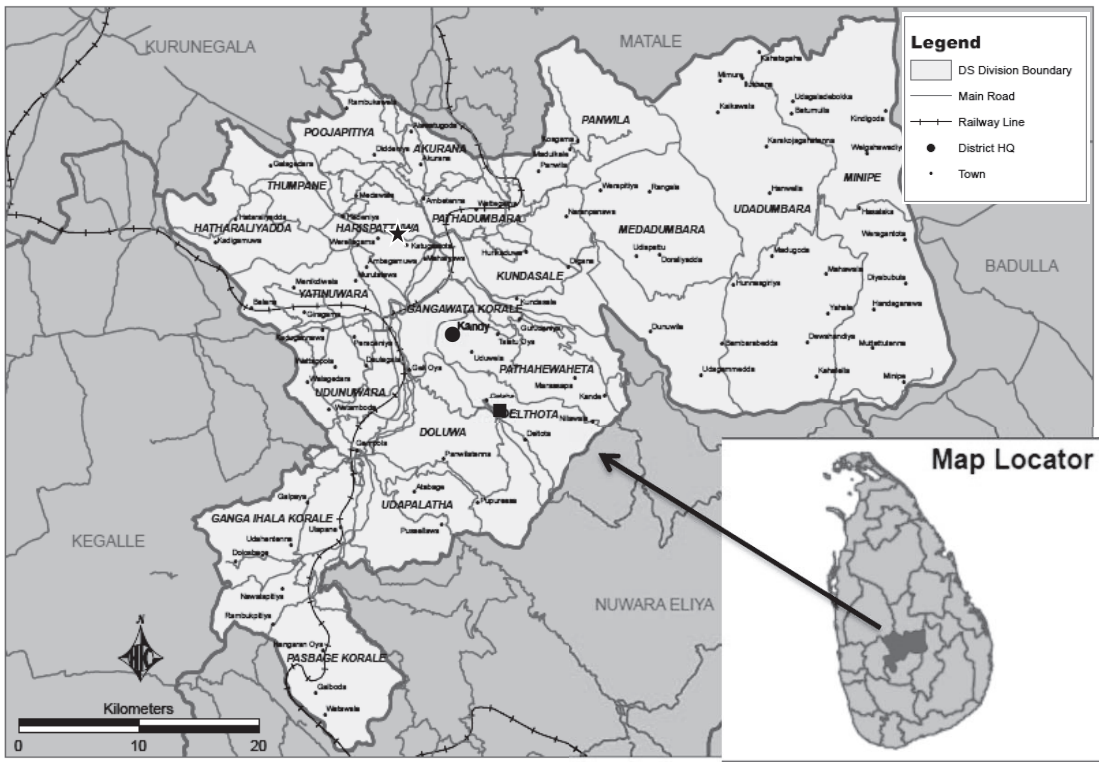

Figure 1. Kandy district map showing study areas (Source: UN HIC, 2005.)
(●Kandy, ★: Kulugammuna, ■: Godammuna)

survey was conducted amongst 15 of the same Godammuna households and 14 of the same Kulugammuna households. The survey data were evaluated by statistical analysis. The selection of the surveyed villages was based on agro-ecological regions of Kandy district.

The major components of the questionnaires comprised:

a) Survey 1: Homegarden Survey Questionnaire 2012

- General information of households including age, education, and occupation;
- Household economic background;
- Homegarden and paddy land use;
- Layout of current land use;
- Crop patterns and species diversity;
- Agricultural inputs and expenses;
- Species vulnerability and tolerance against drought, temperature rise, and heavy rain; and
- Traditional knowledge used to adapt to climate change.

b) Survey 2: Homegarden Survey Follow-Up Questionnaire 2013

- Land management changes over the past decade;
- Future plans for land management systems;
- Influences on land management, including government policies, water availability, market prices, and wild animals;
- Dependency on markets for food, fertilizer, fuel, and water;
- Importance of homegarden benefits for household well-being; and
- Opinions on biosafety and organic certification.

A focus group with Peradeniya agriculture students was also conducted to gather opinions from the next generation of homegardeners. Two Grama Nilhadari (government appointed village leaders) and one Samurdhi official (a national poverty alleviation program) were interviewed in Godammuna on implementing government policies to support homegardens.

To determine market value of food commonly consumed by local homegardeners, two supermarkets in Kandy and Peradeniya and the wholesale Kandy Central Market were surveyed.

