FINAL REPORT for APN PROJECT
Project Reference: ARCP2010-03CMY-Marambe

Vulnerability of Homegarden Systems to Climate Change and its Impacts on Food Security in South Asia

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Final Report submitted to APN

OVERVIEW OF PROJECT WORK AND OUTCOMES

Non-technical summary

The changes in temperature and rainfall, current status of the diversity in homegardens, socio-economic characteristics of homegardeners, and the extent to which climate shocks have influenced the usage of adaptation strategies by the homegardeners under changing climate were studied in three sites in Sri Lanka and one site each in India and Bangladesh. All study sites have experienced increased variability of seasonal rains over the past five decades (1961-2010). The minimum and maximum temperatures showed an increasing trend. The analysis of plant, tree and animal composition of homegardens over past two decades (1991-2010) revealed that they have not changed substantially despite the climatic variations.

The homegardens in study areas showed resilience to climate change and considerable contribution to household food security. The type of employment, age, sex, education level of household head, experience in farming, homegarden size, diversity of homegardens, and perceptions towards climate change have influenced the decision of homegardeners to adopt different strategies such as, changes in planting dates, agronomic practices, and technology (use of new varieties and irrigation equipments, use of soil and water conservation measures), to cope up with climate change. Development programs to promote adaptation to climate changes should be designed taking above determinants into consideration.

Objectives

The main objective of the project was:

To assess the degree of vulnerability of different homegarden systems in South Asia under changing climate.

The specific objectives were:

(a) to document key characteristics of home-garden systems covering major climatic zones in Sri Lanka and selected locations in India and Bangladesh.
(b) to establish patterns of climate change and their indicators in the above regions over a period of 50 years.
(c) to develop a bio-economic model to identify the contribution of climate change on the status of food security.

Amount received and number years supported

The Grant awarded to this project was:

US$ 35,000 for Year 1:

US$ 40,000 for Year 2:

Activities undertaken

The activities undertaken during the two year project period are given in Tables 1 and 2.

Table 1. Activities performed during year 1

Activity	1st Year (in months from the starting date)											
	1	2	3	4	5	6	7	8	9	10	11	12
Start-up Meeting (Sri Lanka)			■									
Selection of sites			■	■								
Meteorological data collection and analysis				■	■	■						
Development of Scenarios for Climate Change and simulations						■	■	■				
Survey - Primary Data Collection					■	■	■	■	■			
Progress Review Meeting (Bangladesh)										■		
Data Analysis								■	■		■	■

Table 2. Activities performed during year 2

Activity	2nd Year (in months from the starting date)											
	1	2	3	4	5	6	7	8	9	10	11	12
Data analysis and mathematical modeling			■	■	■	■	■	■				
Draft Report on project outputs									■	■		
Progress review meeting and Workshop to discuss final results and drafting of Policy Recommendations (India)										■		
Dissemination Seminars, Debates, quizzes, at National Level (Sri Lanka, India, Bangladesh)										■	■	
Final Project Meeting/ Finalization of report/Draft Research Papers												■
APN project & financial reporting												■

Results

Despite the evidence that climate change has taken place in the past 50 years (1961-2010), the composition of homegardens in Sri Lanka, India and Bangladesh has not changed substantially. Strategies adapted by homegardeners over the past two decades have enabled them to cope with changes in climate and ensure food security. Socio-demographic factors of homegardeners and their perception towards climate determine the type of adaptation strategy used. Homegardeners, who have perceived climate change correctly, are more prone to adapt to the changes using different techniques and technologies.

Relevance to the APN Goals, Science Agenda and to Policy Processes

Integrated research approaches in developing countries, including interdisciplinary analysis of the effects and consequences of development pathways, and potential strategies to cope up with such impacts are encouraged by the APN. The proposed project aims at assessing the degree of vulnerability of different homegarden systems in selected South Asian countries under changing climates. This has direct relevance with the Science Agenda item 2 (ecosystems, biodiversity and land use) and item 4 (use of resources - food, water, energy, materials - and pathways for sustainable development. One of the key objectives of the proposed project was to disseminate knowledge among relevant parties at national and regional levels, and to develop draft policy recommendations for consideration by the policy makers. This will help creating awareness among stakeholders on the scientific information gathered by the project activities to identify the degree of vulnerability of different homegarden systems in South Asia, which is required to design appropriate strategies to mitigate the adverse impacts. Hence, the proposed study has direct relevance to the APN policy agenda commitment 'Strengthening appropriate interactions among scientists and policy makers, and providing scientific information to policy decision-making and scientific knowledge to public (Goal 2)'.

Self evaluation

The project objectives framed have no doubt assisted in identifying the vulnerability status of the homegardens in south Asia to climate change. The project team is satisfied with the progress of activities except for the delay in transferring finances to India and Bangladesh to facilitate the activities. The detailed analysis included in the project on the adaptation strategies in place of the bio-economic model has strengthened and provided a more useful outcome keeping in line with the project objectives, in terms of identifying the level of resilience of the homegardens to climate change. The project team is highly satisfied with the overall achievements and outcomes of the projects.

Potential for further work

- A detailed analysis on the extent of utilization of homegarden trees, plants and animals by household using the proportions of harvest consumed by the members of the household (the actual amount of nutrients provided by each homegarden) would assist in further strengthening of the information on the contribution of homegardens in meeting food and nutrition security of the household. This would also help in identifying the trees, plants and animals that are vulnerable to climatic changes and comment on the degree to which food supply from the homegardens will be affected due to changes in climate.
- The homegardens selected for this study were found to be climate resilient. However, as the present investigation captured information from homegardens with specific features as described in the technical report, this study should be replicated in other agro-ecological regions to understand whether similar pattern could be observed. For examples, the homegardens which have come under development programs of the government of Sri Lanka in the recent past are different to what was considered in the present study.
- The study team learns that collection of data at frequent intervals is better than obtaining information through re-calling. Collection of a panel data set covering a few identified homegardens over a long time span is hence suggested to carryout a similar analysis.

Publications:

Weerahewa J, Pushpakumara G, Silva P, Daulagala C, Punyawardena R, Premalal S, Miah G, Roy J, Jana S, and Marambe B (2012): Are Homegarden Ecosystems Resilient to Climate Change? An Analysis of The Adaptation Strategies of Homegardeners in Sri Lanka. APN Science Bulletin 2: 22-27

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 homegardens of Sri Lanka. Proceedings of the WCRP Open

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Daulagala C, Pushpakumara G, Weerahewa J, Silva P, Punyawardena R, Premalal S, and Marambe B (2011): Homegardens in Sri Lanka and their associated benefits. Poster Paper presented at the APN SPG-IGM meeting, 6-8 April. Colombo, Sri Lanka
Kumara R, Pushpakumara G, Kandangama N, Weerahewa J, Silva P, Punyawardena R, Premalal S, and Marambe B (2011): Tree diversity and structure of homegardens of Sri Lanka. Poster Paper presented at the APN SPG-IGM meeting, 6-8 April. Colombo, Sri Lanka
Kandangama, N, Wijeratne B, Kumara R, Premalal S, Weerahewa J, Pushpakumara G, Silva P, Punyawardena R, Miah G, Roy J, Jana S, and Marambe B (2011): Perceptions of Farmers in Sri Lanka on Climate Change. Poster Paper presented at the APN SPG-IGM meeting, 6-8 April. Colombo, Sri Lanka
Wijeratne B, Kandangama N, Kumara R, Weerahewa J, Pushpakumara G, Silva P, Punyawardena R, Premalal S, Miah G, Roy J, Jana S, and Marambe B (2011): Are Homegarden Ecosystems Resilient to Climatic Changes? An Analysis of Strategies Adapted in Homegardens in Sri Lanka. Poster Paper presented at the APN SPG-IGM meeting, 6-8 April. Colombo, Sri Lanka

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TECHNICAL REPORT

Preface

Homegardens are special food production systems in South Asia and climate change is one of the key global challenges that could adversely affect their functions. The developing countries generally pay special attention on adapting to climate change, and the degree of climate resilience of homegardens would vary with the adapted strategies and their costs, homegardeners, location, and the external factors beyond the control of the homegardeners. Addressing interdependencies and interactions among homegardens-climate change-adaptation level would no doubt fill the information gaps and assist in successful implementation of developmental projects on homegardens under changing and variable climate, to ensure food security.

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1.0 Introduction

Projections at the global level indicate strongly that climate change could severely affect agricultural production, with cereal production in developing countries being affected the most. It is expected that global average temperature would rise by 2-3 °C over the next 50 years, with implications for the frequency and intensity of rainfall and extreme weather events. These climatic changes are predicted to have serious implications for food production, in varying degrees, in different parts of the world and South Asia is not an exception.

South Asian Agriculture is characterized by a large number of small farmers of which majority live under poverty. Approximately 125 million holdings are operating in an area of around 200 million hectares, with an average size of 1.6 hectares in the region. Of these, more than 80% are extremely small, with an average size of less than 0.6 hectares. A significant component of the small holdings in the region is represented by homegarden farming systems. Given the nature of South Asian agriculture, climate change can have significant adverse impacts not only on food production but also on food insecurity, poverty and malnutrition. Therefore, ensuring national and regional level food security for all and at all times is a need in the face of projected climate change.

"Homegarden" is a complex sustainable land use system that combines multiple farming components, such as annual and perennial crops, livestock and occasionally fish, of the homestead and provides environmental services, household needs, and employment and income generation opportunities to the households. Homegarden (HG) agro-ecosystems are an agroforestry system. In Sri Lanka that covers about 14 % of the total area of the country. Climatic changes are predicted to have adverse effects on food production, in varying degrees, in different eco-systems and homegardens are no exceptions. The extents to which the impacts of climate change are felt depend largely on the extent of adaptation. However, they could also play a significant role in adaptation to CC *i.e.* change the microclimate, provide permanent cover, diversify the agricultural systems, improve resource use efficiency, improve soil fertility, reduce carbon emissions and increase sequestration (Rao *et al*, 2007) and also rich in biodiversity. There is a growing body of literature examining the types of adaptation strategies and the determinants of the same (Below *et al.* 2010; Deressa *et al.* 2010, 2008; Rao *et al.,* 2007, Nhemachena and Hassan, 2007). Despite the large empirical evidence on adaptation, there is a dearth of studies, especially in South Asia, examining the extent to which homegardeners have adapted to climatic changes.

Food security in rural South Asia and food production in homegardens is intrinsically related; hence, climate change may have significant implications on food security. According to recent studies conducted in Sub Saharan Africa, homegardens are more prone to cushion the shocks arising from climate change than those by monocultures, and farmers use a variety of adaptation measures to mitigate the adverse effects of climate change. The influence of climate change on food production and food security of homegardens has not been well established yet. This study was therefore, proposed to evaluate the effects of climate change on homegarden systems, which are the predominant types of highland farming in South Asia.

The objective of this study is to assess the degree of vulnerability of different homegarden systems in South Asia under changing climates. The major specific objectives were;

(a) to document key characteristics of homegarden systems covering major climatic zones in Sri Lanka and selected locations in India and Bangladesh.
(b) to establish patterns of climate change and their indicators in the above regions over a period of 50 years.
(c) to develop a bio-economic model to identify the contribution of climate change on the status of food security.

2.0 Methodology

Site Selection:

This multi-country project was carried out in Sri Lanka (project proponent), India and Bangladesh. Three project sites were selected in Sri Lanka, where two (02) sites were from areas in the Low Country Dry Zone with considerable fluctuations in rainfall intensity and distribution pattern, and one site selected from an area in the Mid Country Wet Zone with a modest variation in rainfall intensity and distribution pattern. The three sites were also selected to represent different temperature regimes. Similar criteria were used in selecting one site each from Bangladesh and India where areas with comparable climatic conditions to that of the Sri Lankan sites were given priority to facilitate direct comparison of information generated across partner countries. The site selection process was finalized at the Project Inception meeting held in Dambulla, Sri Lanka in November 2009 and the 8-point criteria adopted are given in Box 1, the site characteristics are given in Table 1.

Box 1: Criteria adopted for selecting project sites

1. Availability of Home Gardens (HG) to suit the definition
2. Key characteristics of HG
   - Extent (< 0.5 ha)
   - Maturity (at least 20 yrs)
   - Composition (Trees and annual are a must, domesticated animals are preferable)
   - Structure (at least a 3-tiered plant structure)
   - Sites not subjected to significant man-made changes (*i.e.,* construction of roads, establishment of irrigation reservoirs, development of market places)
3. Access to background information on factors other than the climate change, affecting HG
4. Climatic regions
   - Mid country (300 – 900 m amsl) Wet Zone (> 2500 mm/year)
   - Low country (< 300 m amsl) Intermediate Zone (1750-2500 mm/year)
   - Low country (< 300 m amsl) Dry Zone (< 1750 mm/year)
5. Availability of climatic data (from Meteorological Department)
6. Easy Access to HG
7. Number of home gardens surveyed per country should be a minimum of 100.
8. Commonness among south Asia

Table 1. The study sites

Country and Villages	Agroclimatic/ Climatic zone	Number of Homegardens surveyed	GPS locations of the study sites
Sri Lanka			
Keeriyagaswewa	Low Country Dry Zone	59	7.86^0 N, 80.65^0 E
Siwalakulama	Low Country Dry Zone	30	7.95^0 N, 80.75^0 E
Pethiyagoda	Mid Country Wet Zone	59	7.27^0 N, 80.6^0 E
India			
Ledagamar and Keshia	Sub-humid	100	22.80^0 – 22.83^0 N 87.32^0 – 87.32^0 E
Bangladesh			
Borjona, Nakasini, Koroli, Goshaigao, Tatulia, and Charbaria	Subtropical Monsoon Region	120	24.3^0 - 24.16^0 N 90.3^0 – 90.42^0 E

The study area in India falls in the dry zone, high altitude, with a rich bio-diversity and well established homegardens. There is scope of up scaling homegardens in these villages. The study area in Bangladesh falls in central part/terrace zone (intermediate range of temperature, rainfall and humidity). The production systems, particularly homesteads in this region are well developed and are almost free from floods.

Documentation of the key characteristics of the homegardens:
A household survey was carried out through a structured questionnaire to obtain the information on general household characteristics, structure and composition of the homegarden. The primary survey questionnaire was developed to obtain information on the agronomic, socio-economic and demographic characteristics of existing homegarden systems, and pre-tested in all partner countries prior to its execution.

- In Sri Lanka, the survey was carried out from May to December 2010 in the three selected sites. A total of 148 homegardens were surveyed. Site visits were made to complete the questionnaire survey and obtain the inventories of the components of the homegardens.

- In India, the snowball sampling procedure was adopted. A few respondents were initially interviewed from selected study site. Subsequently the respondents who meet the selection criteria of homegarden and who might be interested to participate in the project were interviewed. Initially Ledagamar village was the only focus of the project team. However, as 100 observations could not be obtained in Ledgamar, the second village namely, Keshia was selected.

- In Bangladesh, survey was carried out in 3 stages. At the first phase all the homesteads in the selected villages were recorded. Out of these 120 homesteads which fell in the selection criteria of homegardens were randomly selected for data collection. At the second phase, all the homesteads were visited and their homestead systems, practices, plant and animal resources were monitored and recorded. At the third phase several Focal Group Discussions (FGD) were held to verify the information.

- Data collected were of three types namely (i) general household characteristics, (ii) components in the homegarden *i.e.* trees and animals, and (iii) incomes and costs. The general household characteristics include the number of members in the family, their age, gender, relationship to the head of the household, level of education and occupation. Total acreage cultivated and managed by each household was recorded in terms of their type (homegarden, lowland, Chena, other) proportion and ownership (owned, tenant, other). The land distribution pattern was further elaborated by portion devoted for each crop, animals and other elements present in the homegarden. The nature of management (i.e. cultivated by self or not) was also recorded.

- During the survey, plants and animals in homegarden were observed, counted, and measured by the enumerators. They were then recorded in categories by the common names. Plants were identified under crops, woody trees and naturally grown plants categories. Trees above 5 cm diameter were inventoried and their composition and management practices were recorded along with height and diameter at breast height (DBH) i.e. the diameter of the tree trunk at height 1.37 m from the ground level. In addition the time of planting and the age of trees were also recorded where applicable.

- The contribution of homegarden products to households' consumption and income was obtained in terms of the portion consumed, given as gifts and sold, out of the total production. The unit price of sold products was also recorded. These data were collected for both animal and plants species.

- The animal component was recorded in terms the number of female and male animals, type and level of breed i.e. indigenous, hybrid or other. Portion of meat, eggs and milk consumed by the family, gifted, and sold and the unit price were recorded where applicable.

- In estimating the costs, the type of fertilizers, housing materials, feeding materials and unit prices costs were also collected.

Establishment of climate change in the study sites: Historical data on temperature and rainfall were collected from the Meteorology Departments of the respective countries for the climate data analysis.

- For Sri Lankan sites, the average annual minimum and maximum temperature data and annual rainfall data along with the onset of respective growing seasons, namely *Yala* and *Maha* seasons were used in the analysis Analysis of onset of the season was confined to most recent last two decades (1991-2010) to be in line with the perception questions of the questionare survey.

- For the site in Bangladesh, climate data as identified above were analyzed for the *Kharif* I and *Kharif* II seasons.

- All data were carefully examined for their accuracy and consistency. Mising values of the primary data (daily data) were estimated using Normal Ratio Method. Trend analysis for average annual minimum temperature, maximum temperature and annual rainfall were carried out for the entire data set of 50 years starting from 1961 to 2010.

Assessment of vulnerability of existing homegarden systems and Food Security:

As mentioned earlier, projections at the global level indicate that climate change could severely affect agricultural production. One can hence anticipate that homegardens are no exceptions to this general rule. However, the key informant surveys conducted during the initial visits made to the homegardens and participatory rural appraisals conducted in study sites, particularly in Sri Lanka, indicated that no major changes to crop and animal production in the homegardens had taken place during the past 20 years. This was in spite of the changes in rainfall and temperature observed using meteorological data and noticing of changes in climate through other observations (changes in leaf fall, changes in types of plants around the wall of the well etc.).

There is ample literature to explain such seemingly puzzling observations. A number of empirical studies conducted in this area suggest that the above phenomenon is due to adaptation of the farming community to the changes in natural environment. Such studies reveal that farmers use a variety of adaptation strategies to cope up climatic shocks and the type of strategies used by the farmers is determined by a number of factors. The socio-economic characteristics of the farmers, the natural environment within which farmers operate and access to infrastructure have been identified as the key determinants. In such contexts a thorough assessments of types of adaptation strategies and determinants of the probability of using an adaptation strategy are the appropriate investigations. Accordingly, the investigations were performed using descriptive statistics and a series of probit models instead of developing and using a bio-economic model as initially proposed in this study. The latter would have been more appropriate if farmers had significantly changed the crop and animal mix and the cultivation practices so as to stimulate the equilibrium in absence of a change in climate.

- The questionnaire survey stated above was used to obtain the information on changes made during the past 20 years, perception on temperature and rainfall changes, and information on adaptation strategies. Vulnerability of homegardens was assessed using information on food security (malnutrition in particular), and food consumption pattern (dependence on homegarden vs. market), and climatic, plant and animal species composition, ecological information, production from plants and animals, diseases outbreaks, shift of flowering and fruiting, adjustment to cultivation practices, and marketing information and shifts.

- Perception on temperature and rainfall changes was captured by asking open ended questions from the respondents ("What is your view about day/night temperatures (amount of rain fall/ rainy period, wind-turn, mist, fog, flood, drought and storm) compared to past 20 years?"). Respondents referred number of changes made in homegardens during the past 20 years with regard to crops, woody trees, naturally grown plants, domestic animals. They also explained changes in natural vegetation, wild animals, their reproduction patterns and pest and disease incidents based on observation. Adaptation strategies were identified and a variable was developed across the sites based on these answers.

- The perception data were further refined by the participatory rural appraisals and focus group discussions held at each study site in the three countries.

<u>Data Analysis</u>:

- The socio-economic characteristics of the homegardeners are presented using descriptive statistics.

- Plant diversity: The Shannon-Wiener Index (SWI) was used to evaluate the species richness and abundance of trees in all five locations (Margurran, 1988). 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 ($\ln p_i$). The resulting product is summed across species, and multiplied by -1 (equation 1). SWI of individual households across the five locations was used as an explanatory variable in probit analysis.

$$SWI = -p_i\left[\ln\left(p_i\right)\right] \text{--} \textit{(Equation 1)}$$

- Food security: The status of household food security was measured using the total expenditure on food, food ratio (expenditure on food as a proportion of total expenditure), proportion of the harvest of the homegarden produce consumed, and the contribution of homegarden in meeting of the food needs of the household (obtained by the response of the household head to a direct question raised).

- Nutrition security: Nutrition grids were developed for the five locations using nutrients available in different food species available in homegardens. Composition of nutrients of the food items was taken from USDA nutrient data laboratory. First, the amount of nutrient intake for each 100 KJ intake was calculated. Next, the values were compared with Recommended Daily Allowance of the same nutrients. If a certain food provided at least 10 percentage proportion of the RDA of a given nutrient such species were shaded in the relevant column of the nutrient grid (see Annex -1).

- Perceptions on climate change by the homegardeners: The deviations between perceptions on changes in temperature and rainfall and actual changes were noted. A series of Logit models were estimated to assess the determinants of making a correct perception. Age of the homegardener, number of years lived in the village, number of family members occupied in farming/non-farm, Shannon-Weiner Index of homegarden as dummy variables, and gender, location, level of education and ownership of livestock/lowland were as explanatory variables and whether a correct prediction was made or not was treated as the dependent variable.
- Adaptation strategies: The probability of adapting a strategy is hypothesized to be influenced by homegardeners' intra household parameters, indigenous knowledge, survival mechanisms, natural resources endowment (land size, household assets), access to information (farmer extension service from government, NGO's, farmer to farmer extension), access to credit, availability of formal institutions such as input output markets. Accordingly, a probit model was used to analyze the factors which influence the decision to adapt a climate changes following Deressa *et al.* (2010). The dependent variable was treated as one if a certain farmer adopted the strategy and 0 otherwise. The independent variables include; SWI, number of individuals employed in farming/ off-farming, education level of the household-head (a dummy variable = 1 for primary, = 0 otherwise), household size, sex of the household-head (a dummy variable = 1 for male, = 0 female), age of the household head (number of years), homegarden size, experience in agriculture, perceived change in temperature (a dummy variable = 1 for perceived change, = 0 otherwise) perceived change in rainfall (a dummy variable = 1 for perceived change, = 0 otherwise) and ownership of animals (a dummy variable = 1 for owned livestock, = 0 otherwise.

3.0 Results & Discussion

3.1. Socio-economic Characteristics of the Households

The socio-economic characteristics of the study sites are presented in Table 2. The average age of the homegardeners in India and Sri Lanka were 55 years and that in Bangladesh was 51 years. More than 80 % of the homegardeners were males in Sri Lanka and India but in Bangladesh the majority were females (97 %).The household size was larger in Bangladesh and India than that in Sri Lanka. An average family consists of four members in each site in Sri Lanka. In India and Bangladesh the average household size was higher (6 and 5, respectively) with the ranges of 2 to 15 and 2 to 10, respectively. Among the homegardens surveyed, 29 % of homegardeners (household head) in India has not attended school education and 49 % were educated up to secondary level or above. In Bangladesh, 14% have not attended school education, but 48 % and 37 % have had education up to primary and secondary levels, respectively. In Sri Lanka, 13 % and 3 % of the homegardeners were in "up to secondary or above" and "no schooling" categories, respectively. In all three countries the majority of the respondents belonged to the low income categories (Table 2). The proportions of low-income farmers are 93 %, 65 % and 61 % in India, Bangladesh and Sri Lanka respectively. In addition to farming, 11 % in India were also occupied in other employments.

Table 2. Socio-Economic Characteristics of the Households

Attribute	Category	Bangladesh	India	Sri Lanka		
				KG[#]	SW	PG
Size of the household (number)	Average Range	5.0 2-10	5.9 2-15	4.0 1-8	3.5 1-5	4.1 1-7
Age of the household head (HH) (years)	Average Range	51 20-90	55 22-85	55 30-83	58 30-86	54 26-78
Sex of the HH (% in each category)	Male Female	97.5 2.5	84.0 16.0	86 14	80 20	81 19
Education level of the HH (% in each category)	No schooling Up to primary Secondary & above	14.2 48.3 37.5	29 22 49	5.1 84.7 10.2	1.3 83.3 13.3	1.7 86.4 11.9
Occupation of the HH (% in each category)	House work Farming Farming and other* Non-farming Not responded	0.0 93.3 0.0 6.7 0.0	13.0 65.0 11.0 11.0 0.0	0 78 0 15 7	3.3 93.3 0 3.3 0	8 28 0 50 14

*Number of respondents who are engaged in farming and other occupations

[#] KG = Keeriyagaswewa, SW – Siwalakulama, PG - Pethiyagoda

The largest extent of the homegardens surveyed was recorded in Sri Lanka (average 0.29 ha) followed by India and Bangladesh (0.07 ha and 0.12 ha, respectively).

3.2. Tree and Crop Species Diversity of Homegardens

3.2.1. Diversity of Homegardens among different study sites of Sri Lanka

A total of 116 woody tree species were identified in the three sites of Sri Lanka where highest taxic diversity was reported from Keeriyagaswewa (KG) followed by Pethiyagoda (PG) and Siwalakulama (SK) (Figure 1). The KG reported significantly higher number of species compared to PG though PG homegardens are located in the wet zone whereas KW represents the dry zone of the country. This may be due to the some level of dominance of commercial species (spice crops) in homegardens of PG.

A total of 28 species were found in common to all the three sites (Figure 1; see Table 3 for list of common species among three sites). These common species are important species for food security in all three villages. Homegardens in Pethiyagoda harbor the highest number of unique species (27) followed by Keeriyagaswewa (22) and Siwalakulama (4). Keeriyagaswewa and Pethiyagoda shared 47 species in common, Keeriyagaswewa and Siwalakulama share 43 species while Pethiyagoda and Siwalakulama share 29 species in common (Figure 1; Table 3). Annex 1-3 show lists of species recorded in homegardens of Keeriyagaswewa, Pethiyagoda and Siwalakulama, respectively. Characteristics of homegardens in three sites are exemplified in Plate 1 where structurally the homegardens in Pethiyagoda are superior (more than three vertical strata) to homegardens in Keeriyagsawewa and Siwalakulama.

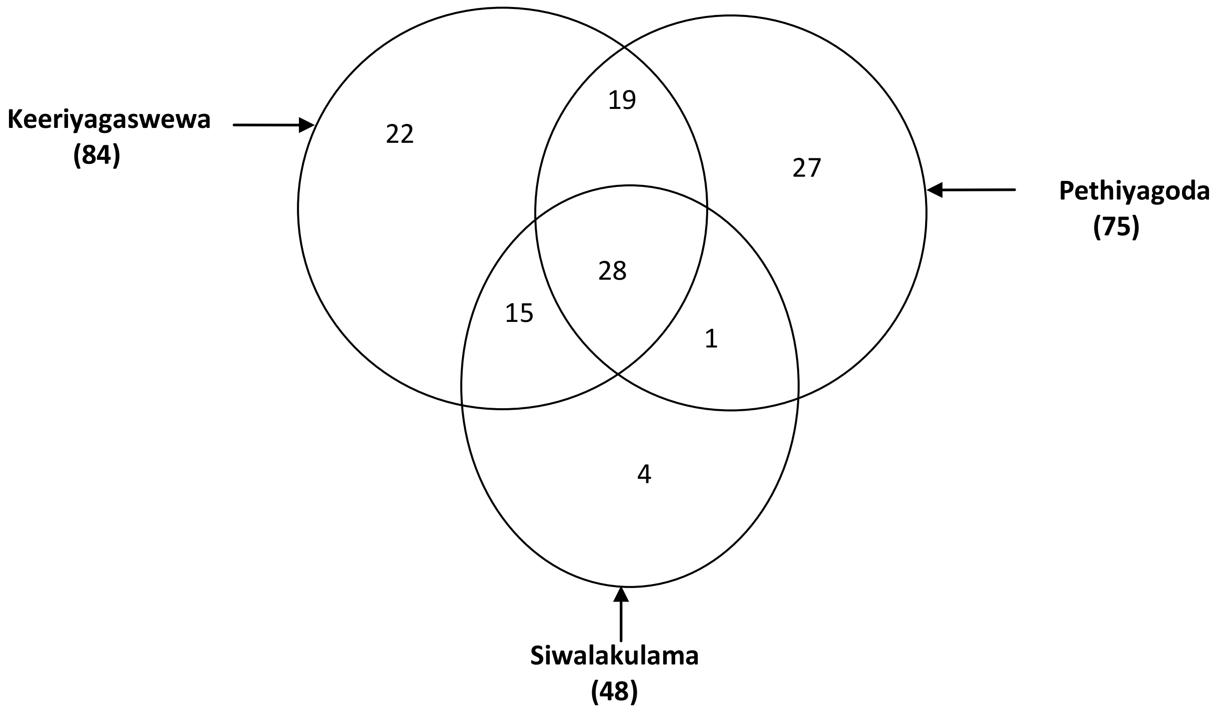


Figure 1: Distribution of Woody Trees and Naturally Grown Plants in Three Sites of Sri Lanka.

