Universität für Bodenkultur Wien
Department für Wald- und Bodenwissenschaften

Department of Forest and Soil Sciences

Institute of Forest Ecology

Head of Institute: Ao. Univ. Prof. Dr. Klaus Katzensteiner

Advisor: O. Univ. Prof. Dr. Gerhard Glatzel

Co-advisor: Ao. Univ. Prof. Dr. Monika Kriechbaum

The Present Status of the Homegardens in Galle District of Sri Lanka Affected by the December 26, 2004 Tsunami

A Comparison with Non-affected Homegardens in Connection with Restoration

Dissertation
for obtaining a Doctorate Degree
at the University of Natural Resources and Applied Life Sciences (BOKU), Vienna

Submitted by
Wijetunga Mudiyanselage Gamagedara Asanga Sanjeeva Tikiri Bandara Wijetunga

Vienna, November 2008

Declaration

I, the undersigned, hereby declare to the University of Natural Resources and Applied Life Sciences, Vienna, Austria that this is my original research work and all sources of materials used are duly acknowledged. This work has not been submitted to any other educational institution for achieving any academic degree awards.

Name: Wijetunga Mudiyanselage Gamagedara Asanga Sanjeeva Tikiri Bandara Wijetunga

Signature:

Place and Date: Vienna, November 2008

Dedication

This work is dedicated to my mother Mrs Karuna Wijetunge and my late father Mr Somathilaka Wijetunga in gratitude with love and to my two sons Haritha Chayana and Asitha Rawana with love.

Acknowledgements

First and foremost, I would like to express my heartfelt gratitude to my mother Mrs Karuna Wijetunge for upbringing me with countless sacrifices. I should mention that, my mother has not asked me for anything but my success and she has given me lot of moral support with words of encouragement in completing this study and looked after my family. "Thank you, Ammi"

A few words on paper alone will not express my gratitude to Professor Dr. Gerhard Glatzel, my Advisor for offering me the opportunity to do the doctoral study at the Institute of Forest Ecology, University of Natural Resources and Applied Life Sciences (UNI-BOKU), Vienna and for his advice, guidance, supervision and understanding throughout the study period, without which it would not have been possible to complete this study. "Thank you, Sir". Further, I would like to express my gratitude to Professor Dr. Monika Kriechbaum, my Co-advisor for her support and care.

I wish to thank Austrian Exchange Service, ÖAD for awarding me the scholarship for doctoral studies and for the financial support for my field work in Sri Lanka through North-South Dialog Programme and the staff of ÖAD Vienna Branch Office, for friendly nature extended to me throughout my study programme.

I extend my sincere gratitude to Professor Klaus Katzensteiner, Head of the Institute of Forest Ecology, the teachers and the staff including Professor Monika Sieghardth, Gerlinde Rolf, Melanie, Anita, Karin, Gabriela, Martin, Hans, Sabine, Maria and Mrs Horwarth for their enthusiasm in assisting me in various ways and my friends and colleagues at UNI-BOKU, for their friendship and support during my stay in Vienna.

My special word of thanks is due to Mrs Malini Goonetilleke, Mr Manjula Wijesundara, Dr Anjani Karunaratne, Dr Deepthi Yakandawala and Mr Neel Narampanawa at the Department of Botany and Mrs Shanthi Dharamarathne at the Department of Zology, Faculty of Science, University of Peradeniya, Sri Lanka for helping and encouraging me in various ways. My special thank is due to Mrs Carmaline Gregory Ranawana at University of Peradeniya for encouraging me to do higher studies.

I take this opportunity to thank Professor N.K.B. Adikaram, the Head and the other academic staff members, my colleagues and friends at the Department of Botany, the Dean and the staff of Dean’s Office, Faculty of Science, the administrative and the other staff members of the Non-academic Establishments Section, the Registrar and the Vice Chancellor, University of Peradeniya, Sri Lanka for the prompt attention paid in helping me in various ways.

My special thank is due to the coastal community in the villages of Galle District, Sri Lanka for their kind cooperation and support extended to me during my field survey. Further, I would like to acknowledge Sanjaya Wijekoon, Samantha Kumara Bogahapitiya, Lasantha Hettiarachchi, Janaka Athapaththu, Pradeep Nilantha Jayasena, Prasad Caldera, Sanjaya Dilshan, Jaliya Asela Wijekoon, Gayanath Jeevantha, Nuwan Jayaweera and Mr Ariyasena Silva with thanks for their tireless assistance during my field work in various ways, and Dananjaya, Raju and Kamala for their kind support during our stay at Akurala.

I wish to record my love and appreciation for the way my wife Achini handled the responsibilities of the family taking care of my sons. I am happy that she too has gained lot of experiences and matured during my absence and she is able to face any situation. My special thank is due to my sons Haritha Chayana and Asitha Rawana with love for their patience during my absence. I am very much grateful to my sister Nilakshi and brother-in-law Anurudh for supporting me with continuous encouragement and specially for looking after my two sons, pouring them with much love and care during my absence.

My special thank is due to my parents-in-law Mrs Hemalatha Wijekoon and Mr Chandrasekera Wijekoon for encouraging and helping me in various ways. I get this opportunity to acknowledge my aunty Mrs Hema Gunawardena, my uncle Mr K.W.M. Wijekoon and aunty Mrs Chandra Wijekoon, and my cousins Damayanthi, Chandimal, Ayanthi, Anusha and niece Ruwanthi with a special word of thanks for supporting me in various ways during my studies.

I appreciate the homely atmosphere created and friendly gestures extended to me by Mr and Mrs: Arjun and Nelum Witanachchi and their two daughters Savithri and Anushka and other Sri Lankan families, friends and well-wishers I met in Vienna and other provinces of Austria including Dr. Vijayarajapura Seelavansa Thero, Professor Rose Samuel and Mr and Mrs: Nihal and Pushpa Harishchandra.

The team of the EU-ASIA Link Project “Peradeniya-BOKU-Aberdeen” is acknowledged with many thanks for introducing me to my supervisor, BOKU and Vienna, Austria in summer 2004 through a technical training programme.

Last but not least, I take this opportunity to thank my grandparents, relations, teachers, friends and well-wishers who encouraged and supported me in various ways throughout my studies. In addition to my mother, late father and two sons, this work is dedicated to my wife Achini, sister Nilakshi, brother-in-law Anurudh, aunty Mrs Kudamenike Wijetunga and late aunty Mrs Chandra Gurugamage.

Abstract

Title: The Present Status of the Homegardens in Galle District of Sri Lanka Affected by the December 26, 2004 Tsunami: A Comparison with Non-affected Homegardens in Connection with Restoration

On December 26, 2004, the massive Asian Tsunami caused catastrophic damage to the community and environment of Sri Lanka. Role of vegetation in mitigating the effect of tsunami and establishment of a green belt were highlighted. A study was conducted from 2006 - 2008 in tsunami affected homegardens in Southern Sri Lanka. A questionnaire survey was done to investigate the impact of the tsunami. Then, I compared the vegetation of tsunami affected homegardens with non-affected homegardens in the 100 m belt and in the 100-200 m belt from the shoreline. Woody perennials ≥ 1 cm DBH and ≥ 1.5 m height were identified and counted in one 10 m x 10 m plot from each homegarden. Seedlings of woody perennials < 1 cm DBH and < 1.5 m height were identified and counted using one 1m x 1m quadrats within each 10 m x 10 m quadrat. Then, the composition of live fences around homegardens was studied qualitatively. Finally, surveyed the uses of selected 15 plant species and investigate the preference of integrating them by the coastal community. Questionnaire survey revealed some valuable information on the damage caused by tsunami on homegardens. Floristic richness of woody perennials was highest in the homegardens of the tsunami affected 100 m belt, while the density was highest in the non-affected 100 m belt. The total basal area was highest in the homegardens of the tsunami affected 100 m belt, while the mean DBH was highest in the affected 100 m belt. *Cocos nucifera* was the most dominant species in all 4 categories of homegardens. Woody perennial plant diversity and evenness were highest in the homegardens of the non-affected 200 m belt. Floristic richness of seedlings of woody perennial plants was highest in the homegardens of the tsunami-affected 100 m belt, while the density was highest in the homegardens of the tsunami affected 200 m belt. Diversity of seedlings of woody perennial plants was highest in the homegardens of the non-affected 200 m belt, while the evenness of seedlings of woody perennial plants was highest in the homegardens of the non-affected 100 m belt. The live fences around the coastal homegardens comprised of both native and exotic plant species and abundance of native coastal species in live fences is an important feature. Some plant species had a high demand for various purposes and some others were considered as less important by the community. *Cocos nucifera* is the most important among the 15 surveyed species and reached the highest preference by the community to integrate them in their affected coastal homegardens.

Key words: Sri Lanka, tsunami, coastal community, homegardens, vegetation, impacts

Zusammenfassung

Titel: Der Zustand der Homegarden im Galle District, Sri Lanka, drei Jahre nach der Tsunami Katastrophe vom 26. Dezember 2004

Der massive Tsunami im Indischen Ozean vom 26. Dezember 2004 verursachte auch in Sri Lanka katastrophale Schäden. In dieser Arbeit wird die Bedeutung der Vegetation, insbesondere von Schutzgürteln zur Abmilderung der Schäden untersucht. Untersuchungsobjekt waren von dem Tsunami betroffene Homgarden im Süden Sri Lankas. Mit Hilfe von Befragungen wurde das Ausmaß der Schäden von tsunami-betroffenen und nicht betroffenen Gärten innerhalb der ersten 100 m und 200 m von der Küste ermittelt. In 10 x 10 m Probeflächen wurden alle Holzpflanzen von mehr als 1 cm Durchmesser und mehr als 1,5 m Höhe aufgenommen. Zusätzlich wurden auch die dort üblichen lebenden Zäune untersucht. Letztendlich wurde die Präferenz der lokalen Bevölkerung für bestimmte Baumarten abgefragt. Die gegenwärtige pflanzliche Vielfalt an Holzpflanzen war in den vom Tsunam betroffenen Homegarden der küstennahen Zone am höchsten. Die Bestandesdichte hingegen in den nicht betroffen Gärten. Die Kokospalme war in allen 4 Kategorien die häufigste Baumart. Die floristische Vielfalt der Verjüngung von Holzpflanzen war im küstenfernen, vom Tsunami betroffenen Bereich am höchsten, während die Diversität im nicht betroffenen, küstenfernen Bereich am höchsten war. Die Evenness war in den nicht betroffenen küstennahen Gärten am höchsten. Für die lebenden Zäune werden sowohl einheimische als auch fremdländische Holzpflanzen verwendet. Der Anteil an einheimischen Küstenpflanzen ist ein wichtiger Aspekt. Die Bewohner hatten sehr klare Vorstellungen über den Nutzen und die Verwendbarkeit verschiedener Gehölze. Von den 15 untersuchten Arten ist die Kokosnuss am beliebtesten und wird wegen der vielfältigen Nutzbarkeit auch bei der Wiederherstellung verwüsteter Gärten bevorzugt. Aber auch Bäume die Holz für den Bootsbau oder Möbel liefern werden wieder gepflanzt, obwohl sie lange Zeit bis zur Nutzbarkeit benötigen.

Schlagworte: Sri Lanka, Tsunami, Küstenbereich, Homegarden, Vegetationsschäden, Vegetationszustand

Table of contents

1 Introduction

This chapter is comprised of three sections. Section (1.1) Prologue: presents a concise introduction on Sri Lanka and describes the December 26, 2004 Indian Ocean Tsunami and the damage caused by the tsunami in brief. Section (1.2) Rationale: provides the definition of the research topic (the research problem); "The Present Status of the Homegardens in Galle District of Sri Lanka Affected by the December 26, 2004 Tsunami: A Comparison with Non-affected Homegardens in Connection with Restoration" and in Section (1.3) the objectives and approaches of the study are described.

1.1 Prologue

Figure 1.1: Picturesque Akurala Beach, Galle District, Sri Lanka

Sri Lanka (The Democratic Socialist Republic of Sri Lanka) is an island in the Indian Ocean to the south of India. It is positioned between 5°55' N and 9°50' N latitudes and 79°31' E and 81°53' E longitudes. The main island of Sri Lanka has a maximum length of 435 km in the north-south direction and a maximum width of 240 km in the east west direction. The land area is 65,525 km^2; together with Internal Waters of 1,570 km^2, the area within the national boundary is 67,095 km^2 (VITHANAGE 1997). The length of the coastline is about 1,340 km. The administrative structure of Sri Lanka at present consists of 9 Provinces, 25 Districts; and further Divisional Secretary's Divisions, Grama Niladhari Divisions and Villages (LEITAN 1997); fourteen districts have coastal boundaries. The present study was conducted in some villages in Galle District (south-west oriented) of the Southern Province of Sri Lanka.

December 26, 2004 is an unforgettable day for all Sri Lankans as well as for the whole world. On that fateful day, a huge tsunami struck the Eastern and Southern coasts as well as some parts of the Northern and Western coasts of Sri Lanka and claimed many lives and caused catastrophic damage; swept people away, caused flooding and devastation of houses and infrastructure. This tsunami (the Indian Ocean Tsunami, the Boxing Day Tsunami) was caused by the great earthquake of moment magnitude 9.3 on the Richter scale in the Andaman–Sumatran subduction zone (WIJETUNGE 2006). Since many Sri Lankans did not have any pervious experience of this nature, the damage caused to their lives was unbelievable; 13 of the 14 districts situated along the coastal belt were affected. The death toll was nearly 31,000 with 21.500 people injured and about 113,700 housing units either completely or partially damaged leaving one million people homeless and causing massive disruption to livelihoods (ANONYMOUS 2005). Table 1.1 presents the December 26, 2004 tsunami: situation report of Sri Lanka as at January 31, 2005. Source: ANONYMOUS (2005).

Table 1.1: December 26, 2004 Tsunami - Situation report of Sri Lanka as at January 31, 2005

Province	District	Affected families	Displaced families	Deaths	Missing	Injured	Damaged houses	
							Completely	Partially
Northern	Jaffna	13,482	10,637	2,640	540	1,647	6,084	1,114
	Killinochchi	2,295	318	560	1	670	1,250	400
	Mullaitivu	------	6,007	3,000	433	2,590	5,033	400
Eastern	Trincomalee	30,102	27,746	1,078	337	------	5,974	10,394
	Baticaloa	63,717	12,494	2,840	952	2,375	15,477	5,541
	Ampara	38,624	32,385	10,436	876	6,365	14,403	6,940
Southern	Hambantota	16,994	3,334	4,500	963	361	2,303	1,744
	Matara	20,675	2,766	1,342	612	6,652	2,362	5,659
	Galle	24,583	1,472	4,218	554	313	5,970	6,529
Western	Kalutara	6,905	6,905	256	155	400	2,780	3,116
	Colombo	9,647	5,290	79	12	64	3,398	2,210
	Gampaha	6,827	308	6	5	3	292	307
North Western	Puttalam	232	18	4	3	1	23	72
Total	13 districts	234,083	109,680	30,959	5,443	21,441	65,349	48,272

Considerable amount of vegetation and ecosystems along the coast also got damaged due to tsunami and at the same time it is assumed that some areas were protected and the damage had been mitigated significantly by the vegetation cover against tsunami. It is believed that the destruction of vegetation near coastal zones was partly due to damage from salt water intrusion, which caused a die-off of the affected lowland forests.

Figure 1.2: Damage caused by tsunami to the southern railway line (a), A-2 highway (b) and coastal houses (c) and (d); a few days (c) and 2 years (d) after tsunami

After the Tsunami disaster, several discussions, workshops and seminars were held by some leading institutes, authorities and scientists from Universities in Sri Lanka on natural disaster management systems in the future for all natural disasters such as cyclones, floods, landslides, coastal erosion and sea level rise.

“No build zone” of 100 m width from the high water mark for immediate activities to protect lives, property and the coast has been identified and declared by the Ministry of Urban Development and Water Supply, Sri Lanka (MINISTRY OF URBAN DEVELOPMENT et al. 2005). It was suggested that the “no build zone” should be treated as a “Green Buffer Zone”. It was recommended that the demarcation of this zone should be defined scientifically taking some criteria into account. One of them was, the contour of the affected area based on vegetation and the protective reefs. It was also suggested that the “Green Buffer Zone” could save as a safety buffer by introducing suitable plant species for various climatic and soil conditions, with landscape architecture, and thus would be of both aesthetic and economic value.

Figure 1.3: Coastal vegetation – Bentota beach, Galle District, Sri Lanka (before December 24, 2006 tsunami)

Some areas of research that need immediate attention were identified. "Studies on the vegetation that resisted the tsunami (taking into account the mangroves, coconut trees and other species)" is one of them. Importance of the selection of suitable trees for replanting programmes considering the characters possessed by the trees which were resistant to the effect of tsunami was highlighted.

Accordingly, the importance of adequate and suitable vegetation along the coast line in order to mitigate the harm from natural disasters like tsunami and cyclones is obvious. Hence, the present study was proposed to investigate the present status of the vegetation in homegardens of some selected coastal villages in the Galle District, in the Southern Province of Sri Lanka in connection with restoration (regreening) of them; and to find out, by interviewing the community, the preferable plant species for this purpose. This study was conducted during the periods from March to September 2006 and August 2007 to March 2008. A study of this nature would be of immense benefit to the country in future regreening programmes in coastal belt in order to mitigate the damage due to the unexpected sea borne natural hazards.

1.2 Rationale

On 26th of December 2004, a huge tsunami in South East Asia claimed many lives and caused catastrophic damage, both to the community and to the natural and built environment in Sri Lanka. Impact on vegetation and the role of vegetation in mitigating the effect of tsunami were highlighted. The regreening or establishment of a green belt along the coast was at high priority at that time and construction work was banded in the first 100 m from the shoreline.

Restoration of mangroves was one of the major events taken place just after the disaster and also the research and surveys were mainly focused on mangroves (DAHDOUH-GUEBAS et al. 2005, KATHIRESAN and RAJENDRAN 2005 etc.). Studies on the role of non-mangrove vegetation were of lesser priority, except of a few (JAYATISSA et al. 2006).

Sri Lankan mangroves are not extensive and are often limited to narrow strips. The country has only about 100 km^2 of mangroves. Their extent is small compared to other coastal vegetation and land use. Sri Lankan mangrove forests have become reduced and fragile and cannot withstand a high degree of exploitation, as being done in other countries. Our mangroves are found bordering lagoons and estuaries and the length of the shoreline containing mangrove formations in Sri Lanka is said to be about 500 km (DE SILVA and DE SILVA 2006), and it is about 37% of the shoreline (1,340 km). Most of the mangrove areas have been subjected to human interference for a long time and the full effect of 2004 tsunami on our mangroves has not yet been estimated (DE SILVA and DE SILVA 2006). However, replanting of mangroves can only be done in the sheltered areas suitable for them.

Nearly 60% of the coastline consists of non-mangrove vegetation. Dense and open coastal forest areas are limited only along the southeastern (Yala / Ruhunu National Park and Bundala National Park) and northwestern (Wilpattu National Park) parts of the country; some forest patches are scattered along the coast line: the majority of them are arid scrublands and others are sand dune vegetation. *Casuarina equisetifolia* plantations can also be found in some areas, especially Hambantota. *Prosopis juliflora* (Mesquite) and *Opuntia dillenii* (Prickly pear cactus) invasion is nowadays at a problematic level in the southern and southeastern part of the county. Most of the costal belt is nowadays comprised of manmade ecosystems, in particular Coconut plantations, Palmyra plantations, homegardens (mainly), parks, hotels and recreational areas. Therefore, the studies on suitable non-mangrove species are essential for the future regreening programmes of the coastline.

Some tree species have already been planted along the road sides in the tsunami affected coastal zones by Government Institutions and/or Non Governmental Organizations (NGO) during the last 2 years. In addition to that, some plant species have been distributed among villagers to grow in their homegardens within the first few months after the tsunami disaster. Some programmes were unsuccessful, as the community was not satisfied with the plants they have been given and on the other hand some species were not suitable for the prevailing conditions of the coastal zone. Some of the green belts established soon after the tsunami are composed of only one (monocultures) or two species of plants; the spacing is in most cases inappropriate; consequently some of these new belts aesthetically do not blend with the typical natural environment.

Instead of establishing only green belts along the coastline, strengthening the coastal homegardens with suitable tree species is more appropriate and may cause less conflict. The trees used in this practice must definitely be useful for the coastal community (i.e. multipurpose tree species) as well as they must be with suitable properties to mitigate the natural disasters. Hence, the integration of both types of species in regreening programmes is suggested. Screening of the suitable trees must essentially be performed with the community participation; otherwise the feasibility and the progress of such programmes will always encounter problems in the future.

1.3 Objectives and Approaches

This study was planned to investigate the present status of the homegardens in some selected locations (villages) in Galle district of Sri Lanka affected by the December 26, 2004 tsunami, a comparison with non-affected homegardens in order to assess the feasibility of restoration (regreening) with the following specific objectives.

1 Investigate the impact of tsunami on homegarden vegetation, explore the survived vegetation and find out the role of vegetation during tsunami and aftermath flooding.

2 Compare the present status, vegetation structure and composition of affected homegardens with non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline.

3 Investigate the ground layer vegetation of affected homegardens and non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline in order to survey the regeneration of woody perennials.

4 Survey the live fence species in the selected homegardens

5 Survey the uses of selected 15 plant species.

6 Investigate the preference of integrate the selected 15 plant species in the home gardens.

A summary on the approaches involved in the present study is given in Table 1.2. It was initially planned to conduct a survey on the preference of coastal vegetation and coastal regreening programme by both the local and the foreign visitors (tourists) at seaside of southern Sri Lanka, as the final part of the study. However, it was not possible to conduct the survey as a sufficient number of tourists (a test sample) was not available in the coastal area during the study period due to the security condition of the country prevailed at that time.

Table 1.2: A summary of the approaches involved in the present study

No.	Objective	Method involved	Size of the sample	Nature of the expected information
1	Impact of tsunami on homegarden vegetation	Questionnaire Survey among randomly selected house holds in the selected tsunami affected villages (Distributed and collected)	126	Qualitative Semi-quantitative
2	Survived vegetation after the tsunami	Questionnaire Survey among randomly selected house holds in the selected tsunami affected villages (Distributed and collected)	126	Qualitative Semi-quantitative
3	Role of vegetation during tsunami and aftermath	Questionnaire Survey among randomly selected house holds in the selected tsunami affected villages (Distributed and collected)	126	Qualitative Semi-quantitative
4	Comparison of present status of affected homegardens with non-affected Structure and Composition	Homegardens were selected randomly from tsunami affected areas and adjacent non-affected areas in 0-100 m belt and 100-200 m belt from the shoreline, i.e. there were 4 categories viz. 1. Tsunami affected within 0-100 m from shoreline 2. Tsunami affected within 100-200 m from shoreline 3. Tsunami non-affected within 0-100 m from shoreline 4. Tsunami non-affected within 100-200 m from shoreline Carried out plot sampling in 10mX10m quadrats.	240 samples altogether and distributed in 4 categories as follows: 1. 60 2. 60 3. 60 4. 60	Quantitative

No.	Objective	Method involved	Size of the sample	Nature of the expected information
5	Ground layer vegetation Regenerationof woody perennials	Homegardens were selected randomly from tsunami affected areas and adjacent non-affected areas in 0-100 m belt and 100-200 m belt from the shoreline, i.e. there were 4 categories viz. 1. Tsunami affected within 0-100 m from shoreline 2. Tsunami affected within 100-200 m from shoreline 3. Tsunami non-affected within 0-100 m from shoreline 4. Tsunami non-affected within 100-200 m from shoreline Carried out plot sampling using 1mX1m quadrats.	240 samples altogether and distributed in 4 categories as follows: 1. 60 2. 60 3. 60 4. 60	Quantitative
6	Live fence species around the homegardens	Observations of live fence species around the homegardens (randomly selected) in 4 categories 1. Tsunami affected within 0-100 m from shoreline 2. Tsunami affected within 100-200 m from shoreline 3. Tsunami non-affected within 0-100 m from shoreline 4. Tsunami non-affected within 100-200 m from shoreline	240 samples altogether 1. 60 2. 60 3. 60 4. 60	Qualitative Semi-quantitative
7	Preference of selected 15 plant species by the community	Questionnaire Survey (Explained and allowed to select)	150	Quantitative
8	Uses of selected 15 plant speceis	Questionnaire Survey (Interviewed)	150	Qualitative

2 Literature Review

This chapter starts with an introduction, giving definitions to natural hazards and natural disasters with special emphasise on tsunami facts (Section 2.1). Then the past tsunami records in Sri Lankan history is described briefly (Section 2.2). In Section 2.3, literature (studies) related to December 26, 2004 tsunami in Sri Lanka and other countries (impacts on vegetation and mitigation of impacts by vegetation) are presented. Other relevant information and studies on the 2004 Indian Ocean tsunami (non-vegetational) is given in Section 2.4. Some details on homegardens and live fences are given in Section 2.5. Bibliographies, data bases and reviews on various tsunami studies are presented in Section 2.6 (for further reference) at the end of this chapter.