3. RESULTS

(1) Characteristics of the Communities Studied

Table 1 shows the average profiles for households in the two study areas. The major differences were in employment, where 50% of Godammuna households' primary employment was in agriculture (including paddy and hired labour) compared to 24% in Kulugammuna. Some primary farmers, including retired householders, produced only for home consumption and had significant family support to supplement their incomes.

Table 1 Profile of households interviewed in Godammuna and Kulugammuna villages

Characteristics	Godamm-una (N=40)	Kuluga-mmuna (N=25)
Average age of household heads (years)	58	57
Completed secondary education or higher (%)	65.0	76.0
Primary occupation (% of households):		
Farming and hired agricultural labor	50.0	24.0
Private sector	35.0	20.0
Retired	10.0	12.0
Own business	5.0	16.0
Government employee	0.0	28.0
Average homegarden area (ha)	0.41	0.42
Average income (Rs. per month)	20,001 – 30,000	30,001 – 40,000

The household income of Kulugammuna villagers was higher than Godammuna villagers, suggesting lower incomes in primarily agricultural households. As shown in Table 1, 64% of the households in Kulugammuna had a monthly income of over 30,000 Sri Lankan rupees (Rs.), while only 20% of Godammuna households earned over 30,000 Rs. The average monthly income in Godammuna was 23,750 Rs. per household, which was lower than the mean national monthly household income in 2009/10 of 36,451 Rs.[11)]

(2) Ecosystem services from Kandyan homegardens

Typified by rich species diversity, forest-like structures, deliberate land management, and close relationships to household well-being, Kandyan homegardens provide a vast number of ecosystem services. The major homegarden ecosystem services valued by households were the value of crops for income and food (provisioning); water purity and soil stability (regulating and supporting); and ornamental and aesthetic preferences (cultural).

a) Provisioning Services

Over 75 dominant tree, medicine, and spice species were identified in the homegardens, with the kinds of plant varying according to household and market demand. Rice and vegetables occupied the largest planted areas in paddy areas separate to the homegarden, with spices occupying the largest land areas in homegardens themselves. Dominant spices planted in the homegardens were pepper,

nutmeg, ginger, and turmeric. Different crop choices in the two study villages reflected different climatic conditions of 'wet' Kulugammuna and the 'intermediate' climate of Godammuna. Nutmeg, clove, and jak were the dominant tree species in Kulugammuna (in that order), while jak, coconut, and mango were dominant in Godammuna. Gliricidia prevalence was not recorded in the Kulugammuna surveys although it is very prominently used in both areas for fencing, as a source of compost and to support pepper growth.

Crops for income

Participants were asked to identify agricultural and off-farm income, and the results are shown in **Table 2** (overleaf). Godammuna was shown to generate income from a wider diversity of species than Kulugammuna, where most households generated income from either spices or off-farm employment. In Godammuna pepper was the main homegarden crop grown for market, while in Kulugammuna nutmeg was the dominant crop for market.

Crops for food

Table 3 (overleaf) shows the market dependency rates for individual crops across each village study area. Dependency ratios were recorded on a scale of 0 to 1, where 1 indicates the item is fully sourced from market, and 0 indicates fully sourced from homegarden or surrounding lands. Based on average incomes in the area, household consumption as a proportion of income was slightly lower in Godammuna, at between 71% and 83%, compared to Kulugammuna, at between 75% and 83%. The major differences in market dependency were full market dependency for rice in Kulugammuna, largely due to lack of available paddy labour; higher market dependency for all items in Kulugammuna except water, likely due to smaller land area and high macaque damage to former crops; high market dependency for water in Godammuna, likely due to seasonality of available water sources; and high market dependency of all households for vegetables and fruit due to worsening water availability and wild animal incursions.

Other provisioning services

Hunting for wild meat and raising livestock was uncommon, due mostly to religious observances preventing harm to animals, but also laws against hunting and selling wild animals, and a lack of available labour to tend livestock. Pruning homegarden canopies provided most household cooking and heating fuel, reducing expenditure on expensive gas fuel. Timber was often harvested at maturity for sale, and replanted as an investment for children or retirement. Medicinal plants such as ambul dodam (sour lime), nelli (Indian gooseberry), delum (pomegranate), kohomba (neem), ginger, and turmeric were frequently identified in Godammuna, and less commonly in Kulugammuna. In Kulugammuna water was often sourced from an on-site spring or well, but the significance of natural household water sources compared to tap lines diminished in Godammuna where dry seasons were more pronounced, affecting year-round natural water availability and crop choices. In Godammuna nutrition provided by homegardens and wild plants for food and fodder were also considered very important.

b) Regulating and Supporting Services

In Kulugammuna the regulating or supporting services identified by participants as most important to household well-being were water purity followed by soil stability, while in Godammuna the order was reversed.