Plate 1: Diversity of Homegardens of Pethiyagoda (A), Keeriyagaswewa (B), and Siwalakulama (C).

Table 3. Species common to all three sites in Sri Lanka

Type of Tree Crop	**Local name**	**Species Name**	**Family**
Fruits	Weli anoda	*Annona reticulata* L.	Annonaceae
	Lawulu	*Chrysophyllum roxburghii* G. Don.	Sapotaceae
	Embul Dodam	*Citrus aurantium* L.	Rutaceae
	Heen naran	*Citrus reticulata* Blanco	Rutaceae
	Peni dodam	*Citrus sinensis* (L.) Osbec	Rutaceae
	Amba	*Mangifera indica* L.	Anacardiaceae
	Rata Nelli	*Phyllanthus acidus* (L.) & Skeels	Euphorbiaceae
	Pera	*Psidium guajava* L.	Myrtaceae
	Delum	*Punica granatum* L.	Punicaceae
	Wal ambarella	*Spondias pinnata* (L. f.) Kurz	Anacardiaceae
	Dan	*Syzygium caryophyllatum* (L.) Alston	Myrtaceae
	Dehi	*Citrus aurantifolia* (Christm. & Panzer) Swingle	Rutaceae
Timber	Halmilla	*Berrya cordifolia* (Wild.) Burret	Tiliaceae
	Thekka	*Tectona grandis* L. f. f. grandis	Verbenceae
Basic food	Kos	*Artocarpus heterophyllus* Lam.	Moraceae

	Pol	*Cocos nucifera* L.	Palmae
	Del	*Artocarpus incisus* L.F.	Moraceae
Leafy Vegetables	Kathuru murunga	*Sesbania grandiflora* (L.) Poir.	Fabaceae
Vegetables	Murunga	*Moringa oleifera* Lam.	Moringaceae
Other	Puwak	*Areca catechu* L.	Palmae
	Kohomba	*Azadirechta indica* A. Juss.	Meliaceae
	Ketakela	*Bridelia retusa* (L.) A. Juss.	Euphorbiaceae
	Kithul	*Caryota urens* L.	Palmae
	Pihimbiya	*Filicium decipiens* (Wight & Arn.)Thw.	Sapindaceae
	Kona	*Gliricidia sepium* (Jacq.)Walp.	Fabaceae
	Ipil Ipil	*Leucaena leucocephala* (Lam.)de Wit	Fabaceae
	Koan	*Schleichera oleosa* (Lour.) Oken	Sapindaceae
	Siyambala	*Tamarindus indica* L.	Fabaceae

According to the frequency of occurrence of species (Table 4), the most prominent species in homegardens of study sites in Sri Lanka are Coconut (*Cocos nucifera* L.) followed by Mango (*Mangifera indica* L.) and Neem (*Azadirechta indica* A. Juss.). Coconut was also the most abundant plant species in three sites recording a total of 527 trees (Table 5). Tree count ranking also indicates that Neem and Mango are the other abundant species as in descending order. Details of frequency distribution of species and number of trees in each species at each site are given in Annex 4 and 5, respectively.

Table 4. Frequency of woody plant species in three study sites of Sri Lanka

Local name	Scientific name	Frequency of occurrence
Coconut	*Cocos nucifera* L.	105
Mango	*Mangifera indica* L.	96
Neem	*Azadirechta indica* A. Juss.	86
Jack fruit	*Artocarpus heterophyllus* Lam.	63
Guava	*Psidium guajava* L.	55

Table 5. Tree counts of woody species in three sites of Sri Lanka.

Local name	Scientific Name	Number of Trees
Pol	*Cocos nucifera* L.	527
Kohomba	*Azadirechta indica* A. Juss.	510
Amba	*Mangifera indica* L.	248
Puwak	*Areca catechu* L.	232
Halmilla	*Berrya cordifolia* (Wild.) Burret	187

3.2.2. Diversity of Homegardens in Three Study Sites in Sri Lanka

A total of 88 naturally grown plants and woody tree species were recorded from Keeriyagaswewa. Out of 59 households in the village the prominent and also the abundant species was Neem (*Azadirachta indica* A. Juss.). It was recording in 52 households, amounting 385 trees. Mango (*Mangifera indica* L.) followed by Murunga (*Moringa oleifera* Lam.) were in second and third places of the frequency of occurrence ranking (Table 4). Halmilla (*Berrya cordifolia* (Wild.) Burret) Coconut (*Cocos nucifera* L.) ranked second and third in number of trees (Tables 6 and 7, see Annex 4 and 5 for details of other species).

Table 6. Frequency of 0ccurrence of woody plants in Keeriyagaswewa.

Local name	Scientific name	Frequency of occurrence
Kohomba	*Azadirechta indica* A. Juss.	52
Amba	*Mangifera indica* L.	36
Murunga	*Moringa oleifera* Lam.	36
Siyambala	*Tamarindus indica* L.	34
Pol	*Cocos nucifera* L.	33

Table 7. Species abundance of woody plants in Keeriyagaswewa.

Local name	Scientific. Name	Number of trees
Kohomba	*Azadirechta indica* A. Juss.	385
Halmilla	*Berrya cordifolia* (Wild.) Burret	169
Pol	*Cocos nucifera* L.	155
Amba	*Mangifera indica* L.	127
Thekka	*Tectona grandis* L. f. f. grandis	81

In the homegardens of Pethiyagoda 75 woody trees and naturally grown plants species were recorded. Prominent and the abundant species was Beetle nut (Areca catechu L.) which occurred in 46 out of 59 households followed by Coconut (*Cocos nucifera* L.) and Kona (*Gliricidia sepium* (Jacq.) Walp.) (Table 8). Mahogany (*Swietenia mahagoni* (L.)) and Coconut were ranking second and third in the tree counts table (Table 9).

Table 8. Frequency of occurrence of woody plants in Pethiyagoda.

Local name	Scientific Name	Frequency
Puwak	*Areca catechu* L.	46
Pol	*Cocos nucifera* L.	43
Kona	*Gliricidia sepium* (Jacq.)Walp.	38
Mahogany	*Swietenia mahagoni* (L.) Jacq.	37
Amba	*Mangifera indica* L.	37

Table 9. Number of Trees of Woody Plants in Pethiyagoda.

Local name	Scientific Name	Number of trees
Puwak	*Areca catechu* L.	205
Mahogany	*Swietenia mahagoni* (L.) Jacq.	177
Pol	*Cocos nucifera* L.	156
Kona	*Gliricidia sepium* (Jacq.)Walp.	112
Kos	*Artocarpus heterophyllus* Lam.	87

In the 39 homegardens which were surveyed in of Siwalakulama Coconut was the prominent species in both occurrence and abundance. Coconut was recorded in 29 households, counting a total 216 tress. Neem followed by Mango were the second and third prominent species as well as in abundance Table 10. A total of 48 woody tree species were recorded in Siwalakulama.

Table 10. Tree count and frequency of occurrence of species in Siwalakulama.

Local name	Scientific Name	Number of trees	Frequency of occurrence
Pol	*Cocos nucifera* L.	216	29
Kohomba	*Azadirechta indica* A. Juss.	118	28
Amba	*Mangifera indica* L.	67	23
Thekka	*Tectona grandis* L. f. f. grandis	62	20
Kos	*Artocarpus heterophyllus* Lam.	29	12
Pera	*Psidium guajava* L.	23	13

3.2.2.1 Shannon-Weiner Index (SWI)

The maximum species diversity in an individual homegarden, as indicated by the Shannon-Weiner Index (SWI), was in Pethiyagoda (3.000) followed by Keeriyagaswewa (2.980). Similarly the minimum diversity was recorded from a homegarden in Keeriyagaswewa (0.885) (Table 11, see Annex 6 for individual SWI values of homegardens in three sites of Sri Lanka). The species diversity in about 63 % of the homegardens in Keeriyagaswewa indicated a SWI greater than 2. More than 40 % of homegardens in Siwalakulama falls in SWI values between 2-1.5. Only 7 % homegardens in Keeriyagaswewa recorded a SWI bellow 1.5 where as it was as higher as 23 % in Siwalakulama (Table 12). Analysis of variance indicates a significant difference between the diversity expressed by the SWI in homegardens of the three sites (Table 13; Figure 2).

Table 11. Details of SWI of Three Sites in Sri Lanka.

Categories	Keeriyagaswewa	Pethiyagoda	Siwalakulama
Mean SWI	2.13	1.99	1.77
Standard Deviation	0.43	0.40	0.38
Standard Error	0.06	0.05	0.07
Maximum SWI	2.98	3.00	2.48
Minimum SWI	0.89	1.27	0.94

Table 12. Distribution of SWI Categories of Three Sites of Sri Lanka.

SWI	Number of households %		
	>2	2-1.5	1.5-0.7
Keeriyagaswewa	63	30	7
Pethiyagoda	49	39	12
Siwalakulama	33	44	23

Table 13. Analysis of Variance of SWI of Three Sites of Sri Lanka.

Source of Variation	SS	df	MS	F	P-value
Between Groups	2.568993	2	1.284496	**7.700497**	**0.000663*** **
Total	26.756	147			

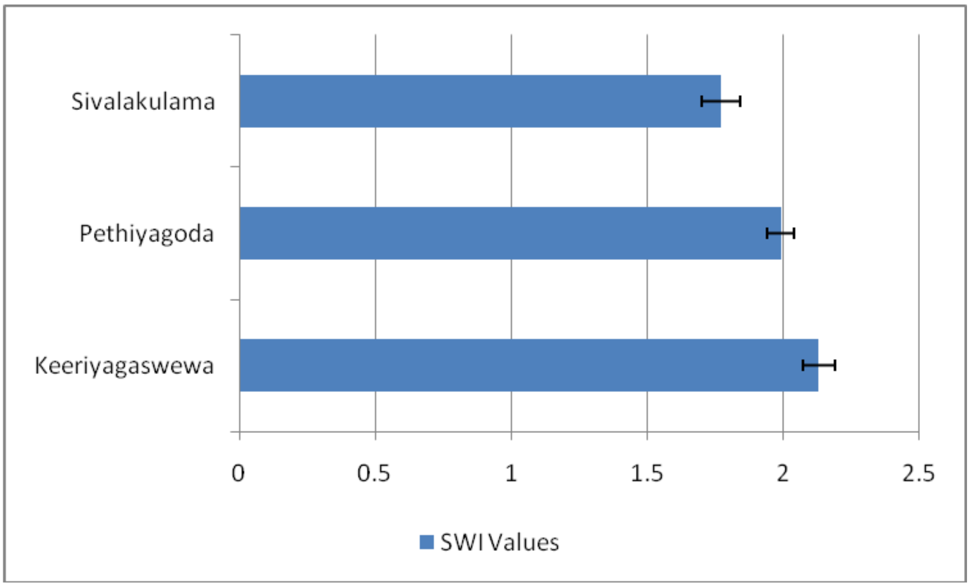


Figure 2: Average of SWI of Homegardens in Three Sites of Sri Lanka.

3.2.3. Diversity of Homegardens among Countries

3.2.3.1. Taxi diversity of woody plants

A comparison of taxic diversity of woody plants in three countries is given in Table 14. It is clear from Table 14 that homegardens in Sri Lanka consists with comparatively higher species, generic and family diversity of woody species than India and Bangladesh. Bangladesh represents the lowest level of diversity of woody plants at all three levels. Annex 7 and 8 show lists of species recorded in India and Bangladesh, respectively.

Table 14. Taxic Diversity of Woody Species in Homegardens of Three Countries.

Category	Sri Lanka	India	Bangladesh
Species	116	75	47
Genera	85	71	47
Families	37	37	28

In India Neem (Azadirachta indica A. Juss.) is the prominent species in homegardens followed by Mango (*Mangifera indica* L.), Jackfruit (*Artocarpus heterophyllus* Lam.), Coconut (*Cocos nucifera* L.) and Guava (*Psidium guajava* L.) in descending order. In Bangladesh prominent species were Jack (*Artocarpus heterophyllus* Lam.), Mango (*Mangifera indica* L.), Coconut (*Cocos nucifera* L.), Litchi (*Litchi chinensis* Sonn.) and Mahogany (*Swietenia mahagoni* L. Jacq.) in descending order.

Sixteen species of woody trees and naturally grown plants were found common in homegardens of all the three countries (Figure 4; Table 15). These common species are important for food security directly or provide income from timber. In addition 34 tree species were common to Sri Lanka and India while 18 species were common to Sri Lanka and Bangladesh. The Annex 9 shows a list of the common species to India and Sri Lanka. In India and Bangladesh 56 % and 37 % of the species were found unique, respectively (Figure 3). Moreover 43 % of the species found in Bangladesh homegardens were common to Sri Lanka and India as well. Annex 10 and 11 show lists of species common to India and Bangladesh and Sri Lanka and Bangladesh, respectively.

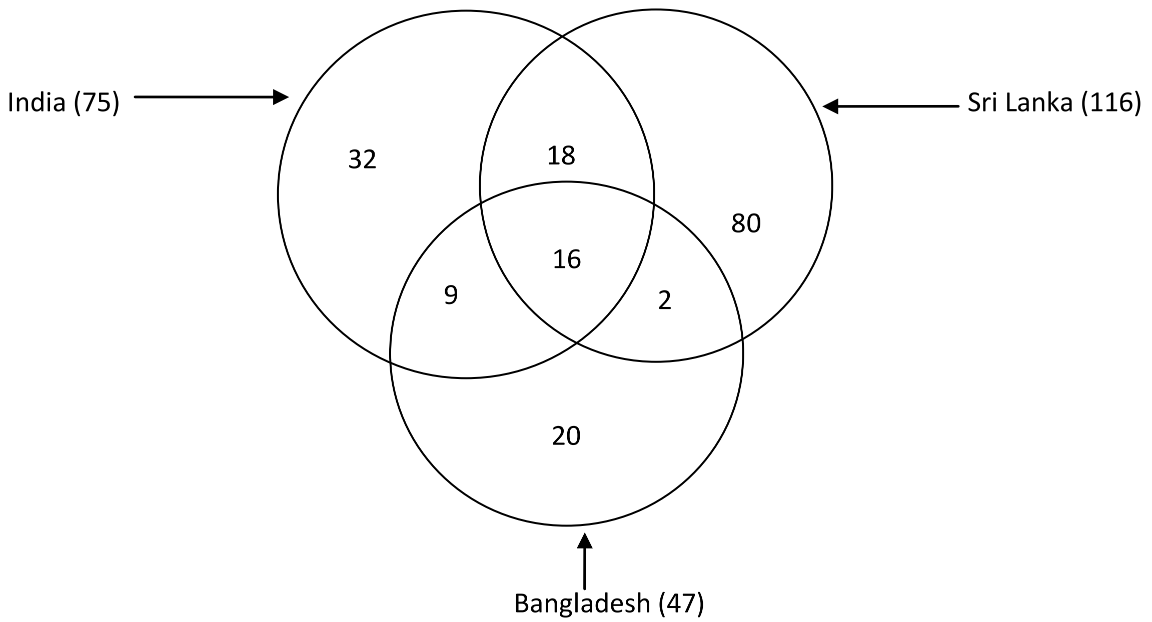


Figure 3. Distribution of Woody Species in Three Countries.

Table 15. Common homegarden species in three countries.

Category	Local name	Scientific name	Family
Fruits	Wood apple	*Aegle marmelos* (L.) Correa	Rutaceae
	Papaya	*Carica papaya* L.	Caricaceae
	Banana	*Musa sapientum* L.	Musaceae
	Mango	*Mangifera indica* L.	Anacardiaceae
	Starfruit	*Averrhoa carambola* L.	Oxalidaceae
	kind of sour fruit	*Carissa carandas* L.	Apocynaceae
	Guava	*Psidium guajava* L.	Myrtaceae
Timber	Teak	*Tectona grandis* L. f. f. grandis	Verbenceae
	Mahogany	*Swietenia mahagoni* L. Jacq.	Meliaceae
Multipurpose	Coconut	*Cocos nucifera* L.	Palmae
	Jackfruit	*Artocarpus heterophyllus* Lam.	Moraceae
Other	Betel nut	*Areca catechu* L.	Palmae
	Neem	*Azadirachta indica* A. Juss.	Meliaceae
	Silk cotton	*Bombax ceiba* L.	Bombacaceae
	Sal	*Shorea robusta* Gaertn. f.	Dipterocarpaceae
	Tamarind	*Tamarindus indica* L.	Leguminosae

3.2.3.2. Shannon-Weiner Index (SWI) Values of Three Countries.

Highest diversity was recorded in Sri Lanka followed by India and Bangladesh. Thee values are significantly different (Table 16 and Figure 4). Annex 12 shows individual values of SWI in each homegardens of India and Bangladesh.

Table 16. Details of Shannon-Weiner Index (SWI) Values of Three Countries.

Categories	Sri Lanka	India	Bangladesh
Mean SWI	2.00	1.44	1.09
Standard Deviation	0.40	0.32	0.38
Standard Error	0.03	0.03	0.04
Maximum SWI	3.00	2.31	2.12
Minimum SWI	0.89	0.28	0.20

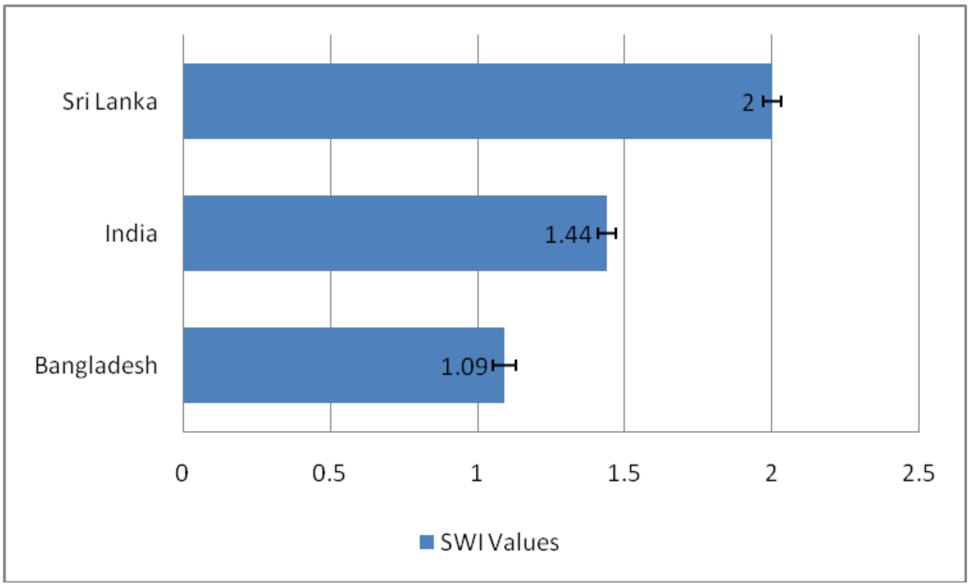


Figure 4. Distribution of SWI Values of Three Countries.

3.2.3.3. Cumulative Number of Species and Area (Cumulative Homegarden Number) Curve

Figure 5 illustrates the cumulative number of species *vs* cumulative number of homegardens curve for three sites of Sri Lanka and all three countries. The results of cumulative number of species and cumulative number of homegarden curve also confirmed that the diversity of homegarden was high in Sri Lanka while it was the lowest in Bangladesh. Fitting of asymptotic model suggests that given sample sizes for three sites of Sri Lanka and three countries are adequate to capture the diversity of homegardens in three sites of Sri Lanka and all three countries (see Annex 13).

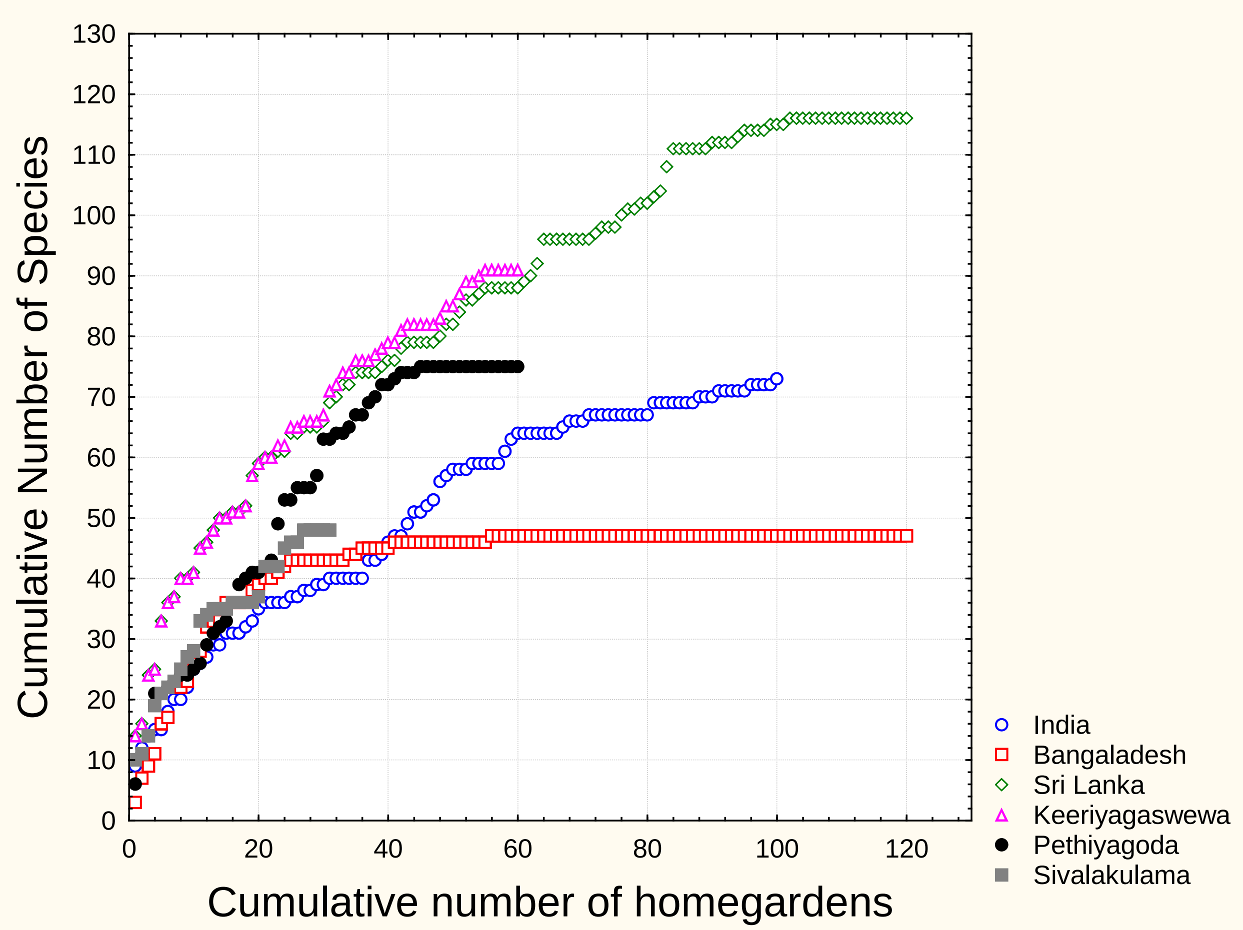


Figure 5. Relationship between Cumulative Number of Species and Cumulative Number of Homegardens in Three Sites of Sri Lanka and three Countries.

3.2.3.4. Taxic Diversity of Crop Species

Total of 108 crop species were recorded from three countries. A comparison of taxic diversity of crops species (largely annuals) in three countries is given in Table 17 whereas Figure 7 illustrates the distribution of species in three countries. Compare to woody plants taxic diversity, crop plant diversity is slightly higher in India but comparable with Sri Lanka. However, values in Bangladesh were half of the values in Sri Lanka and India and significantly different. Twelve crop species were found common to Sri Lanka, India and Bangladesh (Figure 6; Table 18). These species are common vegetables in three countries and important for food and nutritional security. Annex 14-16 provide lists of crop species recorded in three sites of Sri Lanka, India and Bangladesh, respectively.

Cucurbitaceae, followed by Fabaceae and Solanaceae were the prominent crops families in Sri Lanka. *Vigna unguiculata* (L.) Walp. ssp. Cylindrical was the prominent crop species found in Keeriyagawewa (found in 89 % of homegardens) followed by *Capsicum annuum* L. and *Manihot esculenta* Crantz. In Pethiyagoda *Musa acuminate* (Alukesel, curry banana), *Capsicum annuum* L. and *Solanum melongena* L. were the prominent crop species. *Musa sapientum* L. (fruit banana), *Capsicum annuum* L. and *Vigna unguiculata* (L.) were the prominent crop species in homegardens of Siwalakulama.

In India, *Capsicum frutescens* L. was the prominent crop species recording in 84 % of the homegardens. Papaya (*Carica papaya* L.) and Brinjal (*Solanum melongena* L.) were recorded in 58 % and 57 % of households, respectively.

The prominent crop species in Bangladesh were *Lagenaria siceraria* (Molina) (69 % homegardens), *Lablab niger* Medikus (65 % homegardens) and *Capsicum frutescens* L. (31 % homegardens).

Table 17. Taxic Diversity of Crop Species in Homegardens of Three Countries.

Category	Sri Lanka	India	Bangladesh
Species	59	58	25
Genera	50	53	23
Families	26	33	14

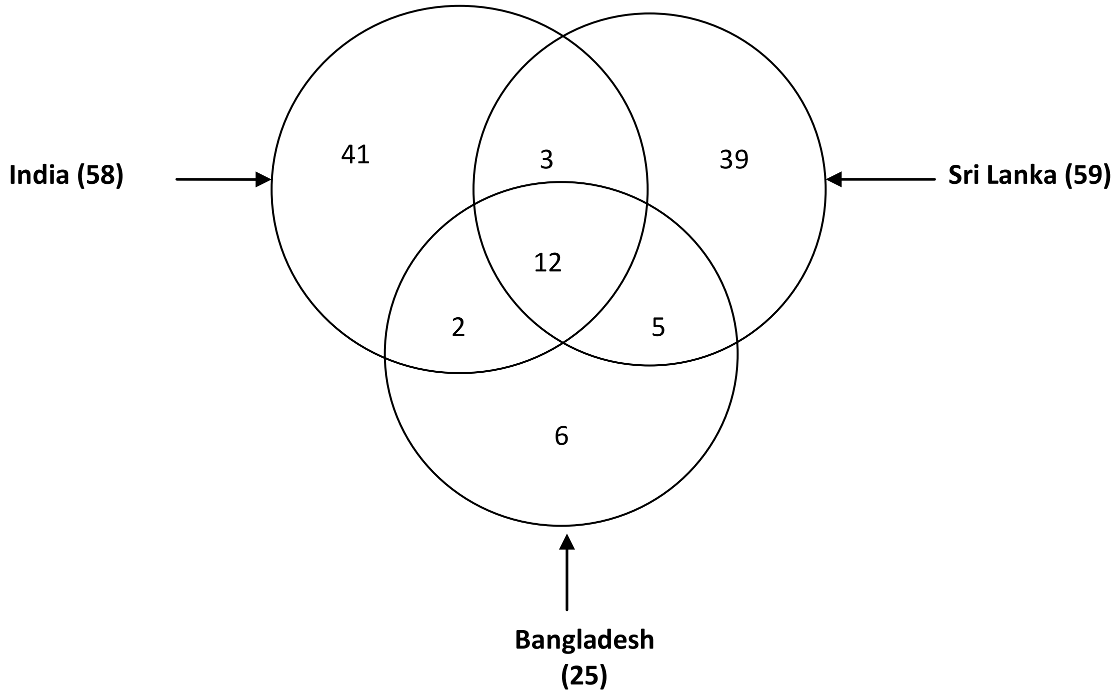


Figure 6. Distribution of Crop Species in India, Sri Lanka and Bangladesh.

Table 18. Crop Species Common to three countries.

Local name	Scientific name	Family
Okra	*Abelmoschus esculentus* (L.) Moench	Malvaceae
Onion	*Allium cepa* L.	Liliaceae
Ash gourd	*Benincasa hispida* (Thumb.) Cogn.	Cucurbitaceae

Chili	*Capsicum frutescens* L.	Solanaceae
Papaya	*Carica papaya* L.	Caricaceae
Turmeric	*Curcuma longa* L.	Zingiberaceae
Bottle gourd	*Lagenaria siceraria* (Molina) Standley	Cucurbitaceae
Tomato	*Lycopersicon esculentum* Miller	Solanaceae
Bitter gourd	*Momordica charantia* L.	Cucurbitaceae
Banana	*Musa sapientum* L.	Musaceae
Brinjal	*Solanum melongena* L.	Solanaceae
Ginger	*Zingiber officinale* Rosc.	Zingiberaceae

3.2.3.5. Diversity of Animal Species Rared in Homegardens

In Bangladesh and India respectively 97 % and 91 % of the households reared either cattle, poultry, goat, sheep, ducks, pigs or a mix of those species. In Sri Lanka animal component was found less prominent compared to India and Bangladesh. In fact only 24 % of the total families reared animals in their homegarden. Further, animals were not found in any homegarden in Pethiyagoda.

