Home gardens in the Paschim Medinipur District of West Bengal in India: a land use system with multiple benefits

Sebak Jana*

Department of Economics with Rural Development,
Vidyasagar University,
West Bengal, India
Fax : 91-03222-275329/275297
Email: sebakjana@yahoo.co.in
*Corresponding author

Joyashree Roy

Department of Economics,
Jadavpur University,
Kolkata, India
Email: joyashreeju@gmail.com

Buddhi Marambe

Faculty of Agriculture,
Department of Crop Science,
University of Peradeniya, Sri Lanka
Email: bmarambe@yahoo.com

Jeevika Weerahewa

Faculty of Agriculture,
Department of Agricultural Economics and Business Management,
University of Peradeniya,
Sri Lanka
Email: jeevikaw@gmail.com

Gamini Pushpakumara

Faculty of Agriculture,
Department of Crop Science,
University of Peradeniya,
Sri Lanka
Email: ngpkumara@pdn.ac.lk

Pradeepa Silva

Faculty of Agriculture,
Department of Animal Science,
University of Peradeniya,
Sri Lanka
Email: pradeepas@pdn.ac.lk

Md. Giashuddin Miah

Bangabandhu Sheikh Mujibur Rahman Agricultural University,
Dhaka, Bangladesh
Email: giash1960@gmail.com

Ranjith Punyawardena

Department of Agriculture,
Natural Resources Management Centre,
Peradeniya, Sri Lanka
Email: batugedara_vrp@yahoo.com

Sarath Premalal

Meteorology Department,
Colombo, Sri Lanka
Email: spremalal@yahoo.com

Abstract: 'Home garden' (HG) is a complex sustainable land use system combining annual and perennial crops, trees, shrubs, livestock and fishery. The flow of goods and services provides not only food and nutrition security and employment, but also other co-benefits. Though HGs have attracted international attention since 1950s, it has not been widely researched especially in the context of rural India. This paper presents the results based on a field study carried out in 100 HGs in Paschim Medinipur District in the West Bengal, located in eastern part of India. A structured questionnaire was used to identify different aspects related to HG characteristics, their role in household consumption, problem areas and the different socio-economic characteristics of the HG owners. The results suggest that home gardeners with a higher level of education and who are using modern inputs are able to derive more benefits from the HGs.

Keywords: home garden; HG; species diversity index; food and nutrition security; co-benefits, India.

Reference to this paper should be made as follows: Jana, S., Roy, J., Marambe, B., Weerahewa, J., Pushpakumara, G., Silva, P., Miah, Md.G., Punyawardena, R. and Premalal, S. (2015) 'Home gardens in the Paschim Medinipur District of West Bengal in India: a land use system with multiple benefits', *Int. J. Environment and Sustainable Development*, Vol. 14, No. 2, pp.191–206.

Biographical notes: Sebak Jana is currently an Associate Professor of Economics at the Department of Economics with Rural Development, Vidyasagar University, Midnapore, West Bengal, India. He obtained his BSc in Economics from Presidency College, Kolkata, MPhil and PhD degrees from Jadavpur University, Kolkata. His recent research interests include natural resource economics and economics of education. He has published four books and about 30 papers in national and international journals and edited books.

Joyashree Roy is currently an ICSSR National Fellow and Professor of Economics as well as coordinator of Global Change Programme of Jadavpur University, Kolkata, India. She is in IPCC-2007 Nobel Peace Prize winning panel, has been a chapter author of Global Energy Assessment, and in winning team of Prince Sultan Bin Aziz award for water. Her recent research interests include economics of climate change, sustainability transition, coastal ecosystem service evaluation, challenges in social embedding of technology in water sector and energy supply and end use sectors in developing countries.

Buddhi Marambe is a Professor attached to the Department of Crop Science of the Faculty of Agriculture, University of Peradeniya, Sri Lanka. His researches are on climate change, invasive alien species and weed science. He is currently the Chairman of the National Experts Committee on Climate Change Adaptation appointed by the Ministry of Environment and Renewable Energy of the Government of Sri Lanka.

Jeevika Weerahewa is a Professor attached to the Department of Agricultural Economics and Business Management, Faculty of Agriculture, University of Peradeniya, Sri Lanka. She currently serves as the Head of the Department and Chairperson of the Board of Study in Agricultural Economics at the Postgraduate Institute of Agriculture, University of Peradeniya. She obtained her BSc and MPhil degrees from the University of Peradeniya and PhD degree from the University of Guleph, Canada. Her primary research area is quantitative policy analysis. She teaches basic and applied courses in economics to undergraduate and postgraduate students at the University of Peradeniya.