2.1 Natural hazards, natural disasters and tsunami facts

A natural hazard is a threat of an event that will have a negative effect on people or the environment. Many natural hazards are related, e.g. earthquakes can result in tsunamis, and drought can lead directly to famine and disease. Hazards are consequently relating to a future occurrence and disasters to past or current occurrences.

A natural disaster is the consequence of a natural hazard which affects human activities. Human vulnerability, exacerbated by the lack of planning or lack of appropriate emergency management, leads to financial, environmental and human losses. The resulting loss depends on the capacity of the population to support or resist the disaster, their resilience. This understanding is concentrated in the formulation: "disasters occur when hazards meet vulnerability”. A natural hazard will hence never result in a natural disaster in areas without vulnerability, e.g. strong earthquakes in uninhabited areas. The term natural has consequently been disputed because the events simply are not hazards or disasters without human involvement (WIKIPEDIA 2008b).

Avalanches, earthquakes, lahars, landslides and mudflows, volcanic eruptions, floods, limnic eruptions (spontaneous release of dissolved gas), tsunamis, blizzards, droughts, hailstorms, heat waves, cyclonic storms, epidemics, famines, fires, space impact events and solar flare are the various natural disasters occurred time to time in the world. At present the frequency of occurrence of some calamities seems to be increasing, may be with the change of world climatic conditions or denser human population and more infrastructures in formerly sparsely inhabitated areas outside the reach of the media. A summarized classification of natural disasters is given in the Figure 2.1.

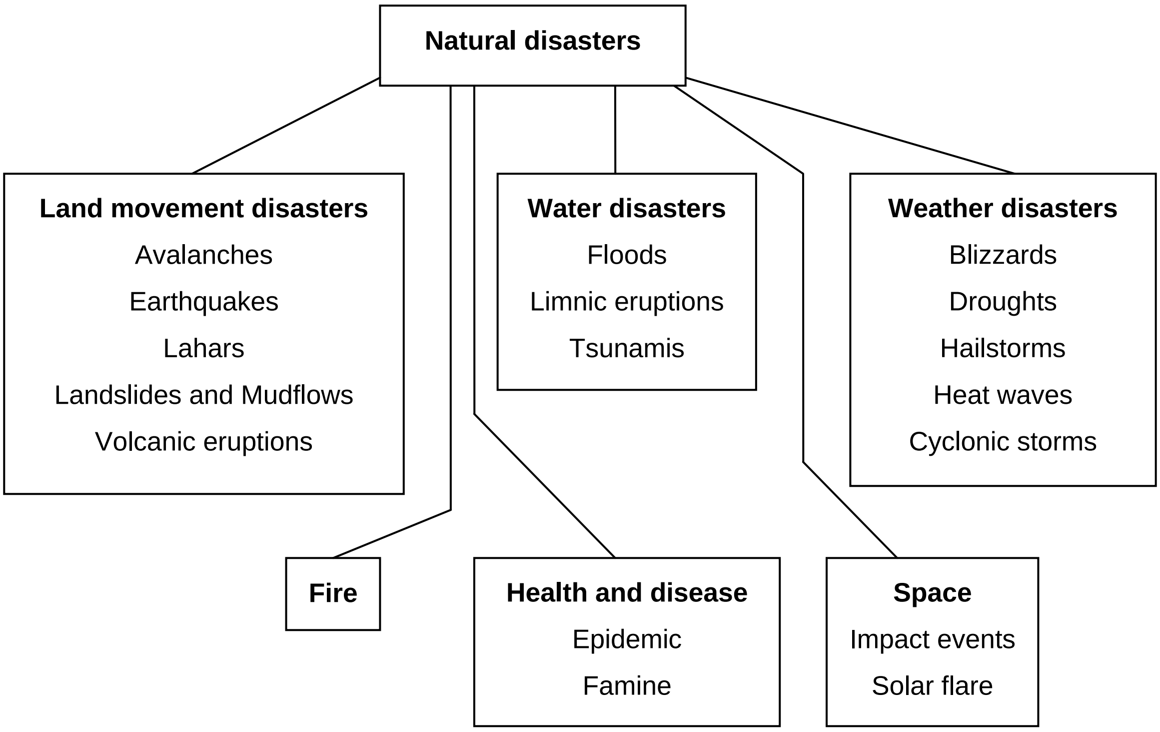

Figure 2.1: Classification of natural disasters (Source: WIKIPEDIA 2008b).

A tsunami is a very long ocean wave that is generated by a sudden displacement of the sea floor. The term is derived from a Japanese word meaning “harbour wave” or “bay mouth wave”. Tsunamis are sometimes referred to as seismic sea waves because submarine and near-coast earthquakes are their primary cause. They are also popularly called “tidal waves”, but this is a misnomer; tsunamis have nothing to do with tides (BIRKELAND and LARSON 1989; MURCK et al. 1996). A tsunami which causes damage far away from its source is sometimes called a "teletsunami", and is much more likely to be produced by vertical motion of the seabed than by horizontal motion (WIKIPEDIA 2008a).

The Greek historian Thucydides was the first to relate tsunamis to submarine quakes, but understanding of the nature of tsunamis remained slim until the 20th century and is the subject of ongoing research (WIKIPEDIA 2008d).

WIKIPEDIA (2008d) dubiously reports that the only other language than Japanese that has a word for this disastrous wave is Tamil language and the word is "Aazhi Peralai". The South Eastern coast of India has experienced these waves some 700 years ago and it seems to have been a familiar event at that time as the stone carvings (scriptures in stone) read. However, according to HARINARAYANA and HIRATA (2005) meanings of the word tsunami found in the literature include seismic sea wave, Flutwellen, vloedgolven, raz de mare, vagues sismique, maremoto and they also reported that the term tidal wave was also used earlier in a general sense but now it is considered as incorrect.

Sea-borne hazards or coastal hazards can conveniently be classified as ‘‘fast’’ and ‘‘slow’’ hazards and can also be divided into ‘‘physical’’, e.g. sea level rise, wave impacts and beach erosion, and ‘‘chemical–biological’’ hazards, e.g. pollution and eutrophication-triggered algal blooms. Accordingly tsunami is a “fast physical hazard” (Figure 2.2). The main natural sea-borne ‘‘fast’’ wave hazards in South East Asia are cyclone-driven storm surges and tsunamis. On most coastlines, cyclone storms and associated storm surges are far commoner than tsunamis. Although storm surges normally hit the coast at lower speeds than tsunamis, the continued driving force of wind may cause them to penetrate deeply inland. Indeed, large storm surges persisting for several hours during a cyclone may cause greater physical destruction to infrastructure and ecosystems (KRISHNA 2005; COCHARD et al. 2008).

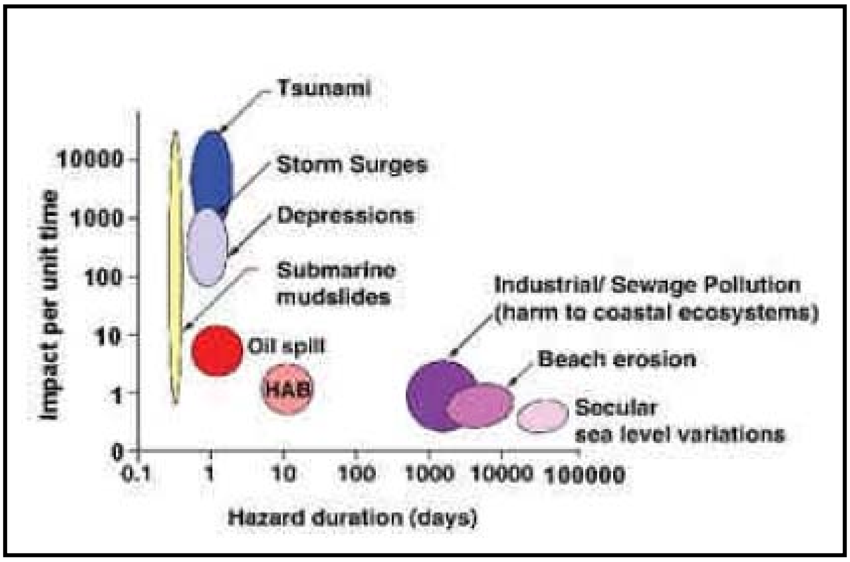

Figure 2.2: Schematic of each coastal hazard in terms of duration of an event (abscissa) and its impact on life and property per unit time (ordinate). HAB: Harmful algal blooms (Source KRISHNA 2005)**.**

Tsunamis can occur with little or no warning, bringing death and massive destruction to coastal communities and as mentioned above they are usually generated in response to disturbances on the ocean floor, such as fault displacement or earthquake-caused landslides. Other possible causes are related to volcanism. One could be an underwater volcanic blast. Another could be the formation of caldera at or below sea level. Common to all causes is the instantaneous displacement of large volumes of water, usually to the sea floor. In contrast, ordinary waves are formed gradually by the frictional drag of air masses over water and only a surface skim of the ocean (BIRKELAND and LARSON 1989; MURCK et al. 1996).

DAWSON et al. (2004) properly presents 6 types of tsunami sources as follows: (1) Offshore earthquake associated with localized vertical displacement (faulting) of the seabed, (2) Underwater sediment slide, (3) Offshore earthquake that causes not only seafloor displacement but also an underwater sediment slide(s) [a variety of (1) and (2)], (4) Asteroid (bolide) impact (5) Landslide originating above sea level that rapidly moves into the sea (includes also the collapse of the flank of a volcano into the ocean) and (6) Collapse of a volcanic crater into the sea. Additionally, tsunamis can also be occurred as results of underwater explosions and nuclear earthquakes due to nuclear explosions (PREMASIRI and ABEYSINGHE 2005; FAGHERAZZI and DU 2007).

Tsunami-like waves, a related phenomenon sometimes occurred in enclosed bodies of water such as lakes, bays and reservoirs, known as Seiches. Seiches are usually caused by unusual winds, currents or changes in atmospheric conditions (MURCK et al. 1996).

2.2 Past tsunami records in Sri Lankan history

Sri Lanka's local tradition holds that the overflow of the ocean has occurred several times during prehistoric times, submerging large areas in the country. Very little information is available on the nature and extent of damage and loss of life, and there is no information on the location of some earthquakes that led to tsunami events in Sri Lanka in the past.

There are Greek, Indian and Sri Lankan accounts which support that an earthquake and a tsunami occurred in the South Asian region around 325 – 326 B.C. However, the reports and dates on this event are somewhat conflicting as to whether it occurred in 325 BC or 326 BC. According to the Sri Lanka records, the reported tsunami was the same that destroyed the ancient city of Kalyani Kanika and other townships along the Eastern Seaboard of the island. However, the dates do not match, since the tsunami in Sri Lanka is purported to have occurred at the time of King Kelanitissa - in the 2nd Century BC (PARARAS-CARAYANNIS 2006).

The ancient chronicles Rajawaliya and the Mahawamsa have preserved the memory of the overflow of the ocean which occurred in the 2nd century BC, over 2200 years ago, during the reigns of King Kelanitissa (Maya Rata in the West) and King Kawantissa (Ruhunu Rata in the South). The interesting story of Viharamahadevi is associated with this Tsunami. The story goes that King Kelanitissa who, in the 2nd century BC, angered over a love affair between his wife and his brother, executed a Buddhist monk. The story continues that the Devas of the sea and the guardian deities of Sri Lanka were angered by this rash act and the sea began to encroach rapidly upon the west coast of the country. Kelaniya, which was then seven gawwas (45 km) away from the sea, was reduced to less than six. To appease the 'Devas' of the sea, much against the king's will, his daughter, princess Devi was placed in a boat and launched into the ocean as a form of sacrifice. The floods then subsided and upon hearing the stories of the havoc wrought by the waters, the king proceeded to view the devastated land. Princes Devi had safely landed at Kirinda in the Southern province. She was rescued by King Kawantissa. According to the Mahawamsa, King Kavantissa married her and she, Viharamahadevi became the mother of Dutugemunu one of Sri Lanka's most heroic kings (HEWAPATHIRANE 2005; PANAGODA and WITHANAGE 2005; PARARAS-CARAYANNIS 2006).

In 17th and 19th centuries there had been two occasions that Sri Lankans have died due to the flooding of the sea due to tsunamis (PANAGODA and WITHANAGE 2005). A tsunami was generated in the Bay of Bengal by an earthquake occurred at Car Nicobar Island on December 31, 1881. Waves attributed to this tsunami were also observed at Batticaloa and Trincomalee on the east coast of Sri Lanka on January 01, 1882 (BERNINGHAUSEN 1966 in RASTOGI and JAISWAL 2006). As DOERNER et al. (2008) reports, since the time when British took over power in Sri Lanka in 1796 and in the time after the British government, two tsunami occurrences have been recorded: In 1883, a tsunami with a run-up height of 1.2 m was observed (Note: The average run-up height of the 2004 tsunami was about 6.5 m near Galle).

2.3 December 26, 2004 Asian tsunami: Impacts on vegetation and mitigation of impacts by vegetation, studies done in Sri Lanka and/or other affected countries

There is considerable evidence that coastal forests can reduce the force, depth and velocity of a tsunami, lessening damage to property and reducing loss of life. Numerous anecdotes, field surveys and scientific studies in India, Indonesia, Japan, Malaysia, Maldives, Myanmar, Sri Lanka, and Thailand of the 2004 tsunami and other tsunamis show a connection between areas with the highest levels of damage and the absence of coastal forests (FORBES and BROADHEAD 2007).

In the case of mangroves, for any particular elevation or distance from the sea front, tsunami hazard is consistently lower for areas behind mangroves. Furthermore, plantations of pine in Japan have proved effective against various tsunamis. Many *Casuarina* shelterbelts in India, Sri Lanka and Thailand, established to protect coasts from cyclones, tsunami and other coastal hazards were effective against the 2004 Indian Ocean tsunami as well. Natural beach forests and plantations of tree crops, such as cashew nut with their low, widely branching canopies or *Pandanus* with mangrove-like stilt roots and dense foliage, have also protected coasts in many instances. There are also a significant number of cases where coastal forests failed to protect coastlines from a tsunami. Rather than an indictment of coastal forests in general, however, these failures can be attributed to a rare, massively large tsunami or insufficiency of one or more forest attributes such as forest width, density, age or some other parameter important in providing protection. This was frequently the case with degraded or altered beach forests with widely spaced trees, replacement tree species susceptible to breaking, or sparse undergrowth (FORBES and BROADHEAD 2007).

Similarly, in Sri Lanka, *Rhizophora* spp. and *Ceriops* spp. were severely damaged in the first 2-3 meters, while the remaining 3-4 meters were much less damaged by a 6 meter tsunami. Once the destructive forces are spent, the remaining forest will further mitigate the tsunami flow. In beach forests, sufficient forest width is necessary to absorb enough of the tsunami's energy to reduce flow velocity and depth before exiting the forest. In Indonesia, for example, 40 meters of beach forest was effective in the 2006 West Java tsunami in reducing 6-7 meter waves to just 1.6 meters (LATIEF and HADI 2006). In Sri Lanka, *Pandanus* spp. and *Cocos nucifera* arrested the 2004 tsunami at 100 meters for 4.5-5.5 meter wave (RANASINGHE, 2006), and elsewhere at 155 meters for a 6.0 meter wave (TANAKA et al. 2007). However, it is likely that coconut trees contributed significantly less than the *Pandanus* given the relative difference demonstrated elsewhere in Sri Lanka: *Pandanus* belts, 10 meters in width reduced inundation distance by 24 percent while 110 meters width of coconut trees was necessary for an equivalent reduction. Similarly, a band of *Pandanus* in front of a coconut grove 100 meters in width reduced the distance by another 30 percent. The difference in mitigation capacity is attributed to the greater density of the *Pandanus* (FORBES and BROADHEAD 2007).

In other instances, forests failed to protect coasts during the 2004 tsunami. Insufficient width was one cause. For example, in Sri Lanka an area of highly populated settlements behind shelterbelt plantations of *Casuarina equisetifolia* were not protected. The shelterbelts were, however, only 10-15 meters wide and were themselves badly damaged, which indicates the trees were perhaps also not very large as maximum wave heights were only 6-9 meters. For other species, even a width of 200 meters may be insufficient. Evidence, also from Sri Lanka, documents that a 200 meter wide mangrove of *Sonneratia* spp. were uprooted or collapsed under the tsunami. Factors other than width, such as immaturity, stem diameter, or anchorage strength, may have contributed to the failure. The mitigation effects for a simulated coastal forest of *Hibiscus tiliaceus* at Sissano, Papua New Guinea have shown a substantial reduction in inundation depth and hydraulic force (FORBES and BROADHEAD 2007).

Post-tsunami field surveys in Sri Lanka and Thailand showed that older *Casuarina equisetifolia* shelterbelts withstood the tsunami, but failed to provide protection (TANAKA et al. 2007). The tsunami passed through the shelterbelt without resistance from lower-level branches or undergrowth, a condition typical of the species. For a coastal forest of mature *Casuarina* the mitigation effect is marginal and only slightly more than *Cocos nucifera*. Very young stands, on the other hand, less than 10-15 cm diameter were uprooted and washed away providing no mitigation. A similar forest-age effect was found for *Manilkara spp.* in Sri Lanka (TANAKA et al. 2007).

Typical widths of shelterbelts in Sri Lanka and India are in the range of 10 to 20 meters. In the face of the 2004 tsunami, either the trees were too young (2 years old) so that they were uprooted and swept away or too old and hence provided little resistance because of the moderately wide spacing and species' minimal branching at lower levels. Shelterbelts of an intermediate age would have provided more protection. In India, houses situated within plantations were mostly protected by 35-year old shelterbelts with average diameters at breast height of about 10-20 cm and densities of 19-22 trees per 100 m^2 (DANIELSEN et al. 2005). At 200 meters in width, however, they were 10 times the width of typical shelterbelts, which makes direct comparison with earlier mentioned cases difficult.

With regard to altered forests, which are characterized by a significant proportion of tree species not native to beach forests, evidence from Sri Lanka suggests that introduced ornamental and fruit tree species broke more easily than native species when struck by the tsunami. Replacing species adapted to storm waves and winds, these introduced species diminish the overall mitigation capacity of the beach forest. However, this does not imply that all native species retained in the altered forest have high breaking strengths. For example, *Borassus flabellifer* (Palmyra) is more vulnerable to tsunamis than *Cocos nucifera* (FORBES and BROADHEAD 2007).

The study of TANAKA et al. (2007) explored the effects of coastal vegetation on tsunami damage based on field observations carried out after the Indian Ocean tsunami 2004. Study locations covered about 250 km on the southern coast of Sri Lanka (19 locations) and about 200 km on the Andaman coast of Thailand (29 locations). The representative vegetation was classified into six types according to their habitat and the stand structures of the trees. The impact of vegetation structure on drag forces was analyzed using the observed characteristics of the tree species. They showed that the drag coefficient, including the vertical stand structures of trees, $C_{d\text{-}all}$, and the vegetation thickness (cumulative trunk diameter of vegetation in the tsunami direction) per unit area, dN_u (d: reference diameter of trees, N_u: number of trees per unit area), varied greatly with the species classification. Based on their field survey and data analysis, *Rhizophora apiculata* and *R. mucronata* (*R. apiculata type*), kinds of mangroves, and *Pandanus odoratissimus* (a representative tree that grows in beach sand) were found to be especially effective in providing protection from tsunami damage due to their complex aerial root structure. Further it is stated that two layers of vegetation in the vertical direction with *P. odoratissimus* and *Casuarina equisetifolia* and a horizontal vegetation structure of small and large diameter trees were also important for increasing drag and trapping floating objects, broken branches, houses, and people.

TANAKA et al. (2007) also found that the vertical structure too provided an effective soft landing for people washed up by the tsunami or for escaping when the tsunami waves hit, although its dN_u is not large compared with *R. apiculata* type and *P. odoratissimus*. In addition, the creeks inside mangroves and the gaps inside *C. equisetifolia* vegetation are assumed to be effective for retarding tsunami waves and they suggested the information presented them should be considered in future coastal landscape planning, rehabilitation, and coastal resource management.

Mangrove forests thrive in the intertidal zones of tropical and subtropical coasts. They have several ecological, socioeconomical, and physical functions that are essential in maintaining biodiversity and protecting human populations. Their complex architecture, combined with their location on the edge of land and sea, makes mangrove forests strategic greenbelts that have a doubly protective function. They protect seaward habitats against influences from land, and they protect the landward coastal zone against influences from the ocean. The tsunami that occurred on December 26, 2004, revealed the valuable buffering functions of mangroves (DAHDOUH-GUEBAS 2006).

Forest width is one of the most important factors in mitigation. Over the width of the forest, energy is progressively dissipated by drag and other forces created by tree trunks, branches and foliage, as well as the undergrowth, as the tsunami passes through the forest. Even when energy levels are high, the width effect remains strong. There is evidence that some coastal areas very close to the epicentre of the earthquake that caused the 2004 Indian Ocean tsunami were protected by extensive mangroves. In a few locations on the Aceh coast, Nicobar Islands and Andaman coast, mangroves were sufficiently wide to mitigate the massive near-field tsunami. Width effect remains intact under a broad range of conditions. Simulations show a coastal forest of 200 meters width reduced the hydraulic force of a three meter tsunami by at least 80 percent, and flow velocity by 70 percent for all scenarios examined (HARADA and IMAMURA 2003).

Forest age (the average age of trees of the dominant size class) is directly correlated with both tree height and diameter. Increases in age, diameter and height generally enhance the mitigation effects of coastal forests. Diameter growth also enhances the breaking strength of trunks and branches. It also raises the resistance of the forest being toppled, up to a point after which resistance falls. On more mature stems the rate of increase in strength, stiffness and diameter slows relative to accumulation of mass in the canopy such that mechanical failure is more likely if the tree is subjected to an external force. Simulation exercises for forest widths of 200 meters show that forest growth or aging can have a significant effect on tsunami mitigation (HARADA and KAWATA 2005).

A study conducted by KATHIRESAN and RAJENDRAN (2005) after the 2004 Indian Ocean tsunami in 18 coastal hamlets along the south-east coast of India reiterates the importance of coastal mangrove vegetations and location characteristics of human inhabitation to protect lives and wealth from the ferocity of tsunami. They stated that the tsunami caused human death (number of human casualties) and loss of wealth and these decreased with three potential predictor variables viz. area of fore-lying coastal vegetation cover, distance from the sea edge and elevation above sea level of human inhabitation. Furthermore they suggested that human inhabitation should be encouraged and permitted more than 1 km from the shoreline in elevated places, behind dense mangroves and or other coastal vegetation but not in front of the forest. They have recommended that the habitats between human inhabitations and sea should be planted with suitable plant species to protect the coastal lives against natural calamities and some plant species, suitable to grow on mangroves (intertidal, estuarine and backwater areas), embryonic dunes, mid shore dunes and hind shore dunes for coastal protection, are suggested. However, the results of KATHIRESAN and RAJENDRAN (2005) have been criticized by KERR et al. (2006) and indicated some errors. Their findings have further been explained by KATHIRESAN and RAJENDRAN (2006) as a reply for KERR et al. (2006) with some other previous evidences to support their results. Results of KATHIRESAN and RAJENDRAN (2005) has further been analyzed and explained by VERMAAT and THAMPANYA (2006).

Review of ALONGI (2008) assesses the degree of resilience of mangrove forests to large, infrequent disturbance like tsunamis and their role in coastal protection, and to chronic disturbance events like climate change and the future of mangroves in the face of global change. According to this author, from a geological perspective, mangroves come and go at considerable speed with the current distribution of forests a legacy of the Holocene, having undergone almost chronic disturbance as a result of fluctuations in sea level. Mangroves have demonstrated considerable resilience over timescales commensurate with shoreline evolution. This notion is supported by evidence that soil accretion rates in mangrove forests are currently keeping pace with mean sea-level rise. Further support for their resilience comes from patterns of recovery from natural disturbances such as storms and hurricanes which coupled with key life history traits, suggest pioneer-phase characteristics.