In Keeriyagaswewa and Siwalakulama 35 % and 23 % of the households reared at least one breed of cattle respectively. Out of all cattle breeds indigenous and Jersey (Hybrid) types were found prominent accounting to 78 % and 28 % respectively. In addition poultry and buffalo were recorded from three households in Keeriyagaswewa. Goats were also recorded from a homegarden in Keeriyagaswewa (Table 19).

Table 19. Frequency of occurrence of animals in study sites in Sri Lanka.

Type	Breed	Keeriyagaswewa only	Siwalakulama only
Cattle	All breeds	21	7
	Indigenous	14	2
	Cross Sahiwal	1	0
	Hybrid Sahiwal	1	0
	Hybrid Jersy	5	5
Buffaloes		3	0
Poultry	Indigenous	3	1
Goats	Indigenous	1	0

Cattle were the prominent animal species in homegardens in India followed by poultry and Goat. In addition duck were recorded from 18 % of the households. Animals breed related data was not available for India.

In Bangladesh 85 % of the households reared poultry and cattle. Similar to Sri Lanka indigenous breeds were prominent accounting to 72 % and 82 % respectively for poultry and cattle. Moreover, duck were recorded from 38 % of the households in Bangladesh. Other animal types include goat pigs and sheep (Table 20).

Table 20. Frequency of Occurrence of animals in study sites in Bangladesh

Type	Breed	Frequency of occurrence
Cattle	all types	102
	Indigenous	84
	Cross Frishian	8
	Cross Jersy	3
	Hybrid Frishian	1
	Hybrid other	3
Poultry	all types	103
	Indigenous	99
	Hybrids	3
	Cross	1
Pigs	N/A	2
Goats	Indigenous	17
Sheep	Indigenous	1
Hen	Indigenous	7
Duck	Indigenous	46
Others		8

The number of animal species per household was found highest in Bangladesh (Average 2.38) followed by India (average 2.03). In Sri Lanka it was less than one. Table 21 contains the number of animal species per household in three countries.

Table 21. Number of animal species per household in three countries

Number of species	Total households		
	Bangladesh	India	Sri Lanka
0	4	9	118
1	14	26	25
2	40	28	4
3	56	28	1
4	6	8	0
5	0	1	0
Average	2.383	2.03	0.243
Standard Error	0.080	0.115	0.043
Standard Deviation	0.881	1.149	0.529

3.3. *The status of Household Food Security*

The highest contribution to household food security from homegardens was reported from Bangladesh. The average food ratio in Sri Lanka is higher compared to both India and Bangladesh (Table 22).

Table 22. Status of Household Food Security (Note: 1 USD = 127 Sri Lanka Rupees = 51.4 Indian Rupees = 81.7 Bangladesh Taka)

Attribute	Bangladesh (Taka Per month)	India (Rs per month)	Sri Lanka (Rs per month)		
			KG#	SW	PG
Average income	11,172.50	5,075.97	23,216.02	23,531.33	26,195.76
Average expenditure	8,926.75	4,065.72	14,166.10	8,466.67	18,603.45
Average expenditure on food and drinks	5,217.50	1,954.50	6,179.80	3,766.67	10,909.09
Average Food ratio*	0.48	0.39	0.51	0.10***	0.58
Average contribution from the homegarden	1,981.25	192.48	1,154.74	222.22	969.77
% contribution from the homegarden**	67.44	17.66	16.60	0****	28.81

KG = Keeriyagaswewa, SW – Siwalakulama, PG - Pethiyagoda
* total expenditure on food and drinks as a ratio of total household income
**contribution from homegarden as a ratio of total expenditure on foods and drinks
***only 3 valid observations or missing data
**** income from HG is 0 (from 25 cases) or missing data

3.4. *The Utilization of Tree species from Homegardens*

Conventionally homegardens are rich with food trees and serves as primary food source of direct access to the rural families. Homegardeners obtain nutrients from these crops, naturally grown pants and trees via two channels; parts or trees consumed directly, parts consumed by livestock and their products available to family.

In Sri Lanka, Coconut, Mango, Jackfruit and Guava are the most commonly found food tree species in the three study sites (Table 23). In Keeriyagaswewa (KW), 70 % of the total coconut nuts harvested are used for home consumption. Moreover, the harvests of 14 food tree species out of 19 are largely used for family consumption purposes. The main income generating food tree species is Tamarind, where 86 % of the total harvest is sold. In Siwalakulama (SW), coconut harvest is largely being used for income generation *i.e.* 66 % of the harvest was sold. Moreover, harvest of five food tree types out of 10 in SW are largely (>50%) sent to market than consumed or gifted. In Pethiyagoda (PG), too, 4 out of 9 food tree species found in the homegardens are largely for income generation purpose.

In India (Table 23), the prominent food tree species are Mango, Jackfruit, Coconut and Guava (*in descending order*). In Bangladesh prominent species are Jack, Mango, Coconut and Litchi (*in descending order*). Homegardens in Bangladesh (Table 23) are more commercially oriented than

India and Sri Lanka. In Bangladesh more than 85 % of the total Date palm, Hog plum and Litchi harvest, is sold. Harvest of Black berry, Guava and Jrul contribute most for the family nutrition.

Table 23. Tree species utilized in the homegardens in three countries (see Annex 7, 8 and 9 for the scientific names)

Trees (local names)	Bangladesh			India			Sri Lanka (KG*)			Sri Lanka (SW)			Sri Lanka (PG)		
	Con[#]	Gift	Sold	Con	Gift	Sold	Con	Gift	Sold	Con	Gift	Sold	Con	Gift	Sold
Belli							68.6	31.4	0.0	60.0	40.0	0.0			
Katu Anoda							74.1	25.9	0.0				25.0	0.0	75.0
Weli Anoda							70.9	29.1	0.0	100.0	0.0	0.0			
Bread fruit							60.0	40.0	0.0	57.1	42.9	0.0	33.3	21.2	45.5
Jackfruit	35.7	9.6	54.7	62.4	18.3	19.3	68.0	32.0	0.0	100.0			37.0	7.4	55.6
Lawalu							100.0	0.0	0.0						
Peni Dodan							63.0	37.0	0.0	81.3	18.8	0.0	100.0		
Coconut	22.8	9.2	68.1	70.1	8.5	21.4	81.2	8.0	10.8	40.5	1.3	58.2	82.1	0.0	17.9
Woodapple	27.1	3.7	69.3	45.3	15.6	39.1	66.7	33.3	0.0	28.4	16.1	55.5			
Mango	37.9	10.5	51.7	58.4	12.8	28.8	60.9	29.2	9.9	34.3	15.8	49.9	64.8	35.2	0.0
Guava	49.2	2.8	48.0	58.7	25.3	16.0	68.8	31.3	0.0						
Tamarind							10.2	3.5	86.3	8.6	5.7	85.7			
Avocado							50.0	50.0	0.0				85.0	15.0	0.0
Durian													7.1	7.1	85.7
Rambutan													50.0	50.0	0.0
Blackberry	78.0	0.4	21.7												
Date Palm	4.3	1.3	94.4	70.4	16.2	13.3									
Hog Plum	3.0	1.2	95.8												
Jrul	38.8	7.2	53.9												
Jujubi	30.3	19.2	50.5												
Litchi	9.8	3.2	87.0												
Olive	26.2	23.1	50.7												
Pumello	35.7	26.1	38.2												
Jamboline				41.8	13.2	45.0									

*KW - Keeriyagaswewa; PG – Pethiyagoda; SW – Siwalakulama;
[#] Con - Consumption

3.5. Homegardens as a source of nutrients

Tables 24 to 28 present the nutrient grids developed based on the availability of different food tree species in the homegardens (attempts were not made to quantify the actual proportion consumed by the household).The most nutritionally dense (highest shaded area in the grids) homegardens are found in (the descending order) Pethiyagoda (PG) > Keeriyagaswewa (KG) > Siwalakulama > India > Bangladesh. Tree species in Bangladeshi, Indian and Sri Lankan homegardens are rich particularly in Carbohydrate, vitamin C, Riboflavin, Fe and vitamin B6. Most nutrient rich species in homegardens are Guava, Black berry and lemon in Bangladesh, Guava, Mulberry and Oranges in India while drumstick (pod), sesbania (flower) and guava (raw fruit) in Sri Lanka.

Table 24. Nutrient supply from food trees found in homegardens in Bangladesh (see annex 8 for the scientific names)

Local name	Pro	Fat	Carb	Ca	Fe	Mg	P	K	Na	Zn	V-C	Thiamine	Riboflavin	Niacin	V-B6	Folate	V-B12	V-A	V-E	V-D	V-K
Custard apple																					
Jack Fruit																					
star fruit																					
Jambola																					
Lemon																					
Coconut-meat																					
Litchi																					
Mango																					
Olive																					
Date palm																					
Guava																					
Black berry																					
Rose apples																					
Tamarind																					
Indian jujube																					

Table 25. Nutrient supply from food trees found in homegardens in India (see annex 7 for the scientific names)

Local name	Pro	Fat	Carb	Ca	Fe	Mg	P	K	Na	Zn	V-C	Thiamine	Riboflavin	Niacin	V-B6	Folate	V-B12	V-A	V-E	V-D	V-K
Cashew Nuts																					
Pine Apple																					
Soursop																					
Star Fruit																					
Oranges																					
Jambola																					
Coconut-Meat																					
Litchi																					
Mango																					
Mulberry																					
Jack Fruit																					
Date Palm																					
Guava																					
Pomegranate																					
Tamarind																					
Jujube																					

Table 26. Nutrient supply from food trees found in homegardens in Keeriyagaswewa, Sri Lanka (see annex 9 for the scientific names)

Local name	Pro	Fat	Carb	Ca	Fe	Mg	P	K	Na	Zn	V-C	Thiamine	Riboflavin	Niacin	V-B6	Folate	V-B12	V-A	V-E	V-D	V-K
Cashew Nuts																					
Soursop																					
Custard Apple																					
Jack Fruit																					
Bread Fruit																					
Star Fruit																					
Sapodilla																					
Lime																					
Oranges																					
Coconut-Meat																					
Mango																					
Drumstick																					
Panama Berry																					
Avocado																					
Nelli																					
Guava																					
Pomegranate																					
Sesbania-Flower																					
Tamarind																					

Table 27. Nutrient supply from food trees found in homegardens in Siwalakulama, Sri Lanka (see annex 9 for the scientific names)

Local name	Pro	Fat	Carb	Ca	Fe	Mg	P	K	Na	Zn	V-C	Thiamine	Riboflavin	Niacin	V-B6	Folate	V-B12	V-A	V-E	V-D	V-K
Cashew Nuts																					
Soursop																					
Custard Apple																					
Jack Fruit																					
Bread Fruit																					
Sapodilla																					
Lime																					
Oranges																					
Coconut – Meat																					
Mango																					
Drumstick																					

Nelli																					
Guava																					
Pomegranate																					
Sesbania-Flower																					
Tamarind																					

Table 28. Nutrient supply from food trees found in homegardens in Pethiyagoda, Sri Lanka (see annex 9 for the scientific names)

Local name	Pro	Fat	Carb	Ca	Fe	Mg	P	K	Na	Zn	V-C	Thiamine	Riboflavin	Niacin	V-B6	Folate	V-B12	V-A	V-E	V-D	V-K
Custard Apple																					
Soursop																					
Jack Fruit																					
Bread Fruit																					
Sapodilla																					
Lime																					
Oranges																					
Jambola																					
Coconut-Meat																					
Durian																					
Mangus																					
Mango																					
Drumstick																					
Panama Berry																					
Rambutan																					
Avocado																					
Nelli																					
Guava																					
Pomegranate																					
Sesbania-Flower																					
Rose Apples																					
Tamarind																					

3.6. Analysis of Climate Data:

3.6.1. Analysis of data – Sri Lanka

- Anuradhapura meteorological station – Keeriyagaswewa (KW) site

At this site, both average annual minimum and maximum temperatures are rising signficantly (Figures 7 and 8). It is very clear that rate of rise in nighttime minimum temperature is more pronounced than that of daytime maximimum tempaerature, a phenomenon which has been evident in most parts of the world including Sri Lanka.

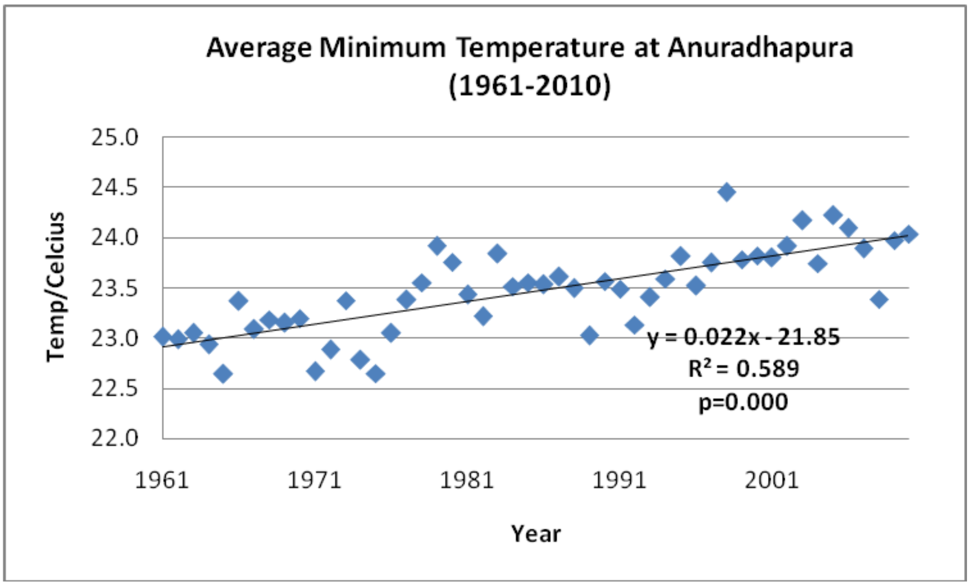


Figure 7. Change of average minimum temeperature at Anuradhpura during last 50 years

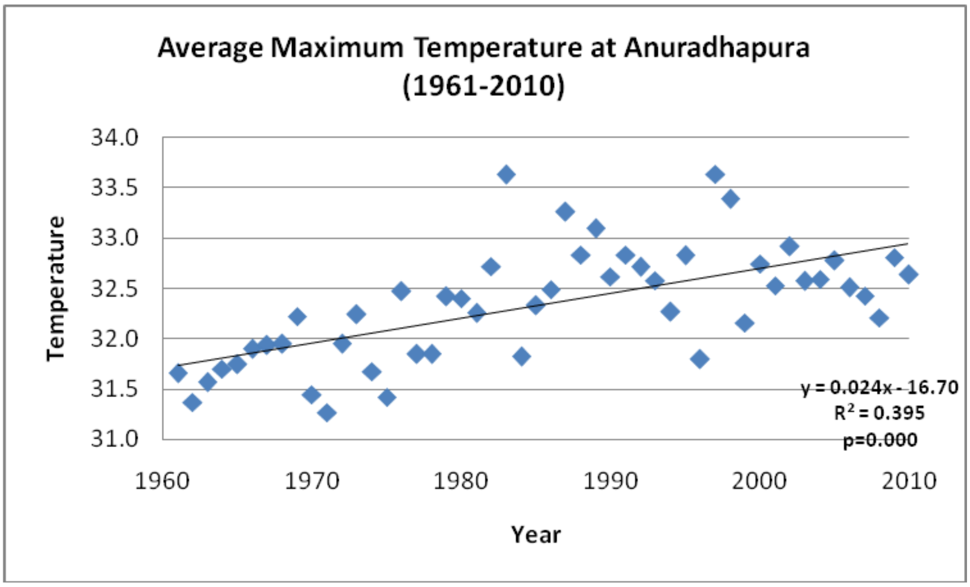


Figure 8. Change of average maximum temeperature at Anuradhpura during last 50 years

Change of annual rainfall doesn't reveal any discernible trend, but a high variability (Figure 9). However, analysis of onset time of the Yala and Maha growing seasons shows that during last two decades on set of the Maha season has become highly variable (Figure 10).

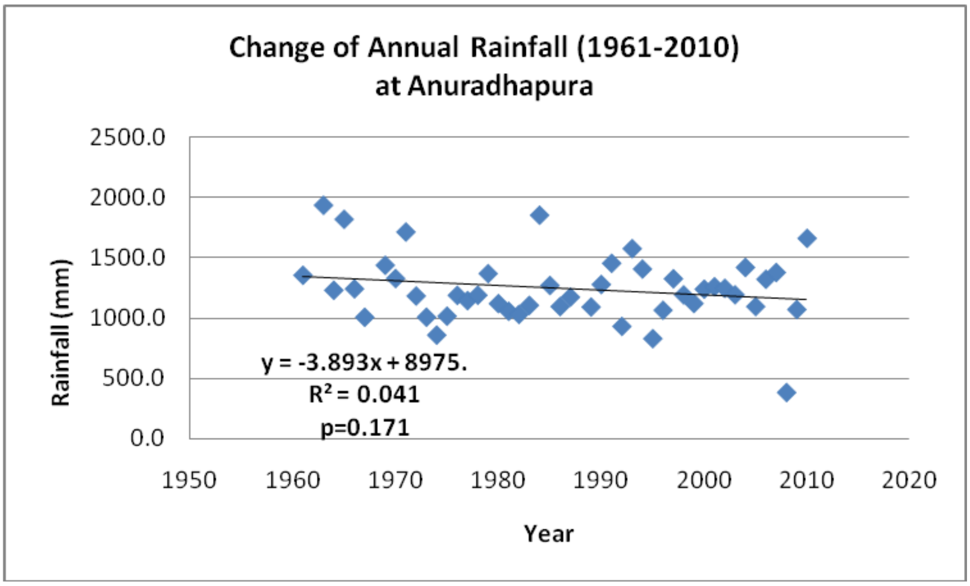


Figure 9. Change of annual rainfall at Anuradhpura during last 50 years

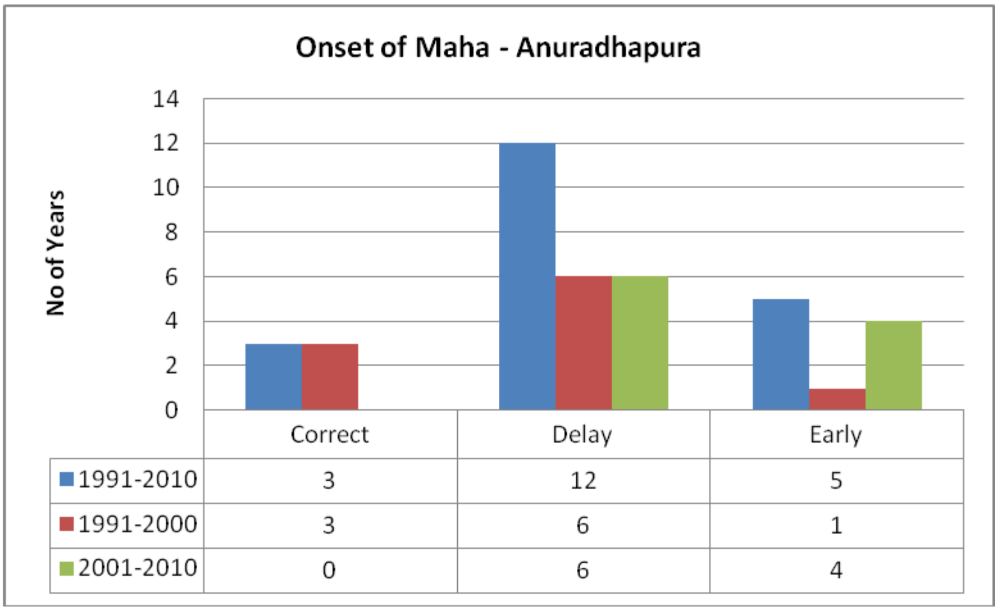


Figure 10. State of the onset of the Maha season at Anuradhpura during last 20 years

Out of 20 Maha seasons during last two decades 85% of instances the season has not been set on time. During this period, onset of the season has been delayed in most years. In contrast, the Yala season onset has not been subject much variation during the study period. During most recent decade of 2001 – 2010, 70 % of the time the rains of Yala season has arrived on time. The same is true for the preceeding decade as well (Figure 11).

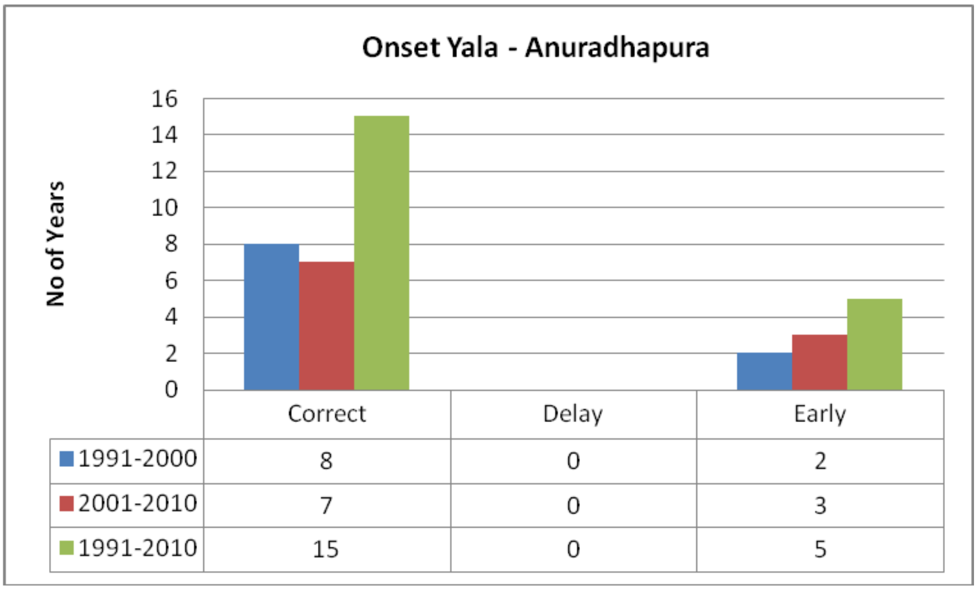


Figure 11. State of the onset of the Yala season at Anuradhpura during last 20 years

- <u>Kandy meteorological station – Pethiyagoda (PG) site</u>

As in the case of Anuradhapura site, both average annual minimum and maximum temperatures at Kandy are rising signficantly (Figures 12 and 13). The penomenon of high gradient of rising nighttime minimum temperature is remained true for this site as well. The change of annual rainfall doesn't show any apparent trend at this site, but a high variability during last a few years of the study period (Figure 14).

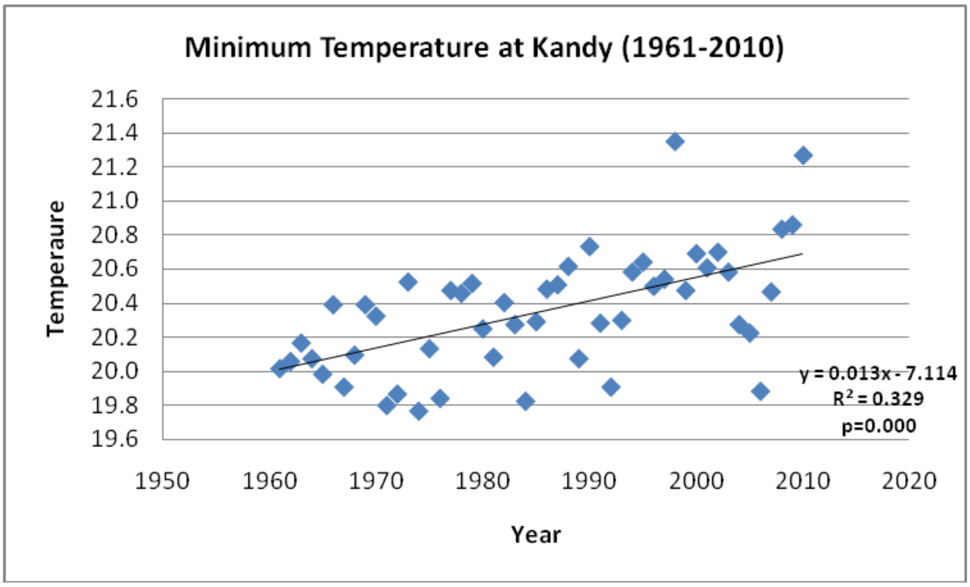


Figure 12. Change of average minimum temeperature at Kandyduring last 50 years

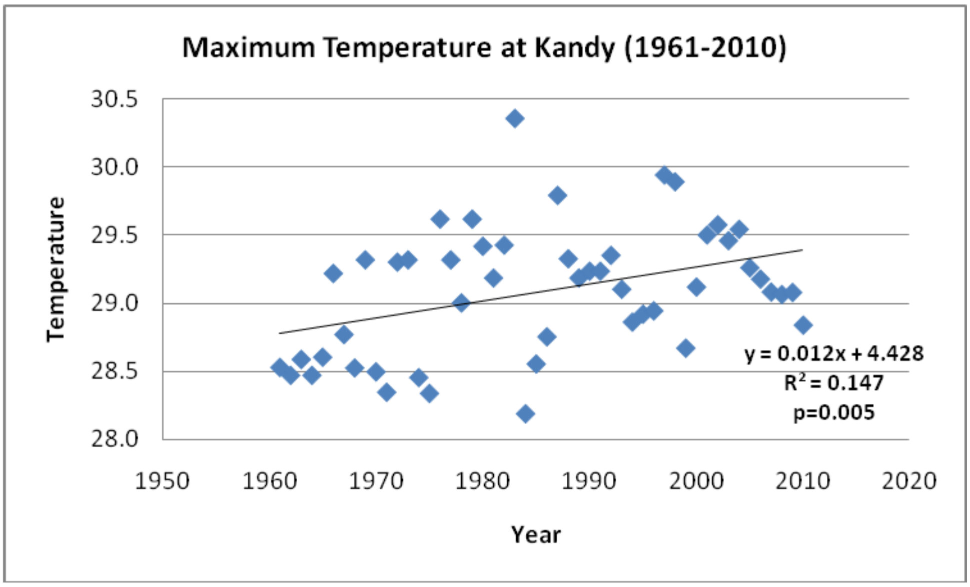


Figure 13. Change of average maximum temeperature at Kandyduring last 50 years

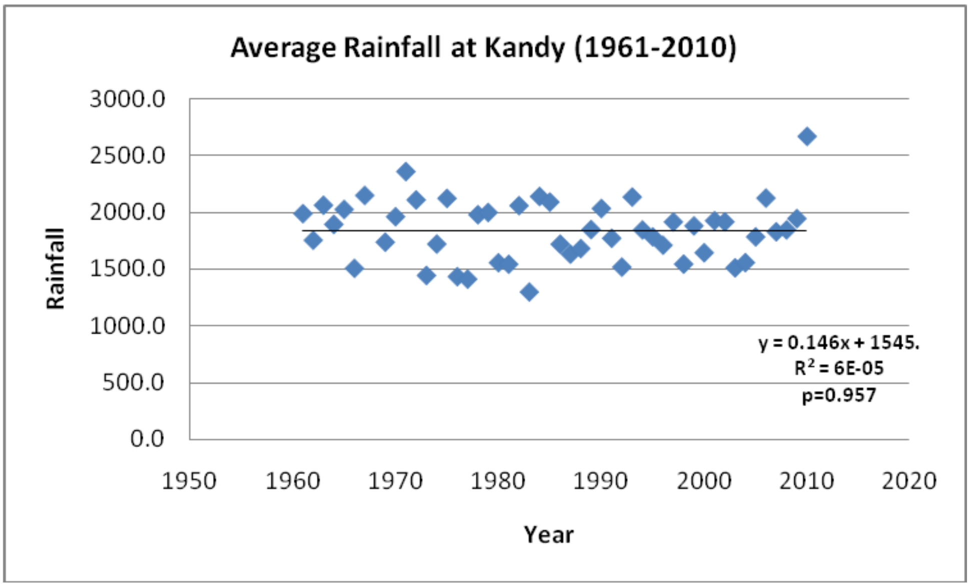
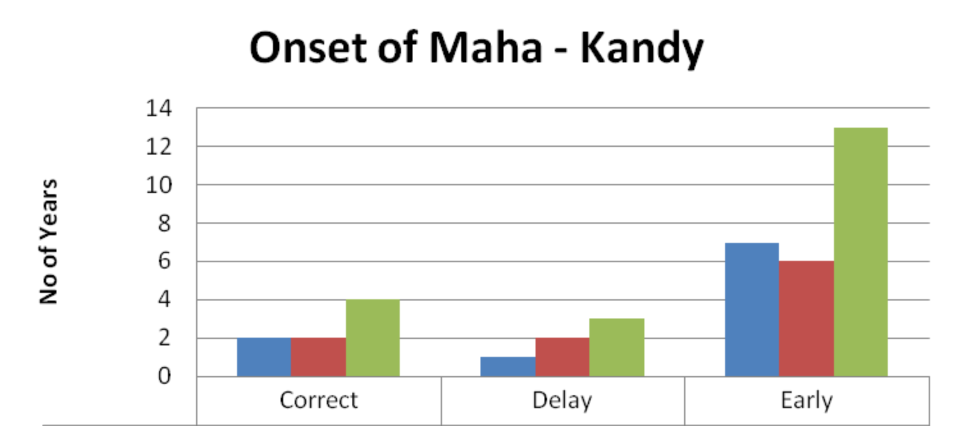


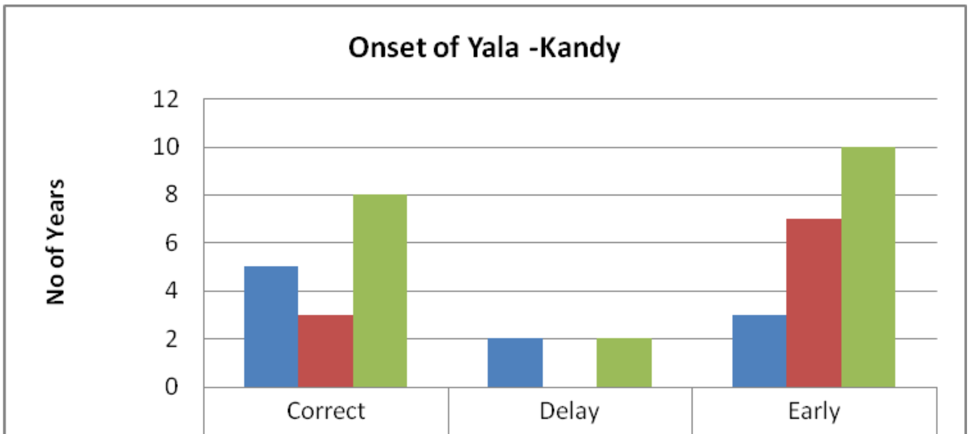
Figure 14. Change of annual rainfall at Kandy during last 50 years

Analysis of onset time of the Yala and Maha growing seasons during last two decades show an oppsite trend compared to Anuradhapura site (Figure 15). Out of 20 Maha seasons during last two decades 65% of instances the rains during Maha season has arrived early compared to expected time. This situation has become more pronounced during the most recent decade of 2001 – 2010. Onset of the Yala season during last 20 years has been either on correct time or early in the season. Occurrence of delayed onset of Yala season was only about 10 % of the years in the 20 year period. However, during most recent decade of 2001 – 2010, the onset time of Yala rains has never been delayed (Figure 16).