Gamini Pushpakumara is a Professor in the Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka. Since 2005, he also serves as the Country Liaison Scientists to the World Agroforestry Centre (ICRAF). He is a graduate of the University of Peradeniya and has done his Masters and Doctoral degrees in the University of Oxford. His research interests include agroforestry and homegardens, tree domestication, agrobiodiversity, diversity of ferns, climate change and plant invasions.

Pradeepa Silva is a Professor in Animal Science at the Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka. Her recent research interests include evaluation of animal genetic resources with special reference to indigenous livestock and poultry.

Md. Giashuddin Miah is a Senior Academician and Researcher having doctorate degree and 30 years experiences in the field of agroforestry, land-use and climate change. He has supervised 14 PhD and 89 MS students in diversified disciplines. He attended and presented papers in 54 conferences, meetings and workshops across the world. He has been serving to the APN as Scientific Planning Group (SPG) member since 2005. He is acting as the Country Liaison Scientist of World Agroforestry Centre/ICRAF, Bangladesh since 2003. He has published two books on agro forestry (in Bengali), three chapters of books and 73 scientific publications in the national and international reputed journals.

Ranjith Punyawardena is the Senior Climatologist of the Department of Agriculture, Sri Lanka. His present interests focus on climate, climate change and community-based adaptation to hydro-meteorological hazards.

Sarath Premalal joined the Department of Meteorology as a Meteorologist in 1988 and currently he is working as a Director, Training, Research and Development. He obtained his BSc special degree in Physics, and Master in Physics at the University of Peradeniya, Sri Lanaka. After that, he entered the University of Reading, UK and obtained his Master in Meteorology in 1993. He participated in several international and national trainings, workshops and meetings. He was a member of several international and national projects on climate and climate change. He has a number of national and international research papers.

This paper is a revised and expanded version of a paper entitled 'Home garden eco-system and food security – a case study in West Bengal' presented at the International Conference on Nature, Economy and Society: Understanding the Linkages, Indian Society for Ecological Economics (INSEE), CESS, Hyderabad, India, 20–22 October 2011.

1 Introduction

'Home garden' (HG) is a complex sustainable land use system (Marambe et al., 2012a; Weerahewa et al., 2012), which generally combines multiple farming components, i.e., annual and perennial crops, trees, shrubs, livestock and fishery. The flow of goods and services from the HG not only provides the household needs and employment support, but also environmental services similar to those of natural forests as a result of being a mixed farming system consisting of fruits, vegetables, trees and animals. The other co-benefits include biodiversity conservation, providing habitat niches in over-storey, under-storey and ground layers, conserving useful species, diversifying the agricultural systems, improving food and nutrition security, expanding habitat and refuges for mammals, birds, butterflies, soil micro life to beneficial insects including pollinators, birds and other wildlife, reducing carbon emissions by increased sequestration, adapting to climate change, improving resource use efficiency, soil fertility, and microclimate.

Studies on HGs have been reported from many countries highlighting their economic and environmental values. HGs provide the households with a cash income and increase the resilience of households to withstand market shocks and volatility with regard to their supplies of food and income and health. This reduces vulnerability of poor households. The 'HG Report' of the United Research Services (URS, 2004) highlights the successful initiatives of home gardening in the countries like Bangladesh, Philippines and Thailand for tackling the nutritional needs of the poor. There is still a vast potential for home gardening to improve the livelihood of people in developing countries, especially in

Africa, Latin America and the dry regions of Asia. The importance of HGs in livelihood generation and food and nutrition security has also been discussed by various authors (Crowell et al., 1991; Attygalle, 1996; Hitinayake et al., 1996; Lebel et al., 2010; Weerahewa et al., 2011; Pushpakumara et al., 2012; Rao et al., 2007; Saikia et al., 2012). Nair and Kumar (2006) observed that almost all HG systems have evolved to provide food and other requirements of households through generations under the influence of resource constraints. Nguyen (1997) reported that the HGs have an important role in regulating both micro-nutrients and supply of marketed surplus. The issue of plant diversity of HG in two Peruvian Amazon communities has been reported by Ban and Coomes (2004). Blaylock and Gallow (1983) using the US Department of Agriculture's (USDA) 1977 Nationwide Food Consumption Survey data reported that the household decision to produce vegetables at the household is influenced significantly by the area of household residence, homeownership, race, source of income, the number and ages of adults in the household and the potential for saving money. A study conducted in Vietnam (URS, 2004) revealed the problem areas of home gardening with respect to lack of market information, lack of water in dry season, low plant diversity, low education, lack of technology and finance, etc. Traditional HGs have been maintained as a part of rural survivals over generations in many parts of India (Tangjang and Arunachalam, 2009). In the context of climate change, HG assumes an immense importance. Despite the large empirical evidence on adaptation, a limited number studies have been reported in South Asia, examining the extent to which the home gardeners have adapted to climatic changes (Marambe et al., 2011, 2012a, 2012b; Pushpakumara et al., 2012; Weerahewa et al., 2012).