A 2002 United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) study on how Sri Lankan homegarden water management systems cope with seasonal variations in water supply and annual rainfall changes found two benefits of these systems to water regulation: the high intensity of plant species helped conserve water, and shared ponds also collect water for common water flow regulation[12]. Some farmers also build canals to divert stream water to their homegardens. Traditional plowing techniques using forks to mix soil increases water absorption capacity and soil nutrients. This survey found the contribution of homegardens to water purity in ponds and streams is also attributable to low chemical use in traditional homegardens.

Species density, compost ground cover, multilayered canopy cover, and spill and lock drain systems are all features of homegardens that contribute to improved soil stability[13]. Soil erosion in Sri Lankan homegardens is only 0.05 t ha^{-1} $year^{-1}$, comparable to natural forests, and less than 1% of the rate in annual cultivation systems[14),15].

c) Cultural Services

Both study sites identified ornamental and aesthetic preferences as the most important cultural service. Social fabric through produce sharing was the second most important cultural benefit in Kulugammuna, and the capacity for participation and control of land use choices provided by independent homegarden systems was the second most important in Godammuna. Eating preferences and personal satisfaction were often indicated by householders to drive maintenance of homegarden

Table 2 Number of households by major sources of income

Income Sources	Godammuna (N=40)							Kulugammuna (N=25)						
	No. of HH	% of HH	Contribution to total income					No. of HH	% of HH	Contribution to total income				
			<= 20%	21-40%	41-60%	61 - 80%	81-100 %			<= 20%	21-40%	41-60%	61-80%	81-100 %
Farm income:														
Rice & maize	24	60	8	5	3	7	1	1	4	1				
Fruits	10	25	9	1				1	4	1				
Spices	24	60	20	2	2			17	68	10	3	1		3
Tea	2	5		1			1							
Livestock	4	10	3		1									
Off-farm income:														
Government or private employment	30	75	6	4	7	3	10	23	92	1		2	3	15
Forest products and wild vegetables	1	2.5	1					1	4	1				
Children's support	2	5			1		1							

No. of HH: the number of households

Table 3 Proportion of household staples sourced from market

Food staples	Godammuna (N=13)				Kulugammuna (N=12)			
	HH with consump-tion <0	Average per capita consump-tion	Unit/ month	Average market dependency ratio	HH with consump-tion <0	Average per capita consump-tion	Unit/ month	Average market dependenc y ratio
Rice	13	12.68	kg	0.62	12	8.14	kg	1.00
Pulses	13	2.20	kg	0.99	12	1.14	kg	1.00
Wheat flour or bread	8	0.53	kg	1.00	6	0.97	kg	1.00
Rice flour	9	0.50	kg	0.81	9	0.94	kg	1.00
Coconuts	13	15.15	nuts	0.39	12	11.22	nuts	0.51
Other fruits	12	727.78	Rs.	0.65	12	425.71	Rs.	0.83
Vegetables	13	7.32	kg	0.65	12	4.59	kg	0.91
Dry/powdered chili	13	288.62	g	0.85	12	269.50	g	0.98
Fresh chili	13	420.71	g	0.55	11	194.44	g	0.81
Curry powder	13	161.36	g	1.00	12	140.96	g	1.00
Pepper	13	3.36	g	0.22	no data	no data	no data	no data
Ginger	13	83.33	g	0.11	no data	no data	no data	no data
Turmeric	13	55.65	g	0.70	no data	no data	no data	no data
Other spices	13	270.49	g	0.71	12	343.06	g	0.52
Betel & arecanut	5	1.67	bunches	0.60	3	0.10	bunches	0.83
Meat (chicken/other)	11	0.60	kg	1.00	6	0.29	kg	1.00
Meat (boar)	2	0.20	kg	0.50	0	0.00	kg	n/a
Fish	13	1.11	kg	1.00	11	0.36	kg	1.00
Eggs	11	8.79	eggs	1.00	10	10.07	eggs	1.00
Milk (1 kilo Anchor powder :. 8L fresh)	13	0.85	kg	1.00	11	0.76	kg	1.00
Loose leaf tea	13	221.59	g	0.85	12	200.00	g	1.00
Sugar	13	1.25	kg	1.00	12	1.12	kg	1.00
Coconut oil	13	1.38	750ml bottle	0.73	12	0.61	750mL bottle	0.92
Other staples								
Water	13	n/a	Rs.	0.56	12	n/a	Rs.	0.35
Firewood	13	n/a	n/a	0.07	11	n/a	n/a	0.27
Chemical fertilizer	9	9.19	kg	0.67	2	n/a	n/a	0.10
Livestock Feed	3	4.52	kg	0.20	0	0.00	kg	n/a
Gas cylinder	5	0.93	kg	1.00	9	1.03	kg	1.00
Electricity for cooking, pump, and heating	12	189.02	Rs.	1.00	10	173.21	Rs.	1.00