ALONGI (2008) further states that the stand composition and forest structure are the result of a complex interplay of physiological tolerances and competitive interactions leading to a mosaic of interrupted or arrested succession sequences, in response to physical/chemical gradients and landform changes; the extent to which some or all of these factors come into play depends on the frequency, intensity, size, and duration of the disturbance. ALONGI (2008) also states that mangroves may in certain circumstances offer limited protection from tsunamis; some models using realistic forest variables suggest significant reduction in tsunami wave flow pressure for forests at least 100 m in width. The magnitude of energy absorption strongly depends on tree density, stem and root diameter, shore slope, bathymetry, spectral characteristics of incident waves, and tidal stage upon entering the forest.

Surveys of villages in Sri Lanka and post-tsunami observations of DAHDOUH-GUEBAS et al. (2005) make it clear that mangroves play a critical role in storm protection, but with the subtle point that this all depends on the quality of the mangrove forest. They also found that there can be contributions to protection against ocean surges from other coastal vegetation types: salt marshes, seashores sand dunes and their vegetation. The more general message is that how humans use, plan and manage their habitats and landscapes can have profound and undesirable consequences. The conversion of mangrove land into shrimp farms, tourist resorts, agricultural or urban land over the past decades as well as destruction of coral reefs off the coast, have likely contributed significantly to the catastrophic loss of human lives and settlements during the recent tsunami event. DAHDOUH-GUEBAS et al. (2005) further states that, while it may be a good investment to establish early warning systems for the next tsunami, it could be far more effective to restore and protect mangrove forests and other natural defences in parallel.

DAHDOUH-GUEBAS AND KOEDAM (2006) stated that the concept of cryptic ecological degradation in mangrove forests of Sri Lanka is even more important in light of these forests having provided less protection during the recent tsunami. Unprotected villages in the northern portion of the study site were compared with villages partly protected by *Casuarina* in the south, but no villages with and without mangroves were equidistant from the coast. Their results and data from Sri Lanka suggest that by maintaining or planting coastal forests, humans enhance protection of coastal areas against tsunamis. Observations of tropical cyclone impact further suggest the need for a coordinated strategy to maintain or restore coastal wetlands, forests, or sand dunes, especially along vulnerable tropical and subtropical coastlines. They further state that, such a strategy would not only provide protection against tsunamis but also mitigate the impacts of storms and sea level rise.

According to GIRI et al. (2008), the tsunami-affected coastal areas of Indonesia, Malaysia, Thailand, Burma (Myanmar), Bangladesh, India and Sri Lanka in Asia lost 12% of its mangrove forests from 1975 to 2005, to a present extent of c. 1,670,000 ha. Rates and causes of deforestation varied both spatially and temporally. Annual deforestation was highest in Burma (c. 1%) and lowest in Sri Lanka (0.1%). In contrast, mangrove forests in India and Bangladesh remained unchanged or gained a small percentage. Net deforestation peaked at 137,000 ha during 1990–2000, increasing from 97,000 ha during 1975–90, and declining to 14,000 ha during 2000–05. The major causes of deforestation were agricultural expansion (81%), aquaculture (12%) and urban development (2%). GIRI et al. (2008) assessed and monitored mangrove forests in the tsunami-affected region of Asia using the historical archive of Landsat data. They also measured the rates of change and determined possible causes. The results of their study can be used to better understand the role of mangrove forests in saving lives and property from natural disasters such as the Indian

Ocean tsunami, and to identify possible areas for conservation, restoration and rehabilitation. GUNAWARDENA and ROWAN (2005) has highlighted the importance of mangroves as barriers in mitigating natural disasters. According the study of GUNAWARDENA and ROWAN (2005) it is clear the increasing threat on Mangrove ecosystems in Sri Lanka from development projects, especially shrimp aquaculture.

In the Maldive Islands, the coastal vegetation provided important protection to the residents of the islands. Where the vegetation was thick, it provided significant protection to the buildings, and limited the damage by tsunami impact. Where vegetation was missing the tsunami flood inundated the buildings, breaking down concrete block walls, breaking in windows, tearing off front and back doors, etc. as well as flooding the buildings (KEATING and HELSLEY 2005).

According to KEATING and HELSLEY (2005), many people of the Maldives have recommended that mangrove vegetation is useful for coastal protection in similar disasters. Conceptually that is a valid suggestion, but in practice it has proved problematic. Mangroves are extremely invasive plants. Furthermore, some mangroves are nuisance plants, since stand may become so dense that they often become barriers that make it impossible to reach the ocean. Although it might protect portions of the coastline, it would virtually consume all of the land area on these small islands if left unchecked. During their survey, they did not note any mangroves on the islands they visited. KEATING and HELSLEY (2005) further states that mangroves were introduced to Hawaii and they have become a real nuisance, because the plants are so invasive, that they greatly reduce access to the water in many beach parks. The mangrove plants are detrimental to many local indigenous species, and when the plants have been removed from beach parks, the environmental damage done by siltation along the shoreline is very heavy.

An assessment of coastlines after the tsunami by DANIELSEN et al. (2005) indicates that coastal vegetation such as mangroves and beach forests helped to provide protection and reduce effects on adjacent communities. In recent years, mangroves and other coastal vegetation have been cleared or degraded along many coastlines, increasing their vulnerability to storm and tsunami damage. Establishing or strengthening greenbelts of mangroves and other coastal forests may play a key role in reducing the effect of future extreme events.

Mangrove forests shelter wildlife, serve as a source of food, herbs, and firewood, and act as a buffer against wind and waves. Although Asia boasts nearly 40% of the world’s mangrove coverage, it was losing the fragile wetlands at an alarming rate even before the tsunami: Between 1980 and 2000, India, Indonesia, Sri Lanka, and Thailand lost nearly a third of their total mangrove area, IUCN notes. Clearance for settlements and conversion to shrimp farms are major reasons for the declines. Tsunami damage was magnified in areas with degraded coastal ecosystems (STONE 2006). On Sri Lanka's south coast, for instance; one hotel that had leveled a sand dune, suffered enormous damage from the tsunami, while another nearby that had retained its dune suffered little. The simple lesson is that, intact ecosystems help protect coastal infrastructure (STONE 2006).

Ecosystem degradation can exacerbate the human consequences of natural disasters. The role of ecosystem changes, such as wetland loss, deforestation, canalization of rivers and loss of coral reefs, was evident during the 2004 Asian tsunami and the 2005 hurricane in New Orleans, USA. The capacity of ecosystems to mitigate natural hazards such as floods, droughts, storms and tsunamis appears to be decreasing, although there is considerable variability among regions (CARPENTER and FOLKE 2006).

A spatial and statistical analysis has been performed by CHATENOUX and PEDUZZI (2007) to identify what geomorphological and biological configurations (mangroves forests, coral and other coastal vegetation) are susceptible to decrease or increase coastal vulnerability to tsunami. The results indicate that the width of flooded land strip was, in vast majority, influenced by the distance to fault lines as well as inclination and length of proximal slope. Areas covered by sea-grass beds were less impacted, whereas areas behind coral reefs were more affected. They further state that the remaining mangroves forests being only identified in sheltered area in the observed cases. It is, therefore, difficult to distinguish whether the areas covered by mangroves forests suffered less impact because of their intrinsic nature, or because they were sheltered by coastline or other physical protection.

FERNANDO et al. (2006) surveyed and studied the damage caused to vegetation, early response of vegetation, and effects on animals in tsunami affected Yala National Park (a natural ecosystem) in southeast Sri Lanka. They stated that the tsunami incursion was patchy and much of the coast being protected by sand dunes. Although impact on vegetation within inundated areas was intense, survival and resiliency of the flora were high. Recovery of vegetation will be rapid and mainly a process of regeneration rather than primary succession. Few large animals were impacted by the tsunami. The occurrence of any major long-term effects on fauna is unlikely.

According to KARIYAWASAM (2005), a number of fresh water tanks and water holes in Yala National Park Block 1 (Sri Lanka) were impacted to some degree by the tsunami. While small patches of mangrove vegetation such as these in Maha Seelawa were almost completely destroyed, the larger tracts as in Pillinewa, Gajabawa etc. were relatively intact with damage only to areas close to the sea. In the Ruhuna Block II six main areas of impact were identified, namely, Yala wela, Pillinewa, Agara Eliya, Uda Pottana, Gajabawa, and Kumbukkan Oya estuary. In Yala East, the Kumana lagoon was impacted by the tsunami wave. Apart from this, the Lunama-Kalametiya Sanctuary and Proposed Rekawa Sanctuary and Turtle Refuge were considerably damaged. In all of these areas the vegetation was impacted much more than large animals or birds.

Three types of impacts on vegetation were identified. The most obvious was the complete or partial uprooting and breaking of trees due to the force of the wave close to surrounding the shore, and along the central region of flooding, leading to death, complete drying and subsequent defoliation of trees. The other two types of damage were deposition of sand carried inland with the wave, and inundation with seawater, which heavily impacted the understorey vegetation such as grasses and herbs (KARIYAWASAM 2005).

Natural ecosystems (Yala National Park, Sri Lanka) have functioned as the first line of defense against the tsunami waves. Especially the sand dunes have withstood the force of the wave very successfully, and if not for them, the southern and southeastern coasts would have received a higher level of damage. Other coastal and offshore ecosystems such as beach vegetation, mangroves, and coral reefs have also provided protection to the coastline where these ecosystems were preserved in a relatively good condition (KARIYAWASAM 2005). On the other hand in areas where natural ecosystems have been degraded due to over utilization, the damage to the coastal areas has been more extensive. It has also become apparent that these natural ecosystems can offer a greater resistance against this kind of natural disaster rather than man-made structures such as breakwaters and rip rap structures that are in place to prevent erosion (KARIYAWASAM 2005).

Tsunami affected non mangrove areas of the east, south and west coasts of Sri Lanka have been examined for the damages on the vegetation (JAYATISSA et al. 2006). Based on physical and/or physiological damages, plants were placed into three categories as ‘not affected’, ‘dead’ and ‘affected, but recovered later’. In some cases, individuals of the same species were distributed in the both, second and third groups, but individuals of the ‘not affected group’ hardly intermingled with the other groups. When it was searched for the ecological identity of this tolerant species or species in the ‘not affected group’, it was discovered that all these species except cultivated plants, are constituents of the natural sea shore vegetation and dune forming vegetation occurred in the past with a clear zonation. JAYATISSA et al. (2006) further stated that although there are some implications that the maritime vegetation in Sri Lanka in the past had given a better protection against ocean driven disasters, these tolerant species was unable to give a considerable protection against the last tsunami as they were isolated or the community was fragmented. However, if those maritime communities are reconstructed on coastal areas with a proper structure and natural zonation, it could be a good green barrier along the coastline of non-mangrove areas, against future tsunami and other ocean surges.

The protection of the coastal environment is critical since coastal natural resources are fundamental components to livelihoods and human security as a physical protection from the tsunami, storms and erosion. For example, communities located inland of reefs degraded from years of coral mining suffered higher damage and loss of life than communities located a short distance away on the same coastline, but sited inland of intact coral reefs (INGRAM et al. 2006). Similarly, sand dunes played a critical role in saving people’s lives. The Yala Safari Game Lodge (Sri Lanka), a beachside hotel where dunes had been removed to create an unobstructed ocean view, was completely decimated with high mortality rates. A few hundred meters away at the Yala Village hotel, located on the same stretch of beach but protected by an extensive natural sand dune system, little damage was recorded. Although the reduction of homes in the buffer zone would likely relax pressure on coastal resources, the vacancy created by the displacement of local populations is, in many places, being filled by expanding hotels, which as the Yala example demonstrates, can have a significant impact on the natural environment (INGRAM et al. 2006).

Effects of Medu (naturally elevated landmass very close to the seashore and elongated parallel to the coast) and coastal topography on the damage pattern during the deadliest Indian Ocean tsunami of December 26, 2004 is reported by NARAYAN et al. (2005a). The damage survey revealed large variation in damage along the coastal region of Tamilnadu (India). It was concluded that the width of continental shelf has played a major role in the pattern of tsunami damage. It was inferred that the width of the continental shelf and the interference of reflected waves from Sri Lanka and Maldives Islands with direct waves and receding waves was responsible for intense damage in Nagapattinam and Kanyakumari districts, respectively (NARAYAN et al. 2005a; NARAYAN et al. 2005b). During the damage survey authors also noted that there was almost no damage or much lesser damage to houses situated on or behind the Medu (NARAYAN et al. 2005a). The tsunami run-up, inundation and damage pattern observed along the coast of Tamilnadu during the Indian Ocean tsunami of 2004 is well documented in NARAYAN et al. (2005b).

According to COCHARD et al. (2008), the 2004 Asian tsunami event has stimulated a debate about the role played by coastal ecosystems such as mangrove forests and coral reefs in protecting low-lying coastal areas. While some observers claim that these ecosystems play an important role, others are more sceptical and fear that financial resources may be diverted away from tsunami preparedness programmes to ecosystem rehabilitation schemes. The role of coastal ecosystems in mitigating sea wave hazards was reviewed by them. In particular, the influence of coastal vegetation in severely affected parts of Aceh and Southern Thailand during the 2004 tsunami was examined.

Assessment of tsunami-inflicted damage to island ecosystems assumes great importance owing to the life sustaining and livelihood support abilities of the ecosystems. Apart from damages caused to life and property, significant damages were caused to ecosystems, which will have long-lasting effects. The tsunami-induced damage to coastal ecosystems was studied in four Nicobar Islands, viz. Camorta, Katchal, Nancowry and Trinkat by RAMACHANDRAN et al. (2005). The extent of damages assessed ranged from 51 to 100% for mangrove ecosystems, 41 to 100% for coral reef ecosystems and 6.5 to 27% for forest ecosystems. The severity of damages and their consequences suggest the need for a definite restoration ecology programme. RAMACHANDRAN et al. (2005) states that, considering the extent of damage, the need of the hour is to initiate restoration of coastal ecology through an Integrated Coastal Zone Management plan.

Observations in Thailand and Sri Lanka on 2004 tsunami impacts revealed that the overall pattern of tsunami run-up and inundation indicate a considerable variation throughout the surveyed coasts even over short coastal stretches (ROSSETTO et al. 2007). Both were seen to be affected by the travel path of the tsunami, energy focusing effects, shape of the coastline and near-shore bathymetry. Furthermore, local topography and the density of buildings and vegetation were seen to play an important role in determining the onshore flow depth attenuation with distance inland. Generally it was observed that large flow depths were maintained over longer distances inland in locations with gently sloping beaches, which did not have densely built up towns and dense coastal vegetation. Small inundation and more rapid attenuation of flow depth with distance from shore are observed where a steeper coastal profile is present (ROSSETTO et al. 2007).

The *Casuarina* shelterbelt has become popular because it was the only undamaged area in Hambantota City in Southern Sri Lanka after the devastating 2004 tsunami (DE ZOYSA 2008). A survey was conducted by DE ZOYSA (2008) to elicit observations and experiences of city dwellers close to the shelterbelt. He reports that the respondents did not consider that the shelterbelt reduced wind speed. Although the belt has increased the size of the sand dunes, the *Casuarina* trees have suppressed the growth of native species as an under-storey. The belt has improved the aesthetic value of the beach. The city dwellers have not recognized the economic importance of *Casuarina* timber but are impressed with the increase of fuel wood supply from the shelterbelt. The attractiveness of the beach for tourism has been enhanced. Empirical evidence reveals that the *Casuarina* belt in Hambantota City has greater environmental and social impacts than economic impacts.

The results of a study carried out in Hambantota district in the south-eastern part of Sri Lanka by MATTSSON (2006) showed that the resilience process of salt intruded lands from the 2004 tsunami has been much improved. The salinity level in the soils was low throughout the district but on the other hand, analyses of well water samplings were still showing evidence of salinity contamination. The carbon sequestration potential turned out to be the highest in natural forests and second highest in coconut plantations.

CHANDRASEKAR et al. (2006) has also stated that the coastal vegetation have been found to be a reliable feature in checking the seawater inundation and they had really served as a initial line of defense in controlling the inundation due to the 2004 Indian Ocean tsunami.

MUNASINGHE (2007) states that; on the environmental side, there was surprisingly little loss of wildlife in game parks extending into coastal areas of Sri Lanka. Apparently, the subsonic vibrations which precede the tsunami provided an early warning to wild animals. There are also some sketchy reports that areas where coral reefs and mangroves had suffered prior damage, tended to be more vulnerable to the waves.

2.4 Other related studies (non-vegetational) on the December 26, 2004 Asian tsunami done in Sri Lanka and/or other affected countries

WIJETUNGE (2006) examines the impact of the massive tsunami of 26 December 2004 on Sri Lanka by tracing the tsunami height, the extent of inundation and the level of damage along the affected coastal belt. The results of an extensive field survey that was carried out in the east, south and west coasts to record the evidence of water levels left behind by the tsunami clearly indicate non uniform spatial distribution of inundation along the affected coastline of the country. The tsunami inundation had been significantly greater for most parts of the east and the south-east coastal areas than the south, south-west and the west coasts of Sri Lanka. The results also indicate the possible influence of the coastal geomorphology on the extent of inundation. On the other hand, the measurements suggest maximum tsunami heights of 3 m – 7 m along the east coast, 3 m – 11 m on the south coast, and 1.5 m – 6 m on the west coast.

WIJETUNGE (2006) further stated that, that the degree of damage due to the 2004 tsunami along the coastal belt of Sri Lanka was not uniform: some areas suffered more damage, some less and in certain other areas, often not far away, there was not any damage at all. This suggests that the level of vulnerability of coastal communities for future events of tsunami exhibits considerable variation even along a short stretch of the shoreline. Such non-uniform spatial distribution of the degree of destruction and damage to lives and property may be attributed to several factors such as the coastal topography, the population density, the construction standards, the type of land use including the density of vegetation and buildings as well as the variations in the tsunami surge height and its velocity owing to the travel path of the tsunami waves, the width of the continental shelf, the energy focusing effects and the near shore bathymetry. Necessity of detailed studies to understand and determine the way in which the above factors have influenced the spatial variations in the distribution of the tsunami height, the extent of the overland flow and the degree of consequent damage along the affected coastline of Sri Lanka has been highlighted by WIJETUNGE (2006).

BIRD et al. (2007) report the results of a study of the physical characteristics and socio-economic impacts of the Indian Ocean tsunami on the tourist island of Langkawi, Malaysia. In comparison with many other locations struck by the tsunami, the immediate physical and socio-economic impacts in Langkawi were relatively minor. A detailed survey of the watermark and ground elevations was undertaken in the worst affected area between Sungei Kuala Teriang and Sungei Kuala Melaka.

The study of BIRKMANN et al. (2005) deals with the development and testing of different methodologies to identify and measure the pre-existing and emergent vulnerability (revealed vulnerability) of coastal communities in Sri Lanka to tsunami and coastal hazards. The study noted that females were more vulnerable to the tsunami than males. Single-story buildings were more vulnerable than multi-story buildings, particularly in the first 100 meters from the sea. Additionally, the study reveals a better recovery potential of households in Galle then in Batticaloa. While for example around 25 percent of the household captured within the survey in Galle need more than 2 years to replace their housing damage, the same category counts for Batticaloa nearly 60 percent. Thus the households in Batticaloa face higher difficulties than in Galle in terms of bouncing back to normal conditions.

Field observations and satellite images indicate that tsunami waves exhibit specific patterns during flooding and recession forming characteristic incisions in the coastal landscape (FAGHERAZZI and DU 2007): To study these incisions FAGHERAZZI and DU (2007) analyzed high resolution remote sensing images of the coastline of Indonesia, Thailand and Sri Lanka impacted by the tsunami of December 26th, 2004. The analysis sheds light on the different mechanisms by which currents scour incisions during the flooding and receding phases of a tsunami. During flooding the high velocity flow indents the levees of existing tidal channels and bays, leaving short flood scours. The receding water then dissects the coastline with equally spaced return channels widening toward the coast.

Measurements and observations of tsunami arrival times and inundation heights and depths were carried out on the western, southern and eastern coasts of Sri Lanka (INOUE et al. 2007). In addition a detailed survey of the inundation area was carried out in Batticaloa. In Sri Lanka, the tsunami phenomenon was not limited to a single wave but a sequence of two or more main waves. The largest inundation heights were measured on the southeast coast and were greater than 10 m. The maximum inundation distance measured in Batticaloa was nearly 2 km (INOUE et al. 2007).

The 2004 Indian Ocean tsunami caused major landscape changes along the southwest coasts of Sri Lanka that were controlled by the flow, natural topography and bathymetry, and anthropogenic modifications of the terrain. Landscape changes included substantial beach erosion and scouring of return-flow channels near the beach, and deposition of sand sheets across the narrow coastal plain. In many areas tsunami deposits also included abundant building rubble due to the extensive destruction of homes and businesses in areas of dense development. Trim lines and flow directions confirmed that shoreline orientation and wave refraction from embayments and rock-anchored headlands locally focused the flow and amplified the inundation. Tsunami deposits were 1 to 36 cm thick but most were less than 25 cm thick. Deposit thickness depended partly on antecedent topography. The deposits were composed of coarse to medium sand organized into a few sets of plane parallel laminae that exhibited overall upward fining and landward thinning trends (MORTON et al. 2007).

In the Northern, Eastern and Southern coastal belts of Sri Lanka over a width of about 800 m to 1.5 km the entire man made resources were damaged due to the Asian tsunami. The passage of vagueness, the wells were polluted by salted water and filed up with sand, mud and debris brought by the wave. Almost all the open dug wells of the affected zone were heavily damaged and groundwater resources were heavily polluted. Tsunami waves have caused many damages to the entire well system converting them to ruins (PIYADASA et al. 2006). In the coastal areas of Eastern Sri Lanka, the majority of the population, which is rural or semi-urban, is relying on groundwater for their domestic and agricultural activities, most predominantly through traditional private shallow open dug wells in the sandy aquifers. Soon after the tsunami, massive efforts to clean the wells were initiated from a range of different actors in an attempt to rapidly return the water supply to normal conditions, or at least ameliorate the immediate impacts of the salinization of the wells (VILLHOLTH et al. 2005).

Variation of tsunami intensity along the coasts of the Kollam, Alleppey and Ernakulam districts of South Kerala Coast (West coast of India) and the consequent morphological changes occurred in the coastal area during tsunami were studied by RASHEED et al. (2006) and also found that the the presence of vegetation on the beach appears to have helped to reduce the intensity and thereby decreased the erosional characteristics of the incoming waves. Most of the vegetation is seen already were wiped off during the run-up of waves, or being destroyed due to high saline conditions in the soil.

Recovery/reconstruction of the tsunami affected areas is highly challenging. A clear understanding of the complex dynamics of the coast and the types of challenges faced by the several stakeholders of the coast is required. Issues such as sustainability, equity and community participation assume importance (SONAK et al. 2007). The concept of ICZM (integrated coastal zone management) has been effectively used in most parts of the world. This concept emphasizes the holistic assessment of the coast and a multidisciplinary analysis using participatory processes. It integrates anthropocentric and eco-centric approaches. SONAK et al. (2007) document several issues involved in the recovery of tsunami-affected areas and recommends the application of the ICZM concept to the reconstruction efforts.

The impact of disasters, whether natural or man-made, not only has human dimensions, but environmental ones as well. Environmental conditions may exacerbate the impact of a disaster, and vice versa, disasters tend to have an impact on the environment. Deforestation, forest management practices, or agriculture systems can worsen the negative environmental impacts of a storm or typhoon, leading to landslides, flooding, silting, and ground/surface water contamination (SRINIVAS and NAKAGAWA 2007).

It is troubling that disaster impacts have been increasing as global economic growth has. This suggests that economic growth has not been properly directed at mitigating disaster risks. The problem is that disasters are still usually (and wrongly) perceived as "exceptional natural events". Our results revealed that a semi-altered landscape and Gross Domestic Product (GDP) significantly reduce mortality rate. However, it remains to be determined the ratio of natural/transformed ecosystems that yield the best protection service. Balance between Human, Built, Social and Natural capitals and an increasing awareness of the consequences of different development decisions, will help human societies to live with rather than cope with coastal disasters (PÉREZ-MAQUEO et al. 2007).