The primary research question that this paper addresses is if there are multiple benefits that flow from HG ecosystem, which can justify their sustenance? There is a paucity of information on the HG ecosystems and their role in food supply system in the Indian context. Though HGs have attracted international attention since 1950s, it has not been widely researched especially in the context of rural India. This paper presents the results based on a field study carried out in Paschim Medinipur District in West Bengal, located in the eastern part of India. The study also investigated changes made to the HGs by the owners over the past 20 years through the recall method of the home gardeners. This helps in understanding the current ecosystem of HGs and assesses their role in household food supply. Description of the study area is given in Section 2, Section 3 presents description of HG owners and HGs based on field observations. Section 4 compares diversity indices calculated for two study villages with other countries and narrates the changes made to HGs over time. Section 5 shows how HGs support food and nutrition of HG owners and value of flow of such provisioning services.

2 Study area

The field survey was conducted in the West Bengal of India during 2009–2010 as a part of a multi-country project involving Sri Lanka and Bangladesh. An internationally uniform desirable criteria was used for choosing HGs for the study namely, 1 size: HGs be less than 0.5 hectare (ha)

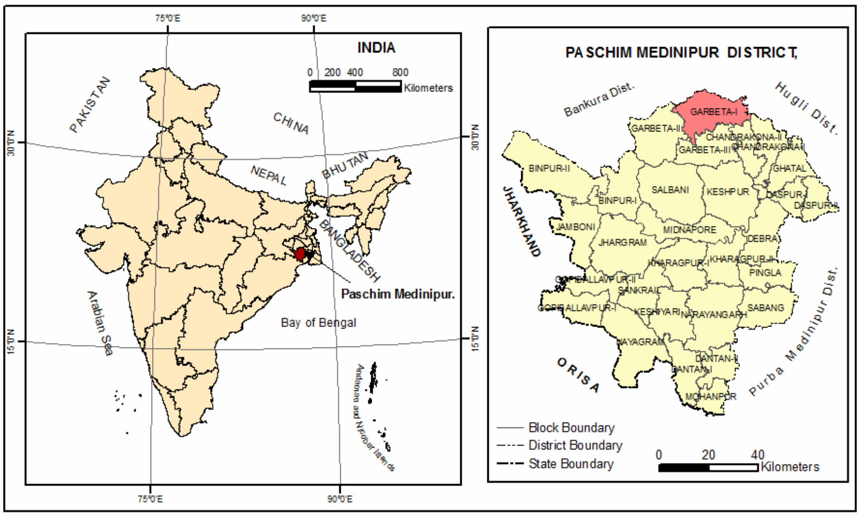
2 composition: trees and animal are a must, domesticated animals are preferable

3 structure: at least a three-tier plant structure with ground strata (like grass, herbs), middle strata (like papaya) and top strata (like mango tree)

4 the region is preferably in the low country (< 300 metre (m) above the sea level above the sea level), dry zone (< 1,700 mm rainfall).

Our choice of district was guided by all these criteria, and was made in favour of Pashcim Medinipur (Medinipur west) district (Figure 1). Additional two villages namely, Ledagamar and Keshia in Garhbeta – I block in Paschim Medinipur district were selected, guided by the criteria. The snowball sampling (Lewis-Beck et al., 2004) procedure was adopted for selecting the households for primary survey, as there was no documentation/listing of HGs and no primary study existed in this field. Snow ball sampling method has helped to identify the households with specified criteria. Following this method, few respondents were interviewed initially from the selected study site and subsequently the respondents who meet the selection criteria of HG, and those who are interested in participating in the project, were interviewed. Ledagamar village was first selected as the project site by the project team, however, as the target of 100 observations could not be obtained in Ledgamar alone, the second village namely, Keshia, was selected. The two villages are located 5 km apart. The latitude and longitude of Ledagamar are 22.833°N and 87.323°E, respectively, and those of Keshia are 22.804°N and 87.329°E, respectively. The altitude of the study site was 66 m above the sea level. Out of the total number of households surveyed (100), 74 households were from Ledagamar and 26 were from Keshia. According to the Census Report (Government of India, 2011), a 'household' is identified as a group of persons who normally live together and take their meals from a common kitchen unless the exigencies of work prevent any of them from doing so. In the two villages surveyed, the total number of households was 1,079. Though many households possessed HGs, about 15% of households were in conformity with the selection criteria. The Census Report (Government of India, 2011) also reveals that there are about 221 million rural households in India. Thus, there is enormous scope of HGs in generating benefits to rural households. All the HGs selected from the two villages met the selection criteria. The scope of the study allows us to study 100 households intensively. The choice of the number of households was made to make it comparable with other countries. The soil of the study area was sandy loam. The region is in the dry zone with an average annual rainfall of 1,500 millimetre (mm). The temperature in the summer season in these regions was about 40°C and the average productivity of paddy was about 2.50 tonnes/hectare (t/ha) with state average being 2.54 t/ha in 2009–2010. About 36% of the households in the study site lived below the poverty line (BPL) as reported by the local administrative office at the time of the survey. A structured questionnaire was used, which included different aspects relating to HG characteristics, their role in household consumption, problem areas and the different socio-economic characteristics of the HG owners.[1]