systems rather than abandoning or simplifying them to more commercial purposes.

(3) Changes in Land Use and Ecosystem Services

Table 4 (overleaf) shows 65% of Godammuna households had reduced cultivated areas due to climate and socio-economic changes, and the proportion of homegardens for housing expanded in both sites. The proportion of land devoted to spices in Kulugammuna, particularly nutmeg, was expected by householders to increase over the next 10 years due to increasing market demand, resilience of spices to wild animals (especially macaques), relatively low required labor, and smaller available agricultural land. In Godammuna, agricultural land use is expected by households to decline overall due to unpredictability in water availability and wild boar incursions. Even though some Godammuna farmers have a small reservoir in the field or receive water from irrigation facilities in the villages, the water is not adequate during the dry season. Most farmers did not have any solution to solving the water shortage problem, but two suggested redistributing upland water reservoirs from new farms on abandoned tea estates to Godammuna users instead.

Common problems identified in the homegardens were low productivity, low infrastructure support for production and marketing activities, and uncertainty of weather conditions like rainfall intensity during October and March, or drought severity from April to September. Heavy rainfalls and droughts are followed by high air humidity and temperature fluctuation that encourage pest and disease dispersion. Urban development and land fragmentation under rising population densities have also reduced the average area of homegardens. These issues have brought instability to homegarden systems and the livelihoods that rely on them, heightening their vulnerability to environmental changes. Drought and wild animals had particularly affected vegetable, fruit and rice paddy harvests, increasing the dependency on markets for these food staples.

Table 4 Proportion of household responses by trend of past and expected land use area change (% of households)

Types of land use	Godammuna (N=40)				Kulugammuna (N=25)			
	Last 10 years		Next 10 years		Last 10 years		Next 10 years	
	Expand	Reduce	Expand	Reduce	Expand	Reduce	Expand	Reduce
Housing land	35		3		40		24	
Agricultural land:								
Rice		70		70		8	4	
Veges.	3	60	3	68	8		16	
Fruits	5	55	5	65	8		16	
Spices	8	60	3	70	36		36	
Tea	3			8	4		4	
Coconut	3	45						
Livestock	5	3	5	10				
Others		10	3	65				

(4) Climate Change Resilience Factors in Kandyan Homegarden

a) Species resilience to climate shocks

The study sought to identify how specific climate shocks affected homegardens, and how households had adapted. Based on field survey interviews with 40 Godammuna households, the most commonly identified vulnerable species were pepper, which 74% of total Godammuna households considered vulnerable to drought, and vegetables, which 49% considered vulnerable to floods and heavy rains (bananas were also considered vulnerable to floods and heavy rains).

In Godammuna, households identified 20 different plant species tolerant to drought, and 6 that were considered tolerant or resilient to floods and heavy rains. Only one household could identify any species sensitive or vulnerable to increased temperature. Jak and coconut were identified by the most households as resilient to drought (60% and 46% of households, respectively). Jak and coconut were also most commonly identified as resilient against floods and heavy rain (43% and 26% of households, respectively) (Kulugammuna surveys did not collect data on species resilience and vulnerability).

b) Traditional knowledge to adapt to climate shocks

Field survey interviews asked 56 of the households (40 Godammuna households and 16 Kulugammuna households) if they used traditional methods for coping with heavy rainfall, extreme drought, and temperature increase. 84% of the total respondents were able to identify some traditional knowledge or practices used to predict weather and adapt to climate changes. The most common were drainage systems to cope with heavy rain (80% of total households), and traditional tillage that avoids plowing to improve water retention during dry periods (73% of total households).