RAO et al. (2008) pointed out that the proposed Sethu Samudram Canal Project (SSCP) between Indian and Sri Lankan landmasses would form a deep ocean route for future tsunamis as a consequence in addition to the impacts on the unique biota and biodiversity of a 10,500 km^2 Marine Biosphere Reserve in the proposed area.

LEROY (2006) states "We must remember that natural events embody tremendous power to cause environmental catastrophes, and this power is as great as the power that humans possess nowadays to damage their environments. Although the number of natural hazards is increasing somewhat, especially hydrometeorological events, it is evident that the number of disasters will rise dramatically in the near future. Indeed colonization of marginal environments caused by population pressures is placing the world at greater risk from natural hazards and catastrophes than ever before. Finally, this new field of geosciences is both challenging and fascinating by its relevance to the world where we live. To survive, we must learn from the past, adapt to environmental changes, and modify our life styles in front of a darkening nature".

2.5 Homegardens and Live fences

2.5.1 Homegardens

Homegarden is a land-use form on private lands surrounding individual houses with a definite fence, in which several tree species are cultivated together with annual and perennial crops; often with the inclusion of small livestock. Homegarden is fundamentally a subsistence farming practice which growing crops and, where appropriate, keeping animals so as to provide food (cereals, pulses, vegetables, fruits and spices), timber, shelter materials, and possibly other products (fibres, medicinals) for family use.

There are many forms of such gardens varying in how intensively they are cultivated and their location with regard to the home, for example, 'village forest gardens', 'compound gardens', 'kitchen gardens'. Multilayered, highly dense homegardens with high diversity of plants and animals found in and around Kandy District, Central Province of Sri Lanka is well known as 'Kandyan Homegardens'. However the homegardens found in the coastal zone of Sri Lanka are not very dense, diverse and complex when compare with the homegardens in the upper elevations, especially with the Kandyan homegardens.

Research on tsunami affected homegardens of Sri Lanka or elsewhere is scanty at present, only some reports on rapid assessments and proposals are available. Also it is clear that less attention paid even on the coastal homegardens of Sri Lanka in general. Details on the homegardens in the mid-elevation (mid country) of Sri Lanka are well documented (HOCHEGGER 1998; McCONNELL 1992; McCONNELL 2003). HOCHEGGER (1998) and McCONNELL (1992) are on Kandyan homegardens, whereas McCONNELL (2003) reports on Kandyan homegardens and the homegardens of other countries in the tropics.

The tsunami affected nearly two thirds of the coastline of Sri Lanka, or about 1000 kilometers along the northern, eastern and southern coasts. Homegardens suffered extensive damage. Home gardens provide about 70 percent of Sri Lanka's timber resources as well as furnish fruit and other products for home consumption and sale on local markets. They are an important component of the livelihoods of many of the coastal inhabitants (ANONYMOUS 2006).

A total of about 2,308 hectares of paddy lands, 589 hectares of other field crops, 473 hectares of vegetable cultivation, and 201 hectares of fruit crop areas were completely destroyed. In addition, about 2,500 home gardens, mainly in the North East, were washed away (ASIAN DEVELOPMENT BANK et al. 2005). The home gardens were not entirely barren of vegetation. Most of the mature trees and palms appear to have held firm. However, smaller trees whose branches were engulfed by the wave have been toppled or washed away. Many of the crops raised below the trees (vegetables, ornamentals) were washed off. There is evidence that mature trees including the palms were brought down by the Tsunami. Some of the standing trees are beginning to show dieback, the crowns were beginning to dry up and in some case there were no more leaves left (APPANAH 2005).

Damage to home gardens has varied depending on distance from the sea and on the salt tolerance of individual species. Trees like Neem, Mango, Tamarind, Indian Willow, Banyan, Temple tree, Oleander and Tulip tree located in the tsunami inundated areas were found to be relatively less damaged, particularly in the distal areas. Banana was found to be stressed in several cases. In general, the species-richness of fauna in severely affected home gardens was found to be very low (BAMBARADENIYA et al. 2005).

2.5.2 Live fences

The International Center for Research in Agroforestry (ICRAF) currently defines live fencing as, "a way of establishing a boundary by planting a line of trees and/or shrubs (the latter usually from large stem cuttings or stumps), at relatively close spacing and by fixing wires to them". It is also referred as 'living fence' in some texts (CHERRY and FERNANDES 1997).

Live fences can be divided into two basic categories; living fence posts and live barriers or hedges. Live fence posts are widely spaced, single lines of woody plants that are regularly pollarded and used instead of metal or wooden posts for supporting barbed wire, bamboo or other materials. Hedges are thicker, more densely spaced fences that generally include a number of different species and usually do not support barbed wire.

The primary purpose of live fences is to control the movement of animals and people; however, they have proven to be extremely diverse, low risk systems that provide farmers with numerous benefits. Besides their main function living fences may provide fuel wood, fodder and food, act as wind breaks or enrich the soil, depending on the species used (CHERRY and FERNANDES 1997).

Damages of live fences due to the tsunami have been reported in Ampara and Batticaloa Districts of Sri Lanka by BAMBARADENIYA et al. (2005). However, detailed description on damage to the live fences was not given.

2.6 Catalogues, Bibliographies and Reviews on tsunami

The review of COCHARD et al. (2008) on the 2004 tsunami and related fields of research provides valuable information on coastal ecosystems, wave hazards and vulnerability; and the mitigation of tsunami affects by coastal vegetation have been critically reviewed by these authors. http://www.fao.org/forestry/media/13416/1/0/ gives the bibliography on the protective functions of trees and forests against tsunamis. A catalogue of RASTOGI and JAISWAL (2006) presents the information on past tsunamis of Indian Ocean in chronological order. WIEGEL, R. L. (2006a) and WIEGEL, R. L. (2006b) provide tsunami information in all disciplines, while status of tsunami science research up to 2006 is described and classified and future directions of research in number of disciplines has been highlighted by KEATING (2006).

3 Materials and Methods

Preview:

This chapter is comprised of ten main sections. Section (3.1) Sri Lanka: Country Profile presents a description of some important facts of the country, Sections (3.2) Study site and site selection, Section (3.3) Vegetation damage survey: Investigation of the impact of tsunami on homegarden vegetation, exploration of the survived vegetation; the role of vegetation during the tsunami and in the aftermath of flooding, Section (3.4) Comparison of the present status (vegetation structure and composition) of tsunami affected homegardens with non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline, Section (3.5) Investigation of ground layer vegetation in order to study the regeneration of woody perennials in tsunami affected homegardens and non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline, Section (3.6) Survey of the live fence species in tsunami affected homegardens and non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline, Section (3.7) Plant species selected to survey the uses and to study the preference to integrate them in coastal homegardens, Section (3.8) Survey of the uses of 15 selected plant species by the coastal community, Section (3.9) Investigation on the preference of 15 selected plant species to integrate in the coastal homegardens and finally the Section (3.10) Data analysis.

3.1 Sri Lanka: Country Profile

3.1.1 General

The Democratic Socialist Republic of Sri Lanka (Sri Lanka) is an island in the Indian Ocean to the south of India (Figure 3.1). It is situated between latitudes 5°55’ N and 9°50’ N and longitudes 79°31’ E and 81°53’ E. The main island of Sri Lanka has a maximum length of 435 km in the north-south direction and a maximum width of 240 km in the east west direction. The land area is 65.525 km^2; together with Internal Waters of 1.570 km^2, the area within the national boundary is 67.095 km^2 (VITHANAGE 1997). The length of the coastline is about 1.340 km. The administrative structure of Sri Lanka at present consists of 9 Provinces, 25 Districts (Figure 3.1); and further 280 Divisional Secretary’s Divisions, 13,983 Grama Niladhari Divisions and 37,300 Villages (LEITAN 1997). Population estimated in 2007 is 19,299,000 (COMMONWEALTH SECRETARIAT, SRI LANKA 2007), approximately 20 million and the average annual population growth rate (per cent) estimated in 2001 is 1.2 (DEPARTMENT OF CENSUS AND STATISTICS, SRI LANKA 2008).

Figure 3.1: Sri Lanka: Location in the Indian Ocean and Major Administrative Divisions

3.1.2 Landform, Relief and Drainage

According to the theory of plate tectonics, Sri Lanka is a small fragment of an ancient super continent Pangea, which broke up about 135 million years ago into North America, Eurasia and Gondwanaland, which broke up further about 100 million years ago. The fragments forming a series of blocks called major plates and platelets, started drifting away from the site of the then super continents. In this process the Indian plate – the Indian peninsula together with the Sri Lankan miniplate – drifted northwards. Thus geologically, Sri Lanka is a part of the South Indian peninsula separated by a series of lineaments in the Palk Strait area. Both India and Sri Lanka stand on the same continental shelf or platform, the submerged edge of which does not extend beyond 19 km from the present coastline. The shelf is shallow and does not exceed 70 m in depth at its maximum. Beyond this edge there is an almost abrupt drop to more than 900 m within 3 km (VITHANAGE 1997).

In surface configuration Sri Lanka comprises, a highland massif, situated in the south-centre, which is surrounded more or less by an intermediate zone of upland ridges and valleys at lower elevation (Figure 3.2). These two sets of topographical features are in many places separated by well marked scraps, so that when a stream descends from one to the other there is a waterfall (there are over 50 such waterfalls in the island). The intermediate zone is in turn surrounded by an outer or lower zone of lowlands. A coastal fringe consisting of sandbars lagoons and islands skirt the main island. From sea level, relief appears to ascend more or less in steps of three peneplains to a maximum elevation of 2524 m at Pidurutalagala. On the basis of height and landforms Sri Lanka has been divided roughly in to 6 topographical regions; The Central Highlands, The Southwest Country, The East and Southeast Country, The uplifted belt of lowlands, The Northern lowlands and The coastal fringe (VITHANAGE 1997).

The rivers of Sri Lanka radiate from the central highlands to the sea. Except for the Mahaweli Ganga which is 335 km, all others are less than 160 km in length. It is an integrated drainage course built up through piercing together parts of several discharge courses of highland drainage. A characteristic of the rivers below 500 m in elevation especially in the southwest and in the east is the close adaptation of the drainage to tectonic lines (VITHANAGE 1997).

3.1.3 Geology

Most of the country is underlain by metamorphic crystalline rocks of Precambrian age, the rest being made up chiefly of Miocene limestone in the north and northwestern coastal regions, including the entire Jaffna peninsula and Quaternary deposits along the northwestern, southern and eastern coastal regions. Two small basins of Jurassic age are faulted into the Precambrian basement in the northwest, at Tabbowa and Andigama (COORAY 1997).

Figure 3.2: Sri Lanka: Relief and Drainage

The Precambrian rocks, which are a part of one of the very ancient, stable parts of the earth's crust, are subdivided into 3 main and 1 subordinate units, on the basis of the rock types and structures present in them. They are: (i) the Highland Complex (HC): occupying the central highlands and extending from southwest to the northeast of the island; (ii) the Wanni Complex (WC): formerly known as the Western Vijayan Complex and occupying the lowlands to the west of the HC; (iii) the Vijayan Complex (VC): formerly known as the Eastern Vijayan Complex and occupying the lowlands to the east of the HC; and (iv) the Kadugannawa Complex (KC): which lies within the HC but consists of rock types markedly different from those of HC. Recent age determinations indicate that the island was formed during Proterozoic time (2500-545 million years ago) by the coming together, through deep-seated movements, of the three main units and forming a small portion of the southern supercontinent known as Gondwanaland (COORAY 1997).

3.1.4 Soils

Fourteen Great Soil Groups have been recognized in Sri Lanka. Ten soils groups; Reddish Brown Earths, Low Humic Gley Soils, Non-Calcic Brown Soils, Red Yellow Latosols, Alluvial Soils, Soils on Old Alluvium, Solodized Solonetz, Regosols (Sandy), Grumusols and Rendzinas are distributed in Dry Zone and Semi-dry Intermediate Zone of the country, whereas the other 4 groups; Red-Yellow Podzolic Soils, Reddish Brown Latosolic Soils, Immature Brown Loams and Bog and Half-Bog Soils are distributed in Wet Zone and Semi-wet Intermediate Zone. However, only two of these groups are found extensively in the island. Reddish Brown Earths occupy most of the dry and intermediate zones, whereas Red-Yellow Podzolic Soils occupy most of the wet zone of the country (PANABOKKE 1997a).

Since the parent material of the Precambrian rocks is relatively uniform over the island mass, weathering by climate appears to be the main determinant of soil type. Soil groups therefore closely coincide with the climatic zones of Sri Lanka.

3.1.5 Climate

The climate of Sri Lanka is ‘tropical monsoonal’ with a marked seasonal rhythm of rainfall. The tropical conditions are due to her location between latitudes 6° and 10° north of the equator with a high average temperature having a diurnal pattern, modified by altitude. The monsoonal conditions refer to two seasonal wind regimes separated by two periods of light and variable winds. The two monsoon periods and the two intermonsoon periods control the rainfall rhythm. Thus the climate is determined mainly by seasonal pressure and wind systems, rainfall and temperature (DE SILVA and FERNANDO 1997).

3.1.5.1 Rainfall

Average annual rainfall has considerable spatial variation. The higher rainfalls are in the Central highlands. The maximum values are on the western slopes with several stations recording values exceeding 5,000 mm. But the annual rainfalls on the eastern slopes are less than 3,500 mm. The lowest annual rainfalls are on the northwestern and southeastern lowlands, less than 1000 mm. The annual rainfall pattern could be divided into four distinctive periods: (i) First Intermonsoon Period, March-April; (ii) Southwest Monsoon Period, May to September; (iii) Second Intermonsoon Period, October-November; (iv) Northeast Monsoon Period, December to February (DE SILVA and FERNANDO 1997).

Based on the mean annual rainfall and its distribution, the country has been classified into three major climatic zones: the Dry Zone, the Intermediate Zone and the Wet Zone. The Wet Zone covers the area, which receives relatively high mean annual rainfall over 2,500 mm without pronounced dry periods. The Dry Zone is the area, which receives a mean annual rainfall of less than 1,750 mm with a distinct dry season from May to September. The Intermediate Zone demarcates the area, which receives a mean annual rainfall between 1,750 to 2,500 mm with a short and less prominent dry season (http://www.agrolanka.net/Agro-ecology%20of%20Sri%20Lanka.htm). In addition, two small areas at the extreme northwest and southeast of the country receiving a mean annual rainfall of less than 1,250 mm, have a very dry climate (having more prolonged and intense drought) and are known as Arid Zones.

3.1.5.2 Temperature Profile

Sri Lanka's equatorial position gives its lowlands a tropical climate, with year around temperatures of 27-28^{o} C. The average annual temperature ranges from a low of 15.8^{o} C in Nuwara Eliya (altitude 1,800 m above mean sea level) and in Pidurutalagala (altitude 2,500 m) the value is 11.5^{o} C in the Central Highlands to a high of 29^{o} C in Trincomalee on the northeast coast, where temperature may reach 37^{o} C. The temperature decreases with increasing altitude approximately 2^{o} C for every 300 m of elevation (lapse rate of temperature). The diurnal average range of temperature in the lowlands is 6^{o} C while the range in the highlands is 10^{o} C (DE SILVA and FERNANDO 1997).

The higher monthly average temperatures are in April, May or June. The low values are in December, January or February. However, the difference in temperature between the warmest and coldest month varies only between 1.5^{o} C and 4^{o} C. The occurrence of frost in some central highland areas above 1,800 m is an irregular phenomenon. It occurs as ground frost when air temperature near the ground falls below freezing point; confined to a few days only in January, February or early March and localized to small contour depressions which act as frost pockets (DE SILVA and FERNANDO 1997).

3.1.5.3 Humidity

The relative humidity varies generally from 70% during the day to 90% at night. During June, July and August to the east of the central highlands, and from February to August in the northcentral regions and inland in the north, northwest and southeast, the relative humidity falls to about 60% by day (DE SILVA and FERNANDO 1997).

3.1.5.4 Wind

The Summer Monsoon or Southwest Monsoon (SWM) is reckoned from May to September. The onset of the monsoon is associated with a cyclonic wind circulation in the low troposphere or with a depression. The Winter Monsoon or Northeast Monsoon (NEM) sets in and lasts for three months from December to February. First Intermonsoon Period is in March-April and the Second Intermonsoon Period is in October-November. The surface winds could change when cyclonic storms and depressions from the vicinity of the country. The cyclonic storm season for Sri Lanka is November-December. However, a severe cyclonic storm crossing the coast is an infrequent occurrence. Depressions frequently occur with the onset of the SWM in late May and early June and again in late September and October (DE SILVA and FERNANDO 1997).

3.1.5.5 Pressure

The atmospheric pressure is seasonal. A diurnal rhythm in pressure exists with a maximum value about 3 hours after sunrise and another 12 hours later. A minimum value occurs about 3 hours after mid-day and another 12 hours later. The pressure distribution is fairly uniform during the months of March-April and October-November. The pressure gradient across the country from May to September is southwesterly with higher pressure in the southwest and lower values in the northeast. From December to February the pressure gradient is northerly with higher pressures in the north and lower values in the south. The change in the gradient of pressure is determined by the seasonal movement of Equatorial Trough of Low Pressure (DE SILVA and FERNANDO 1997).

3.1.5.6 Sunshine and Cloudiness

The annual average totals of sunshine hours have a considerable spatial variation. They range from 2,900 hours in the northern and eastern lowlands to 1,400 hours in the central highlands. The windward slopes show a marked contrast to the leeward area during the monsoon seasons (DE SILVA and FERNANDO 1997).

3.1.6 Vegetation Types

Vegetation of reflects the combined effect of topography, climate and soil. In Sri Lanka the natural vegetation is predominated by a diversity of forest types. Only a small fraction of land is under non-tree-dominated vegetation. This is mainly grassland, and coastal and fresh water wetlands.

The most extensive type of forest in the island is the “dry mixed evergreen forest” found in the dry zone. Although deciduous species exist in these forests, their evergreen character is maintained by a few widespread species and consequently these forests are also referred to as “semi-evergreen forests”. In the arid zones of the northwest and southeast extremities of the country, “thorn scrub” predominates, and this comprises small trees and thorny shrubs. Along the rivers, in both dry and arid zones, where there is no acute shortage of moisture, are impressive “riverine forests” (gallery forests). In the intermediate zone, the vegetation gradually changes to “moist semi-evergreen forests”. Although these forests have a fair proportion of deciduous species, they are essentially evergreen (ASHTON et al. 1997).

In the wet zone, vegetation has been largely categorized by elevation with “wet-evergreen forests” or “rain forests” in the lowlands and hills, “lower montane forests” on the lower slopes of the mountains between 1000 m and 1500 m, and “montane forests” above 1500 m. Although the wet zone is only a small area of 15,000 km^2 in extent, the combination of climate, topography and geological history has resulted in a diversity of species-rich associations in this zone, as compared to the vegetation types in the rest of the country. Consequently, at least nine floristic zones, based on species more or less restricted to each zone, have been recognized in this area. The high proportion of endemic plant species is another unique characteristic of these forests (ASHTON et al. 1997).

The non-forest vegetation types are mostly grasslands, found in small pockets in all climatic zones of the country. Most of these grasslands are secondary in origin and appear to be fire-maintained by humans. The best known grasslands in the country are those of the highland plateau: the Horton plains, Moon plains, Ambewela and Nuwara Eliya. These picturesque montane grasslands are known as “wet patanas” and are interspersed with montane forests. There are fairly large tracts of grasslands in the Kandy, upper Mahaweli and Ratnapura-Rakwana areas known as the “dry patanas”. “Savannas” are found on the eastern and southern sides of the mountains in Uva basin. The dry zone also has “villu grasslands” which are associated with river floodplain systems such as those in the lower reaches of the river Mahaweli. In the wetter areas of the lowland wet zone, “Fern or kekilla lands” (which are of secondary origin) can be found in addition (ASHTON et al. 1997).

In the coastal areas “mangroves” and “salt marshes” colonized inundated inlets (bays and lagoons) and river estuaries with “scrub” vegetation invading sandy shores and dunes. Inland areas inundated by freshwater have “swamp” and “floodplain forests”; nowadays most of these have been converted to paddy lands (ASHTON et al. 1997). “Sea-grass beds” (marine angiosperms) and algal flora around the island are also play a vital role in productivity and providing breeding grounds for rare marine mammals such as Dugongs.

3.1.7 Flora and Fauna (Biological Diversity)

3.1.7.1 Flora

The present flora of Sri Lanka is represented by six floristic elements, namely (i) Sri Lankan, (ii) Indo-Sri Lankan, (iii) Himalayan, (iv) Malayan, (v) African and (vi) Pantropic and Cosmopolitan. In terms of the average number of species per 10,000 km^2, the biodiversity in Sri Lanka is much higher than in any other country in Asia. The indigenous flora of Sri Lanka is unusual in that and it has about 7,500 species (Table 3.1), a large percentage of which is endemic. Based on the angiosperm flora, 15 different floristic regions in Sri Lanka have been recognized, while southwestern lowland has been identified as the floristically richest area of the country (JAYASEKERA 1997).

Of the recorded 3,360 species of flowering plants (angiosperms), around 830 are known to be endemic. Of the 830 endemic flowering plants, about 230 could be considered as threatened as they are now very rare and many of them are considered ‘endangered species’. Our flora has great scientific value as it has at least one species among the most primitive vascular plants such as *Psilotum, Equisetum, Isoetes, Selaginella* and *Lycopodium* (all Pteridophytes). *Cycas circinalis*, a living fossil, is the only indigenous gymnosperm species in Sri Lanka.

Table 3.1: Composition of the indigenous flora of Sri Lanka

Group	Number of species	Percentage Endemism
Algae	896	not available
Fungi	1920	not available
Lichens	>200	not available
Mosses	575	not available
Liverworts	190	not available
Pteridophytes	314	18
Gymnosperms	1	0
Angiosperms	3360	25

Our natural vegetation includes a host of wild relatives of plants that directly or indirectly provide sustenance to the people of Sri Lanka. Over 600 species of local plants are considered to be of medicinal value, about 200 species can be used as food, and many more provide timber, wood products and firewood. Over the last 100 years or so, the highly priced timbers, medicinally important plants etc. have been overexploited in the forest, resulting in extinction of some of the important species. The Sri Lankan flora demands special attention because of its high degree of biodiversity, endemism and its vulnerability to habitat destruction (JAYASEKERA 1997).

3.1.7.2 Fauna

The diversity of Sri Lanka's fauna is both rich and unique. Within the confines of this island of 65,525 km^2 are to be found 628 species of terrestrial vertebrates while its inland and terrestrial waters have over 1,000 species of freshwater and marine fishes. The 628 (116 endemics, 18%) vertebrates are made up of 84 mammals (10 endemics, 12%), 379 birds (21 endemics, 6%), 133 reptiles (70 endemics, 53%) and 32 amphibians (15 endemics, 47%). These range from majestic Asian elephant (*Elephas maximus maximus*), leopard, sloth bear, three species of deer, a galaxy of birds of colourful plumage and strident calls, to the venomous vipers and cobras, huge crocodiles and frogs as large as soup plates or small silver coins, giving depth to this living heritage (DE ALWIS 1997). Numerous terrestrial and aquatic invertebrate species are also recorded as well in addition.

3.1.8 Agro Ecological Regions

An agro-ecological region (AER) represents a represents a particular combination of the natural characteristics of climate, relief and soil which tends to find expression agriculturally in particular farming systems. Sri Lanka is divided into three zones at the first stage of subdivision for agro-ecological purposes based mainly on expected annual rainfall (75% expectancy): viz. Wet Zone (W), Intermediate Zone (I) and Dry Zone (D) and the boundaries of these three zones were demarcated after careful consideration of present agricultural land use, distribution of forest species, rainfall data, topography and soils. The second stage of subdivision based on elevation which takes into account the temperature limitations for the more important plantation and arable crops grown in the country and divided into three sub-divisions: viz. Low Country (L, <300 m), Mid Country (M, 300-900 m) and Up Country (U, >900 m), where Dry Zone falls wholly within Low Country, while the Intermediate and Wet Zones fall within all three subdivisions of Low, Mid and Up Country. The third stage of subdivision is into AERs which represent approximately homogeneous climatic conditions combined with effects of soil, land form and agricultural activities (PANABOKKE 1997b).