Figure 1 The map of West Bengal in India with the study area (see online version for colours)



3 A home gardeners

The average age of the household head is 55 years and more than 80 % of them are male. An average household size is six (range 2 to 15). Among the HGs surveyed, 29% of home gardeners (household head) have not received school education. The proportions of low-income farmers were 93%, though all of them do not belong to the BPL group. In addition to farming, only 11% of the farmers surveyed had off-farm employment.

Table 1 Socio-economic characteristics of the households with HG

Attribute	*Category*	*Value*
Size of the household (number)	Average	5.9
	Range	2–15
Age of the household (HH) head (years)	Average	55
	Range	22–85
Sex of the HH head (% in each category)	Male	84
	Female	16
Education level of the HH head (% in each category)	No schooling	29
	Up to primary	22
	Secondary and above	49
Occupation of the HH (% in each category)	House work	13
	Farming	65
	Farming and other	11
	Non-farming	11
Agricultural land holding (acre)	Average	0.6
	Range	(0–6.9)
Home garden size (acre)	Average	0.18
	Range	(0.03-99)

Source: Field survey

Table 2 Average monthly expenditure (INR)[2]

Items	*INR per month*	*Percentage*
Food and drink	1,800	48
Fuel and light	225	6
Clothing and personal effects	450	12
Personal care and health expenses	315	8
Transport and communication	225	6
Education	360	10
Culture and entertainment	90	2
Durable household goods	45	1
Liquor and tobacco	135	4
Other	45	1
Total household expenditure	3,735	100

Source: Field survey

3.1 HG attributes

The characteristics of HGs have been discussed in terms of area distribution in different components, types of crops, trees grown, diversity of plants and changes made in the HG. A HG is made of a house and other components. The average area of the HG was calculated as 16.8 decimal. The average percentage area of occupation of different components of the HG in the study area is presented in Table 3. Crops, plants and trees occupy the major portion of the HGs surveyed. The average open space of a HG was 18%, which often is used for different household purposes including the threshing of crops, play space for the children, social ceremonial purposes, etc.

Table 3 Distribution of area (average) in HGs

Area distribution items	*Average area (decimal)*	*Percentage area*
House	4.0	30
Crops, plants and trees	7.1	43
Animal house	0.4	3
Tubewell/dug well	0.3	3
Open space	3.0	18
Other	2.0	3
Total	16.8	100

Source: Field survey

About 89% house types were mud-built and 11% brick-built. The roof of the houses was made of tin (66% of households), thatching materials, sheets, etc. Sanitation infrastructure varied: 64% septic tank, 19% open-pit, and 17% in outside the HG land. All the HG owners of the study area lived in the village, except one. The average time allocated per household to maintain the HG was calculated as 850 hrs per annum. No hired labour was used for maintenance of HG.

The vegetation in the HGs can be divided into three categories, viz., crops, woody trees and non-woody trees. Crops such as different vegetables formed the ground strata.

Non-woody trees are mostly the middle-strata whereas the trees are the high-strata plants. A wide variety of plants, trees and animals were observed in the HGs. In the sample of 100 households in this study, 113 types of crops, 72 types of woody trees and 15 types of non-woody trees were recorded. The average age of trees was 17 years. The average number of crop species in the HGs was7.72, ranging from a minimum of 2 to the maximum of 18. Chilli (*Casicum annuum* L) was the most important crop species, which was grown by 84% of households. Table 4 shows the top eight crop species namely, chilli (C. anmuum), papaya (*Carica papaya* L), brinjal (*Solanum melongena* L), bottle gourd [Lagenaria siceraria (Molina) Standl.], leafy vegetables, marigold (*Tagetes* spp) and banana (*Musa* spp) found in the surveyed HGs with the frequency of their occurrences. Vegetables are grown mainly in the months of July to November.

Table 4 Frequency of occurrence of crop species per household per year

English name	*Scientific name*	*% of home gardens*
Chilli	*Capsicum frutescens* L.	84
Papaya	*Carica papaya* L.	58
Brinjal	*Solanum melongena* L.	57
Bottle gourd	*Legenaria siceraria* (Molina) Standl.	45
Leafy vegetable	*Basella rubra* L.	43
Marigold	*Tagetes patula* L.	32
Banana	*Musa sapientum* L.	30

Source: Field survey

The number of woody trees per HG was calculated as 7.17 ranging from the minimum of 2 to the maximum of 16. Top ten frequently observed woody trees with the average number of trees per HG is presented in Table 5. The most frequently occurred tree in the surveyed HGs was mango (*Mangifera indica* L).