However, unpredictable climate conditions in recent times may reduce the efficiency of traditional coping techniques. Homegardeners were able to identify plants adaptable to drought, but the severity of the recent drought has reduced productivity or even killed species previously thought resilient in some homegardens (such as coconut in Godammuna). Rains that followed the

drought were the heaviest since the 1950's, and many adaptive mechanisms (such as lock and spill drains) were not adequate enough to cope with extreme rains, exacerbating soil erosion – a problem amplified by abandonment of some neighbouring cultivation including drain maintenance. Especially in the heavily sloped gardens of Godammuna, these increasingly unpredictable rains washed away many annual crops and young trees planted to replace plants lost to drought.

4. DISCUSSION

(1) General Resilience

Resilience is generally understood as the capacity to deal with change and continue to develop[16]. As such, specific shocks such as climate change are only one component of risks to the resilience of complex socio-ecological livelihoods. Homegarden systems provide a broad bundle of ecosystem services that can provide more general resilience against unforeseen events other than climate unpredictability, such as sources of diverse and nutritious diets where food price shocks render market sources unaffordable, or stored value in multilayered timber canopies providing insurance against unanticipated or infrequent family expenditure (e.g. health problems, education costs, weddings, etc.).

Homegardens do not always require full-time maintenance and are to some extent self-sufficient, but partial reduction of labor inputs for weed removal, drainage, harvesting, replanting, fencing, and composting can lead to secondary forest succession, resulting in loss of services important to well-being. On the other hand, commercial simplification, especially for nutmeg in Kulugammuna and pepper in Godammuna, increases some provisioning services (primarily income) but has negative implications for regulating, supporting, and cultural services. Generally, abandonment and commercialization of homegardens can reduce the resilience of local livelihoods by risking a number of ecosystem service benefits, especially:

- reduced income diversity from harvested produce;
- lost traditional knowledge;
- reduced species diversity, especially in cultivation of annuals;
- increased soil erosion, loss of fertile topsoil, and downstream paddy siltation in heavy rains due to reduced drainage management;
- increased wild animal incursion as abandoned plots become attractive habitats; and
- increased reliance on rising prices in import-heavy markets for food security.

In Godammuna, climate change, understood as increased unpredictability of rainfall, was considered a major driver of reduced ecosystem services and land management in homegardens. In Kulugammuna, where consistent water sources were relatively abundant, climate change was considered less of a problem. Beyond climate change, abandonment and commercial simplification of homegardens were usually attributed to compounding drivers including:

- declining productivity from wild animal incursion;
- ongoing water shortages and drought limiting cultivation opportunities (particularly in Godammuna area);
- simplification of species selection to drought and animal resilient species with higher market demand; and
- labour shortages in rice cultivation due to preferences for off-farm employment.

(2) Resilience to Wild Animals

Abandonment encourages secondary forest regrowth, increasing habitats for wild animal populations. Incursions of monkeys, boars and porcupines across all homegardens destroy young trees and vegetables. Some farmers responded by abandoning fruit harvesting and annual cultivations, diverting homegarden cultivation to existing animal-resistant perennials such as pepper or nutmeg.

(3) Resilience to Changing Employment Aspirations

Available labor for cultivation is reducing in response to preferences amongst current generations for off-farm employment. Homegarden labour intensity is typically low, but significant labor inputs for combating wild animals (such as fencing), replanting, drain building, and harvesting are still required. Still, most householders with off-farm employment tend their homegardens for either economic or cultural reasons, although with limits to the extent of their cultivation. Older householders also indicated that when they previously worked off-farm they would spend free time and weekends tending homegardens, and on retirement increased cultivation for economic and cultural reasons. This suggests that trends in homegarden cultivation change over the lifetime of each householder.

5. CONCLUSION

These two field surveys highlighted the value to local well-being from maintaining homegarden ecosystem services, especially crops for food and income, water purity and soil stability, and ornamental and aesthetic preferences. However, climatic, environmental, and socio-economic pressures are reducing their capacity to deliver these benefits and driving many households to partially abandon cultivation to secondary forest, or reduce species diversity to more simplified cultivation. Recovery from disaster and adaptation of homegardens to climate change is complicated by other factors, also driving abandonment and commercialization. Wild animal incursions, unpredictability of rainfall and water availability, and shrinking land sizes are major drivers behind these changes. Traditional knowledge offers crop choices and practices adaptable to climatic and environmental stress, but is limited especially by the increasingly unpredictable severity of water shortages.

Ecosystem assessments such as this allow us to better inform policy recommendations and judge intervention options, improving resilience of homegarden responses to negative drivers of change through novel recommendations such as: 1) incorporating higher yield, locally sourced crop varieties with lower water requirements and higher resilience to high temperatures; 2) improving irrigation systems and governance for better allocation of water demands; 3) locally appropriate wild animal control; 4) maintaining lock-and-spill drain systems to reduce soil erosion; and 5) adapting economic models to reward more holistic ecosystem management, such as organic certification or local procurement incentives.