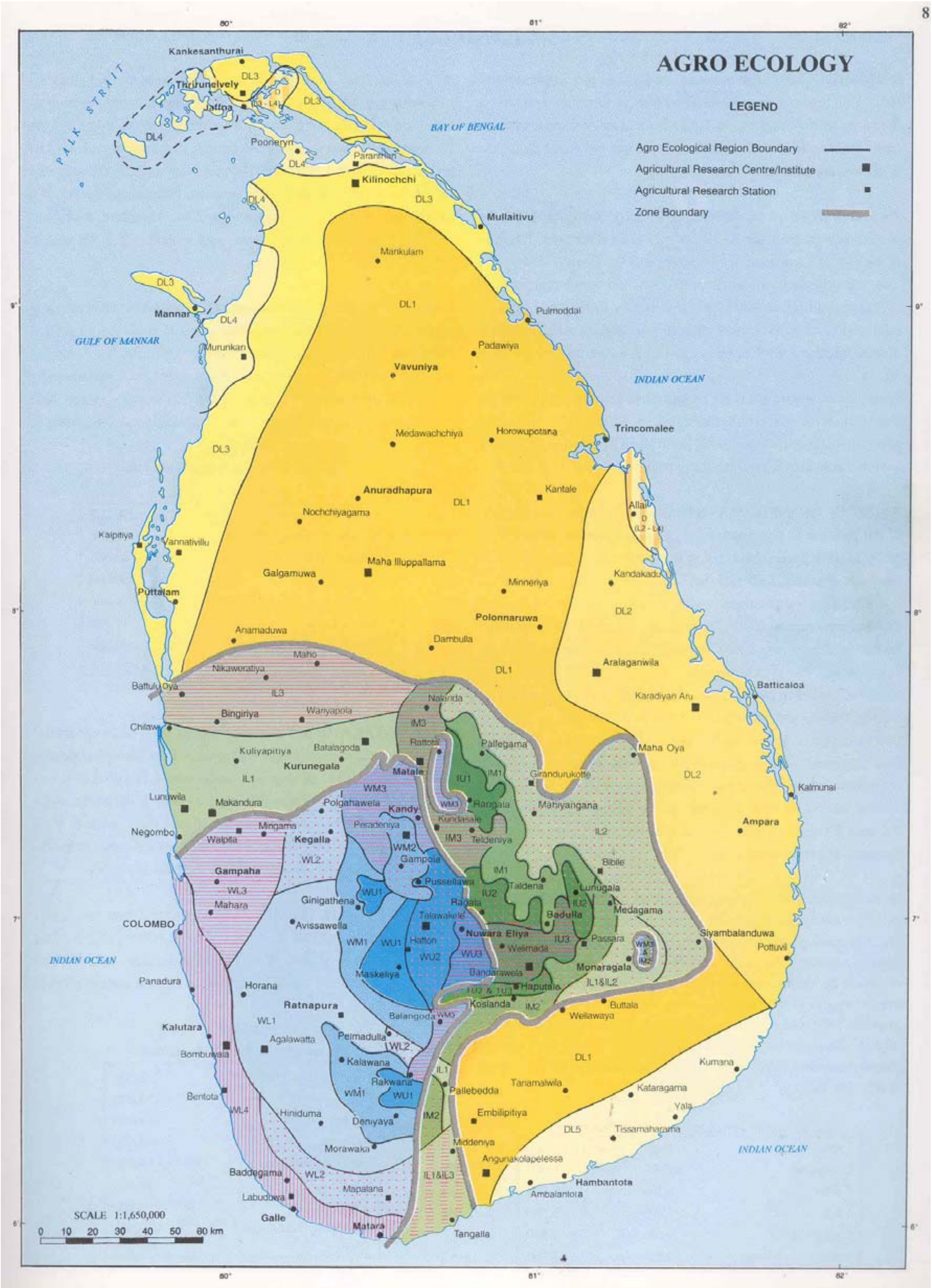

Figure 3.3: Agro Ecological Regions of Sri Lanka

Matching the areas represented by these modal rainfall probability regimes against zonal and elevation boundaries as well as against Soil Map of Sri Lanka, it has been identified and demarcated 10 AERs in the Wet Zone (three in Up Country; viz. WU1, WU2 and WU3, three in Mid Country; viz. WM1, WM2 and WM3 and four in Low Country; WL1, WL2, WL3 and

WL4), 9 AERs in the Intermediate Zone (three in Up Country; viz. IU1, IU2 and IU3, three in Mid Country; viz. IM1, IM2 and IM3 and three in Low Country; IL1, IL2 and IL3) and 5 AERs in the Dry Zone, Low Country (DL1, DL2, DL3, DL4 and DL5). Altogether there are 24 AERs in the country ((PANABOKKE 1997b). The demarcation of the country into these agro ecological regions is shown in the Agro Ecology Map (PANABOKKE and KANNANGARA 1975) of Sri Lanka (Figure 3.3).

3.1.9 Land Use

The pattern of land use has been changing fairly rapidly. In 1800, the population was small and forest covered most of the island. Clearing up the forests for plantation agriculture was the greatest change that took place in the 19^{th} century. In 1901, the population was 3.6 million and the forest cover was 70%. But by 1996, the population had risen to 18.2 million and the forest cover had dwindled to 23.9% of dense forest and 6.9% of sparse and open forest, making a total of 30.8% under forest. The area covered by settlements has grown along with the population and large multipurpose schemes, involving construction of reservoirs for irrigated agriculture and hydro power generation and settling people in these areas by clearing the forests are other land use changes that have occurred during the past century (SOMASEKARAM 1997).

The area available for use is 5,527,300 ha after excluding land under stream and stream reservations, reservoirs, steep land, land above 1525 m contour, barren land and marshes and mangroves (land to be excluded from use is 1,025,000 ha). Estimated area under dense and sparse and open forests is 2,000,000 ha. A total of 1,752,100 ha or 26.7% of the country is agricultural land under different crops; 732,000 ha under Paddy, 193,000 ha under Tea 161,000 ha under Rubber, 442,000 ha under Coconut, 66,500 ha under other export crops (Cinnamon, Coffee, Cocoa, Cardamom etc.), 10,600 ha under Sugarcane, 6,000 ha under Tobacco and 141,000 under subsidiary food crops. The area of homesteads and built up areas has been estimated to be about 900,000 ha, area under other uses (roads, railways, harbours, airports, power and telecom lines, archaeological sites, tourism, coast protection) is 165,000 ha and sparsely used and balance land is 710,200 ha (SOMASEKARAM 1997).

3.1.10 Natural Hazards

Natural event that lead to situations that endanger man and habitat may be called natural hazards. Droughts, floods, landslides, coastal erosion, cyclones and thunderstorms are natural hazards due mainly to vagaries of weather. Earth tremors and earthquakes are also natural hazards although of very small significance to Sri Lanka (DE TISSERA 1997).

Droughts and floods are relatively common over the past history. Frequency occurrence of landslides has been increased nowadays than in the past. Coastal erosion is also at a significant level and some coast conservation measures are now being adopted. Thirteen cyclones had hit the east coast of Sri Lanka during the period from 1901–1995, of which three were severe and caused considerable damage to human life and property. During the intermonsoon months of March-April and October-November, thunderstorms (rain accompanied by lightning and thunder) are common in Sri Lanka and can also occur during monsoons too. Lightning can damage electrical and electronic equipment as well as telecommunication networks and occasionally lives are also lost (DE TISSERA 1997).

Sri Lanka is located outside the global earthquake belts and the landmass considered being of low seismicity. Accordingly it is believed that the potential for earthquake induced problems is very low. The tsunami has been added to the list of natural hazards of Sri Lanka only after December 26, 2004 Asian tsunami. However, it is recorded that in 1614 an earthquake had caused 200 houses to collapse in Colombo Fort (National Archives Reports) and many deaths had also been reported (DE TISSERA 1997).

3.2 Study site and Site selection

3.2.1 Study site

The present study was carried out in some selected villages in Galle District of the Southern Province of Sri Lanka. The study sites located within $80^{O}03'$E – 80 $^{O}09'$E and $6^{O}04'$N–$6^{O}13'$N (Figure 3.4 SURVEY DEPARTMENT OF SRI LANKA 1996; COMMONWEALTH SECRETARIAT, SRI LANKA 2007). The selected villages were situated from Ambalangoda to Boossa (Table 3.2) beside the A2 main road leading to Wellawaya from Colombo, the Capital of Sri Lanka (SURVEY DEPARTMENT OF SRI LANKA 1996). Distance to the study sites along the A4 road ranges between 85 km and 105 km from Colombo and 15 km and 35 km from Galle town, the Capital of Southern Province.

The present study sites were located in the 6th topographical region of the country, the Coastal Fringe (VITHANAGE 1997) which consisting of a series of lagoons, marshes, sand bars, spits, peninsulas, dunes, islands and other associated features. The present study sites situated between the mouths of two main rivers, Bentota Ganga and Gin Ganga [Ganga (S) = river]. Bentota Ganga is at Ambalangoda side (faraway), whereas Gin Ganga at Boossa side (closer) of the present study sites.

Almost all the parts of present study sites is underlain by rocks of Precambrian Highland Complex, metamorphic group with Hypersthene bearing charnockitic gneiss, Biotoc and migmatitic. Additionally the buried patches of coral (later Quaternary deposits) up to several kilometers inland and patches of shell beds several meters above sea level are special geological features in this southern and southwestern coastal zone (COORAY 1997). The present study sites were situated in the Agro Ecological Zone WL4 (Wet Zone, Low Country), the terrain is undulating and flat and the main soil type is Red-yellow Podzolic with soft and hard Laterite and also Bog and Half-Bog soils (PANABOKKE 1997a and PANABOKKE 1997b).

Figure 3.4: South West part of Sri Lanka showing the Location of Study Sites in Galle District of the Southern Province, Sri Lanka

Table 3.2: Selected villages for the present study from Galle District, Sri Lanka

Village	Longitude	Latitude
Urawaththa	80^{O}03'00"	6^{O}13'00"
Usmudulawa	80^{O}03'00"	6^{O}13'00"
Wenamulla	80^{O}03'00"	6^{O}13'00"
Ambalangoda	80^{O}03'24"	6^{O}13'30"
Wellamada	80^{O}04'00"	6^{O}12'00"
Kahawa	80^{O}04'00"	6^{O}11'00"
Uduwaragoda	80^{O}04'00"	6^{O}11'00"
Akurala	80^{O}04'43"	6^{O}11'57"
Thelwaththa	80^{O}04'57"	6^{O}11'28"
Kuligoda	80^{O}05'00"	6^{O}13'00"
Pereliya	80^{O}05'00"	6^{O}10'00"
Werellana	80^{O}05'00"	6^{O}09'00"
Thotagamuwa	80^{O}06'00"	6^{O}09'00"
Gammeddegoda	80^{O}08'00"	6^{O}05'00"
Rathgama	80^{O}09'00"	6^{O}06'00"
Boossa	80^{O}09'25"	6^{O}04'53"

Average annual rainfall of the present study sites is between 2000 mm and 3000 mm, get heavy rains during May to September form Southwest Monsoon. Average annual temperature of the area ranges from 25.0^o C – 27.5^o C (DE SILVA and FERNANDO 1997). Coastal erosion is a major natural hazard of this region. The high sea waves associated with the Southwest Monsoon destroy the part of coast each year (DE TISSERA 1997).

The sandy sea beaches along the coastline in the present study area are very popular among both local and foreign tourists; seasonal shallow rock pool of Akurala beach and live coral gardens of Hikkaduwa are very attractive and famous. Abandoned coral and shell mines in Akurala and nearby villages (some tsunami affected villages in present study) had been transformed to marshes and now comprised of mangroves and other associated wetland flora. The flora and fauna in the area are rich in diversity. Coral and shell mining and lime production (by burning the corals and shells) is a main income of the area next to fishery. However this coral and shell mining activity becomes a problem where it disturbs vegetation and soil structure particularly in protected areas in the coastal fringe (WICKREMERATNE and SAMARAKONE 1997).

Total forested extent of the Galle district is 20,789 ha; 18,903 ha under Lowland Rain Forests, 187 ha under Mangroves and 1,699 ha under Sparse and open forest. According to the forest map of Sri Lanka the present study area is situated in a Sparse and open forested area, however all the settlements has placed under this category. The main land-use type of the present study area is homegardens, settlements and Coconut plantations (BANDARATILLEKE 1997; SOMASEKARAM1997). Additionally, some scattered mangroves and wetlands are located along sheltered intertidal coastlines in association with mouth of rivers and abandoned coral and shell mines. Some small scale Cinnamon plantations were also there in some villages, mostly ahead 200 m from the shoreline.

The income of the community mainly depend on fisheries, coral mining and lime production, tourism, coir production, Coconut plantations, puppetry, masks manufacturing and small scale basket weaving. Their income is daily basis in most instances, except the individuals permanently employed in government or private sector and well established own businesses.

Hikkaduwa Coral-gardens National Park (earlier Hikkaduwa Marine Sanctuary) and two other wildlife sanctuaries (viz. Rocky Islets and Telwatte Sanctuary) are located around the present study sites (DE ALWIS 1997).

The present study area is situated in the 8th region of 14 Tourism Development Regions of the country named as South Coast from Galle to Hambantota. This area is especially famous for the attractive sandy beaches and marine activities including scuba diving at Unawatuna. There are a number of archeological tourist attractions also in the area such as Galle Fort, Seenigama Devalaya etc. Hikkaduwa coral garden, Turtle Hatcheries, puppetry and masks manufacturing at Ambalangoda are some other tourist attractions of the region (DEHERAGODA and TANTRIGAMA 1997).

3.2.2 Site selection

Initially it was planned to conduct some studies in the eastern and south eastern parts of the country. The prevailing security condition was not suitable and I was not allowed to perform field work in those areas. Accordingly sites were selected from Galle District in the Southern Province of Sri Lanka. Matara and Hambantota are the other two districts in the Southern Province. Some coastal areas of them belong to different agro-ecological regions (IL1, IL3, DL1 and DL5) and therefore the sites were not selected from them. Sites were selected within one agro-ecological zone (WL4). The limitation of time and availability of funds were also taken into consideration to limit the extent of study sites. Akurala-Kahawa-Telwaththa-Pereliya area was the severally affected coastal stretch in Galle district and therefore the study sites were intentionally selected form in and around the above coastal stretch.

3.3 Vegetation damage survey: Investigation of the impact of the tsunami on homegarden vegetation, exploration of the survived vegetation and the role of vegetation during and in aftermath of flooding

This survey was conducted in the period from May to August 2006; that was two years and six months after the December 26, 2004 tsunami.

In order to gather basic information on destructions to the homegarden vegetation from tsunami, 150 questionnaires were distributed to 150 families in severely damaged villages described in sections 3.2.1 in Galle District of Southern Province, Sri Lanka.

The questionnaire was originally designed in English and translated into the local language Sinhala to distribute among the community. Questionnaire designing and field survey were conducted according to the standard methods (http://www.analytictech.com..; http://www.cc.gatech.edu..; http://www.statpac.com..; http://www.surveysystem.com..; Burgess 2001). The translated questionnaire was pre-tested before distribution, using a sample group of people from the original sites to check the feasibility and possible errors tend to encountered during the survey (BABBIE 2004; KOTHARI 2004), and made some amendments accordingly. The questionnaire used for the survey is presented in Appendix 1. The survey involved the following steps. First visit the houses and explained the dwellers about the purpose and nature of the survey and asked them to respond the questionnaire. Some responded questionnaires collected during the survey. Some dwellers needed more time and they were provided with self addressed stamped envelopes and asked them to post the duly filled questionnaires.

Out of 150 distributed, 126 responded questionnaires were received and they were considered to analyze data on the destruction to vegetation, survived vegetation and the role of plants which help to survive lives of the community during the tsunami and in aftermath flooding.

In addition to the above, useful information on the favoured plant species to grow in affected homegardens and species have already planted in the homegardens were also collected using the questionnaire. The knowledge on the species suitable for coast conservation was also investigated.

Information on alien plants found in the homegardens after the tsunami were also gathered using the questionnaire.

3.4 Comparison of the present status, vegetation structure and composition of tsunami affected homegardens with non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline

Tsunami affected homegardens were selected for the present study from Wellamada, Wenamulla, Akurala, Kahawa, Thelwaththa, Pereliya, Werellana, Thotagamuwa, Kuligoda, Gammeddegoda and Uduwaragoda villages, whereas the non-affected homegardens were selected from Ambalangoda, Usmudulawa, Urawaththa, Madampe, Rathgama, Owakanda, Wellabada and Boossa villages in the Galle District of the Southern Province, Sri Lanka.

Homegardens were selected randomly from tsunami affected areas (villages) and adjacent non-affected areas (villages) within 0-100m and 100-200m from the shoreline. Accordingly there were 4 categories as follows.

5. Tsunami affected within 0-100m from shoreline
6. Tsunami affected within 100-200m from shoreline
7. Tsunami non-affected within 0-100m from shoreline
8. Tsunami non-affected within 100-200m from shoreline

A schematic representation of the location of study sites, above four categories in a tsunami affected area and in an adjacent non-affected area provides in the Figure 3.5.

I surveyed 60 homegardens from the category (1) Tsunami affected within 0-100m from shoreline, 60 homegardens from the category (2) Tsunami affected within 100-200m from shoreline, 60 homegardens from category (3) Tsunami non-affected within 0-100m from shoreline and 60 homegardens from category (4) Tsunami non-affected within 100-200 m from shoreline.

Fieldwork was conducted from August 01, 2007 to March 31, 2008 in the selected coastal belt from Ambalangoda to Boossa in Galle District, Southern Province, Sri Lanka. Conducted a household survey, interviews with dwellers (mainly with householder) using a pre-tested structured questioner to gather fundamental information on their home gardens.

Then Count Plot Sampling was carried out in 10mX10m quadrates (Figure 3.5). One 10m X 10m plot was sampled in each home garden. 10m X 10m size was decided according to MUELLER-DOMBOIS and ELLENBERG (1974) and confirmed according to HOCHEGGER (1998) as the present homegardens were small in size and with relatively less density of vegetation when compare to the homegardens in mid country wet zone of Sri Lanka (HOCHEGGER 1998). All the individuals of woody perennials equal or above 1 cm DBH (diameter at breast height) and equal or above 1.5 m height were identified and counted. DBH of them were determined using a DBH tape. Altogether, 240 plots (10m X 10 m) were samples from four categories.

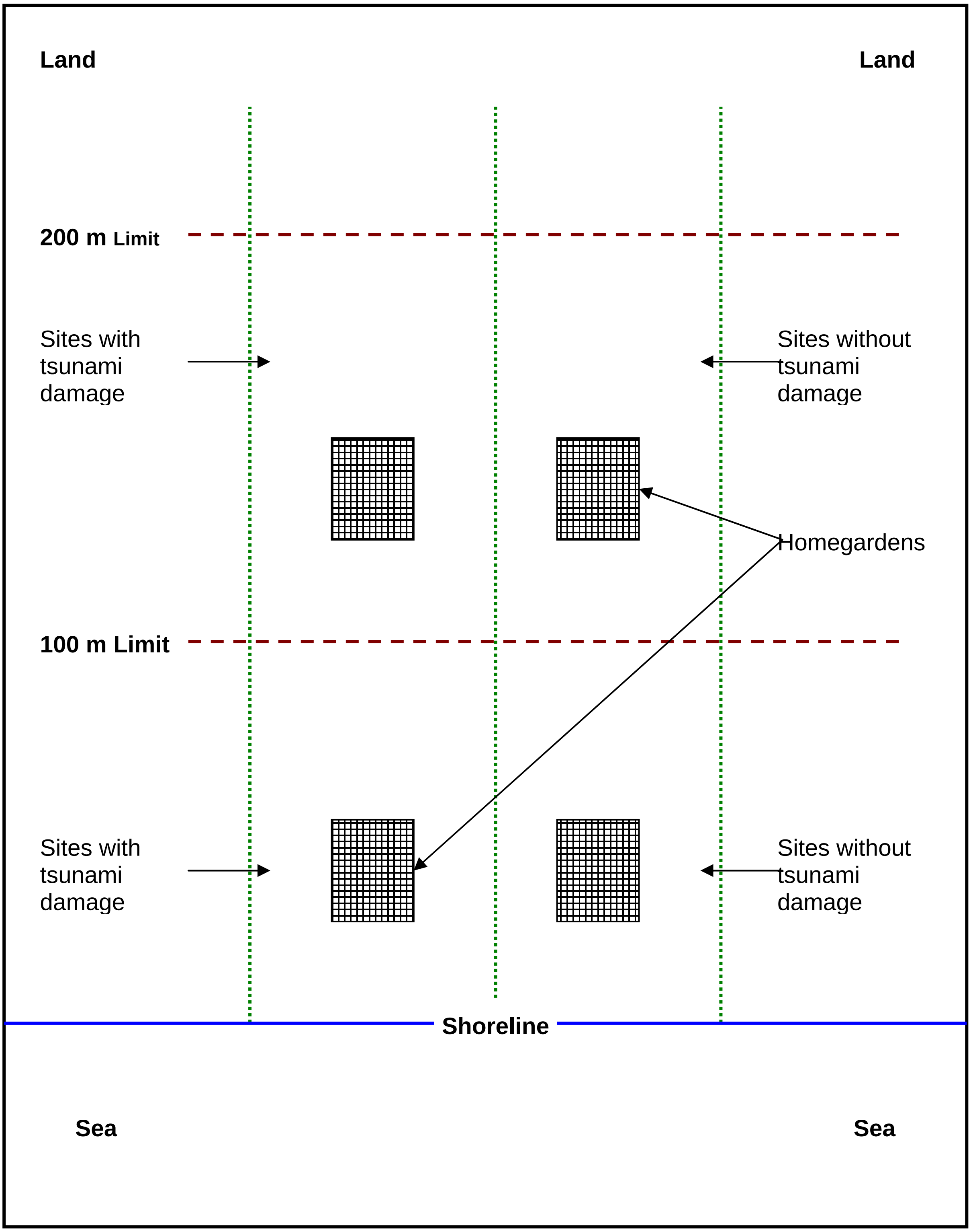

Figure 3.5: Schematic representation of the location of homegardens within four categories of study sites

Vegetation structure and composition were described. Floristic richness (Family, Genera and Species list), Dominance in terms of Importance Value Index (IVI) and girth class distribution were used to describe the structure and composition of 4 different sites (KENT and COKER 1996; MAGURRAN 1998; MAGURRAN 2004). To compare the diversity of 4 different sites Shannon Diversity Index, Evenness, Jaccard similarity coefficient and Rank abundance curves and were used.

3.5 Investigation of ground layer vegetation in order to study the regeneration of woody perennials in tsunami affected homegardens and non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline

Count plot sampling was carried out in a randomly placed 1m X 1m quadrates (Figure 3.6) within each 10m X 10 m quadrates described in the above section 3.4. For this investigation also 1m X 1m size was decided adopting the methods described by MUELLER-DOMBOIS and ELLENBERG (1974) and confirmed according to HOCHEGGER (1998) as the present homegardens were small in size and with relatively less density of vegetation when compare to the homegardens in mid country wet zone of Sri Lanka (HOCHEGGER 1998). All the individuals of woody perennials less than 1 cm DBH (diameter at breast height) and less than 1.5 m height were identified and counted.