Table 5 Frequency of occurrence of woody trees (perennial) in HGs

English name	*Scientific name*	*Family*	*Average number per home garden*	*% of home gardens*
Mango	*Mangifera indica* L.	Anacardiaceae	2.70	89
Jack fruit	*Artocarpus heterophyllus* Lam.	*Musaceae*	1.97	87
Guava	*Psidium guajava* L.	Myrtaceae	0.97	57
Golden apple	*Spondias dulcis* L.	Rutaceae	0.56	41
Indian lilac	*Azadirachta indica* A. Juss.	Meliaceae	0.48	37
Jamboline	*Syzygium cumini* L.	Myrtaceae	0.40	32
Coconut	*Cocus nucifera* L.	Areaceae	1.25	29
Lemon	*Citrus limon* (L.) Burm. f.	Rutaceae	0.24	22
Tamarind	*Tamarindus indica* L.	Caesalpiniaceae	0.24	20
Indian Jujube	*Ziziphus mauritiana* Lam.	Rhamnaceae	0.26	19

Source: Field survey

Table 6 Frequency of occurrence of non-woody trees (perennial) in HGs

English	*Scientific name*	*Family*	*Average number per home garden*	*% of home gardens*
Bamboo	*Bambusatulda* Roxb.	Peaceae	0.55	32
Papaya	*Carica papaya* L.	Cactaceae	0.14	09
Banana	*Musa spp.*	Musaceae	0.10	58
Hibiscus	*Hibiscus spp*. L.	Malvaceae	0.06	05
Clitoria	*Clitoria ternatea* L.	Pipilionaceae	0.02	02
Pomegranate	*Punica granatum* L	*Bromeliaceae*	0.02	02
Tagar	*Valeriana sitchensis* Bong.	Apocynaceae	0.02	02
Pineapple	*Ananas comosus* (L.) Merr.	Bromeliaceae	0.01	01
Kind of flower	Unidentified	Ceasalpiniaceae	0.01	01
Kind of weed	Unidentified	Malvaceae	0.01	01

Source: Field survey

The total number of non-woody tree species per household was calculated to be 1.42 with the maximum of 3 and minimum of 1. The most frequently occurring non-woody tree is bamboo (*Bambusa* spp), which was found in 58% of the households. The percentage frequency of the top ten non-woody trees with the average number of trees per HG is shown in Table 6.

4 Plant diversity in HGs

The Shannon-Wiener Index (SWI) was used to evaluate the species richness and abundance of trees in the study area as done by Marambe et al. (2012a). The proportion of species (*i*) relative to the total number of species (p_i) was calculated and then multiplied by the natural logarithm of the same proportion ($\ln p_i$) [equation (1)]. The resulting product was summed across species, and multiplied by –1 to calculate the SWI of individual HGs.

$$SWI = \sum p_i \left[\ln \left(p_i \right) \right] \tag{1}$$

The average value of SWI of the sample households in the study area was 1.436 with a range of 0.277–2.309 and standard deviation of 0.324. The average value was marginally different for two study villages in India with 1.44 for Ledagamar and 1.42 for Keshia. These values were higher than that reported for a village in Bangladesh (1.09) but lower than those of HGs from three villages in Sri Lanka (2.0; Marambe et al., 2012a).

Over the past 20 years, various human interventions have been made to enhance productivity of HGs. Different changes introduced to the crops and trees in HGs during the past 20 years are shown in Table 7. In order to improve the fertility of the soil, the home gardeners have applied different kinds of fertilisers such as chemical fertiliser (92%

households), compost (22% households), and cattle manure (83% households). About 84% of the households surveyed have recognised the necessity of conserving soil and 91% practiced integrated farming consisting of trees, crops and animals. The survey results revealed that the planting dates have been changed for some crops like chilli (30% households), brinjal (21% households) and bottle gourd (17% households). The major reasons reported by home gardeners for changing planting dates are the changes in the onset of rainfall, shortage of water and lack of timely irrigation supply. Other changes observed in the surveyed HGs were the increasing use of new technologies such as micro irrigation and sprayer machines. Similar results were reported from a study carried out in Sri Lanka covering 148 HGs in three villages to identify adaptation strategies to climate change by home gardeners (Weerahewa et al., 2012). The major reasons for using new technologies were to obtain higher production; prevent/overcome insect pest damages and disease. The major reasons for changing the planting dates of crops in Sri Lanka emerged as the shortage of water, change of the onset of rainfall, obtaining a higher production, and increasing temperature.