	Correct	Delay	Early
1991-2000	2	1	7
2001-2010	2	2	6
1991-2010	4	3	13

Figure 15. State of the onset of the Maha season at Kandy during last 20 years



	Correct	Delay	Early
1991-2000	5	2	3
2001-2010	3	0	7
1991-2010	8	2	10

Figure 16. State of the onset of the Yala season at Kandy during last 20 years

- <u>Mahailuppallama meteorological station – Siwalakulama (SK) site</u>

At in the case of other two sites of the study, average annual minimum temperature in this site also has increased significantly (Figure 17) . But, the change of daytime maximum temperature at this site does not show any perceptible trend. In fact variability of it has markedly decreased during recent times (Figure 18).

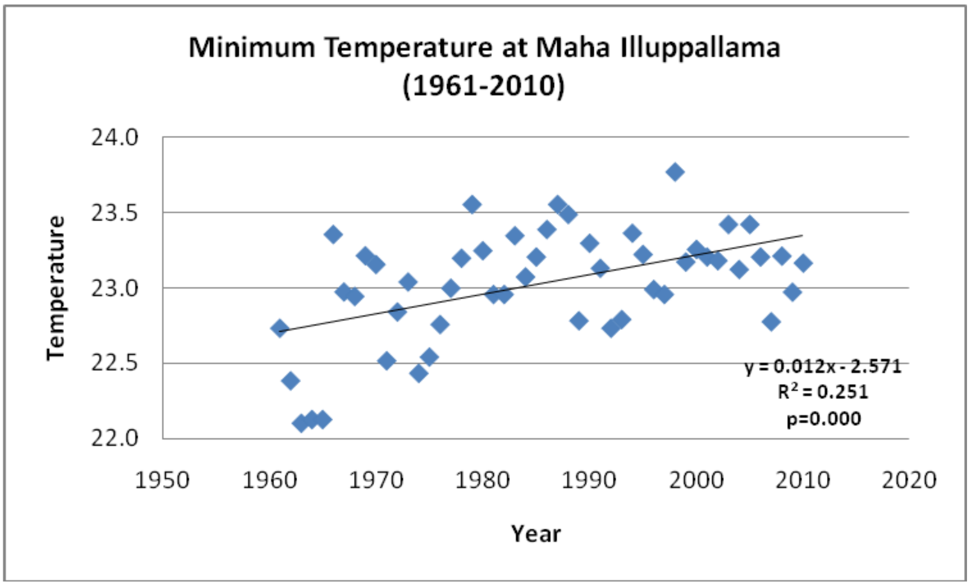


Figure 17. Change of average minimum temeperature at Maha-Illuppallama during last 50 years

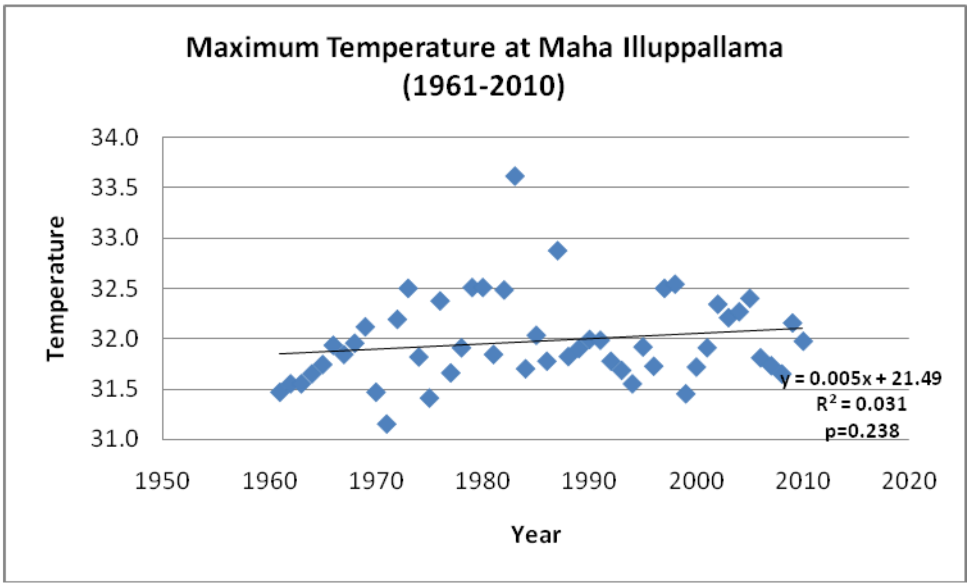


Figure 18. Change of average maximum temeperature at Maha-Illuppallama during last 50 years

A similar trend was observed in some other parts of the island where land use has not been subjected to significant change over the years. Change of annual rainfall doesn't reveal any discernible trend at this site, the most common phenomenon of the rainfall climatology in Sri Lanka (Figure 19). Analysis of onset time of the *Yala* and *Maha* growing seasons shows that during last two decades on set of the Maha season has become highly variable (Figure 20).

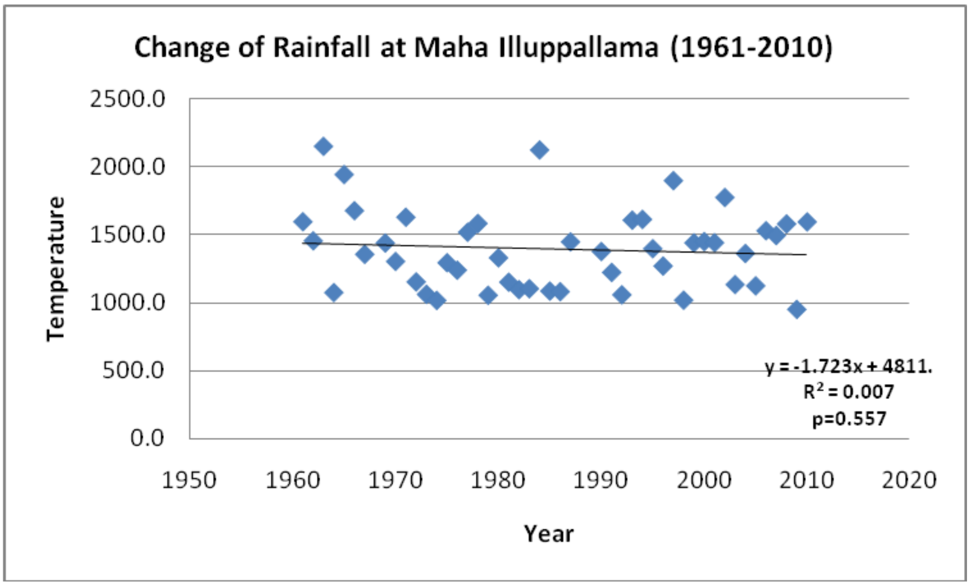


Figure 20. Change of annual rainfall at Maha-Illuppallama during last 50 years

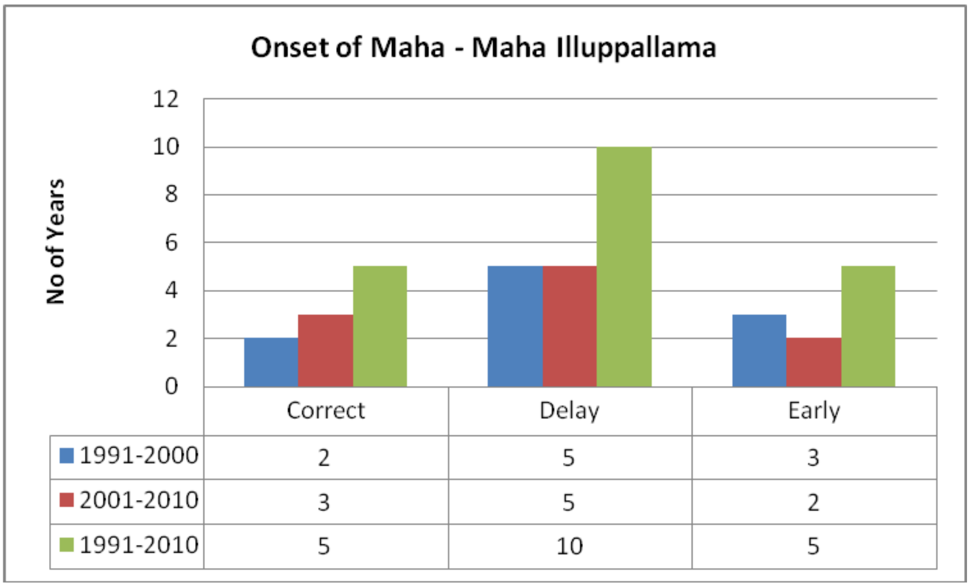
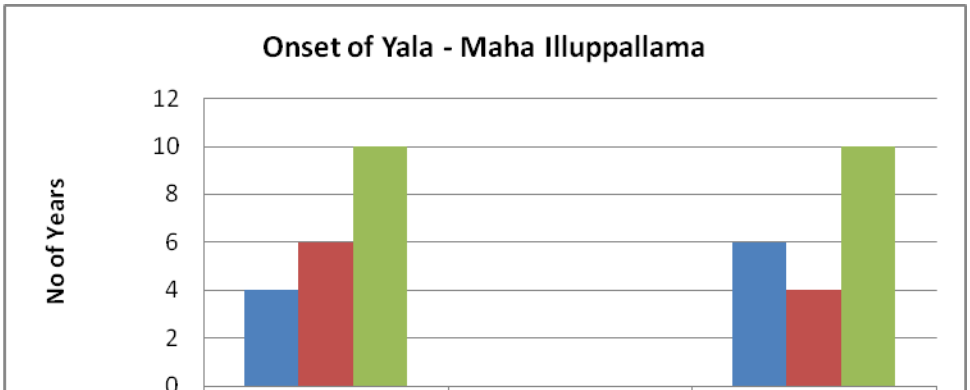


Figure 21. State of the onset of the Maha season at Maha-Illuppallama during last 20 years

Out of 20 Maha seasons during last two decades, in 75 % of instances the season has not been set on time. During this period, onset of the season has been delayed in 50% of the time while 25% of years have been with early onset of the season. The change of onset time of Yala season in this site is not as bad as Maha season. During last 20 years, the onset of Yala season has swinged between the state of correct or early onset. As in the case of Anuradhpura site, the Yala season has never delayed in this site, too (Figure 22), and the onset of Yala season has not been subject much variation during the study period. During most recent decade of 2001 – 2010, 60 % of the time the rains of Yala season has arrived on time.



	Correct	Delay	Early
1991-2000	4	0	6
2001-2010	6	0	4
1991-2010	10	0	10

Figure 22. State of the onset of the Yala season at Maha-Illuppallama during last 20 years

3.6.2. <u>Analysis of data – Bangladesh</u>

It is intersting to note that unlike in Sri Lankan sites, there is no any discernible trend of both maximum in minimum teperature regimes in Bangladesh site (Figures 23 and 24). Apparent trend in maximum trend does not support any conclusive trend. Despite most of other locations in the world show at least an apparent increasing trend in minimum temperature regime, surprisingly this location under review does not support such a generalization (Figure 24).

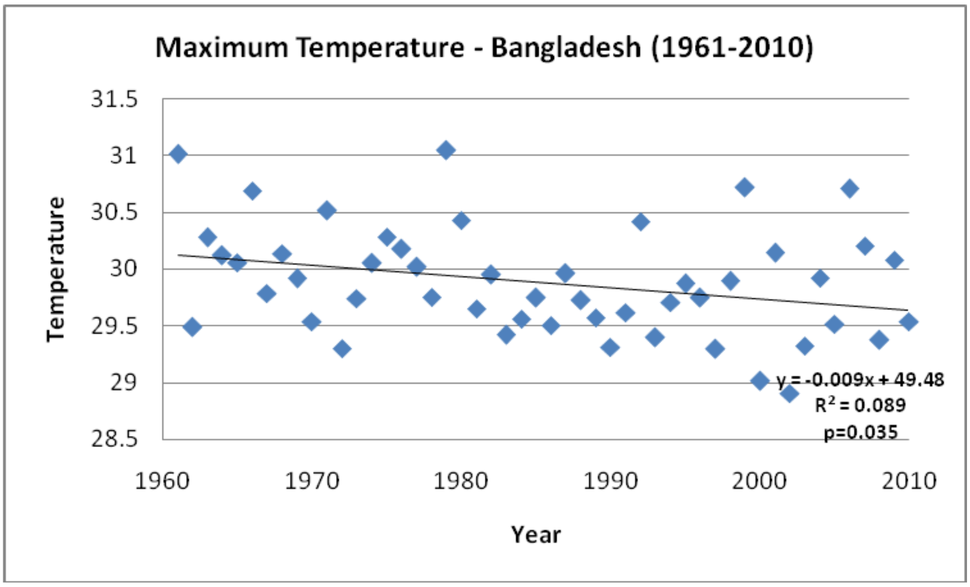


Figure 23. Change of average maximum temeperature at Bangladesh project site

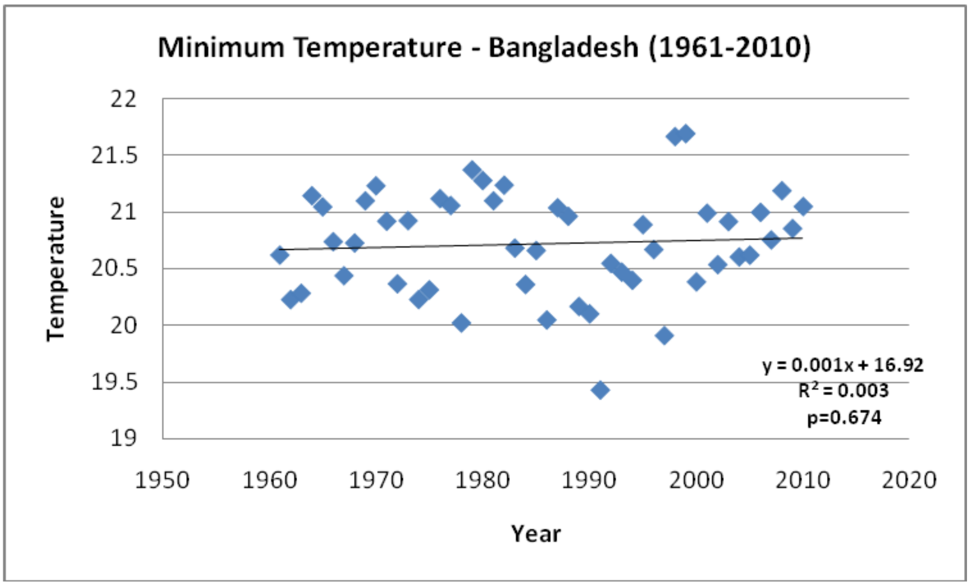


Figure 24. Change of average minimum temeperature at Bangladesh project site

Change of annual rainfall cumulative rainfall at Bangladesh site follows the same trend as in Sri Lankan sites (Figure 25). The variability of annual rainfall during last decade has been very high compared to 1960s in its data series. Unlike in Sri Lanka growing seasons's onset of Bangladesh major rainy seasons has been varible over the last two decades. During the time of most recent decade, 70% of the years, the Kharif I season has started on time (Figure 26) where as Kharif II season has never failed in its onset during all 20 years of the study period (Figure 27).

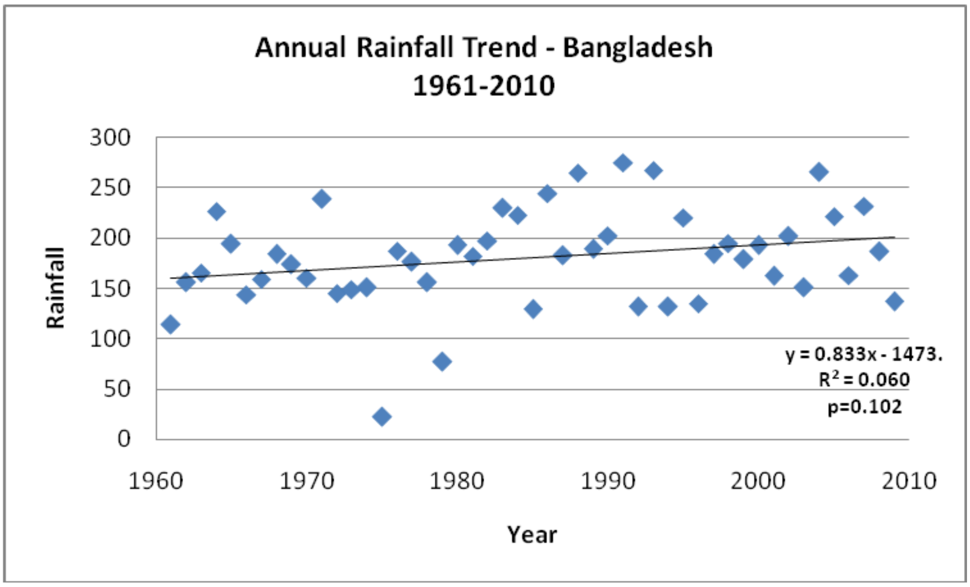


Figure 25. Change of annual rainfall at Bangldesh project site

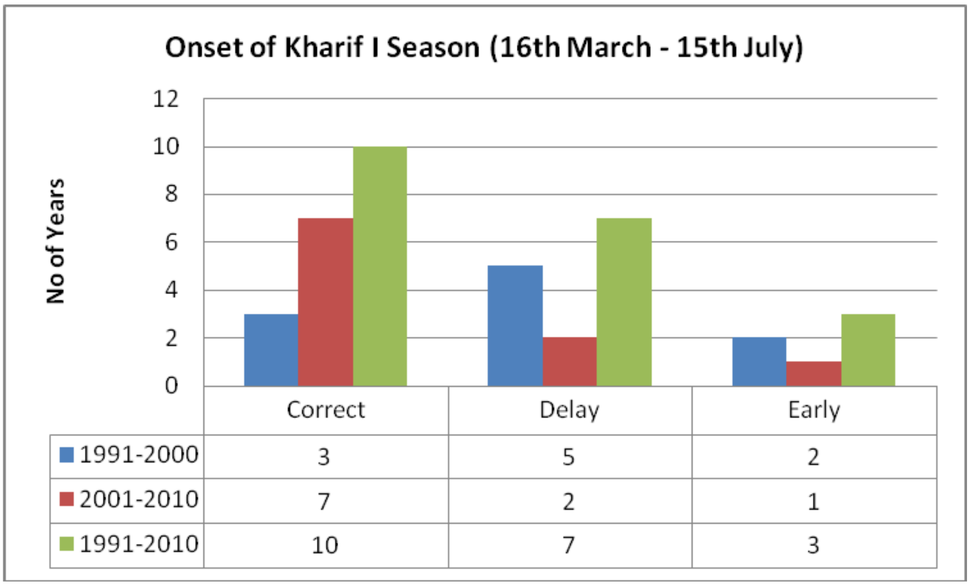


Figure 26. State of the onset of the Kharif I season at Bangladesh project site

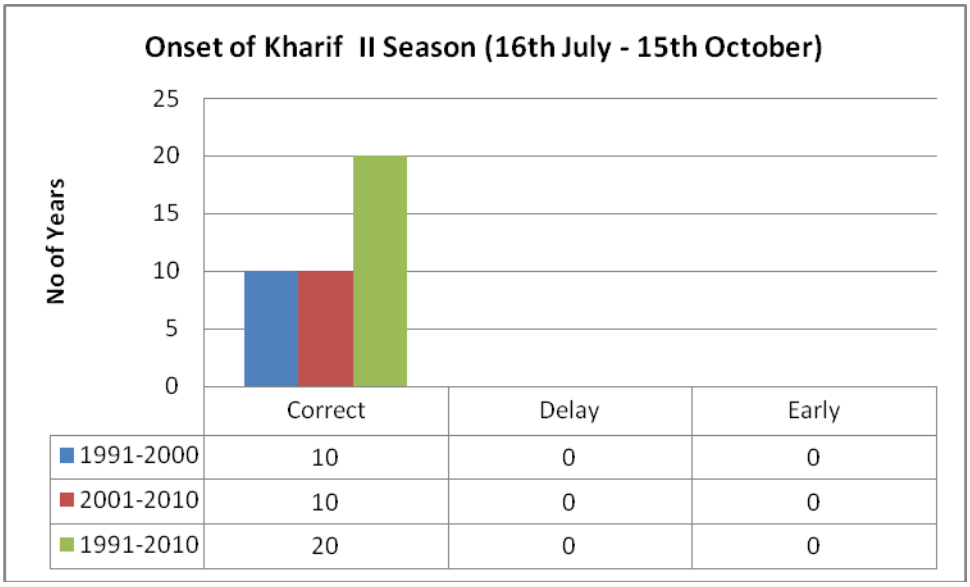


Figure 27. State of the onset of the Kharif II season at Bangladesh project site

3.6.3. Analysis of data – India

The selected site in India, unlike in the case of Sri Lanka and Bangladesh, did not have a good coverage of meteorological data to carry-out a complete anlalysis. However available data from 1969 to 2006 for the minimum temperature data shows a signficant increasing trend as in the case of neighboring Sri Lanka (Figure 28).

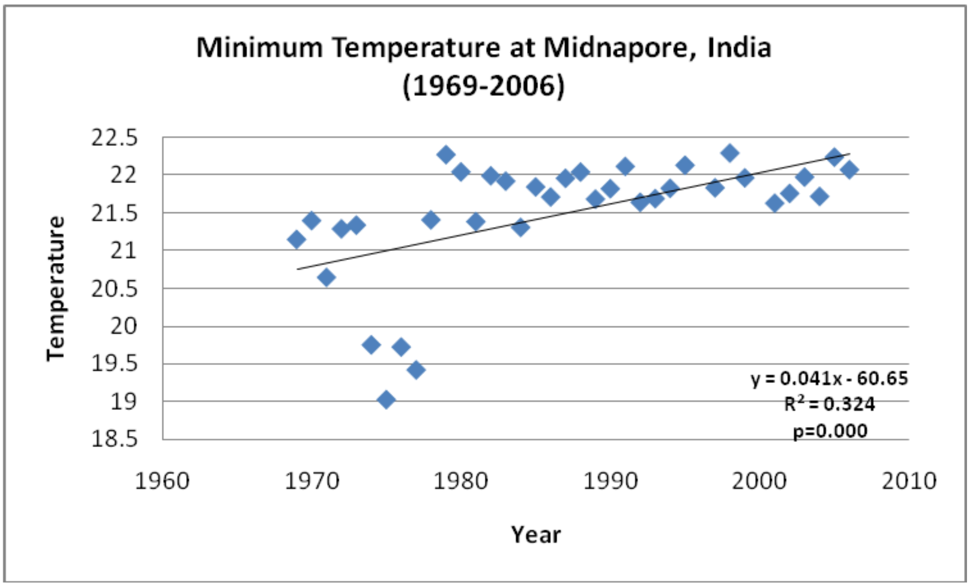


Figure 28. Change of minimum temperature at the Indian project site

Strikingly, the avaiable maximum temperature data for the same period in this location revealed an apparent decreasing trend (Figure 29), which has a very limited predictive value. Change of annual cumulative rainfall at Indian site follows the same trend as in Sri Lankan and Bangladesh sites without any discernible trend (Figure 30). The onset of major growing season during last 16 years has either been on correct time or early in the season (Figure 31). Occurrence of delayed onset during 16-year time period accounts only for 20 %.