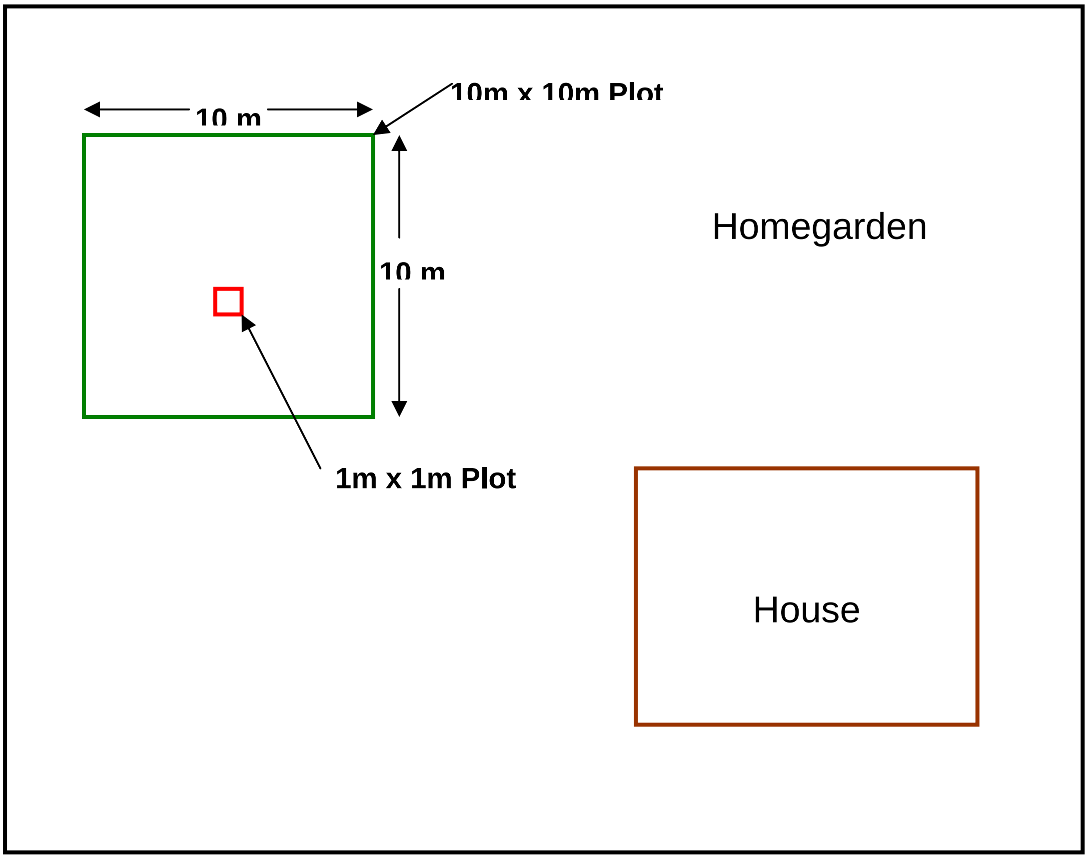

Figure 3.6: Plot Design in Homegardens

Accordingly 1m x 1m quadrates were sampled in each category as follows: 60 from the category (1) Tsunami affected within 0-100m from shoreline, 60 from the category (2) Tsunami affected within 100-200m from shoreline, 60 from category (3) Tsunami non-affected within 0-100m from shoreline, 60 from category (4) Tsunami non-affected within 100-200m from shoreline and altogether 240 quadrates.

Composition of the ground layer vegetation was described. Floristic richness (Family, Genera and Species list) and Dominance in terms of Importance Value Index (IVI) were used to describe the composition of 4 different sites (KENT and COKER 1996; MAGURRAN 1998; MAGURRAN 2004). To compare the diversity of 4 different sites Shannon Diversity Index, Evenness, Jaccard similarity coefficient and Rank abundance curves were used.

3.6 Survey of the live fence species in tsunami affected homegardens and non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline

This survey was also conducted from August 01, 2007 to March 31, 2008 in the selected coastal belt from Ambalangoda to Boossa in Galle District, Southern Province, Sri Lanka parallel to the other surveys. This survey was carried out to find out the composition of live fences qualitatively in order to gather the knowledge on prospective plant species could be used in future regreening programmes. I surveyed 60 homegardens from the category (1) Tsunami affected within 0-100m from shoreline, 60 homegardens from the category (2) Tsunami affected within 100-200m from shoreline, 60 homegardens from category (3) Tsunami non-affected within 0-100m from shoreline and 60 homegardens from category (4) Tsunami non-affected within 100-200 m from shoreline. Plant species found in live fences around 240 coastal homegardens (60 from each category) were identified and recorded.

3.7 Plant species selected to survey the uses for the coastal community and to study the preference to integrate them in their homegardens

3.7.1 Selection criteria

Selection of plants for testing the preference by the community to grow them in their home gardens was done using several criteria. Indigenous species as well as some exotic species were included in the list. Trees, shrubs and some shrubby trees or treelets were selected and included. Most of the species selected were climatic climax species of that particular coastal area and they were from different zones along the transect perpendicular to the coast. Common abundance was also used as a criterion to select plants. Finally the already recommended species by the Government and Non-Governmental Organizations for the tsunami affected areas in the Galle district were also considered and included to the list. Table 3.3 presents the glimpse on the selected plant species. Number of plants tested limited to 15 to minimize the confusion in selection process by the community. If the list is over 15, it was found that the difficulty of selection is problematic according to the preliminary survey (pre-testing). All fifteen species were woody perennials (WIJESINGHE 1994).

Table 3.3: Glimpse on selected plant species

No.	Plant Species	Life form	Origin	Major Uses	Abundant Habitat
1	*Alstonia macrophylla*	Tree	Exotic	Timber	Homegardens
2	*Barringtonia asiatica*	Tree	Indigenous	Shade, Ornamental	Coastal vegetation, homegardens
3	*Calophyllum inophyllum*	Tree	Indigenous	Timber Medicinal	Coastal vegetation, homegardens
4	*Calotropis gigantea*	Shrub	Indigenous	Medicinal	Coastal vegetation
5	*Casuarina equisetifolia*	Tree	Exotic	Coast conservation	Planted in coastal areas
6	*Cocos nucifera*	Tree (Palm)	Indigenous	Multipurpose	Homegardens
7	*Gliricidia sepium*	Shrub / Tree	Exotic	Multipurpose	Homegardens (live fences)
8	*Hibiscus tiliaceus*	Shrubby tree	Indigenous	Fibre for cordage	Coastal vegetation
9	*Morinda citrifolia*	Tree / Shrub	Indigenous	Medicinal	Coastal vegetation
10	*Ochrosia oppositifolia*	Tree	Indigenous	No major uses	Coastal vegetation
11	*Pandanus odoratissimus*	Shrub	Indigenous	Coast conservation	Coastal vegetation
12	*Premna obtusifolia*	Shrubby tree	Indigenous	Medicinal	Coastal vegetation
13	*Scaevola taccada*	Shrub	Indigenous	No major uses	Coastal vegetation
14	*Terminalia catappa*	Tree	Naturalized	Timber, Shade	Coastal vegetation, homegardens
15	*Thespesia populnea*	Tree	Indigenous	Timber	Homegardens (live fences)

Barringtonia asiatica, Cocos nucifera, Pandanus odoratissimus and *Terminalia catappa* have been identified suitable and recommended to plant in the tsunami affected areas in Galle district by Government and Non-Governmental Organizations (DANANJAYA DELGODA, Personal Communication 2007). *C. nucifera* and *T. catappa* have high demand within the community; *C. nucifera* as a multipurpose tree and *T. catappa* as a timber tree.

Casuarina equisetifolia (De Zoysa 2008) and *Pandanus odoratissimus* have been used in coast conservation programmes of Sri Lanka even before the tsunami disaster to protect coast form erosion. *Thespesia populnea* has been highlighted by TANAKA et al. (2007) as an effective tree species for escaping (by climbing and clasping) during natural disasters. *Alstonia macrophylla* and *Gliricidia sepium* are very popular in coastal home gardens; *A. macrophylla* as a good timber tree and *G. sepium* as a multipurpose tree, especially as living fence posts. According to the preliminary observations made by us *Barringtonia asiatica, Calophyllum inophyllum* and *Thespesia populnea* gave the impression that they are very resistant and survived majority of individuals after the tsunami.

Ochrosia oppositifolia is an obligatory coastal tree and confined only to the south-western coastal districts of Sri Lanka and it is a climatic climax species in the present study site. *Calotropis gigantea*, *Morinda citrifolia* and *Premna obtusifolia* are popular medicinal plants and they are true climatic climax species in the littoral zone of the coastal vegetation of Sri Lanka. *Scaevola taccada* is also a climatic climax species in the littoral zone. *Morinda citrifolia* and *Premna obtusifolia* mainly confined to the coastal wet zone. Whereas, *Calotropis gigantea* and *Scaevola taccada* has a wide range of distribution; distributed also in the dry and arid parts of the country. The small spreading shrubs or shrubby trees with dense branches and leaves can act as cushions for effective soft landing for people washed up by tsunami or cyclonic condition (TANAKA et al. 2007).

3.7.2 Details of the selected plant species

Accounts on selected fifteen plant species including their life form, classification, tree architectural model, available vernacular (local) names, origin and/or global distribution, occurrence in Sri Lanka and uses are given below.

3.7.2.1 *Alstonia macrophylla* Wall. ex G. Don (Figure 3.7)

A moderate size tree species, with white gray bark, has a very straight and slender bole to the top with little taper, height is around 125 feet (WORTHINGTON 1959; TISSEVERASINGHE 1971). *A. macrophylla* classified under the family Apocynaceae (SENARATNE 2001), belongs to Koriba's tree architectural model (HALLÉ et al. 1978).

Vernacular names are Havari-nuga, Avari-nuga, Ginikuru-gas, Attonia (S), Velai-maram (T). *A. macrophylla* is not indigenous to Sri Lanka, an exotic, introduced from Malayan region (Malay Penninsula) as a forest tree to Sri Lanka. It is found also in Thailand, Indochina, the Philippines, Celebes and Borneo (HUBER 1983a). The place of origin of this species is Philippines (WORTHINGTON 1959). *A. macrophylla* rapidly became naturalized in the moist region up to an elevation of 1200 – 1500 m since the beginning of the 20th century. Now it is one of the most prominent species of the secondary forests in the island, also reported from coastal districts like Colombo and Galle. The timber of *A. macrophylla* is of superior quality (harder and stronger) to that of *A. scholaris* (L.) R. Br., another species of *Alstonia* indigenous to Sri Lanka and less liable to attack by boring insects. This is very suitable for use as transmission and telegraph poles (especially due to the tapering nature of the bole) after preservative treatment. In reforestation the tree is the best pioneer for poor grassland (TISSEVERASINGHE 1971; HUBER 1983a). Timber used in general purposes, plywood framery of windows and doors, panelling and ceiling boards and packing cases and chests (WORTHINGTON 1959; ASHTON et al. 1997). Wood density is 640 kg m^{-3} and classified into general purposes timber class III and plywood quality class III by Sri Lanka State Timber Corporation (ASHTON et al. 1997). Nowadays this is a very popular tree species in coastal homegardens in south western parts of Sri Lanka. However, it seems not very resistant to tidal waves and cyclones according to the recent observations.

Figure 3.7: ***Alstonia macrophylla***

3.7.2.2 *Barringtonia asiatica* (L.) Kurz (Figure 3.8)

A tree species with a fissured bark up to 30 m tall (MACNAE and FOSBERG 1981). It is classified under the family Lecythidaceae (SENARATNE 2001). According to the growth and branching pattern, *B. asiatica* can be classified into Leeuwenberg's tree architectural model (HALLÉ et al. 1978). The common vernacular name is Diya-midella (S), and also known as Moodilla and Midella (S) in southern parts of Sri Lanka where the present study sites are located. This species is distributed from Comoro Island and Madagascar eastwards to Tahiti and from Vietnam to North Queensland. It has been introduced widely to tropical islands, such as Hawaii, the West Indies and St. Helena. In Sri Lanka, *B. asiatica* is found among seashore vegetation, common as a street tree and in shoreward gardens, parks and hotel yards in Colombo and south-western coastal districts; some of these trees are probably growing truly wild, and were not planted (MACNAE and FOSBERG 1981), also reported as a mangrove associate or common back mangrove species in Sri Lanka (JAYATISSA et al. 2002; DE SILVA and DE SILVA 2006). This is mainly planted as an ornamental tree (ASHTON et al. 1997). Wood used in light construction, scaffolding and poles and as firewood. According to the preliminary observation made by us, it can be stated that this is promisingly a very resistant species for sea-born natural hazards, due to the characteristic architecture of the tree and the sturdy anchorage of the root system. Roots, fruits, seeds and bark of *B. asiatica* are used in medicine (JAYAWEERA 1981b).

Figure 3.8: *Barringtonia asiatica*

3.7.2.3 *Calophyllum inophyllum* L. (Figure 3.9)

This is a tree species, glabrous in all its parts, up to 20 m high and 50 cm diameter. Mature trees with deeply fissured, grey to blackish bark and the live bark pink with clear yellow exudates. Wood is reddish brown and heavy (KOSTERMANS 1980). *C. inophyllum* is classified under the family Cluciaceae (SENARATNE 2001) and belongs to the Attims' tree architectural model (HALLÉ et al. 1978). *C. inophyllum* is known as Alexandrian laurel (E).

Domba (S), Punnaga (SK), Punai, Punnaigam, Dommakottai (T) are the other vernacular names. This species is distributed in sandy and rocky seashores of Malaysia, Pacific, East Africa and India, going as far as Taiwan and Australia, on coral islands often forming a belt parallel to the coast. In Sri Lanka, *C. inophyllum* is found naturally in lowland, along coast and individuals found in inland are planted or spontaneous (KOSTERMANS 1980), also reported as a mangrove associate or common back mangrove species in Sri Lanka (JAYATISSA et al. 2002; DE SILVA and DE SILVA 2006). Ornamental tree, planted on roadsides for the heavy shade and handsome, dark, evergreen foliage. Seeds afford a lamp oil and oil for painting wood work, supplies the Mariae balsam and yellowish green resin known as Tacamahaca. Timber is used for knees, masts and spars of boats, railway sleepers, building construction, plywood, ceiling boards, planking and furniture etc. Wood density is 608 kg m^{-3}. Leaves, flowers, fruits and bark gum of *C. inophyllum* have medicinal properties (WORTHINGTON 1959; TISSEVERASINGHE 1971; KOSTERMANS 1980; JAYAWEERA 1981b; ASHTON et al. 1997).

Figure 3.9: ***Calophyllum inophyllum***

3.7.2.4 ***Calotropis gigantea*** **(L.) R. Br. (Figure 3.10)**

This is a shrubby treelet with young stems and inflorescences cottony pubescent, stems 1-5 m high (HUBER 1983b). It is classified under the family Asclepiadaceae (SENARATNE 2001) and Ela-wara, Hela-wara, Wara, Muduwara (S), Manakkovi, Errukalai, Urkkovi, Arakkam (T) are some vernacular names of more than twenty. *C. gigantea* is distributed from Pakistan and Nepal through India to Sri Lanka, the Maldive Islands (Hulula), South China and Malesia. It is common in disturbed vegetation and in waste places throughout the dry and arid parts of Sri Lanka, less frequently as a weed in the humid zone, confined to low country and flowering all the year (HUBER 1983b). The bark, root, milky juice and dried latex of this shrub are used in medicine. The root of the white flowered form (Ela-wara in Sinhala) is a specific in the treatment of snake bites. A fine fibre is obtained from the stem is used in traditional fishing line to catch a particular fish species, *Katsuwonus pelamis* (Balaya in Sinhala), belongs to family Tunidae (JAYAWEERA 1981a; HUBER 1983b; ASHTON et al. 1997).

Figure 3.10: ***Calotropis gigantea***

3.7.2.5 *Casuarina equisetifolia* L. (Figure 3.11)

This is a conifer-like large fast-growing tree with straight boles and drooping branches (ABEYWICKRAMA 1996); classified under the family Casuarinaceae (SENARATNE 2001); belongs to the Attims' tree architectural model (HALLÉ et al. 1978) and known by vernacular names Kassa (S), Chavukku (T) and Whip Tree (E). *C. equisetifolia* distributed in South East Asia from Chittagong southwards and in Australia and widely cultivated elsewhere in the Tropics. Much cultivated especially in coastal areas and other sandy places in Sri Lanka. It thrives best on well drained soils on coasts where sand accretion is taking pace. It has root nodules with N_2-fixing bacteria. In favourable locations it is grows to a height of about 30 m and reaches a diameter of about 60 cm at breast height. A good sand-binder, it is useful for reclamation of sand dunes; its wood has a high caloric value. Sometimes pruned and trained as a hedge-plant (ABEYWICKRAMA 1996).

Figure 3.11: ***Casuarina equisetifolia***

Casuarina equisetifolia is also used in windbreaks, light construction work and as posts, as an ornamental, as firewood etc. Wood density is 960 kg m^{-3} (WORTHINGTON 1959; ASHTON et al. 1997).

3.7.2.6 *Cocos nucifera* L. (Figure 3.12)

This is a palm tree, the stem is smooth, grey, to about 35 m high, diameter about 30 cm at the breast height, swollen at the base; leaves pinnate and 6-7 m long (DE ZOYSA 2000); classified under the family Arecaceae (SENARATNE 2001); belongs to the Corner's tree architectural model (HALLÉ et al. 1978). Coconut, King-coconut (E), Pol, Polgaha, Thambili, Wewara, Kurumba, Kundira, Bodiri or Bodili, Nawasipol, Ranthambili, Gonthamili (S) and Thengai (T) are the vernacular names use in Sri Lanka for coconut and some of its local varieties. It is distributed in Tropics and in warm Subtropics. In Sri Lanka it is cultivated as plantation crop throughout the coastal belt and in the homegardens up to an elevation of about 500 m. *C. nucifera* is regarded a strand plant but will flower and fruit in humid equatorial regions at altitudes up to 900 m above sea level. Its natural habitat may well have been strand vegetation (DE ZOYSA 2000). Coconut is one of the most important tropical crops with a large number of commercial and domestic uses. The wood is used for construction, rafters, handicrafts; leaves for thatch, basket weaving and fuel; the inflorescence for sugar syrup, which is then converted into alcohol (arrack) and vinegar (also made treacle and jaggery), inflorescence also used for ceremonial purposes; fruit for food and drink, fibres (coir) from mesocarp (husk) for brooms, carpets, ropes and mattresses etc., hard woody endocarp for utensils and fuel, endosperm processed for coconut milk, desiccated coconut (for confectionary etc.), copra and coconut oil (for cooking, lamps etc.), the endosperm fluid for drinking and the waste after extracting oil as a feed (Punnakku) for livestock, a by-product. Coconut oil, roots, flowers, fibrous leaf sheath are used in indigenous medicine (ASHTON et al. 1997; DE ZOYSA 2000).

Nearly all parts of the coconut palm are useful, and the palms have a comparatively high yield, up to 75 fruits per year; it therefore has significant economic value. The name for the coconut palm in Sanskrit is “Kalpa-vriksha”, which translates as "the tree which provides all the necessities of life". In Malay, the coconut is known as “pokok seribu guna”, "the tree of a thousand uses". In the Philippines, the coconut is commonly given the title "Tree of Life". It its theorised that if you were to become stranded on a desert island populated by palm trees, you could survive purely on the tree and coconut alone, as the coconut provides all of the required natural properties for survival (http://en.wikipedia.org/wiki/Cocos_nucifera).

Figure 3.12: ***Cocos nucifera***

3.7.2.7 *Gliricidia sepium* (Jacq.) Walp. (Figure 3.13)

G. sepium is a tree, to about 10(-15) m tall; young stems puberulent or subsericeous, glabrescent with age; bark grey to brownish with white lenticels (RUDD 1991); classified under the family Fabaceae (SENARATNE 2001). Kona (S, T) is the only vernacular name stated in RUDD (1991) and WORTHINGTON (1959). However, it is also known by Wetahira, Giniseeriya, Kirideesiya (S) and Ladappa (S, T) in some areas. This is native to tropical America but widely introduced in the Old World tropics. It is commonly planted in Sri Lanka as shade for cocoa, tea and coffee, as a support to grow pepper wines, in alley cropping and as a multipurpose tree. Because of quick rooting it is often planted as living fences. Leaves, flowers and seeds are used as a poison for rats. Used as a firewood and mature trees used as timber (very hard and heavy) for tool handles etc. Leaves are good source of fodder for livestock (WORTHINGTON 1959; RUDD 1991; ASHTON et al. 1997). Fresh crushed leaves are applied on wounds, in some coastal areas of Sri Lanka, but not a very popular practice.

Figure 3.13: ***Gliricidia sepium***

3.7.2.8 *Hibiscus tiliaceus* L. (Figure 3.14)

H. tiliaceus a tree, up to 6 m or tall, or large shrub, much branched, attractive yellow flowers with crimson to maroon-red centre (PHILCOX 1997); classified under the family Malvaceae (SENARATNE 2001); belongs to the Scarrone's tree architectural model (HALLÉ et al. 1978). Belipatta, Wal-beli (S), Arita, Nir-paratthi (T) and Bala (SK) are the vernacular names use in Sri Lanka (JAYAWEERA 1982a; PHILCOX 1997). This species is widespread in the tropics and subtropics of both hemispheres, particularly along coasts. It is distributed in low country, chiefly near the coast; near rivers and streams (PHILCOX 1997), also reported as a mangrove associate or common back mangrove species in Sri Lanka (JAYATISSA et al. 2002; DE SILVA and DE SILVA 2006). Aqueous extract of bark, powdered bark, roots and young leaves of *H. tiliaceus* are used in medicine. Bark fibre used for making cordage (JAYAWEERA 1982a). Leaves used by the coastal community for wrapping, especially some traditional sweetmeats.

Figure 3.14: ***Hibiscus tiliaceus***

3.7.2.9 *Morinda citrifolia* L. (Figure 3.15)

A shrub or small tree up to 9 m, distributed in continental Southeast Asia, Malesia and Pacific. This is common along the sea coast in the moist regions in Sri Lanka, often cultivated in backyard gardens inland (RIDSDALE 1998). *M. citrifolia* classified under the family Rubiaceae (SENARATNE 2001); belongs to the Petit's tree architectural model (HALLÉ et al. 1978); known by the vernacular names Ahu (S), Manjabavattai, Manjatti, Nuna, Seyal etc. (T) and Indian Mulberry (E). This is a popular medicinal pant; roots, tender leaves and unripe berries (fruits) are used in Medicine. It is also planted as an ornamental (JAYAWEERA 1982a; ASHTON et al. 1997). In Sri Lanka, in the present study area, fruits of *M. citrifolia* are used in exorcism as a substitute for lime fruits.

Figure 3.15: ***Morinda citrifolia***

3.7.2.10 *Ochrosia oppositifolia* (Lam.) Schum. (Figure 3.16)

This is a small to medium-sized tree. Branches glaucous with the leaves often crowded at the end of a year's growth (HUBER 1983a). This is classified under the family Apocynaceae (SENARATNE 2001); belongs to the Koriba's tree architectural model (HALLÉ et al. 1978); Sri Lankan vernacular names are Gonna and Mudu-kaduru (S). *O. oppositifolia* distributed in Maldive Islands, Andaman Islands, Malay Peninsula, Thailand, Malesia and West Pacific (New Caledonia, Fiji, Ellice Island) and absent from the Deccan Peninsula. In Sri Lanka, it is confined to the southwest coastal districts; always growing near the seashore and slightly resistant to salt but not a member of the mangrove formation (HUBER 1983a).

Figure 3.16: ***Ochrosia oppositifolia***

3.7.2.11 *Pandanus odoratissimus* L. f. (Figure 3.17)

Coarsely branched trees with a tendency to candelabriform branching, the secondary branches sympodial by development of a lateral vegetative bud at the base of the terminal inflorescence; branching dichotomous or trichotomous, or irregular. Main stems rarely more than 20 cm thick, erect or more or less decumbent, much branched adult plants. Main stem and not rarely upper stem and lower branches producing prop-roots up to 10 cm thick, but usually more slender. Adult plant seldom over 10 m tall and suckering from base occasional. Occurrence in groves is common (STONE 1981). This is classified under the family Pandanaceae (SENARATNE 2001); belongs to Stone's tree architectural model (HALLÉ et al. 1978) and known by vernacular names Watta-keyiya, Mudu-keyiya (S), Kaidai, Kechiya, Madi, Mudangal (T) etc. as cited in STONE (1981) and JAYAWEERA (1982a). *P. odoratissimus* occurs along the coasts of tropical Asia, Andaman Islands, Polynesia and Mauritius. It is very common in Sri Lanka along the sea coast, usually forming a belt above the high water mark (JAYAWEERA 1982a). Various parts of this plant are used in medicine, leaves used to weave baskets, bags, boxes, mats and hats, roots used to make brushes for painting and also used in live fences (JAYAWEERA 1982a; ASHTON et al. 1997). This is used very commonly in green belts for coast conservation.