Table 7 Changing practices in HGs in past 20 years

Changes made		*Home gardens (HG) making changes*	
		% of HGs out of those that made changes	*% of total HGs*
Changing planting dates		60	56
Using new technologies	Micro-irrigation	70	66
	Sprayers	7	7
	Other	74	70
	Varieties	19	18

Source: Field survey

5 HGs support food and nutrition

HG contributes much to the consumption needs of households. The food items are divided into four categories namely, cereals, vegetables, egg and meat. As main cereals like rice and wheat were not the main crops cultivated in the HG, the contribution of HG in these was not considerable. The HGs surveyed contributed significantly in providing the consumption needs of vegetables, meat and eggs of the households (Table 8). Higher values represent higher resilience to market volatility.

Table 8 Household average annual consumption and contribution of HG for different food items

Crop – cereals	*Total quantity (kg)*	*Food obtained from*			
		Home garden (%)	*Other farm area (own cultivations) (%)*	*Gifts (%)*	*Purchased (%)*
Rice	13,553.17	0.12	67.05	0.07	32.75
Finger millet	446.66	0	98.88	0	1.11
Wheat	1,274.66	4.97	4.90	2.2	87.93
Other cereals	3,964.75	0	85.05	0	14.95
Total cereals	19,239.25	0.42	67.38	0.2	32.01
Vegetables	6,011.06	31.04	46.38	0.35	22.23
Leafy vegetables	1,283.33	22.38	25.57	0.47	51.58
Total vegetables	7,294.40	29.52	42.72	0.37	27.4
Meat	446.50	28.59	0	0	71.41
Eggs (number)	2,698	31.69	0	0	68.31

Source: Field survey

6 Flow value from HGs

The flow value is the value of annual return from annual crops and trees (including fruit crops). In case of the non-marketed food items, this value is imputed at their 2009–2010 market prices. The average flow value per household in the study sites was calculated as INR 59,000 per annum. The flow value of HGs is the monetised flow of produces from HG at market price. The flow value from HGs is generated both from trees and annual crops. The woody and non-woody trees generate different flow values. As shown in Table 9, the highest flow value was generated from mango from among the woody and non-woody trees. It should be noted that livestock was not taken into account in flow value calculation.

Table 9 Annual flow value of the woody and non-woody trees in HGs (top ten)

English name	*Scientific name*	*Flow value per household (INR per annum)*
Mango	*M. indica*	1,391.85
Jack fruit	*A. heterophyllus*	755.55
Bamboo	*B. tulda*	427.50
Coconut	*C. nucifera*	228.15
Guava	*P. guajava*	224.55
Tamarind	*T. indicus*	200.25
Golden Apple	S. cythereaL.	166.95
Indian Lilac	*A. indica*	152.10
Palm	*Borassus flabellifer* L.	138.15
Moringa	*M. oleifera*	128.70

Source: Field survey

7 Determinants of flow value from HG

The production decisions made for the HG may depend on the socio-economic characteristics, and labour and non-labour incomes of the households (Marambe et al., 2012a). The median annual flow value of HGs under study was observed to be INR 4,309.50 with the maximum INR of 25,312 and the minimum of INR 424. Out of 100 HGs, 50 households had a flow value either equal to or above the median flow value. In the present study, we were interested in finding the determinants of high flow value from the HGs. A high flow value was defined in this study as the value which is above the median flow value. The median here was used instead of the mean to avoid bias arising out of extremely small or large observation. The probability of getting high flow value from HG was hypothesised to be influenced by the intra-household parameters of home gardeners' (household size, education status), indigenous knowledge, natural resources endowment (land size, household assets), access to information (farmer extension service from government, NGOs, farmer to farmer extension), access to credit, availability of formal institutions such as input output markets, etc. Accordingly, a logit model [equations (2), (3) and (4)] (Wooldridge, 2002; Heij et al., 2004) was used to analyse the factors, which influence the high flow value (a value greater than median flow value).

Latent variable can be given by the equation below

$$y_i^* = \beta_1 + \beta_2 x_{2i} + \ldots\ldots\ldots + \beta_k x_{id} + u_i \quad (2)$$

y_i^* is unobservable but $y_i = \begin{cases} 1, & if \ \ y_i^* > 1 \\ 0, & if \ \ Otherwise \end{cases}$

where $y_i = 1$, if flow value is greater than the median flow value; $y_i = 0$, otherwise.