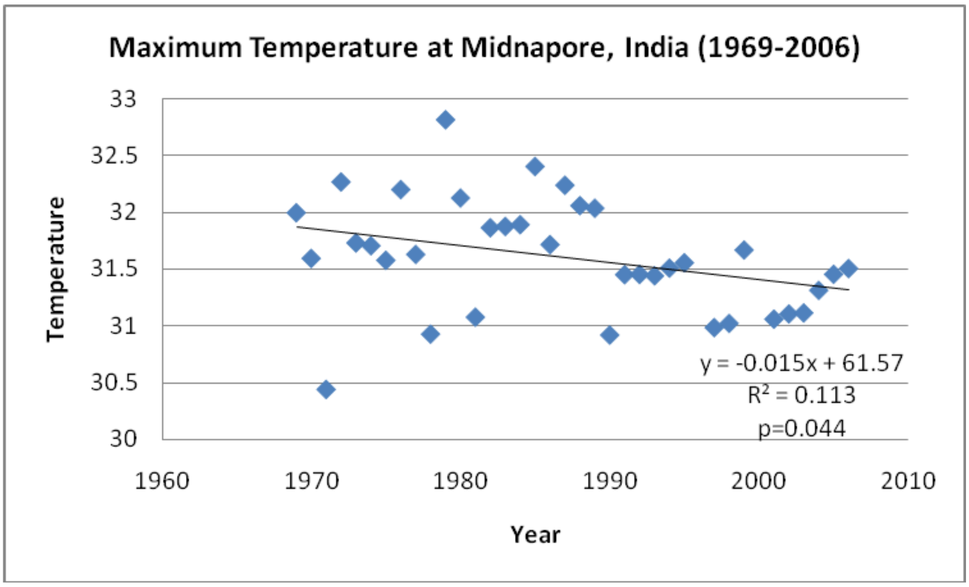


Figure 29. Change of maximum temperature at the Indian project site

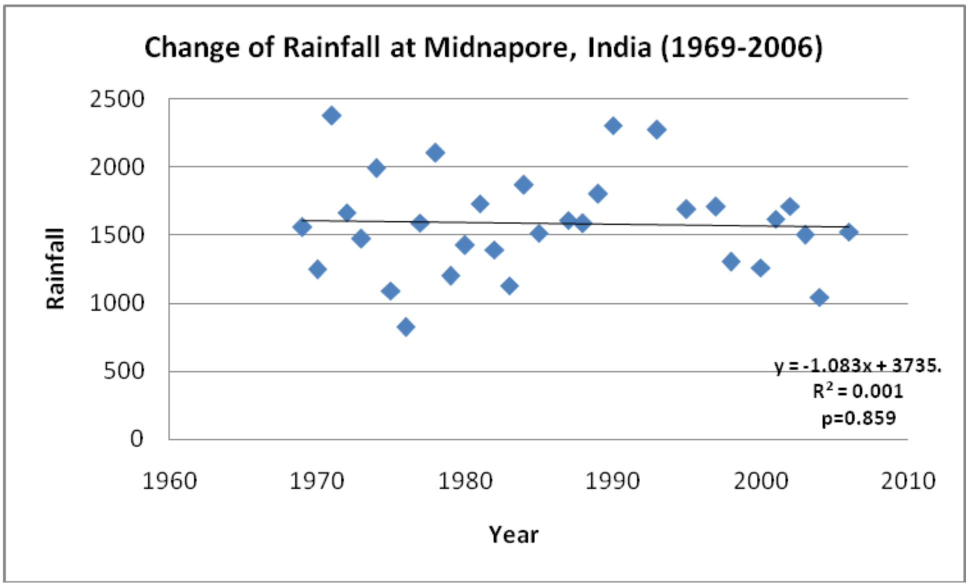
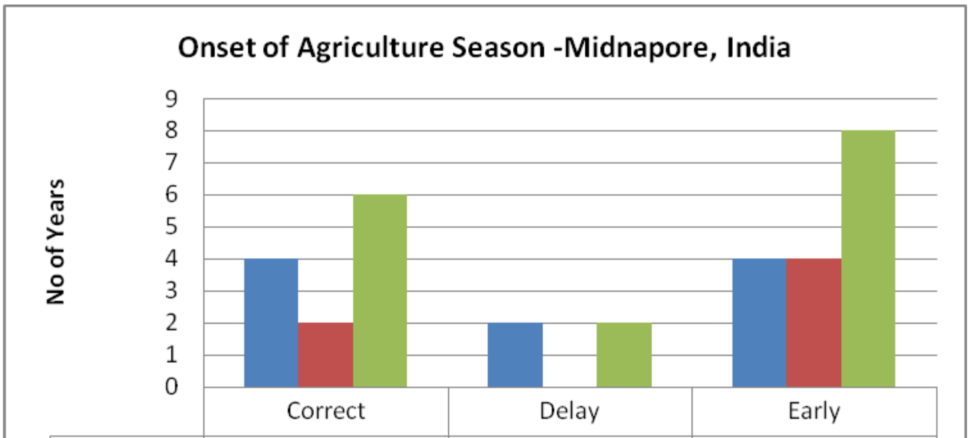


Figure 30. Change of annual rainfall at the Indian project site



	Correct	Delay	Early
1991-2000	4	2	4
2001-2006	2	0	4
1991-2006	6	2	8

Figure 32. State of the onset of the growing season at Indian project site

3.7. Perceptions of Homegardeners on Climate Change

In three location of Sri Lanka respondents have perceived different levels of changes in each rainfall and day and night temperatures In the Keeriyagaswewa (KW) site in Sri Lanka, the majority of the respondents perceived reduced amount of rainfall and changed onset of the rainy period and increased day/night temperatures. In Siwalakuluma (SK), the majority of the respondents have not perceived a change in amount of rainfall or onset of the rainy period or day/night temperatures, while in Pethiyagoda (PG), the majority of the respondents have perceived reduced amount of rainfall, changed onset of the rainy period and increased day/night temperatures (Table 29).

In Bangladesh, the majority of the homegardeners experienced decreased in amount of rainfall, delay in the onset of rains, and increase in the day/night temperatures (Table 29). However, in India all the respondents have perceived increased day/night-time temperatures and decreased amount of rainfall.

Table 29. Perception on climatic changes during the past 20 year as a percentage of the total respondents in each category

Incident	Nature of Perception	Bangladesh	India	Sri Lanka		
				KG	SW	PG
Amount of Rainfall	Increased	7.7	0	13.6	30.0	67.8
	Decreased	69.2	100	66.1	16.7	8.5
	Fluctuate	23.1	0	8.5	6.7	3.4
	No change	0	0	11.9	43.3	20.3
	No idea	0	0		3.3	
Rainy period	Onset changed	84.6	<1	81.4	40.0	52.5
	Fluctuate	7.7	99	5.1	3.3	25.4
	No change	7.7	0	13.6	53.3	20.3
	No idea	0	0		3.3	1.7
Day temperature	Increased	92.3	99	71.2	23.3	64.4
	Decreased	0	<1	3.4	26.7	5.1
	Fluctuate	7.7	0	1.7	3.3	5.1
	No change	0	0	23.7	43.3	23.7
	No idea	0	0		3.3	1.7
Night temperature	Increased	92.3	99	66.1	13.3	64.4
	Decreased	0	<1	8.5	30.0	5.1
	Fluctuate	7.7	0	1.7	6.7	5.1
	No change	0	0	23.7	46.7	23.7
	No idea	0	0		3.3	1.7

Note: Only valid observations were considered. Missing data not included in “no idea” category.

3.8. Accuracy of Perceived idea on Climate Change

Responses to perceived climate changes (rainfall and temperature) included - increased, decreased, fluctuate, no change and no idea. Proportion who replied having “no idea” to any question was below 3.3% of total respondents in all categories.

Of the respondents in Sri Lanka only 6.1% perceived temperature and rainfall changes correctly. Majority of the respondents correctly perceived change in day temperature and night temperature in Keeriyagaswewa (71.2 % and 66.1 %, respectively) and Pethiyagoda (64.4 % and 64.4 %, respectively) while accuracy of the perceived idea was significantly low in homegardeners at Siwalakulama (23.3 % and 13.3 %, respectively). In all three study sites in Sri Lanka, 53.4 % of the homegardeners correctly perceived the changes in environmental temperatures compared to the changes in the amount of rainfall change (21.6 %). Majority of the respondents in Keeriyagaswewa incorrectly perceived that the amount of rainfall has decreased (66.1 %) and in Pethiyagoda 67.8 % of the homegardeners incorrectly perceived that the amount of rainfall increased, while majority of the respondents at Siwalakulama (43.3 %) correctly perceived that the total amount of rainfall remained unchanged. More than 81% of respondents at Keeriyagaswewa, 52.5 % in Pethiyagoda and 40 % of respondents in Siwalakulama correctly perceived the change in onset of rains. The Logit estimations also revealed that in Sri Lanka, the educated farmers are more likely to perceive climate change correctly. Nevertheless, those who owned low lands and non-farming employments perceived change in temperatures more correctly than the other categories such as older farmers and livestock raring farmers).

In the case of Bangladesh, none of the respondents have correctly perceived the changes observed in temperatures and rainfall amount (the climate data indicates that there have not been any significant change) *i.e.*, the majorty stated that the day temperature (92.3 %) and night temperature (66.1 %) has increased and amount of rainfall has decreased (69.2 %). Majority of the respondents (84.6 %) have not percived that the onset of rains have shifted while only 5.5 % have percieved that changes in the onset of rains correctly. In the case of India the homergardeners did not percieve the maximum temperature correctly sa the meteorological data have indicated that there is a decrease in day termpature over the past 5 decades. However, the homergardeners have correctly perceived the increase in night temperature prevailed uring the same period. Interestingly no homegardener perceived that the onset of rainfall has changed over the period despite that fact that actual data celarly show of such an event in the recent past.

3.9. Use of adaptation strategies

The specific adaptation strategies used by the homegardeners in five locations are changing planting date, changing agronomic practices, changing technology such as use of new varieties and irrigation equipments, and use of soil and water conservation measures. In Sri Lanka and Bangladesh changing technology was the most commonly adapted strategy while in India soil and water conservation methods were much popular.

In Keeriyagaswewa (KW) in Sri Lanka, more than 80 % of the homegardeners have changed planting dates during the past 20 years. At the same time in Siwalakulama (SK), which is also located in the dry zone only less than 20 % proportion of the total respondents have changed panting dates. However in both SK and KW, a higher number of dwellers have changed planting date compared to other adaptive strategies. In Pethiyagoda (PG) soil and water conservation methods were popular than in other three sites as well as above other adaptive strategies. Nearly a proportion of 60% has employed soil and water conservation practices in their homegardens. In both SK and PG, changing technology has been employed by more than 40 % of the homegardeners.

In Bangladesh, India and Sri Lanka over 90 %, 85 % and 55 % proportions of the homegardeners have changed the technology adapted in homegardens, during the past twenty years. In Bangladesh use of other adaptive strategies was also found higher compared to India and Sri Lanka. According to the probit regression determinants of adaptation strategies are also different in Bangladesh. Figure 32 depicts the proportion of homegardeners who adapted particular strategies in five locations.

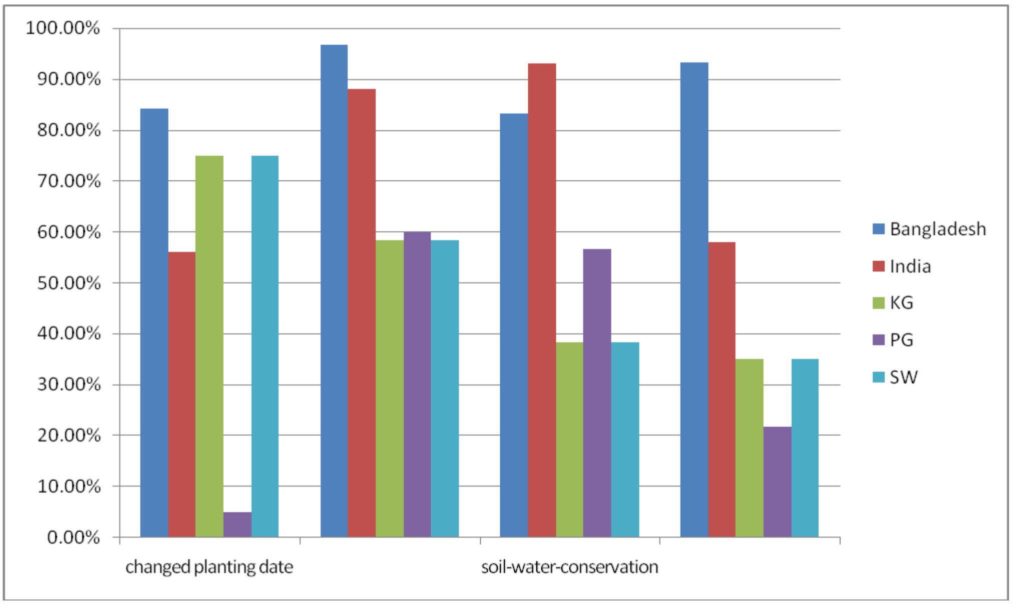


Figure 32. Types of Adaptation Strategies Used
(KG – Keeriyagaswewa, PG – Pethiyagoda, SW – Siwalakulama)

3.9.1. <u>Determinants of Changing Technologies</u>

<u>Bangladesh</u>: The ownership of animals, age and sex of the household head significantly influence the likelihood of using of new technologies by households in Bangladesh. Young and male farmers, those who own livestock, those who are relatively more educated and experienced are more likely to adapt. However, those who have larger homegardens are less likely to adapt (Table 30).

<u>India</u>: Families who have lived a long years in the village are more likely to change technologies in India (Table 30). The households with relatively higher number of members in non-farm compared to farming are less likely to change technologies. However, the results revealed that families who have less time available for homegardening have changed technologies more during the past 20 years. The level of education, experience in agriculture, and homegarden size also contribute to changing technologies.

<u>Sri Lanka</u>: Male headed households, family size and perceptions on climate change positively affect the likelihood of adaption of new technologies (Table 30). The factors negatively affect adaptation include ownership of animals, homegarden size, age of the head of the household head and plant diversity of the homegarden.

Table 30. Determinants of changing technology

Independent variable	Description	Mean	Bangladesh	India	Sri Lanka
The level of education of the head of the household (HH)	Dummy variable; No school / primary =0 otherwise=1		0.5817		
The highest school grade a family member attended	Takes values 2 to 17	9.38		0.1116	

Number of years living in the village			42.5		0.0478***	
Amount of time allocated for homegarden	Proportion of time as a percentage of total per year		1.59		-0.2610**	
The number of members in the family occupation is farming			1.77		-0.0829	
The number of members in the family employed other than farming			2.11		-0.2918***	
Ownership of animals	Dummy variable; not owned=0 owned=1			2.732***		-0.0154
The homegarden size		Bangladesh	0.279	-1.406	0.322	-0.0766
		India	0.167			
		Sri Lanka	0.714			
The income from plant products			64034.86	4.15e-06		
The age of the HH number of years		Bangladesh	50.641	-0.064***		-0.0078
		Sri Lanka	55.405			
experience in agriculture; number of years		Bangladesh	31.398	0.037	0.02223	
		India	27.56			
Gender	Dummy variable; if female=0 male=1			1.8625**		-1.1287**
Household size			3.973			0.1227
SWI			1.985			-0.0484
Perceived a change in temperature	Dummy variable; If not perceived increased day time temperature=0 If perceived=1					0.7212**
Natural rate	Value of constant			-0.3851	-0.5762	0.8390

*, **, *** statistically significant at the p=0.1, 0.05 and 0.01, respectively.

3.9.2. Determinants of Changing Planting Date

Bangladesh: The level of education, off-farm employment and homegarden size contribute to changing planting date in homegarden while income from livestock and poultry and plant diversity negatively affect (Table 31).

India: Families who have a higher number of members engaged in farming are more likely to change the planting date more than otherwise. The homegardeners who posses homegardens with higher plant diversity are more likely to change planting dates (Table 31). Other factors, which affect changing planting date, include level of education of the head of household, ownership of animals, ownership of low-lands and degree of commercial orientation.

Sri Lanka: Families headed by relatively younger individuals, possess homegardens with high plant diversity, and with higher number of members engaged in farming are more likely to change planting dates (Table 31). The ownership of animals, extent of the homegarden and level of education of the head of the households also influence the likelihood to change planting date.

Table 31. Determinants of changing planting date

Independent variable	Description	Mean		Bangladesh	India	Sri Lanka
The level of education of the HH	Bangladesh	Dummy variable; No school / primary=0 otherwise=1				
	India	Highest school grade	4.95	0.03631	-0.2696	-0.0544
	Sri Lanka	Ranked; No school=1 up to primary=2 above=3				
The number of members farming		Bangladesh	1.5			
		India	1.77	-0.1318	0.2235***	0.3248**
		Sri Lanka	1.65			
The number of members off-farming		Bangladesh	3.48			
		India	2.11	0.02213	-0.2405***	-0.3067**
		Sri Lanka	1.03			
The individual household SW index		Bangladesh	1.09			
		India	1.45	-0.5296	1.0491***	0.8714**
		Sri Lanka	1.985			
Ownership of animals	Dummy variable; not owned=0 owned=1				-0.8787	0.2953
Ownership of lowland	Dummy variable; not owned=0 owned=1				0.8801***	
The homegarden size		Bangladesh	0.279			
		India	0.167	0.1989	0.47436	0.4198
		Sri Lanka	0.714			
The income from livestock products		1130.558		-0.000034		
The income from plant products		64034.86		4.40e-06		

Age of the HH; number of years		Bangladesh	50.641	0.027		-0.0210**
		Sri Lanka	55.405			
The number of years of experience in agriculture		Bangladesh	31.398	-0.0136	0.0095	
		India	27.56			
Ratio of crop harvest consumed to total product		0.75			-0.1385	
Natural rate (constant)				0.7011	-0.2763	-1.4792*

*, **, *** statistically significant at the p=0.1, 0.05 and 0.01, respectively.

3.9.3. Determinants of Adoption of Soil and Water Conservation Methods

Bangladesh: The practicing of soil and water conservation is less likely in more diversified homegardens and by experienced farmers (Table 32). Age and level of education of the head of the household, number of family members in off-farm employment, ownership of livestock and poultry and homegarden size also influence the likelihood of adapting soil and water conservation measures.

India: Livestock farmers and experienced farmers the likelihood of practicing soil and water conservation is high. The size of the homegarden has a negative relationship with the likelihood of practice of soil and water conservation methods (Table 32).

Sri Lanka: The number of family members engaged in farming, plant diversity, and perception on changing day temperature significantly contribute to the likelihood of adoption of soil and water conservation methods (Table 32). Ownership of animals, age of the household head, experience in agriculture, homegarden size also influence this aspect.

Table 32. Determinants of adapting a soil and water conservation

Independent Variable	Description	Mean		Bangladesh	India	Sri Lanka
The level of education of the head of the household	Dummy variable; No school / primary =0 otherwise=1			0.1819		
The number of members farming		Bangladesh	1.5	-0.1357		0.2099**
		Sri Lanka	1.65			
The number of members off-farming		3.48		0.00683		
The HH size		5.85			-0.1031	
The individual HH SW index		Bangladesh	1.09	-0.7179**		0.2324
		Sri Lanka	1.985			
Ownership of animals	Dummy variable; If not perceived increased day time temperature=0 If perceived=1			0.0334	2.2472***	0.1747

The homegarden size		Bangladesh	0.279	0.9709	-2.458**	-0.3053
		India	0.167			
		Sri Lanka	0.714			
Age of the HH; number of years		Bangladesh	50.641	.055821***		0.0027
		Sri Lanka	55.405			
The experience in agriculture; number of years		Bangladesh	31.398	-0.0384**	.05932***	0.1227
		India	27.56			
		Sri Lanka	34.56			
Ratio of crop consumed to total harvest		0.75			-1.396628	
Percived change in teperature	Dummy variable; If not perceived increased day time temperature=0 If perceived=1					0.3785*
Natural rate (constant)				-0.0966	0.59137	-1.1056*

*, **, *** statistically significant at the p=0.1, 0.05 and 0.01, respectively.

3.9.4. Determinants of Changing Agronomic Practice

Bangladesh: Ownership of livestock and poultry significantly contribute to changing agronomic practice in Bangladesh (Table 33). Other contributors include level of education and age of the household head and homegarden extent. Factors negatively affecting include household size and experience in Agriculture.

India: Ownership of livestock and poultry, age of the household head, household size, age and gender contribute to changing agronomic practice (Table 33). More educated and experienced farmers in India change agronomic practices less while the same is true for homegardens with a larger extent.

Sri Lanka: Changing agronomic practice is less in families headed by more educated individuals (Table 33). Homegarden extent significantly contributed to the same. Other contributors are household size, ownership of animals, age/gender/experience in agriculture of household heads.

Table 33. Determinants of changing agronomic practices

Independent variable	Description		Mean	Bangladesh	India	Sri Lanka
The level of education of the HH	Bangladesh	Dummy variable; No school/ primary=0 otherwise=1		0.172	-0.108	-0.9291**
	India	Highest school grade	4.95			
	Sri Lanka	Ranked; No school=1 up to primary=2, above=3				

The HH size		Bangladesh	5.0	-0.081	0.0456	0.0456
		India	5.85			
		Sri Lanka	3.97			
Ownership of animals	Dummy variable; If not perceived increased day time temperature=0, If perceived=1			1.745**	0.118	0.138
The homegarden size		Bangladesh	0.279	0.987	-0.524	0.8244**
		India	0.167			
		Sri Lanka	0.714			
Age of the HH; number of years		Bangladesh	50.641	0.007	0.0007	0.0009
		India	55.000			
		Sri Lanka	55.405			
Gender	Dummy variable; if female=0 male=1				0.471	0.3981
Experience in agriculture; number of years		Bangladesh	31.398	-0.016	-0.005	0.001
		India	27.56			
		Sri Lanka	34.56			
Percived change in temperature	Dummy variable; If not perceived increased day time temperature=0 If perceived=1					0.181

*, **, *** statistically significant at the p=0.1, 0.05 and 0.01, respectively.

4.0 Conclusions

The main objective of the study was to assess the degree of vulnerability of different homegarden systems in South Asia under changing climate, with three specific objectives, *i.e.* (a) to document key characteristics of home-garden systems covering major climatic zones in Sri Lanka and selected locations in India and Bangladesh, (b) to establish patterns of climate change and their indicators in the above regions over a period of 50 years and (c) to develop a bio-economic model to identify the contribution of climate change on the status of food security. The latter specific objectives has to be modified during the course of the project activities as there are no major changes have been made in the annual crops and animal production aspects in the homegardens. This is in spite of the changes in rainfall and temperature observed using meteorological data and noticing of changes in climate through other observations (changes in leaf fall, changes in types of plants around the wall of the well etc.). In addition, almost all homegardens were dominated by the tree crop species thus making the system more stable and modifications done to the system are rare. As the socio-economic characteristics of the farmers, the natural environment within which farmers operate and access to infrastructure have been identified as the key determinants, a thorough investigation of types of adaptation strategies and determinants of the probability of using an adaptation strategy was considered as more appropriate investigations, replacing the initially proposed bio-economic model to assess the level of vulnerability/resilience. In addition the, the Shannon Weiner Index (SWI) provided a relative measurement of climate resilience among the homegardens in five difference study sites.

The main conclusions of the project are as follows:

Status of Homegardens:

- The level of education among the homegardeners (household head) varied among countries, where about 29 % in India, 14 % in Bangladesh and 3 % in Sri Lanka have not had any formal education.
- In all three countries the majority of the respondents belonged to the low income categories
- The maximum species diversity in an individual homegarden, as indicated by SWI, was in Pethiyagoda (3.000) followed by Keeriyagaswewa (2.980).
- Highest diversity was recorded in homegardens in Sri Lanka (mean SWI = 3.0), followed by India (mean SWI=1.44) and Bangladesh (mean SWI=1.09). Homegardens in Sri Lanka consisted with comparatively higher species, generic and family diversity of woody species than India and Bangladesh. Homegardens studied in Bangladesh had the lowest level of diversity of woody plants at all three levels.
- In Sri Lanka the animal component was found less prominent in homegardens compared to India and Bangladesh. In Bangladesh and India 96.7 % and 91 % of the households respectively reared either cattle, poultry, goat, sheep, ducks, pigs or a mix of those species while only 24% of the total homegardeners surveyed, reared animals in their homegardens (animals were not found in any homegarden in Pethiyagoda - mid country wet zone).
- The analysis of plant, tree and animal composition of homegardens over past two decades (1991-2010) revealed that they have not changed substantially despite the climatic variations observed.
- Homegardens in Bangladesh are more commercially oriented than India and Sri Lanka
- The highest contribution to household food security from homegardens found in Bangladesh. The average food ratio in Sri Lanka is higher compared to both India and Bangladesh
- Tree species in Bangladeshi, Indian and Sri Lankan homegardens are rich particularly in Carbohydrate, vitamin C, Riboflavin, Fe and vitamin B6. Most nutrient rich species in

homegardens are Guava, Black berry and lemon in Bangladesh, Guava, Mulberry and Oranges in India while drumstick (pod), sesbania (flower) and guava (raw fruit) in Sri Lanka

Climate Change:

- All study sites in Sri Lanka, India and Bangladesh have experienced increased variability of seasonal rains over the past five decades (1961-2010), and especially the onset of rains have changed, which would have played a crucial role in determining the timing of the cultivating season.
- The minimum and maximum temperatures showed an increasing trend, thus affecting the productivity of the crops (annual and tree crops) and animal species.

Vulnerability and Food Security:

- The homegardens studied are resilient to climate change and contributed to household food and nutrition security.
- According to SWI, homegardens in Sri Lanka are more climate resilient than those in India and Bangladesh due to high diversity.
- The specific adaptation strategies used by the homegardeners in five locations are changing planting date, changing agronomic practices, changing technology such as use of new varieties and irrigation equipments, and use of soil and water conservation measures.
- In Sri Lanka and Bangladesh changing technology was the most commonly adapted strategy while in India soil and water conservation methods were much popular.
- During the past 20 years, about 55 % of the dwellers have changed the technology adapted, 41% used soils and water conservation measures, while 39 % changed the agronomic practices and 37 % changed the planting dates of the crops in homegardens.
- The type of employment, age, sex, education level of household head, experience in farming, homegarden size, diversity of homegardens, and perceptions towards climate change have influenced the decision of homegardeners to adopt a given strategy namely, changes in planting dates, agronomic practices, and technology (use of new varieties and irrigation equipments, use of soil and water conservation measures), to cope up with climate change. Development programs to promote adaptation to climate changes should be designed taking above determinants into consideration.

5.0 Future Directions

Policy level recommendations to be made in order to promote climate resilient homegardens aiming at food security:

- The diversity of homegardens and homegardeners observed in this study highlights that the programs and policies on homegarden development for food security should be targeted on the most needy.
- The changes observed in climate in the study sites suggest that the homegardeners need to be prepared to meet such global environmental challenges to ensure food security.
- Many homegardeners could not perceive the climate change correctly, highlighting the need for awareness programs to build the capacity of homegardeners to determine what could be expected in the future in terms of climate change. Such programs should be specially targeted towards the groups who did not have correct perceptions.
- The most commonly used adaptation strategies for climate change identified in this study should be promoted among the homegardeners after further research, where the policy makers would be in a position to identify the most efficient and effective adaptation strategies.
- The special characteristics of the homegardeners who did not use adaptation strategies have been identified and the policy makers should target their homegarden development programs on such individuals or homegardens to ensure food security.

Research Directions required to facilitate policy level recommendations:

- A detailed analysis on the extent of utilization of homegarden trees, plants and animals by household using the proportions of harvest consumed by the members of the household (the actual amount of nutrients provided by each homegarden) would assist in further strengthening of the information on the contribution of homegardens in meeting food and nutrition security of the household. This would also help in identifying the trees, plants and animals that are vulnerable to climatic changes and comment on the degree to which food supply from the homegardens will be affected due to changes in climate.
- The homegardens selected for this study were found to be climate resilient. However, as the present investigation captured information from homegardens with specific features as described in the technical report, this study should be replicated in other agro-ecological regions to understand whether similar pattern could be observed. For examples, the homegardens which have come under development programs of the government of Sri Lanka in the recent past are different to what was considered in the present study.
- Recording of data at frequent intervals is better than obtaining information through re-calling. Collection of a panel data set covering a few identified homegardens over a long time span is hence suggested to carryout a similar analysis.