Figure 3.17: *Pandanus odoratissimus*

3.7.2.12 *Premna obtusifolia* R.Br. (Figure 3.18)

P. obtusifolia is a shrub or tree, to 8 m tall, rarely scandent, trunk to 10 cm diameter at breast height; wood with very large medullary rays; branches and branchlets medium-slender or slender, brown or brownish (MOLDENKE and MOLDENKE 1983). It is classified under the family Verbenaceae (SENARATNE 2001) and Mahamidi, Mideegas, Midi, Sihinmidi, Walwelmidi (S), Erumaimulla, Munnai, Pasumunnai (T) and Headache-tree (E) are some vernacular names use commonly for *P. obtusifolia* (JAYAWEERA 1982b; MOLDENKE and MOLDENKE 1983). This species in its typical form (*P. obtusifolia* var. *obtusifolia*) is found from Bangladesh to Thailand and southern China, westward to Seychelles, Mauritius, Madagascar, and the coasts of Mozambique and Tanzania, eastward to the Ryukyu Islands, Taiwan, the Philippines, and most of the islands of Pacific Oceanica, south to Australia. In the Ryukyu Islands this species used to make sea- and wind-breaks on coastline. *P. obtusifolia* is extremely variable and polymorphic and three varieties are found in Sri Lanka

(MOLDENKE and MOLDENKE 1983). *P. obtusifolia* is a common back mangrove (mangrove associate) species in Sri Lanka (DE SILVA and DE SILVA 2006). This species is used medicinally as a decoction in the treatment of rheumatism and neuralgia and as one of the ten ingredients of “Dasamularishta” in Indian Ayurveda and also for various other diseases like fevers, dropsy, urticaria, flatulence (JAYAWEERA 1982b; MOLDENKE and MOLDENKE 1983). This plant is a very popular medicinal plant in Sri Lanka and it is very rare in the inland, mostly confined to the coastal area.

Figure 3.18: ***Premna obtusifolia***

3.7.2.13 *Scaevola taccada* (Gaertn.) Roxb. (Figure 3.19)

This is a rounded to prostrate shrub, stems terete, vegetatively glabrous or nearly so; leaves alternate, somewhat fleshy, shiny and pale green, blades up to 7(-8) cm long, broadly spatulate or obovate, apex conspicuously rounded (FOSBERG 1997). *S. taccada* is classified under the family Goodeniaceae (SENARATNE 2001); according to the growth and branching pattern, can be classified into Aubréville’s tree architectural model (HALLÉ et al. 1978). Takkada (S) is the only vernacular name reported from Sri Lanka to date (FOSBERG 1997), and known as Half-flower tree (E) in some countries. However, “Garanda” (or “Garanda-bata-gas”) is the Sinhala vernacular name commonly used in the present study area for *S. taccada* (and therefore at the beginning of the survey, some problems were uncounted with the local name). This is distributed on shores and occasionally somewhat inland throughout Indo-Pacific as far east as Henderson Island, Polynesia. In Sri Lanka it is common generally in strand habitats (FOSBERG 1997). This eye-catching species is planted as an ornamental as well as in live fences, especially in tourist hotels and restaurant along the coastal area. During the present survey it was found that the stem piths are used in handicraft, in small scale, but not very popular.

Figure 3.19: ***Scaevola taccada***

3.7.2.14 *Terminalia catappa* L. (Figure 3.20)

This is a tree, 10-35 m tall, deciduous. Leaves spirally arranged or more usually clustered at the ends of branches (PHILCOX 1995); classified under the family Combretaceae (SENARATNE 2001); belongs to the well known Aubréville's tree architectural model (HALLÉ et al. 1978) and known in Sri Lanka by vernacular names Kottamba, Kottan (S), Amandi, Nattuwadumai, Siruppinga (T) and Sea-almond (E) in some other countries (PHILCOX 1995; JAYAWEERA 1980; HALLÉ et al. 1978). *T. catappa* occurs naturally in Tropical Asia, northern Australia and Polynesia, but widely planted in Tropics. Although normally a denizen of coastal areas, in Sri Lanka it is more commonly found planted inland and up to altitudes exceeding 800 m. This species is not native to Sri Lanka, but its use is widespread as a shade tree and as such, is frequently encountered outside of towns and cities where it is commonly used (PHILCOX 1995). Now it is well established and naturalized and found within the indigenous flora in inland districts (Matale, Kandy, Ratnapura, Kurunegala, Badulla, etc.) of Sri Lanka, almost as a native. Fruit (mesocarp) and seeds (almond-like) are edible, bark and leaves are used in medicine and pruned branches and trunks used as firewood, trunks especially for the lime production in coastal areas. This is commonly planted as a shade tree and for the ornamental leaf-colour, at senescence leaves conspicuous, either bright yellow or scarlet red, depending on the variety. Timber is hard but light; however it is very popular among coastal communities as a good source of timber. Wood density is 512 kg m^{-3} (WORTHINGTON 1959; JAYAWEERA 1980; ASHTON et al. 1997).

Figure 3.20: ***Terminalia catappa***

3.7.2.15 *Thespesia populnea* (L.) Sol. ex Correa (Figure 3.21)

This is a small tree or shrub, 4-10 m or more tall with striking yellow flowers, fading to purple-pink all the year. *T.populnea* is widely distributed throughout the tropics; also cultivated as a shade tree in many places. This is a strand plant of many tropical sandy shores. In Sri Lanka it is popularly planted as living fence posts (PHILCOX 1997), also reported as a mangrove associate or common back mangrove species in Sri Lanka (JAYATISSA et al. 2002; DE SILVA and DE SILVA 2006). *T.populnea* classified under the family Malvaceae (SENARATNE 2001). Gan-suriya, Suriya (S), Kavarachu, Puvarathu (T) and Portia-tree, Tulip-tree (E) are some vernacular names of *T.populnea* (JAYAWEERA 1982a).

Figure 3.21: ***Thespesia populnea***

This is a very popular tree species among coastal community as a very good quality timber for furniture, boats and vehicles, as a live fence species an also as an ornamental plant. Wood density is 784 kg m^{-3}. Leaves and bark of this plant are used in medicine (WORTHINGTON 1959; JAYAWEERA 1982a; ASHTON et al. 1997).

3.8 Survey of the uses of selected 15 plant species by the coastal community

Visited 150 randomly selected houses in the selected coastal belt from Ambalangoda to Boossa in Galle District, Southern Province, Sri Lanka and interviewed the householder or named representative of the family or in some instances the entire family to gather information on uses of selected 15 plant species. Printed forms were used to record uses while interviewing. Laminated coloured picture guide of the 15 selected plants was prepared and used during the survey to avoid the confusions with vernacular names. This survey was also conducted from August 01, 2007 to March 31, 2008 parallel to the vegetation survey (section 3.4 above).

3.9 Investigation the preference of selected 15 plant species to integrate in the coastal homegardens

This survey was also conducted from August 01, 2007 to March 31, 2008 parallel to the vegetation survey (section 3.4 above).

One hundred and fifty (150) households were randomly selected (within the selected coastal belt from Ambalangoda to Boossa in Galle District, Southern Province, Sri Lanka) and they were provided with the printed forms to mark the order of preference to grow the given 15 selected plant species in their homegardens from 1 to 15 against the plant names. House holders and/or families were well explained about the survey in advance and then requested to perform the selection. During this survey also, the laminated coloured picture guide of the 15 selected plants was used to avoid the confusions with vernacular names. First they were well-informed about the plants with photographs and made sure to overcome the problems with identification due to the difference in vernacular names used from place to place.

For this survey, separate set of 150 households were selected and houses selected to investigate the uses were omitted purposely to avoid the possible influence on the survey on preference (BABBIE 2004; KOTHARI 2004).

The total scores earned by each species were calculated by converting the numbers 1 – 15 into 15 – 1 as given in the Table 3.4, in order to evaluate the overall preferences.

Table 3.4: Preferences and Scores

Preference	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Score	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

3.10 Data Analysis

3.10.1 Homegarden vegetation structure and ground layer characteristics

The variations in vegetation structure and ground layer characteristics among four site categories were described using the density, floristic richness, dominance in terms of Important Value Index (IVI), basal area and DBH frequency histograms. IVI was calculated for each species in each category as follows:

$$IVI = \mathrm{Re}\,lative\ Density + \mathrm{Re}\,lative\ Frequency + Rrelative\ Basal\ \ Area$$

Where;

$$\mathrm{Re}\,lative\ Density = \frac{number\ of\ \ individuals\ of\ \ species}{total\ number\ of\ \ individuals}$$

$$\mathrm{Re}\,lative\ Frequency = \frac{frequency\ of\ \ a\ species}{some\ \ frequency\ of\ \ all\ species}$$

$$\mathrm{Re}\,lative\ Density\ Basal\ \ Area = \frac{basl\ area\ of\ \ a\ species}{sum\ basal\ area\ of\ \ all\ species}$$

Basal area was calculated as follows:

$$BA = \frac{\pi D^2}{4}$$

Where;

D = DBH [diameter at breast height (cm)], BA = Basal are (cm^2)

DBH frequency histograms were used to compare the structural difference in vegetation.

3.10.2 Diversity and evenness of homegarden vegetation

The Shannon-Wiener diversity index (H') and Shannon Equitability/Evenness (E) index were (KENT and COKER 1996; MAGURRAN 1998; MAGURRAN 2004) used to determine the diversity of four site categories, both over storey and ground layer.

Shannon-Wiener diversity index (H'):

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

Where;

s = the number of species

P_i = the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of total cover

ln = log $base_n$

Values of the index (H') usually lie between 1.5 and 3.5, although in exceptional cases, the value can exceed 4.5.

Shannon Equitability/Evenness (E):

$$E = \frac{H'}{H'_{\max}} = \frac{\sum_{i=1}^{s} p_i \ln p_i}{\ln s}$$

Where;

H' = observed diversity

H_{max} = maximum diversity

s = the number of species

P_i = the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of total cover

ln = log $base_n$

Values of the index (E) range between 0 and 1, where 1 is representing a situation in which all species are equally abundant.

The Jaccard similarity coefficient (S_J) was used to compare the similarity of species between four sites.

Where;

Jaccard similarity coefficient (S_J):

$$S_J = \frac{a}{a + b + c}$$

a = number of species common to both quadrats / samples

b = number of species in quadrat / sample 1

c = number of species in quadrat / sample 2

Rank abundance curves were also used compare the diversity within sites.

SPSS 12.0.1 computer software package (DYTHAM 2003) and Biodiversity Professional (BioDiversityPro) Version-2 package were used for data analysis.

4 Results

Preview:

This chapter is comprised of six main sections. Results of the vegetation damage survey (Investigation of the impact of the tsunami on homegarden vegetation, exploration of the survived vegetation; the role of vegetation during the tsunami and in the aftermath of flooding) are described in Section (4.1). Section (4.2) is comprised of the results from the study of a comparison of the present status (vegetation structure and composition) of tsunami affected homegardens with non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline. Section (4.3) presents the results of an investigation of ground layer vegetation in order to study the regeneration of woody perennials in tsunami affected homegardens and non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline. Section (4.4) presents the results of the survey on live fence species in tsunami affected homegardens and non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline. Section (4.5) provides the results of the survey on the uses of 15 selected plant species by the coastal community and results of the Investigation on the preference of 15 selected plant species to integrate in the coastal homegardens are given in Section (4.6).

4.1 Vegetation damage survey: Investigation of the impact of the tsunami on homegarden vegetation, exploration of the survived vegetation; the role of vegetation during the tsunami and in the aftermath of flooding

One hundred and twenty six (126) responded questionnaires were received, out of 150 distributed, and they were designed to investigate the damage to vegetation, surviving vegetation and the role of plants in saving lives of local people.

Out of 126 responded questionnaires, 124 households reported damage to the vegetation in their homegardens. This indicates that the 98.4% of the homegardens of the present study area were affected by vegetation damage due to the tsunami on December 26, 2004.

4.1.1 Uprooted and/or inclined tree species

Uprooted and/or slanted trees were reported from 108 homegardens of 124 reported affected. This shows that in 85.7% of the homegardens of the area trees were either uprooted or became slanted and sometimes both.

Figure 4.1 shows the percentages of uprooted and /or slanted trees recorded from the study area according to results of the questionnaire survey. Banana (*Musa* x *paradisiaca*), Coconut

(*Cocos nucifera*) and Papaya (*Carica papaya*) were the most common uprooted and/or slanted tree species (70%, 11% and 10% respectively) followed by *Artocarpus incisus* (Breadfruit, 7%), *Alstonia macrophylla* (6%), some ornamental plants (names were not specifically mentioned by the respondents, 5%) and *Mangifera indica* (Mango) and *Psidium guajava* (Guava) 3% each. There were other 38 uprooted or slanted plant species (38% of the total) reported and they were less than 3% of the total.

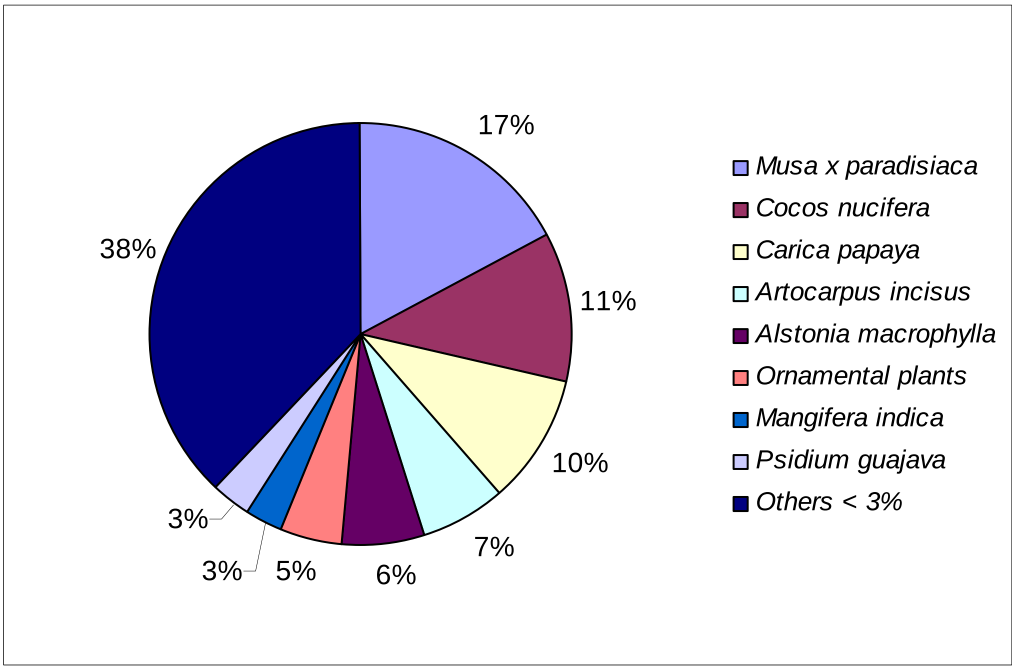

Figure 4.1: Uprooted and/or slanted tree species

4.1.2 Tree species with broken branches

All the 124 households reported that there were trees with broken branches in their affected homegardens, however only 59 (47.6%) of them mentioned names and others stated that they do not remember the trees. Number of records was considered to calculate the percentages.

Figure 4.2 shows the percentages of trees recorded with broken branches as an effect of tsunami from the study area according to the results of the questionnaire survey. *Artocarpus incisus* (Breadfruit) was the highest among them (13%) followed by *Alstonia macrophylla* (9%), *Mangifera indica* (Mango, 8%), *Terminalia catappa* (8%) and *Cocos nucifera* (Coconut, 8%). Please note that the compound leaves of the coconut palms were considered as branches by the community, though they do not branch normally. *Artocarpus heterophyllus* (Jackfruit), *Azadirachta indica* and *Syzygium jambos* were recorded as 4% each and *Gliricidia sepium*, *Persea americana*, *Psidium guajava* and *Thespesia populnea* as 3% each with broken branches. There were other 19 plant species reported (30% of the total) and they were less than 3% of the total.

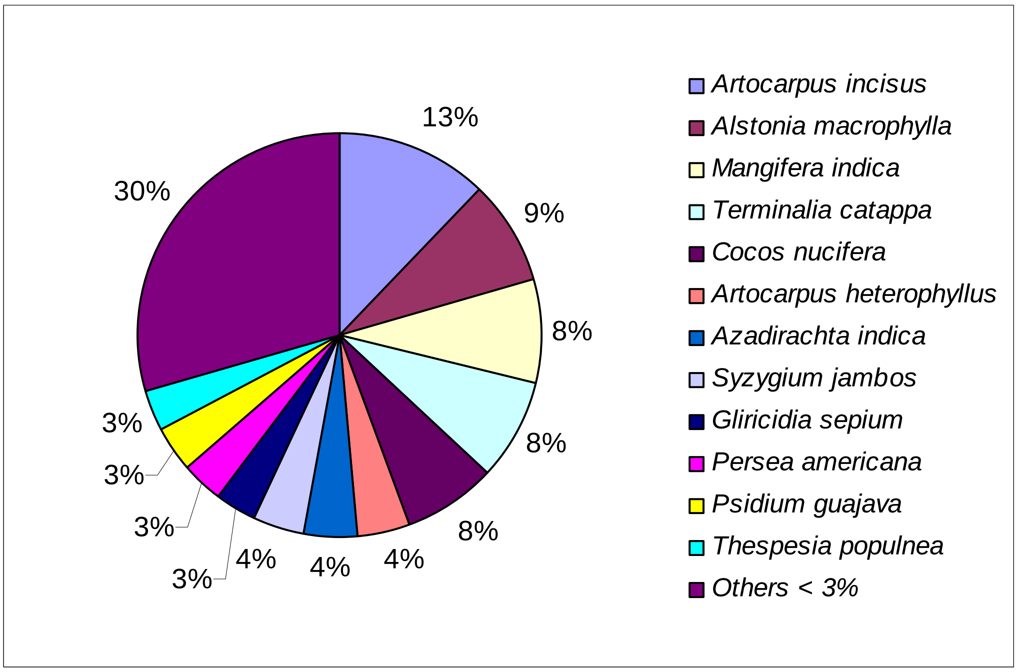

Figure 4.2: Tree species with broken branches

4.1.3 Tree species with broken trunks

Trees with broken trunks were reported only from 30 households (24.2%) and the rest stated that they do not remember or notice the trees. Only 14 species were recorded. The number of records from the 30 households was considered to calculate the percentages of reported trees with broken branches.

Nineteen percent of the trees reported with broken trunks comprised *Musa x paradisiaca* followed by *Cocos nucifera* (Coconut, 15%), *Alstonia macrophylla* (10%), *Carica papaya* (10%), *Mangifera indica* (9%), *Artocarpus incisus* (5%) and 7 other species and ornamental plants (species not mentioned) 4% each (Figure 4.3).

4.1.4 Tree species with broken tops (apical branches)

Trees with broken tops (apical branches) were also reported only from 30 households (24.2%) and the rest stated that they do not remember or notice such damage. Only 16 species were recorded. Number of records from the 30 households was considered to calculate the percentages of reported trees with broken branches.

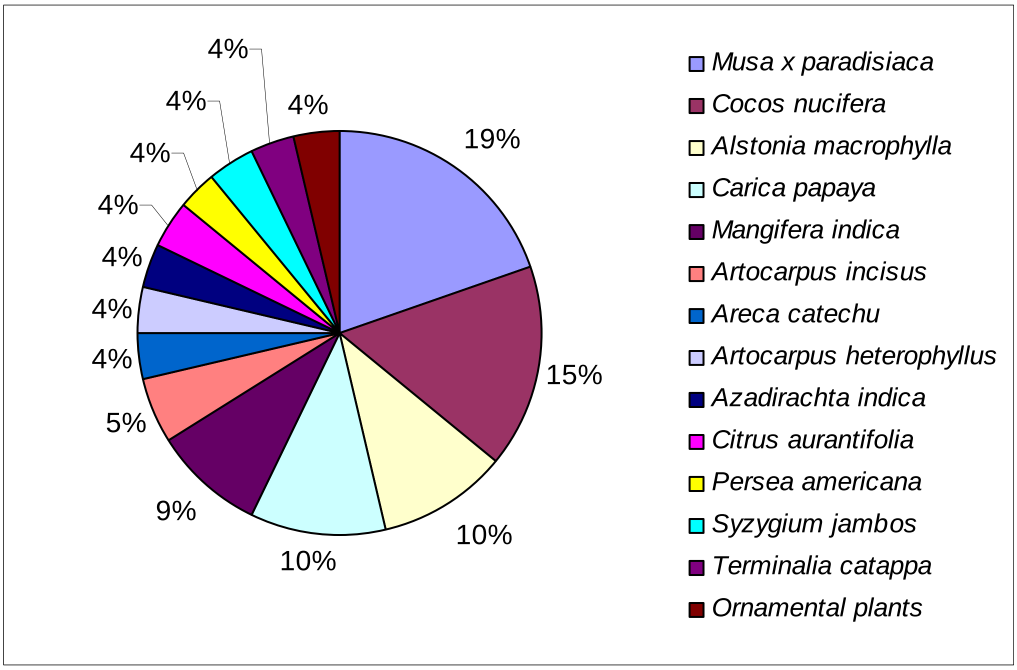

Figure 4.3: Tree species with broken trunks

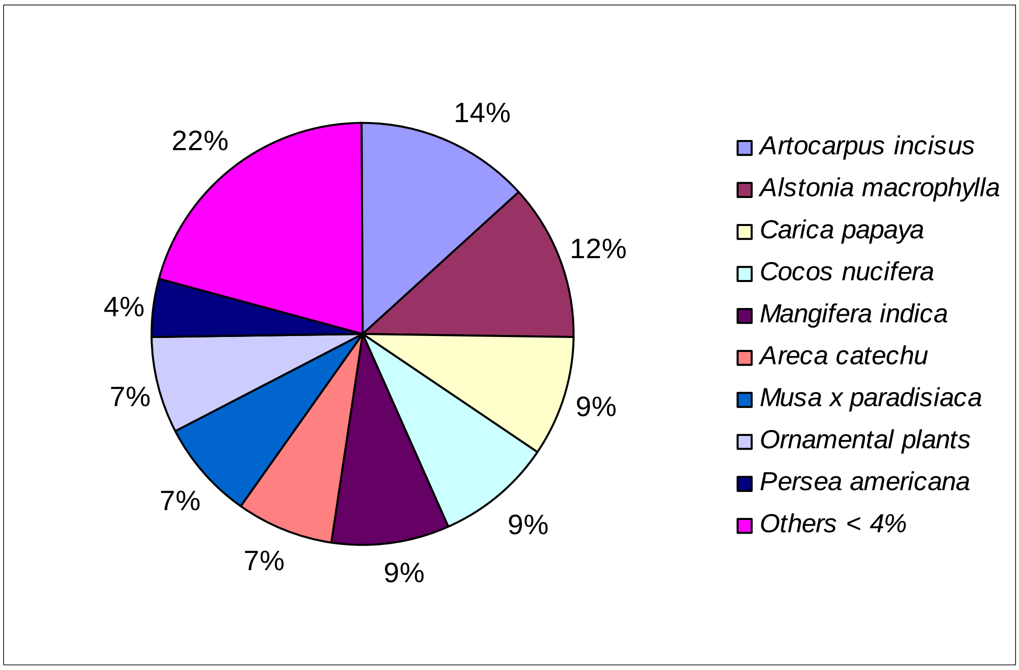

Figure 4.4: Tree species with broken tips

Fourteen percent of the reported trees were *Artocarpus incisus* and *Alstonia macrophylla* 12%, *Carica papaya*, *Cocos nucifera* and *Mangifera indica* 9% each and *Areca catechu*, *Musa* x *paradisiaca* and ornamental plants (species not mentioned) 7% each and 4% of *Persea americana* (Figure 4.4). There were 7 other species with broken branches and each 3% of the total recorded. They were *Artocarpus heterophyllus*, *Codiaeum variegatum*, *Filicium decipiens*, *Hibiscus tiliaceus*, *Spondias dulcis*, *Swietenia macrophylla* and *Terminalia* *catappa*. *Cocos nucifera*, *Areca catechu* and *Musa* x *paradisiaca* do not have the apical branches. However the respondents considered the topmost unopened leaves as branches.

4.1.5 Plant death and defoliation due to tsunami

Out of 124 house holds considered, 84 households (67.7%) reported that there were dead tree species in their compound after a few days of tsunami disaster, 78 households (62.9%) reported that there were some defoliated tree species and later on they recovered and survived up to date and only 32 households (25.8%) reported that there were some tree species which died after one month or later due to the effect of tsunami.

4.1.5.1 Plant death after a few days of tsunami

Nine percent of the of the reported trees those died after a few days of tsunami were *Musa* x *paradisiaca* followed by *Alstonia macrophylla* and *Artocarpus incisus* (each 8%), *Mangifera indica* (7%), *Psidium guajava* (6%), *Artocarpus heterophyllus*, *Cocos nucifera* and *Spondias dulcis* (each 5%), ornamental plants and *Syzygium jambos* (each 4%) and *Carica papaya Citrus aurantifolia* and *Filicium decipiens* (3%). There were other 34 species (30% of the total) reported and they were less than 2% of the total reported (Figure 4.5).