X_{ji}'s are independent variables.

$$P(y_i = 1) = p_i \frac{e^{\beta_1 + +\beta_2 x_{2i} + \qquad + \beta_k x_{ki}}}{1 + e^{\beta_1 + +\beta_2 x_{2i} + \qquad + \beta_k x_{ki}}} \quad (3)$$

Log likelihood of the logit model is given by

$$Log\left(L(\beta)\right) = \sum_{i=1}^{n} y_i \log\left(p_i\right) + \sum_{i=1}^{n} \left(1 - y_i\right) \log\left(1 - p_i\right) \quad (4)$$

Six independent variables were considered finally as given in Table 10. The independent variables included per capita consumption of the household; percent of expenditure on food, the highest level of education attained by any member in family, number of individuals employed in farming, amount of fertiliser used in the HG and ownership of animals (a dummy variable = 1 for owned livestock; = 0 otherwise). The per capita consumption of the household was estimated on the basis of the consumption items like food, including HG, education, health and fuels as reported by the households. The summary statistics of the variables are presented in Table 10. High standard deviation of the amount of fertiliser used compared to its mean arises because of the existence of high values for some households.

Table 10 Summary statistics of the variables used

Variable	*Unit*	*Mean*	*Median*	*Standard deviation*
Annual flow value from home garden	Thousand INR	6.59646	4.90350	5.34729
Per capita annual consumption of the household	Thousand INR	8.42413	6.9988	6.12
Percent of expenditure on food		46.71	50.00	16.86
Highest level of education of the family	No. of years	9.38	9.00	2.83
No. of individuals employed in farming		1.77	2.00	1.31
Amount of fertilizer used in the home garden	Kgs.	27.91	20.00	29.15

Source: Field survey

The logit regression results (using SPSS software) are shown in Table 11. The results suggested that the statistically significant factors affecting the likelihood of high flow value are high per capita consumption, high level of education, high number of individuals employed in farming and high amount of fertiliser used. The home gardeners with a high percentage of expenditure on food and having livestock were less likely to derive a high flow value. The families spending more on food, *i.e.*, poorer families derive less flow values from HG. As the livestock may damage the crop component of the HG while grazing, the flow value may be less. However, households with a high per capita consumption are more likely to fall in the category of higher flow value. The estimated results also revealed that the Nagelkerke $R^2 = 0.403$ and the overall percentage of correct prediction is 75%.

Table 11 Logit estimation results

Independent variable	*Marginal effects*	*Significance level*
Per capita consumption of the household	.105	.064
Percent of expenditure on food	–.049	.002
Highest level of education of the family	.221	.031
No. of individuals employed in farming	.531	.009
Amount of fertiliser used in the home garden	.034	.028
Ownership of livestock	–1.533	.065
Constant	–1.119	.472

Source: Authors' own estimation based on field survey data

8 Conclusions

The paper highlights the different characteristics of HGs and their contribution in household food supply and multiple other benefits in a dry region in India. HGs may play an important role in improving the species diversity and food supply of the people in the rural areas. The results suggested that home gardeners with a higher level of education and who are using modern inputs are able to derive more benefits from the HGs. There is a need of proper extension services, particularly on the part of the government regarding crop planning, land management, providing irrigation facilities, and training for water and soil conservation for the home gardeners to encourage sustainable practice-based land management systems.

Acknowledgements

The authors acknowledge with thanks the financial support from the Asia Pacific Network (APN) for Global Change Research under the three-country project entitled 'Vulnerability of home garden eco-systems to climate change and its impacts on food security in South Asia' (Project no. ARCP2010-03CMY-Marambe).

References

Attygalle, R. (1996) 'Contribution of home garden tree species towards family nutrition – case study', in Gunasena, H.P.M. (Ed.): *Proceedings of the Forth National Workshop on Multipurpose Trees: Research and Development*, Kandy, Sri Lanka, 1–3 April 1994, pp.129–143.

Ban, N. and Coomes, O.T. (2004) 'Home gardens in Amazonian Peru: diversity and exchange of planting material', *Geographical Review*, Vol. 94, No. 3, pp.348–367.

Blaylock, J.R. and Gallow, A.E. (1983), 'Modeling the decision to produce vegetables at home', *Journal of Agricultural Economics*, Vol. 65, No. 4, pp.722–729.

Crowell, E., Cooper, D. and Mulvany, P. (1991) *Agricultural Biodiversity and Livelihoods: Issues and Entry Points for Development Agencies*, cited in Senanayake, R.L. and Sangakkara, U.R.

Government of India (2011) *Census of India* [online] http://censusindia.gov.in/ (accessed 3 February 2014).

Heij, C., Boer, P., Franses, P.H., Kloek, T. and Dijk, H. (2004) *Econometric Methods with Applications in Business and Economics*, Oxford University Press, UK.

Hitinayake, H.M.G.S.B., De Costa, W.A.J.M. and Jayaweera, K.G.D. (1996) 'Food trees in multi-layered home gardens in different Agroecological Zones of Kandy District', in Gunasena, H.P.M. (Ed.): *Proceedings of the Seventh National Workshop on Multipurpose Trees: Multipurpose Trees for Food Security*, Kandy, Sri Lanka, 5 November 1999, pp.252–264.