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Appendix

Conferences/Symposia/Workshops

(a) Project Inception Workshop (Dambulla, Sri Lanka – 23-24 November 2009)

Programme
23rd November 2009

09.00 am	Welcome Address - Prof Buddhi Marambe
09.05 am	Introduction of Participants
09.15 am	Presentation on the project concept and activity schedule- Professor Buddhi Marambe
09.30 am	Climate of Sri Lanka - Dr. BVR Punyawardena
09.45 am	Meteorology data collection in Sri Lanka - Mr. Sarath Premalal
10.00 am	Presentation on the project site selection in Sri Lanka - Dr. Gamini Pushpakumara
10.30 am	Tea
10.45 am	Discussion on India and Bangladesh scenario - Prof. Giashuddin Miah and Dr. Sebak Jana Kumar
11.15 am	Questionnaire Development - Dr. Jeevika Weerahewa & Dr. Pradeepa Silva
11.30 am	Discussion and Fine Tuning of the Questionnaire
12.30 pm	Lunch
02.00 pm	Discussion and Fine Tuning of the Questionnaire (contd..)
03.30 pm	Tea
04.00 pm	Preparation of the Final format of the Questionnaire
05.00 pm	Presentation on the final format of the Questionnaire - Dr. Jeevika Weerahewa & Dr. Pradeepa Silva
05.30 pm	End of day one
07.00 pm	Fellowship and Dinner

24th November 2009

09.00 am	Finalization of the project activity schedule for year 1
10.00 am	Tea
10.30 am	Visit to the Project Site at Ritigala, Sri Lanka
03.30 pm	Return to the Hotel
04.00 pm	Final Discussion
04.30 pm	End of Workshop

(b) Progress Review Meeting (Daka, Bangladesh; 14-15 September 2010)

Programme
14 September 2010 (Day 1)

09.30 am	Welcome Address – Prof. Gaishuddin Miah
09.40 am	Objectives of the workshop – Prof. Buddhi Marambe
09.50 am	Progress of Activities – (Chair: Dr. Pradeepa Silva) Prof. Buddhi Marambe (Sri Lanka) Prof. Giashuddin Miah (Bangladesh) Dr. Sebak Jana (India)
10.30 am	Tea
10.45 am	Presentation of results - Year 1 (Chair – Dr. Ranjith Punyawardena)

Sri Lanka
Bangladesh
India

12.30 pm	Lunch
01.30 pm	Presentation of results contd. – (Chair: Dr. Jeevika Weerahewa)
02.30 pm	General Discussion (Moderator: Dr. DKNG Pushpakumara) Participants: Prof. Buddhi Marambe (Sri Lanka), Prof. Guashuddin Miah (Bangladesh), Dr. Jeevika Weerahewa (Sri Lanka), Dr. Pradeepa Silva (Sri Lanka), Dr. Ranjith Punyawardena (Sri Lanka), Dr. Sebak Jana (India), and Mr. Sarath Premalal (Sri Lanka)
03.30 pm	Tea
03.45 pm	Project activities - Year 2 (Prof. Buddhi Marambe)
04.30 pm	Discussion on the programme for year 2 (all participants)
05.30 pm	End of day 1

15th September 2010 (Day 2)

09.30 am	Re-cap from day 1
09.45 am	Gap identification and details of the Work Schedule for Year 2 (Moderator – Prof. Giashuddin Miah)
10.30 am	Tea
10.45 am	Details of the work schedule for year 2 contd...
12.30 am	Lunch and close of session

(c) Progress Review Meeting (Bangladesh; 15-16 June 2011)

Programme
15th June 2011 (Day 1)

08:30 am	Registration
09:00 am	Welcome of participants - Prof. Joyashree Roy
09:05 am	Objectives of the meeting - Prof. Buddhi Marambe
09:15 am	Climate Change impacts – Country Perspectives

(Note: this is a general overview of the current situation of the respective countries : maximum 20 min for each country presentation)

Sri Lanka:	Mr. Sarath Premalal, Dr. Ranjith Punyawardena and Prof. Pradeepa Silva
India	Prof. Joyashree Roy and Dr. Sebak Jana
Bangladesh	Prof. Giashuddin Miah

10:15 am	Discussion
10:30 am	Tea
11:00 am	Project Progress Review Introductory Remarks: Prof. Buddhi Marambe Presentation of Results: Prof. Buddhi Marambe, Mr. Sarath Premalal and Prof. Gamini Pushpakumara
12:30 pm	Lunch
13:30 pm	Discussion and gap analysis
15:00 pm	Lessons learnt from Year 1 activities – Country Representatives
16:00 pm	Tea
16:30 pm	Second year activities - Prof. Buddhi Marambe

16th June, 2011 (Day 2)

08:30 am	Bio-dynamic models and their use - a discussion led by Prof. Joyashree Roy
10:00 am	Policy implications – a discussion led by Prof. Giashuddin Miah
11:00 am	Tea
11:30 am	Future Activity Plan, project management issues, output timelines and deliverables – a discussion led by Prof. Buddhi Marambe
13:00 pm	Lunch and end of workshop

(d) Final Project Workshop (Colombo, Sri Lanka - 17 March 2012)

09:00 am	Registration
09:30 am	Welcome and Objective of participants - Prof. Buddhi Marambe
09:45 am	Country Presentations

(Note: this is a general overview of the current situation of the respective countries : maximum 20 min for each country presentation)

Sri Lanka:	Mr. Sarath Premalal, Dr. Ranjith Punyawardena, Prof. Gamini Pushpakumara, Prof. Pradeepa Silva and Dr. Jeevika Weerahewa
India	Dr. Sebak Jana
Bangladesh	Prof. Giashuddin Miah

10:15 am	Tea
10:30 am	Country presentation (continued..)
12:30 pm	Lunch
13:30 pm	Discussion and finalization of the project results format
15:00 pm	Lessons learnt from Year 2 activities – Country Representatives
16:00 pm	Tea
16:30 pm	Preparation of final poroject report - Prof. Buddhi Marambe

(e) Project Dissemination Seminar (19th March 2012) – for 35 policy makers in Sri Lanka

Programme

09.30 am	Registration
10.00 am	Welcome address and Project Background Buddhi Marambe, Project Team Leader
10.20 am	Opening Remarks by Giashuddin Miah and Sebak Jana
10.30 am	Climate change in Study Areas Sarath Premalal
10.40 am	Discussion
11.00 am	Tea
11.20 am	Plant and Animal Diversity of Homegardens in the Study Areas Gamini Pushpakumara and Pradeepa Silva
11.40 am	Adaptation Strategies by Homegardeners Chaturanga Daulagala and Jeevika Weerahewa
12.00 noon	General Discussion
01.00 pm	Lunch and End of Session

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List of Young Scientists

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Mr. Ruwan Kumara, Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka
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Mr. Ranga Liyanage, Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka
Ms. Nirukshika Abeykoon, Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka

Glossary of Terms

HH – Household head
KG – Keeriyagaswewa village
SK – Siwalakulama village
PG - Pethiyagoda

In the Appendix section, the report may also include:

Actual data or access to data used in the study
Abstracts, Power Point Slides of conference/symposia/workshop presentations
Conference/symposium/workshop reports

Annexure

Annex 1: Woody Trees and Naturally Grown Plants Species Recorded in Homegardens of Sri Lanka – Keeriyagaswewa.

	Local name	Scientific Name	Family
1	Madatiya	*Adenanthera pavonina* L.	Fabaceae
2	Beli	*Aegle marmelos* (L.) Correa	Rutaceae
3	Suriya mara	*Albizia lebbeck* (L.) Benth.	Fabaceae
4	Gas Rukaththana	*Alstonia scholaris* (L.) R. Br.	Apocynaceae
5	Kaju	*Anacardium occidentale* L.	Anacardiaceae
6	Katu anoda	*Annona muricata* L.	Annonaceae
7	Weli anoda	*Annona reticulata* L.	Annonaceae
8	Puwak	*Areca catechu* L.	Palmae
9	Kos	*Artocarpus heterophyllus* Lam.	Moraceae
10	Del	*Artocarpus incisus* L.F.	Moraceae
11	Kamaranga	*Averrhoa carambola* L.	Oxalidaceae
12	Kohomba	*Azadirechta indica* A. Juss.	Meliaceae
13	Maila	*Bauhinia racemosa* Lam.	Fabaceae
14	Kaha pethan	*Bauhinia tomentosa* L.	Fabaceae
15	Halmilla	*Berrya cordifolia* (Wild.) Burret	Tiliaceae
16	Ela imbul	*Bombax ceiba* L.	Bombacaceae
17	Thal	*Borassus flabellifer* L.	Palmae
18	ketakela	*Bridelia retusa* (L.) A. Juss.	Euphorbiaceae
19	Monaramal	*Caesalpinia pulcherrima* (L.) Sw.	Fabaceae
20	Kithul	*Caryota urens* L.	Palmae
21	Ranawara	*Cassia auriculata* L.	Fabaceae
22	Ehela	*Cassia fistula* L.	Fabaceae
23	Wa	*Cassia siamea* Lam.	Fabaceae
24	Burutha	*Chloroxylon swietenia* DC.	Rutaceae
25	Lawulu	*Chrysophyllum roxburghii* G. Don.	Sapotaceae
26	Hulan hik	*Chukrasia tabularis* A. Juss.	Meliaceae
27	Dehi	*Citrus aurantifolia* (Christm. & Panzer) Swingle	Rutaceae
28	Embul Dodam	*Citrus aurantium* L.	Rutaceae
29	Sidaran	*Citrus medica* L.	Rutaceae
30	Heen naran	*Citrus reticulata* Blanco	Rutaceae
31	Peni dodam	*Citrus sinensis* (L.) Osbec	Rutaceae
32	Damba	*Cleistocalyx nervosum* (DC.) Kosterm. var. nervosum	Myrtaceae
33	Pol	*Cocos nucifera* L.	Palmae
34	Lunuwarana	*Crateva adansonii* DC ssp. odora (Bunch. – Ham.)	Capparidaceae
35	Ram	*Crescentia cujete* L.	Bignoniaceae
36	May-mara	*Delonix regia* (Hook.) Raf.	Fabaceae
37	Thibiri	*Diospyros malabarica* (Desr.) Kostel.	Ebenaceae
38	Kaluwara	*Diospyros quaesita* Thw.	Ebenaceae

39	Weera	*Drypetes sepiaria* (Wight. & Arn.) Pax & Hoffm.	Euphorbiaceae
40	Ehetu	*Ficus trimenii* King	Moraceae
41	Pihimbiya	*Filicium decipiens* (Wight & Arn.)Thw.	Sapindaceae
42	Kona	*Gliricidia sepium* (Jacq.)Walp.	Fabaceae
43	Daminiya	*Grewia damine* Gaertn	Tiliaceae
44	Kolon	*Haldina cordifolia* (Roxb.) Ridsd.	Rubiaceae
45	Godakirila	*Holoptelea integrifolia* (Roxb.)Planch.	Ulmaceae
46	Ipil Ipil	*Leucaena leucocephala* (Lam.)de Wit	Fabaceae
47	Divul	*Limonia acidissima* L.	Rutaceae
48	Kenda	*Macaranga peltata* (Roxb.) Muell.Arg.	Euphorbiaceae
49	Mee	*Madhuca longifolia* (L.) Macbride	Sapotaceae
50	Amba	Mangifera indica L.	Anacardiaceae
51	Palu	*Manilkara hexandra* (Roxb.) Dubard	Sapotaceae
52	Helamba	*Mitragyna tubulosa* (Arn.) Havil.	Rubiaceae
53	Ahu	*Morinda citrifolia* L.	Rubiaceae
54	Murunga	*Moringa oleifera* Lam.	Moringaceae
55	Malberi	*Morus alba* L. var. indica	Moraceae
56	Jam gaha	*Muntingia calabura* L.	Flacourtiaceae
57	Karapincha	*Murraya koenigii* (L.) Spreng.	Rutaceae
58	Kaneru	*Nerium oleander* L.	Apocynaceae
59	Sepalika	*Nyctanthes arbor-tristis* L.	Oleaaceae
60	Aligeta pera	*Persea americana* Miller	Lauraceae
61	Rata Nelli	*Phyllanthus acidus* (L.) & Skeels	Euphorbiaceae
62	Nelli	*Phyllanthus emblica* L.	Euphorbiaceae
63	Panakka	*Pleurostylia opposita* (Wall.)Alston	Celastraceae
64	Araliya	*Plumeria rubra* L.	Apocynaceae
65	Owila	*Polyalthia longifolia* (Sonn.) Thw.	Annonaceae
66	Magul karanda	*Pongamia pinnata* (L.) Pierre	Fabaceae
67	Pera	*Psidium guajava* L.	Myrtaceae
68	Welan	*Pterospermum suberifolium* (L.) Wild.	Sterculiaceae
69	Delum	*Punica granatum* L.	Punicaceae
70	Koan	*Schleichera oleosa* (Lour.) Oken	Sapindaceae
71	Kathuru murunga	*Sesbania grandiflora* (L.) Poir.	Fabaceae
72	Wal ambarella	*Spondias pinnata* (L. f.) Kurz	Anacardiaceae
73	Telabu	*Sterculia foetida* L.	Sterculiaceae
74	Mahogany	*Swietenia mahagoni* (L.) Jacq.	Meliaceae
75	Dan	*Syzygium caryophyllatum* (L.) Alston	Myrtaceae
76	Siyambala	*Tamarindus indica* L.	Fabaceae
77	Kelani thissa	*Tecoma stans* (L.) Kunth	Bignoniaceae
78	Thekka	*Tectona grandis* L. f. f. grandis	Verbenceae
79	Kumbuk	*Terminalia arjuna* (Roxb.) Wight & Arn.	Combretaceae
80	Kottamba	*Terminalia catappa* L.	Combretaceae

81	Suriya	*Thespesia populnea* (L.) Soland ex Correa.	Malvaceae
82	Toona	*Toona ciliate* M. Roemer	Meliaceae
83	Sudu nika	*Vitex negundo* L.	Verbenaceae
84	Milla	*Vitex pinnata* L.	Verbenaceae

Annex 2: Woody Trees and Naturally Grown Plants Species Recorded in Homegardens of Sri Lanka – Pethiyagoda.

	Local name	Scientific Name	family
1	Madatiya	*Adenanthera pavonina* L.	Fabaceae
2	Havari nuga	*Alstonia macrophylla* Wall.ex G.Don	Apocynaceae
3	Amherstia	*Amherstia nobilis* Wallich	Fabaceae
4	Katu anoda	*Annona muricata* L.	Annonaceae
5	Weli anoda	*Annona reticulata* L.	Annonaceae
6	Puwak	*Areca catechu* L.	Palmae
7	Kos	*Artocarpus heterophyllus* Lam.	Moraceae
8	Del	*Artocarpus incisus* L.F.	Moraceae
9	Bilin	*Averrhoa bilimbi* L.	Oxalidaceae
10	Kohomba	*Azadirechta indica* A. Juss.	Meliaceae
11	Kaha pethan	*Bauhinia tomentosa* L.	Fabaceae
12	Halmilla	*Berrya cordifolia* (Wild.) Burret	Tiliaceae
13	Ela imbul	*Bombax ceiba* L.	Bombacaceae
14	ketakela	*Bridelia retusa* (L.) A. Juss.	Euphorbiaceae
15	Monaramal	*Caesalpinia pulcherrima* (L.) Sw.	Fabaceae
16	Wanasapu	*Cananga odorata* (Lam.) Hook. f. & Thomas.	Annonaceae
17	Kara	*Canthium coromandelicum* (Burm.f.) Alston	Rubiaceae
18	Kithul	*Caryota urens* L.	Palmae
19	Lawulu	*Chrysophyllum roxburghii* G. Don.	Sapotaceae
20	Dehi	*Citrus aurantifolia* (Christm. & Panzer) Swingle	Rutaceae
21	Embul Dodam	*Citrus aurantium* L.	Rutaceae
22	Jambola	*Citrus grandis* (L.) Osbec var. grandis	Rutaceae
23	Heen naran	*Citrus reticulata* Blanco	Rutaceae
24	Peni dodam	*Citrus sinensis* (L.) Osbec	Rutaceae
25	Pol	*Cocos nucifera* L.	Palmae
26	Copi	*Coffea arabica* L.	Rubiaceae
27	Lunuwarana	*Crateva adansonii* DC ssp. odora (Bunch. – Ham.)	Capparidaceae
28	Ram	*Crescentia cujete* L.	Bignoniaceae
29	Nam nam	*Cynometra cauliflora* L.	Fabaceae
30	Durian	*Durio zibethinus* Murr.	Bombacaceae
31	Weralu	*Elaeocarpus serratus* L.	Elaeocarpaceae
32	Pihimbiya	*Filicium decipiens* (Wight & Arn.)Thw.	Sapindaceae
33	Uguressa	*Flacourtia indica* (Burm. f.) Merr.	Flacourtiaceae

34	Mangus	*Garcinia mangostana* L.	Clusiaceae
35	Ela goraka	*Garcinia zeylanica* Roxb.	Clusiaceae
36	Kona	*Gliricidia sepium* (Jacq.)Walp.	Fabaceae
37	Ipil Ipil	*Leucaena leucocephala* (Lam.)de Wit	Fabaceae
38	Kenda	*Macaranga peltata* (Roxb.) Muell.Arg.	Euphorbiaceae
39	Amba	*Mangifera indica* L.	Anacardiaceae
40	Lunumidella	*Melia azedarach* L.s.l.	Meliaceae
41	Gini sapu	*Michelia champaca* L. var. champaca	Magnoliaceae
42	Wal Sapu	*Michelia nilagirica* Zenker var. walker Hook. F. & Thom.	Magnoliaceae
43	Murunga	*Moringa oleifera* Lam.	Moringaceae
44	Jam gaha	*Muntingia calabura* L.	Flacourtiaceae
45	Karapincha	*Murraya koenigii* (L.) Spreng.	Rutaceae
46	Sadikka	*Myristica fragrans* Houtt.	Myristicaceae
47	Dawul kurundu	*Neolitsea cassia* (L.) Kosterm.	Lauraceae
48	Rabutan	*Nephelium lappaceum* L. var. lappaceum	Sapindaceae
49	Bala	*Nothopegia beddomei* Gamble	Anacardiaceae
50	Sepalika	*Nyctanthes arbor-tristis* L.	Oleaaceae
51	Nedun	*Pericopsis mooniana* (Thw.) Thw.	Fabaceae
52	Aligeta pera	*Persea americana* Miller	Lauraceae
53	Rata Nelli	*Phyllanthus acidus* (L.) & Skeels	Euphorbiaceae
54	Nelli	*Phyllanthus emblica* L.	Euphorbiaceae
55	Araliya	*Plumeria rubra* L.	Apocynaceae
56	Pera	*Psidium guajava* L.	Myrtaceae
57	Embul pera	*Psidium guineense* Sw.	Myrtaceae
58	Delum	*Punica granatum* L.	Punicaceae
59	Mara	*Samanea saman* (Jacq.) Merr.	Fabaceae
60	Ashoka	*Saraca asoca* (Roxb.) de Wild	Fabaceae
61	Koan	*Schleichera oleosa* (Lour.) Oken	Sapindaceae
62	Kathuru murunga	*Sesbania grandiflora* (L.) Poir.	Fabaceae
63	Sal	*Shorea robusta* Gaertn. f.	Dipterocarpaceae
64	Wal ambarella	*Spondias pinnata* (L. f.) Kurz	Anacardiaceae
65	Mahogany	*Swietenia mahagoni* (L.) Jacq.	Meliaceae
66	Jambu	*Syzygium aqueum* (Burm. f.) Alston	Myrtaceae
67	Karambu neti	*Syzygium aromaticum* (L.) Merr. & Perry	Myrtaceae
68	Dan	*Syzygium caryophyllatum* (L.) Alston	Myrtaceae
69	Siyambala	*Tamarindus indica* L.	Fabaceae
70	Thekka	*Tectona grandis* L. f. f. grandis	Verbenceae
71	Kumbuk	*Terminalia arjuna* (Roxb.) Wight & Arn.	Combretaceae
72	Kokova	*Theobroma cacao* L.	Sterculiaceae
73	Suriya	*Thespesia populnea* (L.) Soland ex Correa.	Malvaceae
74	Toona	*Toona ciliate* M. Roemer	Meliaceae
75	Milla	*Vitex pinnata* L.	Verbenaceae

Annex 3: Woody Trees and Naturally Grown Plants Species Recorded in Homegardens of Sri Lanka – Siwalakulama.

	Local name	Scientific Name	family
1	Beli	*Aegle marmelos* (L.) Correa	Rutaceae
2	Suriya mara	*Albizia lebbeck* (L.) Benth.	Fabaceae
3	Kaju	*Anacardium occidentale* L.	Anacardiaceae
4	Weli anoda	*Annona reticulata* L.	Annonaceae
5	Puwak	*Areca catechu* L.	Palmae
6	Kos	*Artocarpus heterophyllus* Lam.	Moraceae
7	Del	*Artocarpus incisus* L.F.	Moraceae
8	Bilin	*Averrhoa bilimbi* L.	Oxalidaceae
9	Kohomba	*Azadirechta indica* A. Juss.	Meliaceae
10	Maila	*Bauhinia racemosa* Lam.	Fabaceae
11	Halmilla	*Berrya cordifolia* (Wild.) Burret	Tiliaceae
12	Thal	*Borassus flabellifer* L.	Palmae
13	ketakela	*Bridelia retusa* (L.) A. Juss.	Euphorbiaceae
14	Domba	*Calophyllum inophyllum* L.	Clusiaceae
15	Kithul	*Caryota urens* L.	Palmae
16	Ehela	*Cassia fistula* L.	Fabaceae
17	Lawulu	*Chrysophyllum roxburghii* G. Don.	Sapotaceae
18	Dehi	*Citrus aurantifolia* (Christm. & Panzer) Swingle	Rutaceae
19	Embul Dodam	*Citrus aurantium* L.	Rutaceae
20	Heen naran	*Citrus reticulata* Blanco	Rutaceae
21	Peni dodam	*Citrus sinensis* (L.) Osbec	Rutaceae
22	Pol	*Cocos nucifera* L.	Palmae
23	Eucalyptus	*Eucalyptus citriodora* Hook.	Myrtaceae
24	Pihimbiya	*Filicium decipiens* (Wight & Arn.)Thw.	Sapindaceae
25	Kona	*Gliricidia sepium* (Jacq.)Walp.	Fabaceae
26	Daminiya	*Grewia damine* Gaertn	Tiliaceae
27	Kolon	*Haldina cordifolia* (Roxb.) Ridsd.	Rubiaceae
28	Ipil Ipil	*Leucaena leucocephala* (Lam.)de Wit	Fabaceae
29	Divul	*Limonia acidissima* L.	Rutaceae
30	Mee	*Madhuca longifolia* (L.) Macbride	Sapotaceae
31	Amba	*Mangifera indica* L.	Anacardiaceae
32	Helamba	*Mitragyna tubulosa* (Arn.) Havil.	Rubiaceae
33	Murunga	*Moringa oleifera* Lam.	Moringaceae
34	Kaneru	*Nerium oleander* L.	Apocynaceae
35	Rata Nelli	*Phyllanthus acidus* (L.) & Skeels	Euphorbiaceae
36	Pines	*Pinus caribaea* Morelet	Pinaceae
37	Owila	*Polyalthia longifolia* (Sonn.) Thw.	Annonaceae
38	Pera	*Psidium guajava* L.	Myrtaceae
39	Delum	*Punica granatum* L.	Punicaceae

40	Koan	*Schleichera oleosa* (Lour.) Oken	Sapindaceae
41	Kathuru murunga	*Sesbania grandiflora* (L.) Poir.	Fabaceae
42	Wal ambarella	*Spondias pinnata* (L. f.) Kurz	Anacardiaceae
43	Telabu	*Sterculia foetida* L.	Sterculiaceae
44	Geta nitul	*Streblus asper* Lour.	Moraceae
45	Dan	*Syzygium caryophyllatum* (L.) Alston	Myrtaceae
46	Siyambala	*Tamarindus indica* L.	Fabaceae
47	Thekka	*Tectona grandis* L. f. f. grandis	Verbenceae
48	Kottamba	*Terminalia catappa* L.	Combretaceae

Annex 4: Frequency of Occurrence of Wody Trees in Homegardens of Sri Lanka.

Scientific Name	Frequency of occurrence			
	Keeriyagaswewa	Pethiyagoda	Siwalakulama	All three sites
Adenanthera pavonina L.	1	5	0	6
Aegle marmelos (L.) Correa	11	0	2	13
Albizia lebbeck (L.) Benth.	10	0	1	11
Alstonia macrophylla Wall.ex G.Don	0	12	0	12
Alstonia scholaris (L.) R. Br.	1	0	0	1
Amherstia nobilis Wallich	0	1	0	1
Anacardium occidentale L.	22	0	3	25
Annona muricata L.	11	5	0	16
Annona reticulata L.	21	4	5	30
Areca catechu L.	2	46	4	52
Artocarpus heterophyllus Lam.	17	34	12	63
Artocarpus incisus L.F.	2	13	2	17
Averrhoa bilimbi L.	0	2	2	4
Averrhoa carambola L.	3	0	0	3
Azadirechta indica A. Juss.	52	6	28	86
Bauhinia racemosa Lam.	33	0	7	40
Bauhinia tomentosa L.	4	1	0	5
Berrya cordifolia (Wild.) Burret	33	6	2	41
Bombax ceiba L.	7	2	0	9
Borassus flabellifer L.	17	0	4	21
Bridelia retusa (L.) A. Juss.	22	1	8	31
Caesalpinia pulcherrima (L.) Sw.	4	1	0	5
Calophyllum inophyllum L.	0	0	1	1
Cananga odorata (Lam.) Hook. f. & Thomas.	0	1	0	1
Canthium coromandelicum (Burm.f.) Alston	0	1	0	1
Caryota urens L.	1	13	1	15
Cassia auriculata L.	3	0	0	3

Cassia fistula L.	3	0	3	6
Cassia siamea Lam.	2	0	0	2
Chloroxylon swietenia DC.	19	0	0	19
Chrysophyllum roxburghii G. Don.	4	3	2	9
Chukrasia tabularis A. Juss.	3	0	0	3
Citrus aurantifolia (Christm. & Panzer) Swingle	8	2	4	14
Citrus aurantium L.	5	3	1	9
Citrus grandis (L.) Osbec var. grandis	0	5	0	5
Citrus medica L.	1	0	0	1
Citrus reticulata Blanco	6	3	2	11
Citrus sinensis (L.) Osbec	17	3	7	27
Cleistocalyx nervosum (DC.) Kosterm. var. nervosum	1	0	0	1
Cocos nucifera L.	33	43	29	105
Coffea arabica L.	0	9	0	9
Crateva adansonii DC ssp. odora (Bunch. – Ham.)	3	1	0	4
Crescentia cujete L.	1	1	0	2
Cynometra cauliflora L.	0	3	0	3
Delonix regia (Hook.) Raf.	2	0	0	2
Diospyros malabarica (Desr.) Kostel.	2	0	0	2
Diospyros quaesita Thw.	1	0	0	1
Drypetes sepiaria (Wight. & Arn.) Pax & Hoffm.	2	0	0	2
Durio zibethinus Murr.	0	10	0	10
Elaeocarpus serratus L.	0	4	0	4
Eucalyptus citriodora Hook.	0	0	2	2
Ficus trimenii King	3	0	0	3
Filicium decipiens (Wight & Arn.)Thw.	3	3	2	8
Flacourtia indica (Burm. f.) Merr.	0	13	0	13
Garcinia mangostana L.	0	6	0	6
Garcinia zeylanica Roxb.	0	4	0	4
Gliricidia sepium (Jacq.)Walp.	13	38	1	52
Grewia damine Gaertn	2	0	1	3
Haldina cordifolia (Roxb.) Ridsd.	7	0	1	8
Holoptelea integrifolia (Roxb.)Planch.	1	0	0	1
Leucaena leucocephala (Lam.)de Wit	19	1	3	23
Limonia acidissima L.	25	0	8	33
Macaranga peltata (Roxb.) Muell.Arg.	1	3	0	4
Madhuca longifolia (L.) Macbride	8	0	2	10
Mangifera indica L.	36	37	23	96

Manilkara hexandra (Roxb.) Dubard	4	0	0	4
Melia azedarach L.s.l.	0	7	0	7
Michelia champaca L. var. champaca	0	22	0	22
Michelia nilagirica Zenker var. walker Hook. F. & Thom.	0	3	0	3
Mitragyna tubulosa (Arn.) Havil.	12	0	1	13
Morinda citrifolia L.	6	0	0	6
Moringa oleifera Lam.	36	3	6	45
Morus alba L. var. indica	1	0	0	1
Muntingia calabura L.	4	3	0	7
Murraya koenigii (L.) Spreng.	5	4	0	9
Myristica fragrans Houtt.	0	16	0	16
Neolitsea cassia (L.) Kosterm.	0	6	0	6
Nephelium lappaceum L. var. lappaceum	0	19	0	19
Nerium oleander L.	2	0	1	3
Nothopegia beddomei Gamble	0	1	0	1
Nyctanthes arbor-tristis L.	3	2	0	5
Pericopsis mooniana (Thw.) Thw.	0	1	0	1
Persea americana Miller	2	26	0	28
Phyllanthus acidus (L.) & Skeels	13	1	2	16
Phyllanthus emblica L.	6	1	0	7
Pinus caribaea Morelet	0	0	1	1
Pleurostylia opposita (Wall.)Alston	1	0	0	1
Plumeria rubra L.	1	1	0	2
Polyalthia longifolia (Sonn.) Thw.	9	0	2	11
Pongamia pinnata (L.) Pierre	1	0	0	1
Psidium guajava L.	28	14	13	55
Psidium guineense Sw.	0	3	0	3
Pterospermum suberifolium (L.) Wild.	1	0	0	1
Punica granatum L.	3	2	1	6
Samanea saman (Jacq.) Merr.	0	2	0	2
Saraca asoca (Roxb.) de Wild	0	1	0	1
Schleichera oleosa (Lour.) Oken	1	4	3	8
Sesbania grandiflora (L.) Poir.	7	4	4	15
Shorea robusta Gaertn. f.	0	1	0	1
Spondias pinnata (L. f.) Kurz	3	4	1	8
Sterculia foetida L.	3	0	1	4
Streblus asper Lour.	0	0	3	3
Swietenia mahagoni (L.) Jacq.	1	37	0	38
Syzygium aqueum (Burm. f.) Alston	0	12	0	12
Syzygium aromaticum (L.) Merr. & Perry	0	22	0	22

Syzygium caryophyllatum (L.) Alston	6	1	2	9
Tamarindus indica L.	34	7	8	49
Tecoma stans (L.) Kunth	9	0	0	9
Tectona grandis L. f. f. grandis	20	8	20	48
Terminalia arjuna (Roxb.) Wight & Arn.	1	1	0	2
Terminalia catappa L.	6	0	2	8
Theobroma cacao L.	0	1	0	1
Thespesia populnea (L.) Soland ex Correa.	1	2	0	3
Toona ciliate M. Roemer	1	10	0	11
Vitex negundo L.	1	0	0	1
Vitex pinnata L.	3	2	0	5

Annex 5: Abundance of Number of Trees in Three Sites of Sri Lanka.