ACKNOWLEDGEMENT: This research was carried out as a part of the research project 'Strategy to enhance resilience to climate and ecosystem changes utilizing traditional bio-production systems in rural Asia' (CECAR-Asia: FY2011~FY2013) which has been supported by the Environment Research and Technology Development Fund (E-1101) of the Ministry of the Environment, Japan.

REFERENCES

1) MA (Millennium Ecosystem Assessment) : *Ecosystems and human well-being – Summary for decision makers*, Island Press, 2005.
2) Mohri, H., Lahoti, S., Saito, O., Mahalingham, A., Gunatilleke, N., Irham, Hoang, V.T., Hitinayake, G., Takeuchi, K., and Herath, S. : Assessment of ecosystem services in homegarden systems in Indonesia, Sri Lanka, and Vietnam, *Ecosystem Services*, in press, http://dx.doi.org/10.1016/j.ecoser.2013.07.006.
3) Jacob, V.J. and Alles, W.S. : Kandyan gardens of Sri Lanka, *Agroforestry Systems,* Vol. 5, pp. 123-137, 1987.
4) Herath, S. and Kawasaki, J. (eds.) : Comparative studies on development strategies Considering impacts of adaptation to climate change, *CECAR Series*, No. 12, United Nations University: Tokyo, 2012.
5) Wiersum, K.F. : Diversity and change in homegarden cultivation in Indonesia, in Kumar, B.M. and Nair, P.K.R. (eds.), *Tropical homegardens: A time-tested example of sustainable agroforestry*, Springer Science: Dordrecht, Netherlands, pp. 13-24, 2006.
6) Soemarwoto, O. and Conway, G.R. : The Javanese homegarden, *Journal of Farming Systems Research-Extension* Vol. 2, No. 3, pp. 95–118, 1992.
7) Christanty, L., Abdoellah, O.S., Marten, G. and Iskandar, J. : Traditional agroforestry in West Java: The pekrangan (homegarden) and kebun-talun (perennial/annual rotation) cropping systems, in Marten, G.G. (ed.), *Traditional agriculture in Southeast Asia: A human ecology perspective*, Westview Press: Boulder and London, UK, pp. 132-156, 1986.
8) Perera, H.K.W.I., Sonnadara, D.U.J., and Jayewardene, D.R. : Forecasting the occurrence of rainfall in selected weather stations in the wet and dry zones of Sri Lanka, *Sri Lankan Journal of Physics* Vol. 3, pp. 39-52, 2002.
9) Department of Agriculture, Government of Sri Lanka : *Climate of rice growing regions in Sri Lanka*, available at http://www.agridept.gov.lk/index.php/en/crop-recommendations/903 (accessed March 7, 2013), 2006.
10) UN HIC (United Nations Human Information Centre) : *OCHA Sri Lanka Maps*, UNHIC: Colombo, CD-ROM, 2005.
11) Central Bank of Sri Lanka Statistics Department : *Economic and Social Statistics of Sri Lanka 2012,* Central Bank of Sri Lanka: Colombo, 2012.
12) UNESCAP : National Study: Sri Lanka, *United Nations Publication* 161, available at http://www.unescap.org/rural/doc/oa/Sri%20lanka.pdf (accessed March 18, 2013), 2002.
13) Torquebiau, E. : Are tropical agroforestry homegardens sustainable?, *Agriculture, Ecosystems and Environment* Vol. 41, pp. 189–207, 1992.
14) Wagachchi, H. and Wiersum, K. : Water management in agroforestry systems: Integrated buffalo ponds and forest gardens in the Badulla District, Sri Lanka, *Agroforestry Systems* Vol. 35, pp. 291-302, 1997.
15) Pushpakumara D.K.N.G., Wijesekara, A. and Hunter, D.G. : Kandyan homegardens: A promising land management system in Sri Lanka, in Bélair, C., Ichikawa, K., Wong, B.Y.L., and Mulongoy, K.J. (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', CBD Technical Series No. 52, pp. 102–108, 2010.
16) Stockholm Resilience Centre : *Resilience Dictionary*, available at http://www.stockholmresilience.org/21/research/what-is-resilience/resilience-dictionary.html (accessed March 18, 2013), 2007.

(Received July 19, 2013)