Lebel, L., Rattanawilailak, S., Lebel, P., Arfue, A., Sriyasak, P. and Daniel, R. (2010) *The Lazy Garden Bio-Innovation as a Resilience Building Strategy of Farmers in the Uplands of Northern Thailand*, USER Working paper WP-2010-06, Unit for Social and Environmental Research, Faculty of Sciences, Chiang Mai University, Thailand.

Lewis-Beck, M.S., Bryman, A. and Liao, T.F. (2004) *The Sage Encyclopedia of Social Science Research Methods*, Sage Publications, Inc., Thousand Oaks, CA.

Marambe, B., Weerahewa, H.L.J., Pushpakumara, D.K.N.G., Silva, G.L.L.P., Punyawardena, B.V.R., Premalal, S., Miah, G. and Roy, J. (2012a) *Vulnerability of Home Garden Systems to Climate Change and Its Impacts on Food Security in South Asia*, Project Report Submitted to APN, (Project No. ARCP2010-03CMY-Marambe [online] http://www.apn-gcr.org/.../files/3ddf57b875774091a38f95bdfee0b6c9.pdf (accessed 10 September 2012).

Marambe, B., Weerahewa, J., Pushpakumara, G., Silva, P., Punyawardena, R., Premalal, S., Wijerathne, B., Kandangama, N., Kumara, R., Miah, G., Roy, J. and Jana, S. (2011) 'Farmer perception and adaptation to climate change in home gardens of Sri Lanka', *Proceedings of the WCRP Open Science Conference on 'Climate Research Service to Nation'*, Denver, USA.

Marambe, B., Weerahewa, J., Pushpakumara, G., Silva, P., Punyawardena, P., Premalal, S., Miah, G., Roy, J. and Jana, S. (2012b) 'Adaptation to climate change in agro-ecosystems: a case study from home gardens in South Asia', *Proceedings of the MARCO Symposium 2012 – Strengthening Collaboration to Meet Agro-environmental Challenges in Monsoon Asia*, 24–27 September, pp.81–87, Tsukuba, Japan.

Nair, P.K.R. and Kumar, B.M. (2006) 'Introduction', in Kumar, B.M. and Nair, P.K.R. (Eds.): *Tropical Home Gardens: A Time-Tested Example of Sustainable Agroforestry*, pp.1–10, Springer Science, Dordrecht.

Nguyen, T.N.A.N. (1997) *A Study on the Home Garden Ecosystem in the Mekong River Delta and the Hochiminh City*, Working paper No. 7, UNESCO, Division of Ecological Sciences, South-South Co-operation Programme. http://www.unesco.org/mab/activity/s-s/s-home.html (accessed 14 November 2012).

Pushpakumara, D.K.N.G., Marambe, B., Silva, G.L.L.P., Weerahewa, J. and Punyawardena, B.V.R. (2012) 'A review of home garden research in Sri Lanka: the status, importance and future perspectives', *Tropical Agriculturist*, Vol. 160, pp.55–124.

Rao, K.P.C., Verchot, L. and Laarman, J. (2007) 'Adaptation to climate change through sustainable management', *SAT eJournal*, December, Vol. 4, No. 1, pp.1–30, International Crops Research Institute for the Semi Arid Tropics (ICRISAT).

Saikia, P., Choudhury, B.I. and Khan, M.L. (2012) 'Floristic composition and plant utilization pattern in home gardens of Upper Assam, India', *Tropical Ecology*, Vol. 53, No. 1, pp.105–118.

Tangjang, S. and Arunachalam, A. (2009) 'Role of traditional home garden systems in North East India', *Indian Journal of Traditional Knowledge*, January, Vol. 8, No. 1, pp.47–50.

URS (2004) *Home Garden Report*, Quang NGAI Rural Development Program (RUDEP), Phase-2, Participatory Rural Appraisal Report, URS Sustainable Development, Adelaide, Australia [online] http://www.fsnnetwork.org/sites/default/files/participatory_rural_appraisal_report.pdf (accessed 30 August 2010).

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*, March, Vol. 2, No. 2, pp.22–27.

Weerahewa, J., Wijerathne, B. and Pushpakumara, D.K.N.G. (2011) 'Home gardens as a source of micronutrients: an analysis of food harvested from home gardens in Kandy, Kurunegala and Batticaloa Districts in Sri Lanka', *Tropical Agriculturist*, Vol. 159, pp.107–134.

Wooldridge, J.M. (2002) *Econometric Analysis of Cross Section and Panel Data*, 1st ed., MIT Press, England.

Notes

1 Questionnaire can be accessed from corresponding author upon request.

2 Indian Rupees.