Scientific Name	Number Of Trees			
	Keeriyagasw ewa	Pethiyag oda	Siwalakula ma	All three sites
Adenanthera pavonina L.	1	6	0	7
Aegle marmelos (L.) Correa	16	0	3	19
Albizia lebbeck (L.) Benth.	22	0	2	24
Alstonia macrophylla Wall.ex G.Don	0	21	0	21
Alstonia scholaris (L.) R. Br.	3	0	0	3
Amherstia nobilis Wallich	0	1	0	1
Anacardium occidentale L.	39	0	13	52
Annona muricata L.	19	5	0	24
Annona reticulata L.	35	4	5	44
Areca catechu L.	14	205	13	232
Artocarpus heterophyllus Lam.	28	87	29	144
Artocarpus incisus L.F.	2	17	2	21
Averrhoa bilimbi L.	0	2	2	4
Averrhoa carambola L.	3	0	0	3
Azadirechta indica A. Juss.	385	7	118	510
Bauhinia racemosa Lam.	61	0	9	70
Bauhinia tomentosa L.	5	1	0	6
Berrya cordifolia (Wild.) Burret	169	16	2	187
Bombax ceiba L.	7	2	0	9
Borassus flabellifer L.	38	0	6	44
Bridelia retusa (L.) A. Juss.	54	1	12	67
Caesalpinia pulcherrima (L.) Sw.	5	0	0	5
Calophyllum inophyllum L.	0	0	1	1
Cananga odorata (Lam.) Hook. f. & Thomas.	0	1	0	1
Canthium coromandelicum (Burm.f.) Alston	0	1	0	1

Caryota urens L.	2	22	2	26
Cassia auriculata L.	3	0	0	3
Cassia fistula L.	4	0	3	7
Cassia siamea Lam.	2	0	0	2
Chloroxylon swietenia DC.	42	0	0	42
Chrysophyllum roxburghii G. Don.	4	4	2	10
Chukrasia tabularis A. Juss.	3	0	0	3
Citrus aurantifolia (Christm. & Panzer) Swingle	8	2	4	14
Citrus aurantium L.	5	3	1	9
Citrus grandis (L.) Osbec var. grandis	0	5	0	5
Citrus medica L.	1	0	0	1
Citrus reticulata Blanco	9	3	2	14
Citrus sinensis (L.) Osbec	38	3	9	50
Cleistocalyx nervosum (DC.) Kosterm. var. nervosum	1	0	0	1
Cocos nucifera L.	155	156	216	527
Coffea arabica L.	0	17	0	17
Crateva adansonii DC ssp. odora (Bunch. – Ham.)	3	1	0	4
Crescentia cujete L.	1	1	0	2
Cynometra cauliflora L.	0	4	0	4
Delonix regia (Hook.) Raf.	2	0	0	2
Diospyros malabarica (Desr.) Kostel.	2	0	0	2
Diospyros quaesita Thw.	2	0	0	2
Drypetes sepiaria (Wight. & Arn.) Pax & Hoffm.	2	0	0	2
Durio zibethinus Murr.	0	13	0	13
Elaeocarpus serratus L.	0	6	0	6
Eucalyptus citriodora Hook.	0	0	4	4
Ficus trimenii King	3	0	0	3
Filicium decipiens (Wight & Arn.)Thw.	3	5	2	10
Flacourtia indica (Burm. f.) Merr.	0	13	0	13
Garcinia mangostana L.	0	8	0	8
Garcinia zeylanica Roxb.	0	6	0	6
Gliricidia sepium (Jacq.)Walp.	48	112	3	163
Grewia damine Gaertn	3	0	1	4
Haldina cordifolia (Roxb.) Ridsd.	9	0	1	10
Holoptelea integrifolia (Roxb.)Planch.	1	0	0	1
Leucaena leucocephala (Lam.)de Wit	29	1	4	34
Limonia acidissima L.	40	0	19	59
Macaranga peltata (Roxb.) Muell.Arg.	1	3	0	4

Madhuca longifolia (L.) Macbride	11	0	3	14
Mangifera indica L.	127	54	67	248
Manilkara hexandra (Roxb.) Dubard	6	0	0	6
Melia azedarach L.s.l.	0	10	0	10
Michelia champaca L. var. champaca	0	40	0	40
Michelia nilagirica Zenker var. walker Hook. F. & Thom.	0	6	0	6
Mitragyna tubulosa (Arn.) Havil.	14	0	1	15
Morinda citrifolia L.	7	0	0	7
Moringa oleifera Lam.	66	5	9	80
Morus alba L. var. indica	1	0	0	1
Muntingia calabura L.	6	4	0	10
Murraya koenigii (L.) Spreng.	5	5	0	10
Myristica fragrans Houtt.	0	32	0	32
Neolitsea cassia (L.) Kosterm.	0	8	0	8
Nephelium lappaceum L. var. lappaceum	0	22	0	22
Nerium oleander L.	2	0	1	3
Nothopegia beddomei Gamble	0	1	0	1
Nyctanthes arbor-tristis L.	3	2	0	5
Pericopsis mooniana (Thw.) Thw.	0	1	0	1
Persea americana Miller	2	40	0	42
Phyllanthus acidus (L.) & Skeels	15	1	2	18
Phyllanthus emblica L.	7	2	0	9
Pinus caribaea Morelet	0	0	3	3
Pleurostylia opposita (Wall.)Alston	2	0	0	2
Plumeria rubra L.	2	2	0	4
Polyalthia longifolia (Sonn.) Thw.	11	0	4	15
Pongamia pinnata (L.) Pierre	1	0	0	1
Psidium guajava L.	49	18	23	90
Psidium guineense Sw.	0	3	0	3
Pterospermum suberifolium (L.) Wild.	1	0	0	1
Punica granatum L.	3	2	2	7
Samanea saman (Jacq.) Merr.	0	2	0	2
Saraca asoca (Roxb.) de Wild	0	1	0	1
Schleichera oleosa (Lour.) Oken	1	5	3	9
Sesbania grandiflora (L.) Poir.	12	4	6	22
Shorea robusta Gaertn. f.	0	1	0	1
Spondias pinnata (L. f.) Kurz	6	4	2	12
Sterculia foetida L.	3	0	1	4
Streblus asper Lour.	0	0	4	4
Swietenia mahagoni (L.) Jacq.	1	177	0	178

Syzygium aqueum (Burm. f.) Alston	0	13	0	13
Syzygium aromaticum (L.) Merr. & Perry	0	49	0	49
Syzygium caryophyllatum (L.) Alston	8	1	2	11
Tamarindus indica L.	75	8	10	93
Tecoma stans (L.) Kunth	11	0	0	11
Tectona grandis L. f. f. grandis	81	16	62	159
Terminalia arjuna (Roxb.) Wight & Arn.	1	1	0	2
Terminalia catappa L.	10	0	3	13
Theobroma cacao L.	0	1	0	1
Thespesia populnea (L.) Soland ex Correa.	1	2	0	3
Toona ciliate M. Roemer	1	29	0	30
Vitex negundo L.	1	0	0	1
Vitex pinnata L.	3	2	0	5

Annex 6: SWI values for Individual Households of Three Sites of Sri Lanka.

HH	Keeriyagaswewa	Pethiyagoda	Siwalakulama
1	2.538	1.667	2.061
2	2.114	1.640	1.245
3	2.665	1.575	1.741
4	0.886	2.256	2.205
5	2.416	1.730	1.936
6	2.488	1.981	0.937
7	2.335	1.494	1.488
8	2.527	1.471	1.748
9	1.950	1.277	1.664
10	1.651	1.277	1.215
11	1.699	2.119	1.859
12	1.936	2.243	2.170
13	1.494	1.941	1.527
14	2.468	2.137	1.748
15	2.396	2.107	1.189
16	1.946	2.641	2.154
17	1.518	2.042	1.616
18	1.935	1.906	1.635
19	2.280	2.406	1.333
20	2.485	1.631	1.859
21	2.316	2.020	2.481
22	0.937	2.146	2.187
23	2.245	3.000	1.557
24	1.753	2.327	2.181
25	2.281	2.010	1.455
26	2.206	2.344	2.182

27	1.565	1.969	2.166
28	2.433	1.273	2.202
29	2.318	1.899	1.594
30	2.623	2.901	1.906
31	2.652	1.792	
32	2.229	2.306	
33	2.683	1.861	
34	1.692	1.672	
35	2.980	1.669	
36	1.792	2.233	
37	1.450	2.157	
38	2.514	2.535	
39	2.720	2.347	
40	1.990	1.676	
41	1.904	1.831	
42	2.288	2.303	
43	2.379	1.583	
44	1.846	1.973	
45	2.343	2.012	
46	2.095	2.182	
47	2.307	2.261	
48	2.051	1.277	
49	2.845	2.662	
50	1.778	2.075	
51	2.216	1.696	
52	1.798	1.358	
53	1.703	2.860	
54	2.198	1.831	
55	1.868	2.159	
56	2.149	1.925	
57	2.589	2.197	
58	2.115	1.844	
59	2.248	1.539	

Annex 7: List of Woody Trees and Naturally Grown Plants Species in India

1	Acacia	*Acacia moniliformis* Griseb.	Leguminosae
2	Vasaka	*Adhatoda vasica* L.	Acanthaceae
3	Wood apple	*Aegle marmelos* (L.) Corr. Serr.	Rutaceae
4	-	*Alangium salviifolium* (L.f.) Wangerin	Alangiaceae
5	Seven leaf tree	*Alstonia scholaris* (L.) R.Br.	Apocynaceae
6	Shirsa	*Albizia lebbeck* (L.) Benth.	Leguminosae
7	Arum	*Alocasia indica* Shott.	Araceae
8	Cashew nut	*Anacardium occidentale* L.	Anacardiaceae

9	Pine apple	*Ananas comosus* (L.) Merr.	Bromeliaceae
10	Custard apple	*Annona reticulata* L.	Annonaceae
11	Custard apple	*Annona squamosa* L.	Annonaceae
12	Woody tree	*Anthocephalus indicus* (Lamk.) Walp.	Rubiaceae
13	Betel nut	*Areca catechu* L.	Palmae
14	Ester	*Aster grandiflorus*	Compositae
15	Starfruit	*Averrhoa carambola* L.	Oxalidaceae
16	Neem	*Azadirachta indica* A. Juss.	Meliaceae
17	Bamboo	*Bambusa* spp	Gramineae
18	Silk cotton	*Bombax ceiba* L.	Bombacaceae
19	Palm	*Borassus flabellifer* L.	Palmae
20	Kind of flower tree	*Caesalpinia pulcherrima* (L.) Sw.	Leguminosae
21	Kind of pulse	*Cajanus cajan* (L.) Hutch	Leguminosae
22	Balloon Vine	*Calotropis gigantea* (L.) Ait.	Asclepiadaceae
23	Papaya	*Carica papaya* L.	Caricaceae
24	Carunda	*Carissa carandas* L.	Apocynaceae
25	Safflower	*Carthamus tinctorius* L.	Compositae
26	Golden Shower	*Cassia fistula* L.	Leguminosae
27	-	*Cicca acida* L.	Euphorbiaceae
28	Cassia leaf	*Cinnamomum tamala* L.	Lauraceae
29	Orange	*Citrus aurantium* L.	Rutaceae
30	Shaddok	*Citrus maxima* (Burm.) Merr	Rutaceae
31	Orange	*Citrus medica* L.	Rutaceae
32	Bhant	*Clerodendrum viscosum* Vent.	Verbenaceae
33	Coconut	*Cocos nucifera* L.	Palmae
34	Kind of grass	*Cynodon dactylon* (L.) Pers.	Graminae
35	Indian Rosewood	*Dalbergia sissoo* Roxb. ex DC.	Leguminosae
36	Elephant apple	*Dillenia indica* L	Dilleniaceae
37	Eucalyptas	*Eucalyptus* spp.	Myrtaceae
38	Fig	*Ficus cunea* Buch.-Ham. ex. Roxb.	Moraceae
39	Peepul tree	*Ficus religiosa* L.	Moraceae
40	Kind of flower	*Gardenia jasminoides* Ellis	Rubiaceae
41	Woody tree	*Gmelina arborea* Roxb.	Verbenaceae
42	Cotton	*Gosssypium herbaceum* L.	Malvaceae
43	Hibiscus	*Hibiscus rosa-sinensis* L.	Malvaceae
44	Justicia	*Justicia simplex* D.Don.	Acanthaceae
45	Gourd	*Lagenaria siceraria* Molina Standley	Cucurbitaceae
46	Litchi	*Litchi chinensis* Sonn.	Sapindaceae
47	Timber tree	*Litsea glutinosa* (Lour.) C. B. Robins	Lauraceae

48	Mango	*Mangifera indica* L.	Anacardiaceae
49	Sapodilla plum	*Manilkara achras* (Miller) Fosberg	Sapotaceae
50	Mulberry	*Morus alba* L.	Moraceae
51	Jackfruit	*Artocarpus heterophyllus* Lam.	Moraceae
52	Banana	*Musa sapientum* L.	Musaceae
53	Kind of flower	*Nyctanthes arbor-tristis* L.	Oleaceae
54	Holy basil	*Ocimum sanctum* L.	Labiatae
55	Caatus	*Opuntia dillenii* (Ker Gawl.) Haw.	Cactaceae
56	Date palm	*Phoenix sylvestris* (L.) Roxb.	Palmae
57	Guava	*Psidium guajava* L.	Myrtaceae
58	Pomegranate	*Punica granatum* L.	Punicaceae
59	White sandal	*Santalum album* L.	Santalaceae
60	Asok	*Saraca asoca* (Roxb.)	Leguminosae
61	Shal	*Shorea robusta* Gaertn. f.	Dipterocarpaceae
62	Sida	*Sida cordifolia* L.	Malvaceae
63	-	*Solanum nigrum* L.	Solanaceae
64	Hog plum	*Spondias pinnata* (L. f.) Kurz	Anacardiaceae
65	Siamese rough bush	*Streblus asper* Lour.	Moraceae
66	Mohagany	*Swietenia mahagoni* L. Jacq.	Meliaceae
67	Jamboline	*Syzygium cumini* (L.) Skeels.	Myrtaceae
68	Kind of flower	*Tabernaemontana coronaria* (L.) R. Br.	Apocynaceae
69	Tamarind	*Tamarindus indica* L.	Leguminosae
70	Teak	*Tectona grandis* L. f. f. grandis	Verbenceae
71	White murdah	*Terminalia arjuna* (Roxb.) Wight & Arn.	Combretaceae
72	Kind of flower	*Thevetia peruviana* (pers). K Shum	Apocynaceae
73	Vernonia	*Vernonia cinerea* (L.) Less.	Compositae
74	Vitex	*Vitex negundo* L.	Verbenaceae
75	Indian jujube	*Ziziphus mauritiana* Lam.	Rhamnaceae

Annex 8: List of Woody Trees and Naturaly Grown Plants Species in Bangladesh.

	Common name	**Scientific name**	**Family**
1	Acacia	*Acacia auriculiformis* A.Cunn.ex Benth.	Leguminosae
2	Betel nut	*Areca catechu* L.	Palmae
3	Wood apple	*Aegle marmelos* (L.) Corr. Serr.	Rutaceae
4	Koroi	*Albizia* spp	Leguminosae
5	Amaranth	*Amaranthus oleraceae*	Amaranthaceae
6	Custard apple	*Annona squamosa* L.	Annonaceae
7	Rohina	*Aphanamixis polystachya* (Wall.) Parker	Meliaceae
8	Chapalish	*Artocarpus chaplasha* Roxb.	Moraceae

9	Jackfruit	*Artocarpus heterophyllus* Lam.	Moraceae
10	Carambola	*Averrhoa carambola* L.	Oxalidaceae
11	Neem	*Azadirachta indica* A. Juss.	Meliaceae
12	Bamboo	*Bambusa* spp	Poaceae
13	Ash gourd	*Benincasa hispida* (Thumb.) Cogn.	Cucurbitaceae
14	Burmese grape	*Bixa orellana* L.	Bixaceae
15	Silk cotton	*Bombax ceiba* L.	Bombacaceae
16	Palmyra palm	*Borassus flabellifer* L.	Palmae
17	Aroid	*Calocasia alba*	Araceae
18	Carunda	*Carissa carandas* L.	Apocynaceae
19	Starapple	*Chrysophyllum cainito* L.	Sapotaceae
20	Pumello	*Citrus grandis* (L.) Osbeck	Rutaceae
21	Lemon	*Citrus limon* (L.) N.L.	Rutaceae
22	Coconut	*Cocos nucifera* L.	Palmae
23	Datura	*Datura metel* L.	Solanaceae
24	Krishnochura	*Delonix regia* (Boj. ex Hook.) Raf.	Leguminosae
25	Chalta	*Dillenia indica* L	Dilleniaceae
26	Eucalyptus	*Eucalyptus camaldulensis* Dehnh.	Myrtaceae
27	Bajna	*Fagara budrunga* Roxb.	Rutaceae
28	Pakur	*Ficus infectonia*	Moraceae
29	Gamar	*Gmelina arborea* Roxb.	Verbenaceae
30	Phalsa	*Grewia asiatica* L.	Tiliaceae
31	Jarul	*Lagerstroemia speciosa* (L.) Pers.	Lythraceae
32	Litchi	*Litchi chinensis* Sonn.	Sapindaceae
33	Mango	*Mangifera indica* L.	Anacardiaceae
34	Sapota	*Manilkara achras* (Miller) Fosberg	Sapotaceae
35	Olive	*Olea europaea* L.	Oleaceae
36	Date palm	*Phoenix sylvestris* (L.) Roxb.	Palmae
37	Betel leaf	*Piper betle* L.	Piperaceae
38	Guava	*Psidium guajava*	Myrtaceae
39	Sal	*Shorea robusta* Gaertn. f.	Dipterocarpaceae
40	Hog pulm	*Spondias mangifera*	Anacardiaceae
41	Mahogany	*Swietenia mahagoni* L. Jacq.	Meliaceae
42	Black berry	*Syzygium cumini* (L.) Skeels.	Myrtaceae
43	Rose apple	*Syzygium jambos.* L. (Alston).	Myrtaceae
44	Wax jambo	*Syzygium samarangense* (Blume) Merr.	Myrtaceae
45	Temarind	*Tamarindus indica* L.	Leguminosae
46	Teak	*Tectona grandis* L. f. f. grandis	Verbenceae
47	Jujube	*Zizyphus jujuba* Miller	Rhamnaceae

Annex 9: Common Woody Plant Species between India and Sri Lanka.

	Local name	Scientific Name	family
1	Beli	*Aegle marmelos* (L.) Correa	Rutaceae
2	Shirsa	*Albizia lebbeck* (L.) Benth.	Leguminosae
3	Seven leaf tree	*Alstonia scholaris* (L.) R.Br.	Apocynaceae
4	Cashew nut	*Anacardium occidentale* L.	Anacardiaceae
5	Custard apple	*Annona reticulata* L.	Annonaceae
6	Betel nut	*Areca catechu* L.	Palmae
7	Jackfruit	*Artocarpus heterophyllus* Lam.	Moraceae
8	Starfruit	*Averrhoa carambola* L.	Oxalidaceae
9	Neem	*Azadirachta indica* A. Juss.	Meliaceae
10	Silk cotton	*Bombax ceiba* L.	Bombacaceae
11	Palm	*Borassus flabellifer* L.	Palmae
12	Kind of flower tree	*Caesalpinia pulcherrima* (L.) Sw.	Leguminosae
13	Chilli	*Capsicum frutescens* L.	Solanaceae
14	Papaya	*Carica papaya* L.	Caricaceae
15	kind of sour fruit	*Carissa carandas* L.	Apocynaceae
16	Golden Shower	*Cassia fistula* L.	Leguminosae
17	Embul Dodam	*Citrus aurantium* L.	Rutaceae
18	Orange	*Citrus medica* L.	Rutaceae
19	Coconut	*Cocos nucifera* L.	Palmae
20	Gourd	*Lagenaria siceraria* Molina Standley	Cucurbitaceae
21	Mango	*Mangifera indica* L.	Anacardiaceae
22	Mulberry	*Morus alba* L.	Moraceae
23	Banana	*Musa sapientum* L.	Musaceae
24	Kind of flower	*Nyctanthes arbor-tristis* L.	Oleaceae
25	Guava	*Psidium guajava* L.	Myrtaceae
26	Pomegranate	*Punica granatum* L.	Punicaceae
27	Asok	*Saraca asoca* (Roxb.)	Leguminosae
28	Shal	*Shorea robusta* Gaertn. f.	Dipterocarpaceae
29	Hog plum	*Spondias pinnata* (L. f.) Kurz	Anacardiaceae
30	Siamese rough bush	*Streblus asper* Lour.	Moraceae
31	Mohagany	*Swietenia mahagoni* L. Jacq.	Meliaceae
32	Tamarind	*Tamarindus indica* L.	Leguminosae
33	Teak	*Tectona grandis* L. f. f. grandis	Verbenceae
34	Vitex	*Vitex negundo* L.	Verbenaceae

Annex 10: Common Woody Plant Species between India and Bangladesh.

	English Name	Scientific Name	Family
1	Betel nut	*Areca catechu* L.	Palmae
2	Wood apple	*Aegle marmelos* (L.) Corr. Serr.	Rutaceae
3	Custard apple	*Annona squamosa* L.	Annonaceae
4	Jackfruit	*Artocarpus heterophyllus* Lam.	Moraceae
5	Carambola	*Averrhoa carambola* L.	Oxalidaceae
6	Neem	*Azadirachta indica* A. Juss.	Meliaceae
7	Bamboo	*Bambusa* spp	Poaceae
8	Silk cotton	*Bombax ceiba* L.	Bombacaceae
9	Papaya	*Carica papaya* L.	Caricaceae
10	Carunda	*Carissa carandas* L.	Apocynaceae
11	Lemon	*Citrus limon* (L.) N.L.	Rutaceae
12	Coconut	*Cocos nucifera* L.	Palmae
13	Chalta	*Dillenia indica* L	Dilleniaceae
14	Gamar	*Gmelina arborea* Roxb.	Verbenaceae
15	Litchi	*Litchi chinensis* Sonn.	Sapindaceae
16	Mango	*Mangifera indica* L.	Anacardiaceae
17	Sapota	*Manilkara achras* (Miller) Fosberg	Sapotaceae
18	Banana	*Musa sapientum* L.	Musaceae
19	Date palm	*Phoenix sylvestris* (L.) Roxb.	Palmae
20	Guava	*Psidium guajava*	Myrtaceae
21	Sal	*Shorea robusta* Gaertn. f.	Dipterocarpaceae
22	Mahogany	*Swietenia mahagoni* L. Jacq.	Meliaceae
23	Black berry	*Syzygium cumini* (L.) Skeels.	Myrtaceae
24	Wax jambo	*Syzygium samarangense* (Blume) Merr.	Myrtaceae
25	Teak	*Tectona grandis* L. f. f. grandis	Verbenceae

Annex 11: Common Woody Plant Species between Sri Lanka and Bangladesh.

	English Name	Scientific Name	Family
1	Beli	*Aegle marmelos* (L.) Correa	Rutaceae
2	Betel nut	*Areca catechu* L.	Palmae
3	Jackfruit	*Artocarpus heterophyllus* Lam.	Moraceae
4	Carambola	*Averrhoa carambola* L.	Oxalidaceae
5	Neem	*Azadirachta indica* A. Juss.	Meliaceae
6	Silk cotton	*Bombax ceiba* L.	Bombacaceae

7	Papaya	*Carica papaya* L.	Caricaceae
8	Pumello	*Citrus grandis* (L.) Osbeck	Rutaceae
9	Coconut	*Cocos nucifera* L.	Palmae
10	May-mara	*Delonix regia* (Hook.) Raf.	Fabaceae
11	Mango	*Mangifera indica* L.	Anacardiaceae
12	Banana	*Musa sapientum* L.	Musaceae
13	Betel leaf	*Piper betle* L.	Piperaceae
14	Guava	*Psidium guajava*	Myrtaceae
15	Sal	*Shorea robusta* Gaertn. f.	Dipterocarpaceae
16	Mahogany	*Swietenia mahagoni* (L.) Jacq.	Meliaceae
17	Temarind	*Tamarindus indica* L.	Leguminosae
18	Teak	*Tectona grandis* L. f. f. grandis	Verbenceae

Annex 12: Household SWI for India and Bangladesh.

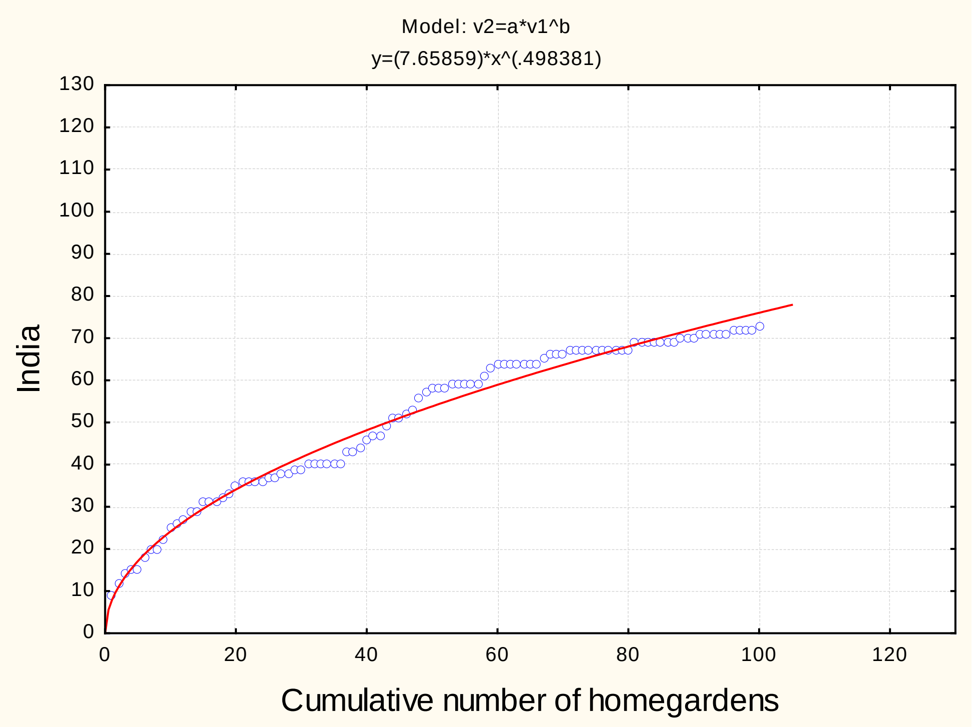
	Bangladesh	India
1	0.914759404	1.689543
2	1.598657675	1.430508
3	1.732530493	1.476197
4	1.533801059	1.032159
5	2.120430841	1.33321
6	1.664075467	1.8126
7	1.630552829	2.061113
8	1.662455338	1.4427
9	1.366663855	1.248403
10	1.595141875	1.599719
11	1.875152734	1.449076
12	1.324098753	1.447491
13	1.686326061	1.217665
14	1.658962633	1.187677
15	1.795723878	1.629519
16	1.456530172	1.105421
17	1.296272209	1.314131
18	1.824450153	1.774146
19	1.130576963	1.476953
20	1.392604866	1.792118
21	1.131248829	1.211663
22	1.618635107	1.516024
23	1.579364681	0.683079
24	1.832941997	1.093433
25	1.286071116	1.712445
26	0.940483	1.704551
27	1.604334606	1.534314

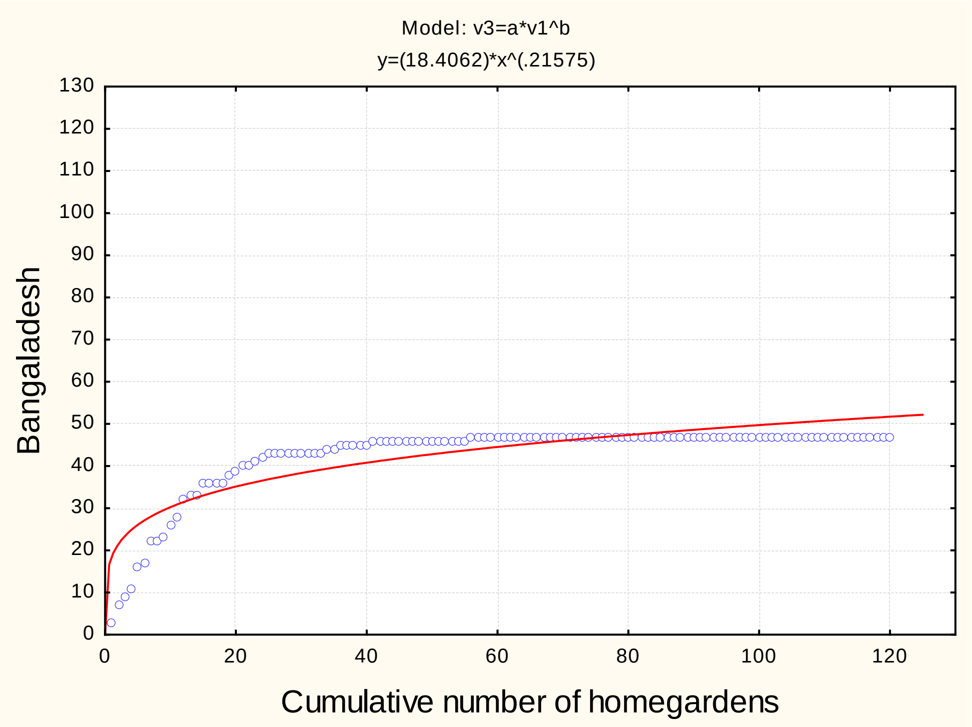
28	1.566390065	1.111628
29	1.333654254	1.886941
30	1.606084158	1.098612
31	0.729734111	1.390281
32	1.166045916	1.201683
33	1.476724833	1.564957
34	0.932729195	1.318868
35	1.312371279	0.277987
36	1.127970642	1.515037
37	1.431868257	1.540225
38	1.513411969	1.429088
39	1.221766523	1.979263
40	1.678596249	1.653524
41	1.245432061	1.517809
42	1.11286155	1.111628
43	1.284209195	1.830911
44	0.77145454	1.355389
45	0.760615771	1.213008
46	1.597526405	1.352812
47	1.243190402	1.404669
48	1.2409353	1.555259
49	1.278582362	1.822036
50	1.30163684	1.81081
51	0.861834064	1.731517
52	0.928174098	1.213008
53	1.360513296	1.166396
54	0.995861927	1.819363
55	1.49050389	1.630774
56	1.037334476	1.483631
57	1.000128616	1.162044
58	0.978719373	1.448481
59	0.752411949	1.15836
60	1.064544684	1.978266
61	0.911476155	1.82615
62	1.101737305	1.066168
63	1.152089723	1.340877
64	0.747925468	1.724291
65	1.019773822	1.779557
66	0.884054542	1.785962
67	0.847067576	1.458273
68	1.15942376	1.229901
69	0.845661735	1.252215
70	0.660679872	1.506732
71	0.535705414	1.165911
72	0.646907116	1.633342

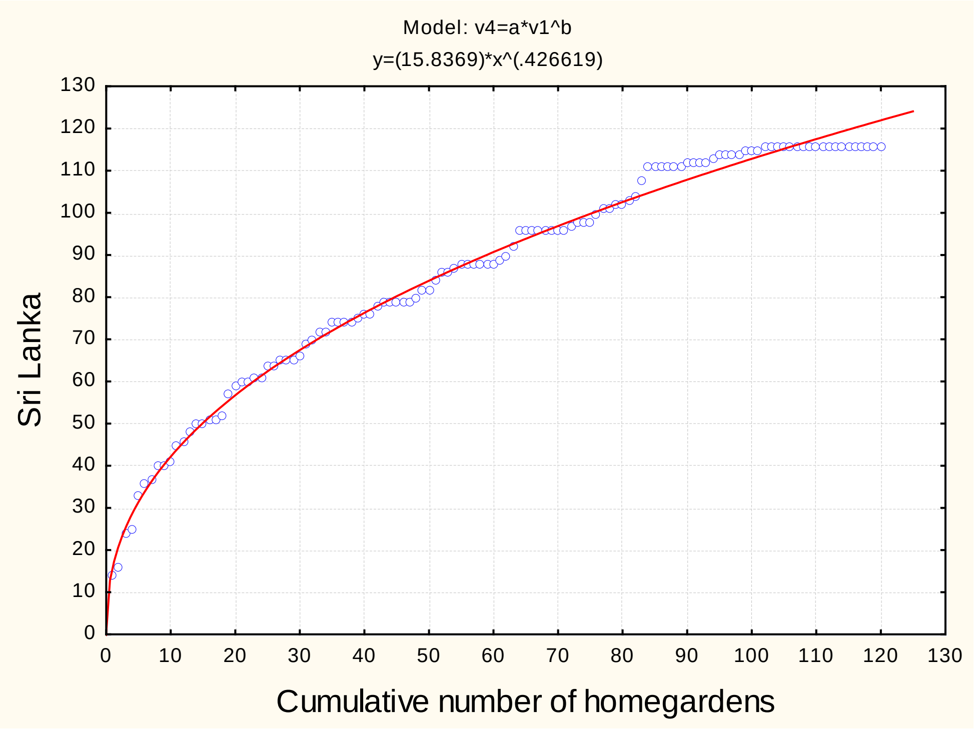
73	0.917739753	1.414406
74	0.737132704	0.778366
75	1.058995815	1.012464
76	0.658778521	1.17375
77	0.958864166	1.912233
78	1.338701282	1.449422
79	0.196095045	1.373855
80	0.790903659	0.94458
81	0.918820018	1.784413
82	0.696478719	1.676731
83	1.314449517	1.507069
84	0.962852512	1.126364
85	1.149503639	1.100285
86	0.549812029	0.700444
87	0.79439528	1.422463
88	1.027995284	1.552538
89	1.149523555	1.404664
90	0.759603261	1.441944
91	0.904203993	0.911621
92	0.607865326	1.144681
93	0.990096961	1.542156
94	0.851237463	1.17375
95	0.954719024	1.713552
96	1.163213063	1.563494
97	0.426266508	1.634831
98	1.121618375	1.499479
99	0.678461812	1.883394
100	0.411832407	2.309427
101	0.617970332	
102	1.005782782	
103	0.670670438	
104	0.698460086	
105	1.028388974	
106	0.705622486	
107	0.392905044	
108	1.133953591	
109	0.497517389	
110	1.077278081	
111	0.564057177	
112	0.892943655	
113	0.635303725	
114	0.717414054	
115	0.841570746	
116	0.769597911	

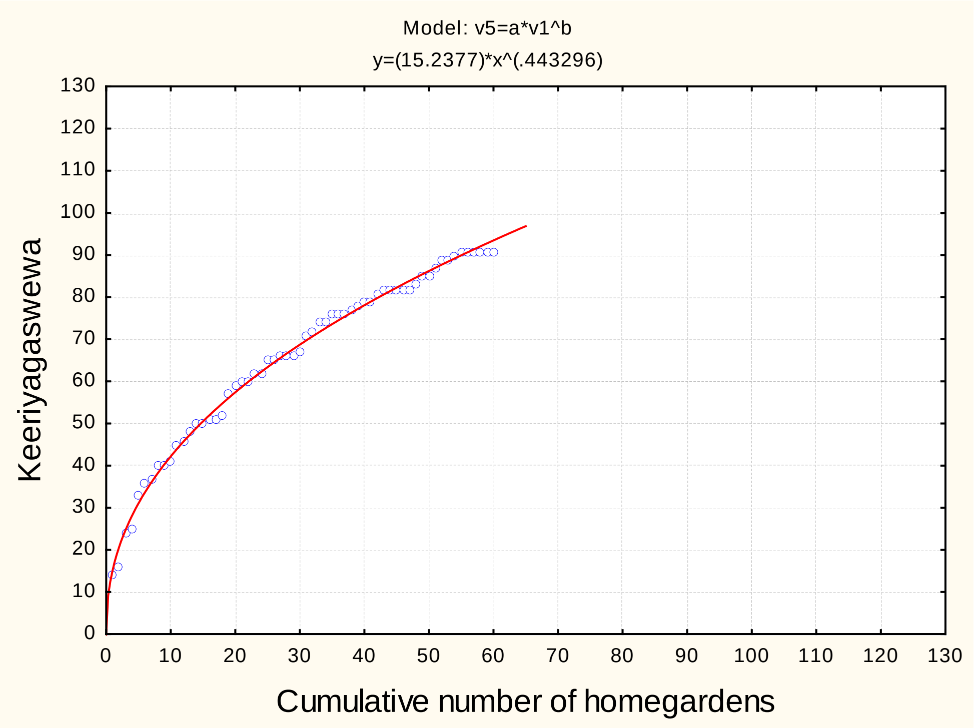
117	0.868898368	
118	0.744478456	

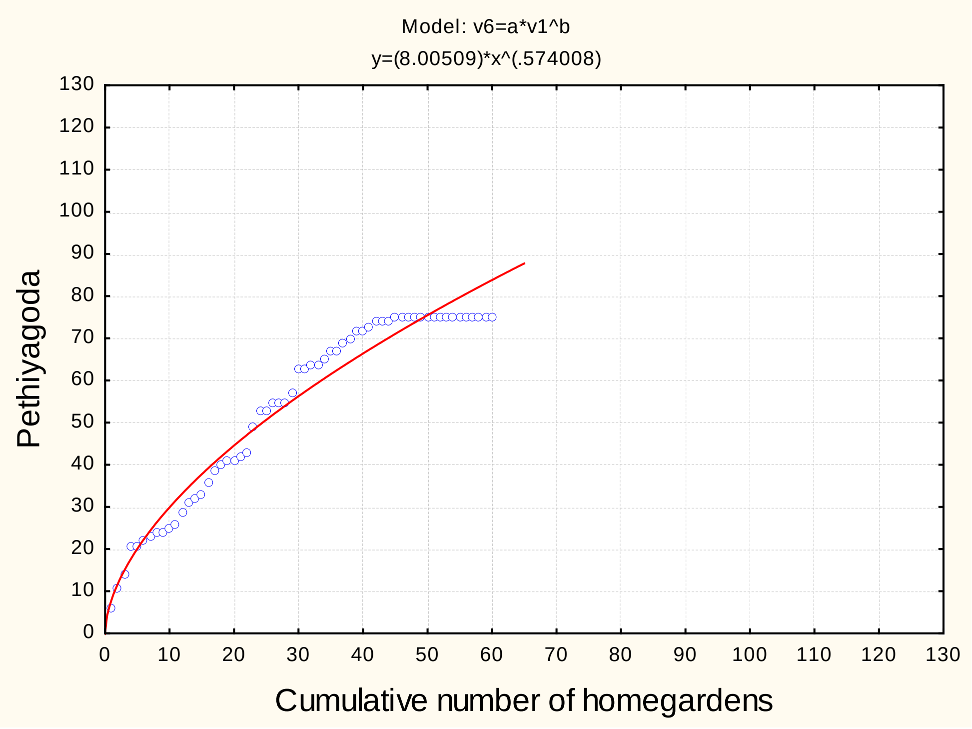
Annex 13: Values of Asympototic Functions between Cumulative Number of Species and Cumulative Number of Homegardens in Three Sites of Sri Lanka and three Countries.

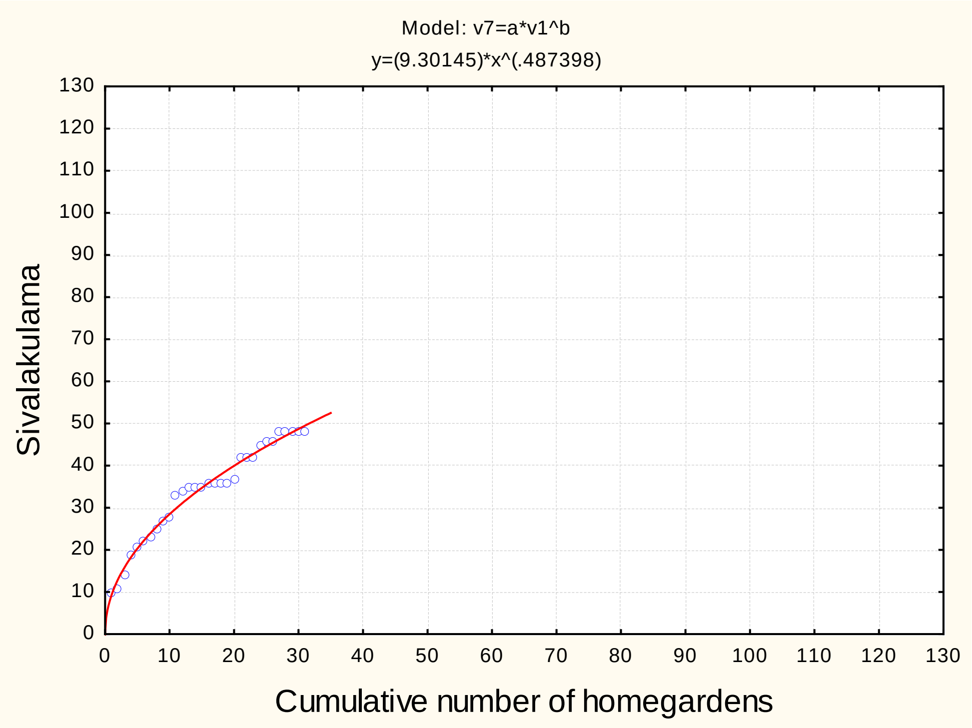





Model: v4=a*v1^b
y=(15.8369)*x^(.426619)
Sri Lanka
Cumulative number of homegardens
0
10
20
30
40
50
60
70
80
90
100
110
120
130


Model: v5=a*v1^b
y=(15.2377)*x^(.443296)
Keeriyagaswewa
Cumulative number of homegardens
0
10
20
30
40
50
60
70
80
90
100
110
120
130





Annex 14: Crop Species Recorded in Three Sites of Sri Lanka.

	Common name	Scientific name	Family
1	Bandakka	*Abelmoschus esculentus* (L.) Moench	Malvaceae
2	Wadakaha	*Acorus calamus* L.	Araceae
3	Rata lunu	*Allium cepa* L. cv. Group Cepa	Liliaceae

4	Mukunuwenna	*Alternanthera sessilis* (L.) DC.	Amaranthaceae
5	Thampala	*Amaranthus viridis* L.	Amaranthaceae
6	Annasi	*Ananas comosus* (L.) Merr.	Bromeliaceae
7	Rata kaju	*Arachis hypogaea* L.	Fabaceae
8	Hathvariya	*Asparagus gonoclados* Baker	Liliaceae
9	Nivithi	*Basella alba* L.	Basellaceae
10	Begoniya	*Begoniya* spp. L.	Begoniaceae
11	Alu puhul	*Benincasa hispida* (Thunb.) Cogn.	Cucurbitaceae
12	Beet	*Beta valgaris* L. ssp. vulgaris	Chenopodiaceae
13	Gova	Brassica oleracea L.	Cruciferae
14	Buthsarana	*Canna indica* L.	Cannaceae
15	Miris	*Capsicum annuum* L.	Solanaceae
16	Kochchi	*Capsicum frutescens* L.	Solanaceae
17	Papol	*Carica papaya* L.	Caricaceae
18	Gotukola	*Centella asiatica* (L.) Urban	Umbeliferae
19	Kekiri	*Cucumis melo* L.	Cucurbitaceae
20	Pipinha	*Cucumis sativus* L.	Cucurbitaceae
21	Wattakka	*Cucurbita maxima* Lam.	Cucurbitaceae
22	Kaha	*Curcuma longa* L.	Zingiberaceae
23	Carrot	*Daucus carota* L.	Umbeliferae
24	Welala	*Dioscorea alata* L.	Dioscoreaceae
25	Draceana	*Dracaena* sp.	Agavaceae
26	Enasal	*Elettaria cardamomum* (L.) Maton	Zingiberaceae
27	Soya bonchi	*Glycine max* (L.) Merr.	Fabaceae
28	Bathala	*Ipomoea batatas* (L.) Lam.	Convolvulaceae
29	Kankun	*Ipomoea aquatica* Forssk.	Convolvulaceae
30	Diyalabu	*Lagenaria siceraria* (Molina) Standley	Cucurbitaceae
31	kohila	*Lasia spinosa* (L.) Thw.	Araceaea
32	Dara wetakolu	*Luffa acutangula* (L.) Roxb.	Cucurbitaceae
33	Thakkali	*Lycopersicon esculentum* Miller	Solanaceae
34	Mangnokka	*Manihot esculenta* Crantz.	Euphorbiaceae
35	Karawila	*Momordica charantia* L.	Cucurbitaceae
36	Alu kesel	*Musa acuminata*	Musaceae
37	Kesel	*Musa sapientum* L.	Musaceae
38	Rampe	*Pandanus amaryllifolius* Roxb.	Pandanaceae
39	Wel dodam	*Passiflora edulis* Sims	Passifloraceae
40	Bonchi	*Phaseolus vulgaris* L.	Fabaceae
41	Bulath	*Piper betle* L.	Piperaceae
42	Gammiris	*Piper nigrum* L.	Piperaceae

43	Dambala	*Psophocarpus tetragonolobus* (L.) DC.	Fabaceae
44	Rabu	*Raphanus sativus* L.	Cruciferae
45	Ukgas	*Saccharum officinarum* L.	Gramineae
46	Chow Chow	*Sechium edule* (Jacq.)	Cucurbitaceae
47	Wambatu	*Solanum macrocarpon* L.	Solanaceae
48	Ela Batu	*Solanum melongena* L.	Solanaceae
49	Thibbatu	*Solanum violaceum* Ortega	Solanaceae
50	Kiriala	*Sonneratia alba* J. Sm.	Sonneratiaceae
51	Asamodagam	*Trachyspermum involucratum* (Roxb.) Maire	Umbeliferae
52	Pathola	*Trichosanthes anguina* L.	Cucurbitaceae
53	Ulundu	*Vigna mungo* (L.) Hepper	Fabaceae
54	Mun	*Vigna radiata* (L.) Wilczek	Fabaceae
55	Mae karal	*Vigna unguiculata* (L.) Walp. ssp. cylindrica	Fabaceae
56	Muddaraspalam	*Vitis vinifera* L.	Vitaceae
57	Desiala/Ratala	*Xanthosoma sagittifolium* (L.) Schott	Araceae
58	Bada iringu	*Zea mays* L.	Gramineae
59	Inguru	*Zingiber officinale* Roscoe	Zingiberaceae

Annex 15: Crop Species Recorded in Homegardens of India.

	Common name	**Scientific name**	**Family**
1	Ginger	*Zingiber officinale* Roscoe	Zingiberaceae
2	Balloon Vine	*Calotropis gigantea* (L.) Ait.	Asclepiadaceae
3	Sugarcane	*Saccharum officinarum* L.	Gramineae
4	Potato	*Solanum tuberosum* L.	Solanaceae
5	Pine apple	*Ananas comosus* (L.) Merr.	Bromeliaceae
6	Kind of pulse	*Cajanus cajan* (L.) Hutch	Leguminosae
7	Brinjal	*Solanum melongena* L.	Solanaceae
8	-	*Barleria lupulina* Lindl	Acanthaceae
9	A kind of gourd	*Benincasa hispida* (Thumb.) Cogn.	Cucurbitaceae
10	A kind of gourd	*Chrysanthemum coronarium* L.	Compositae
11	Pointed Gourd	*Trichosanthes dioica* Roxb.	Cucurbitaceae
12	Dahlia	*Dahlia pinnata* Cav.	Compositae
13	Paddy	*Oryza sativa* L.	Gramineae
14	Coriender seed	*Coriandrum sativum* L.	Umbelliferae
15	kind of flower	*Impatiens balsamina* L	Balsaminaceae
16	Ester	*Aster grandiflorus*	Compositae
17	Marigold	*Tagetes patula* L.	Compositae
18	Kind of flower	*Gardenia jasminoides* Ellis	Rubiaceae
19	Zinnia	*Zinnia elegans* Jacq.	Compositae
20	Rose	*Rosa Centifolia* L.	Rosaceae

21	Alligator weed	*Alternanthera philoxeroides* Griseb.	Amaranthaceae
22	Turmeric	*Curcuma longa* L.	Zingiberaceae
23	Hibiscus	*Hibiscus rosa-sinensis* L.	Malvaceae
24	Jamboline	*Syzygium cumini* (L.) Skeels.	Myrtaceae
25	Kind of flower	*Murraya paniculata* (L.) Jacq.	Rutaceae
26	Green plantain	*Musa x paradisiacal* L.	Musaceae
27	Yam	*Colocasia esculenta* (L.) Schott.	Araceae
28	Balsam apple	*Momordica charantia* L.	Cucurbitaceae
29	Cotton	*Gosssypium herbaceum* L.	Malvaceae
30	White yam	*Dioscorea alata* L.	Dioscoreaceae
31	Pumpkin	*Cucurbita pepo* L.	Cucurbitaceae
32	Banana	*Musa sapientum* L.	Musaceae
33	Terner	*Coccinia grandis* (L.) J. Voigt.	Cucurbitaceae
34	Safflower	*Carthamus tinctorius* L.	Compositae
35	Leafy vegetable	*Amaranthus caudatus* L.	Amaranthaceae
36	Chilli	*Capsicum frutescens* L.	Solanaceae
37	Leafy vegetable	*Amaranthus viridis* L.	Amaranthaceae
38	Gourd	*Lagenaria siceraria* Molina Standley	Cucurbitaceae
39	Litchi	*Litchi chinensis* Sonn.	Sapindaceae
40	Kind of flower	*Madhuca indica* J. F. Gmel	Sapotaceae
41	Pea	*Pisum sativum* L.	Leguminosae
42	Kind of flower	*Catharanthus roseus* (L.) G. Don f.	Apocynaceae
43	Spinach	*Spinacia oleracea* L	Chenopodiaceae
44	Kind of medicinal herb	*Kalanchoe pinnata* (Lam.) (pers.	Crassulaceae
45	Onion	*Allium cepa* L.	Liliaceae
46	Papaya	*Carica papaya* L.	Caricaceae
47	Leafy vegetable	*Basella rubra* L.	Basellaceae
48	Tuberose	*Polianthes tuberosa* L.	Agavaceae
49	Type of bean	*Pachyrhizus angulatus* Rich. ex DC.	Leguminosae
50	Sodom	*Calotropis procera* (Aiton) Aiton fil	Asclepiadaceae
51	Country bean	*Vicia faba* L.	Leguminosae
52	Kind of flower	*Nyctanthes arbor-tristis* L.	Oleaceae
53	Kind of flower	*Tabernaemontana coronaria* (L.) R. Br.	Apocynaceae
54	-	*Centella asiatica* (L.) Urban	Umbelliferae
55	Balsam	*Delphinium ajacis* L.	Ranunculaceae
56	Tomato	*Lycopersicon esculentum* Miller	Solanaceae
57	Holy basil	*Ocimum sanctum* L.	Labiatae
58	Ladies finger	*Abelmoschus esculentus* (L.) Monech	Malvaceae

Annex 16: Crop Spesies Recorded in Homegardens of Bangladesh.

	Common name	Scientific name	Family
1	Bean	*Lablab niger* Medikus	Leguminosae
2	Bottle gourd	*Lagenaria siceraria* (Molina) Standley	Cucurbitaceae
3	Turmeric	*Curcuma longa* L.	Zingiberaceae
4	Teasle gourd	*Momordica cochinchinensis* (Lour.) Spreng.	Cucurbitaceae
5	Chilli	*Capsicum frutescens* L.	Solanaceae
6	Radish	*Raphanus sativus* L.	Cruciferaceae
7	Pumpkin	*Cucurbita moschata* Duch.	Cucurbitaceae
8	Okra	*Abelmoschus esculentus* (L.) Monech	Malvaceae
9	Betel leaf	*Piper betle* L.	Piperaceae
10	Amaranth	*Amaranthus oleraceae*	Amaranthaceae
11	Tomato	*Lycopersicon esculentum* Miller	Solanaceae
12	Spinach	*Basella alba* L.	Basellaceae
13	Aroid	*Calocasia alba*	Araceae
14	Papaya	*Carica papaya* L.	Caricaceae
15	Banana	*Musa sapientum* L.	Musaceae
16	Ginger	*Zingiber officinale* Rosc.	Zingiberaceae
17	Cucumber	*Cucumis sativus* L.	Cucurbitaceae
18	Onion	*Allium cepa* L.	Liliaceae
19	Brinjal	*Solanum melongena* L.	Solanaceae
20	Yard long bean	*Vigna unguiculata* (L.) Walp.	Leguminosae
21	Bitter gourd	*Momordica charantia* L.	Cucurbitaceae
22	Potato	*Solanum tuberosum* L.	Solanaceae
23	Sanke gourd	*Trichosanthes anguina* L.	Cucurbitaceae
24	Ash gourd	*Benincasa hispida* (Thumb.) Cogn.	Cucurbitaceae
25	Sponge gourd	*Luffa cylindrical* L.	Cucurbitaceae

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Are Homegarden Ecosystems Resilient to Climatic Change? An Analysis of Adaptation Strategies of Homegardeners in Sri Lanka

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ABSTRACT: Homegarden ecosystems are considered to be resilient to climate change partly due to the use of efficient and effective adaptation strategies by the homegardeners. This study documents the strategies adopted by homegardeners in Sri Lanka and investigates the determinants of the choice of such strategies. Data gathered from household surveys conducted in three selected locations were analyzed to achieve the study objectives. About 52% of the homegardeners in all locations were found to be small-scale farmers (<0.5 ha) engaged in semi-subsistence farming over a long period of time. The majority (85%) of them were educated up to the primary (elementary) level. Among the homegardeners, more than 63% in Keeriyagaswewa, 54% in Pethiyagoda and 90% in Siwalakulama have not made any significant changes to the plant, tree and animal composition of homegardens over the past 20 years. A number of adaptation strategies have been used by the homegardeners enabling them to maintain diversity in the homegarden ecosystem. Changes in planting dates (37%), agronomic practices (39%), use of soil and water conservation measures (41%) and technology (55%) such as the use of new varieties and irrigation equipment, were the most commonly-used adaptation strategies. A considerable variation in the type of adaptation strategies across the households was noted. The results of the probit analysis indicate that the type of employment, age, sex, education level of household head, experience in farming, homegarden size, diversity of homegarden measured by the Shannon Weiner Index (SWI) and perceptions towards climate change, significantly influence the decision to adopt a given strategy. The development programmes to promote adaptation to climate change in homegardens should hence be designed taking the above determinants into consideration.

KEYWORDS: *Homegardens, climate change resilience, adaptation strategies*

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Session: C1 Poster: M255A

Farmer perception and adaptation to climate change in homegardens of Sri Lanka

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Homegarden (HG) agro-ecosystems are agroforestry systems in Sri Lanka that covers about 14% of the total area of the country. The HGs that are characterized by a high species diversity are viewed as resilient to climate change (CC). This study analyzed the changes in climate in two rainfall regimes i.e. dry zone (DZ) and wet zone (WZ) of the country, and examined the adaptation strategies in HGs based on perception of farmers on CC and determinants of the choice of such strategies. The trends in rainfall (average monthly and weekly), and temperature (minimum and maximum) of the selected sites were analyzed to establish CCs over 6 decades. Data gathered by a household survey conducted among 148 HGs (i.e. 59 from Keeriyagawewa (KW) and 30 from Siwalakulama (SK) in the DZ, and 59 from Pethiyagoda (PG) in the WZ were analyzed to identify the socio-economic profile of the farmers and their perception on CC, tree diversity using Shannon-Wiener Index (SWI) in HGs, CC adaptation strategies during past 2 decades and their determinants using a Probit model. The average HG size was significantly different in three study sites (0.83 ac ± 0.042 in KW, 1.01 ac ± 0.05 in SK and 0.46 ac ± 0.078, in PG; $p<0.05$). The SWI was significantly different in SK (1.75 ± 0.067) compared to that of KW (2.13 ± 0.059) and PG (2.00 ± 0.052) ($p<0.05$). Evenness calculated for HGs was not significantly different ($p>0.05$). Twenty eight species were common to all three sites where 23, 28 and 3 species were found only in KW, PG and SK, respectively. The rainfall (Rf) variability has decreased during the past decade, but the variability within a rainy season and number of consecutive dry days have increased with intense droughts and floods during the period 1990-2010. The analysis of temperature data for the same period, considering the minimum (Min) and maximum (Max) threshold for the sites as 25 and 32.5°C (KW), 22.5 and 32.5°C (SK) and 22.5 and 30°C (PG), respectively, indicated that the Min and Max temperatures and the number of warm days and nights have increased, while the number of cold days and nights has decreased. The majority of the HGs consisted of low-income farmers, mainly with primary education. In DZ-HGs, 50% of the respondents perceived that the Rf has decreased and 68% noticed that the pattern of Rf has changed, while in WZ-HG 52% perceived that Rf has increased and 72% indicated that rains come later than the previous year. About 59% of the total respondents have noticed an increase in the day temperature. Of the respondents, 120 (81% of total) have either changed planting dates of crops, introduced new technologies (e.g. new varieties, irrigation techniques), changed agronomic activities or used soil and water conservation measures in HGs during the period 1990-2010. However, only those who changed planting date of annual crops (55 respondents; i.e. 45 in KG, 8 in SK and 2 in PG) adapted the strategy directly responding to CC (i.e. delay in Rf). Respondents with education at least up to primary level and experience in agricultural activities, and those in higher income categories had a correct perception on CC. The diversity and structure of HGs varied among sites, and HGs in KW and PG showed better resilience than SK. The gender and education level of the household head, and location of the HG mainly determined the decision to practice CC adaptation strategies. The study revealed that 19% of the total farmers surveyed did not adapt strategies in HGs to cope up with CC and 44% did strategic changes to the HG agro-ecosystem without due consideration to CC.