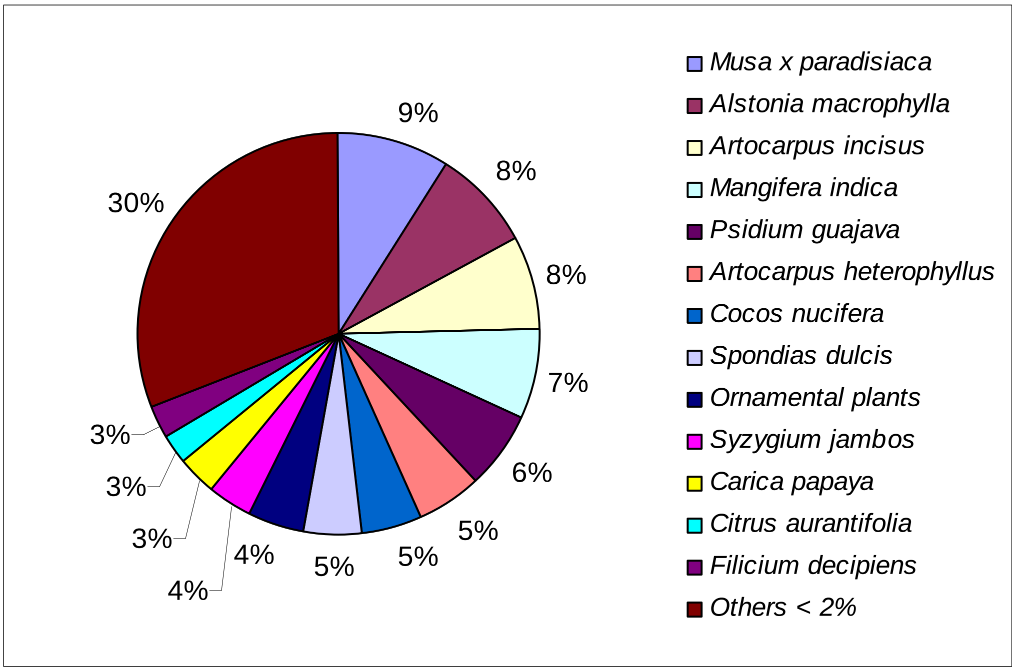

Figure 4.5: Plant death after a few days of tsunami

4.1.5.2 Plants surviving after defoliation

Fifteen percent of the reported plants which survived after defoliation due to the tsunami were *Terminalia catappa* followed by *Azadirachta indica* (10%) *Mangifera indica* (10%)

Artocarpus incisus (8%) *Swietenia macrophylla* (6%) *Spondias dulcis*, *Gliricidia sepium*, *Psidium guajava* and Ornamental plants (each 4% of the total reported). There were other 22 plant species (35% of the total) reported and they were less than 3% of the total reported (Figure 4.6).

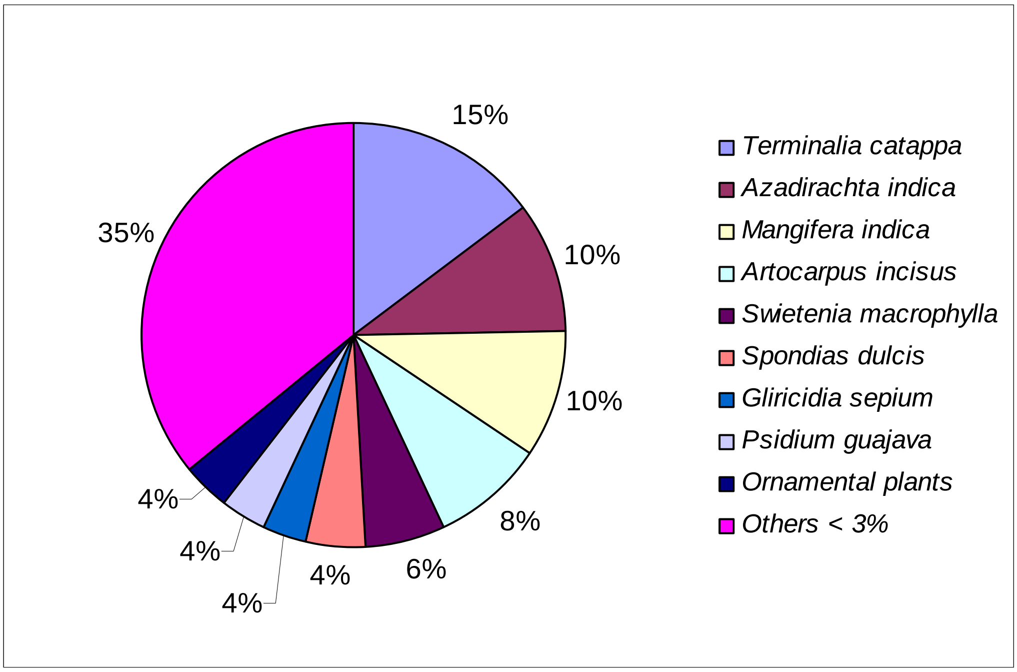

Figure 4.6: Plants surviving after defoliation

4.1.5.3 Plant death after one month or later due to the tsunami

Twelve percent of the plants reported those died after one month or later due to tsunami were *Mangifera indica* followed by *Musa* x *paradisiaca* (10%), *Alstonia macrophylla* *Artocarpus heterophyllus*, *Carica papaya* and *Cocos nucifera* (each 8% out of total reported) *Artocarpus incisus* and *Spondias dulcis* (each 6%) and *Cinnamomum verum* (4%). There were other 14 plant species (30% of the total) reported and they were less than 3% of the total (Figure 4.7).

4.1.6 Alien plant species germinated (found) in homegardens after the tsunami

Out of 126 households, 98 (79%) reported alien plants after the tsunami. 16% of the alien plants (species not present in the homegardens before the tsunami) germinated in the homegardens were *Carica papaya* followed by *Boerhavia spp.* (14%), *Cucurbita maxima* (14%), tall grass species (7%) and *Capsicum annum* (5%). Figure 4.8 gives the details of some other plants reported. Other than these, there were other 32 alien plant species (22% of the total) reported and they were less than 2% of the total.

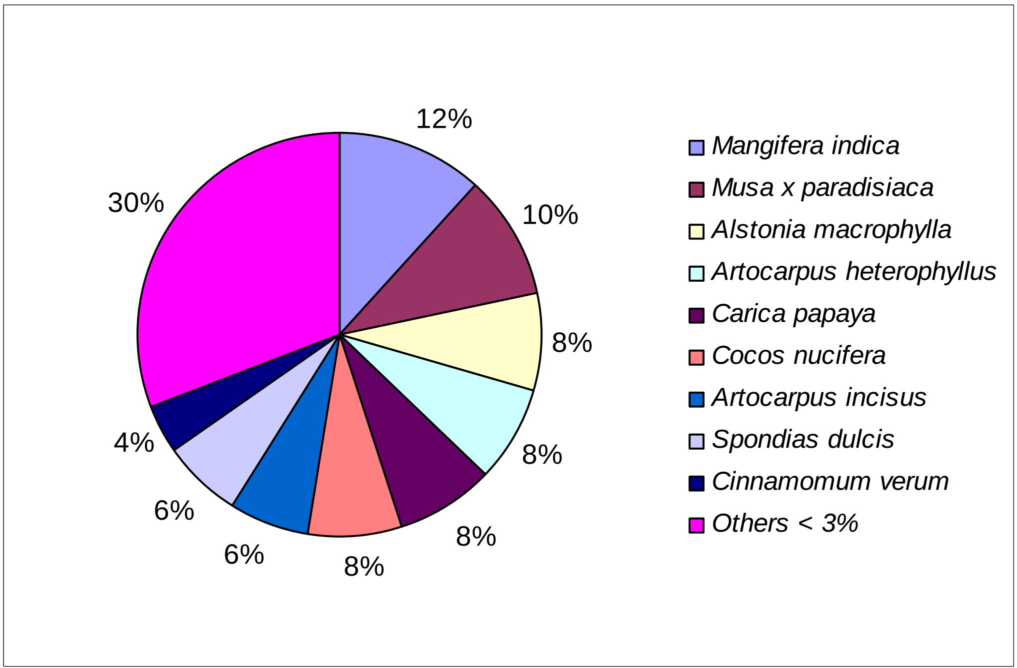

Figure 4.7: Plant death after one month or later due to the tsunami

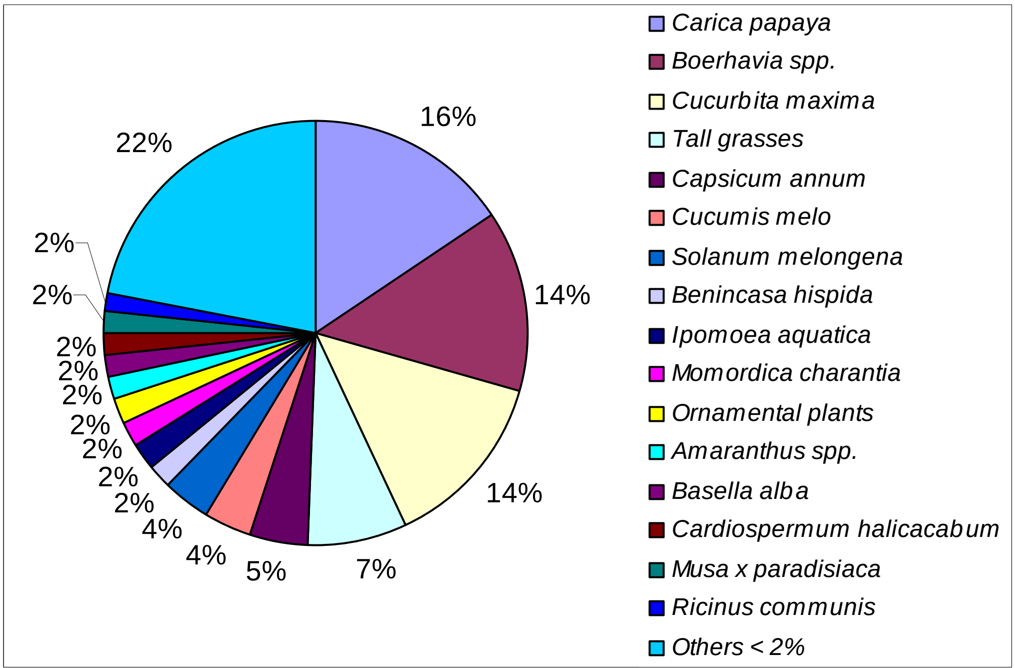

Figure 4.8: Alien plant species found in homegardens after the tsunami

4.1.7 Plants grown after the tsunami

There were a number of recently grown pant species found in the coastal homegardens after the effects of the tsunami. Some of them had been grown by the households without any advice from either governmental or nongovernmental institutions. Some of them had been grown with the advices of some institutions; whereas some households followed both ways (with and without advice) to introduce plants in to their affected homegardens.

4.1.7.1 Plants grown in homegardens after the tsunami, without advice of institutions

Fifteen percent of the reported plants grown without advice were *Musa x paradisiaca* followed by ornamental plants (11%), Cocos nucifera (10%), *Carica papaya* (6%), *Mangifera indica* (6%) and *Murraya koenigii* (4%). Figure 4.9 gives the details of some other plants reported. Other than these, there were other 39 plant species (25% of the total) reported and they were less than 2% of the total.

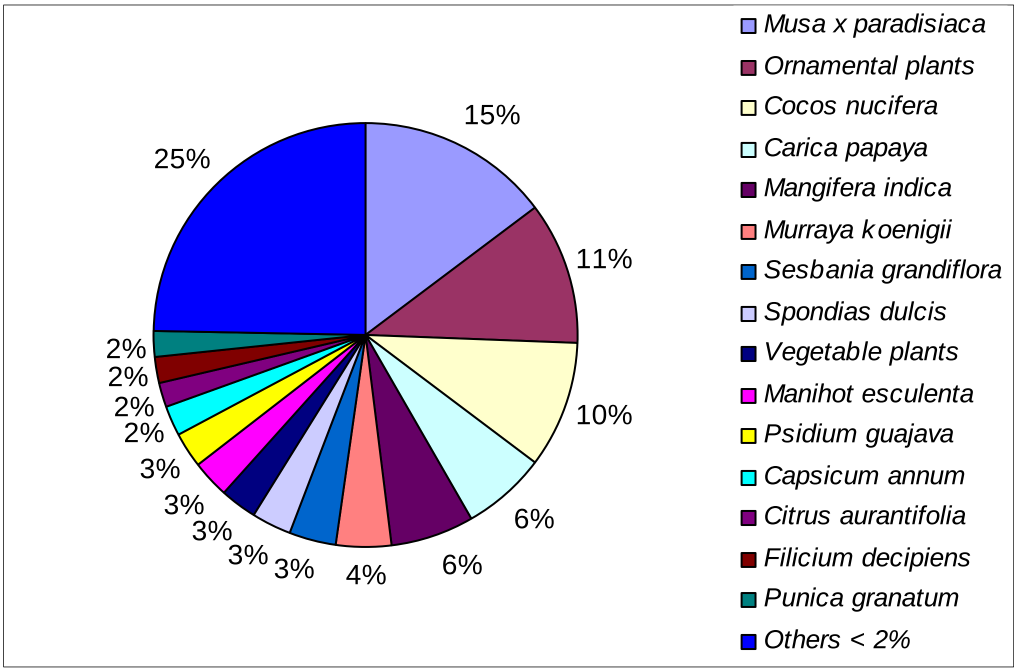

Figure 4.9: Plants grown after the tsunami, without advice of institutions

4.1.7.2 Plants grown in homegardens after the tsunami, with the advices of institutions

Cocos nucifera, *Mangifera indica* and *Sesbania grandiflora* had been grown in 10% of the house holds out of 126 followed by *Citrus aurantifolia, Filicium decipiens, Musa x paradisiaca* and *Swietenia macrophylla*, each in 6% of the households. Details of some other plants reported form home gardens belong to this category are given Figure 4.10. Other than these, there were other 6 plant species (12% of the total) reported and they were less than 4% of the total.

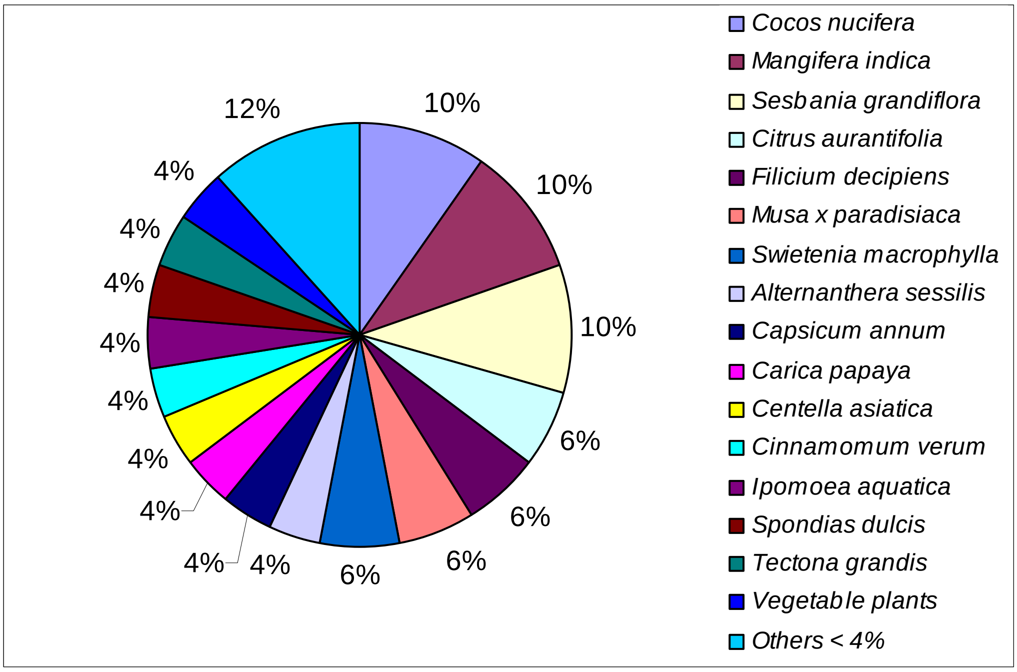

Figure 4.10: Plants grown after the tsunami, with the advices of institutions

4.1.8 Survived plants in homegardens after the effects of the tsunami

In Figure 4.11 is presents the details of plants survived to date in the homegardens after the effects of tsunami reported by the coastal house holds. From 29% of the households *Cocos nucifera* was reported and this was the highest among the survivors followed by *Terminalia catappa* (10%), *Azadirachta indica* (6%) and *Mangifera indica* (5%) of the total reported. Details of the other survivors are given in the Figure 4.11. Other than these 11 species, there were another 29 species (24% of the total reported) reported as survivors and they were less than 3% of the total.

4.1.9 Suitable plants for growing in affected homegardens, as suggested by the community

Plants which have been suggested by the community to be suitable for growing in tsunami-affected homegardens are given in Figure 4.12. *Cocos nucifera* and *Musa x paradisiaca* were suggested by 17% of the respondents (households) followed by *Mangifera indica* (9%), vegetable species, names not specified (6%) and *Azadirachta indica*, *Carica papaya* and *Psidium guajava* (5% each). Details of the other species are given in the Figure 4.12. There were other 24 plant species (25% of the total) reported as suitable to grow in affected homegardens and they were less than 2.5% of the total.

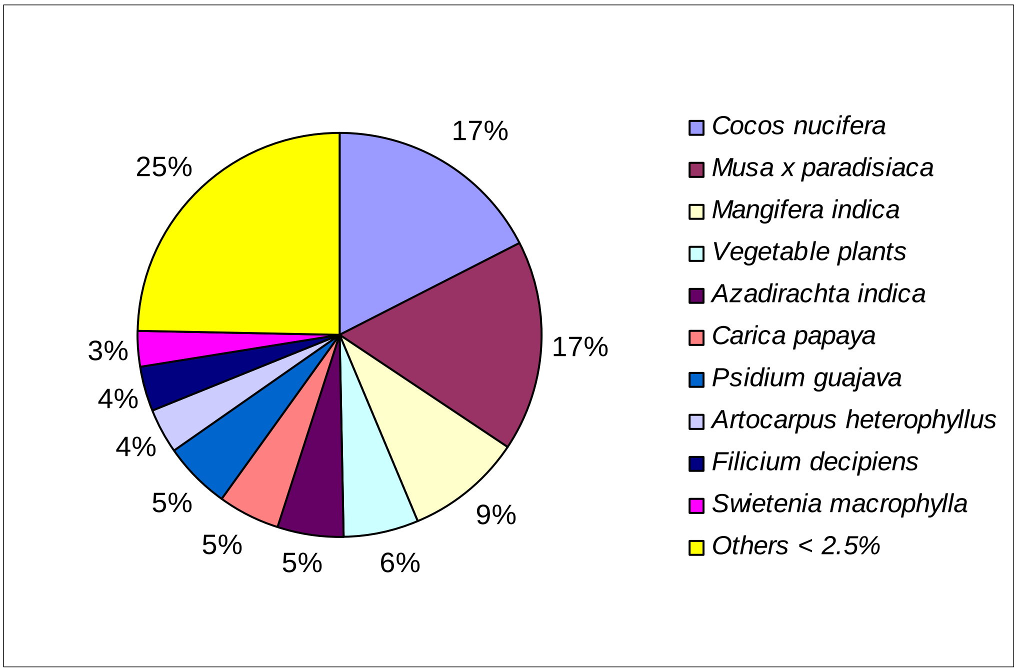

Figure 4.11: Plant species survived after the effects of the tsunami

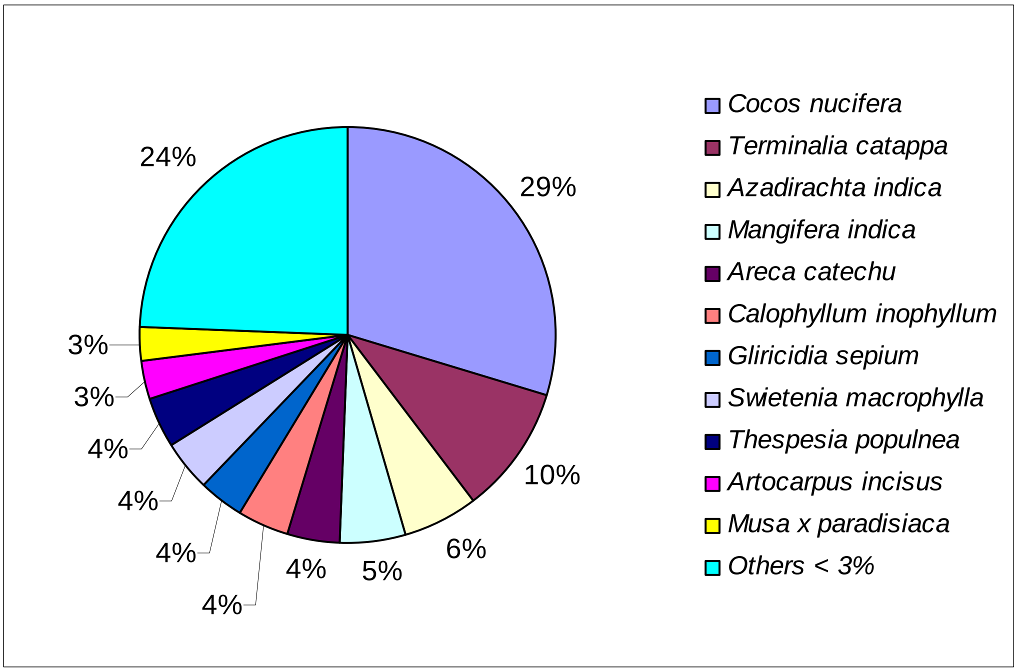

Figure 4.12: Suitable plant species for growing in affected homegardens, as suggested by the community

4.1.10 Plants suitable for coast conservation, as suggested by the coastal community

Suitable plants for coast conservation suggested by the coastal community are given in Figure 4.13. *Pandanus* spp. has been suggested by 34 % of the respondents for coast conservation followed by *Cocos nucifera* (25%), *Barringtonia asiatica* (12%), *Terminalia catappa* (9%), *Ipomoea pes-caprae* (6%) and *Calophyllum inophyllum* (2%). There were other 7 species (6% of the total) recommended for coast conservation by the community and they were less than 2% of the total.

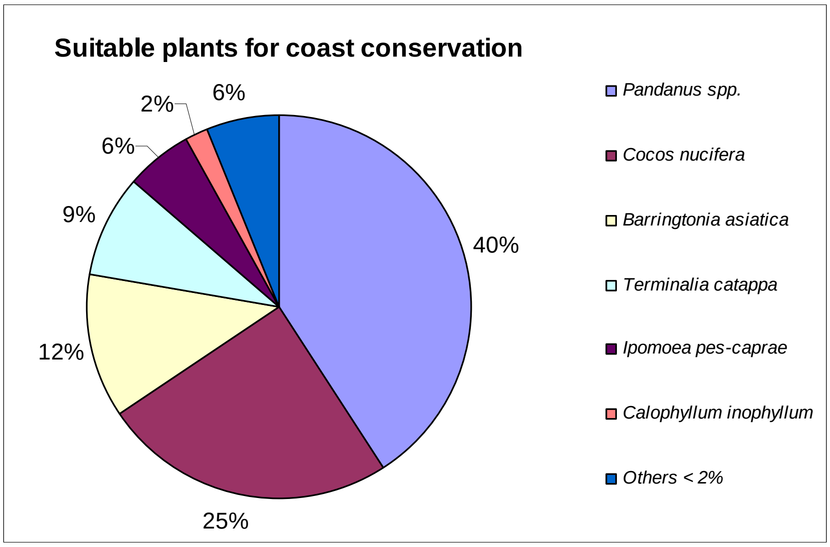

Figure 4.13: Suitable plants suggested by coastal community for coast conservation

4.1.11 Trees which helped to save lives

Out of 126 households, 79 reported trees helped to save their life (either by climbing or clasping) during the flooding by the tsunami. 29% of the trees reported that helped to survive lives were *Cocos nucifera* followed by *Terminalia catappa* (18%), *Azadirachta indica* (8%), *Artocarpus incisus* (6) *Gliricidia sepium* (6%) and *Mangifera indica* (4%). Details of some other species are given in Figure 4.14. There were other 14 plant species reported that helped to survive lives (11% of the total) and they were less than 3% of the total.

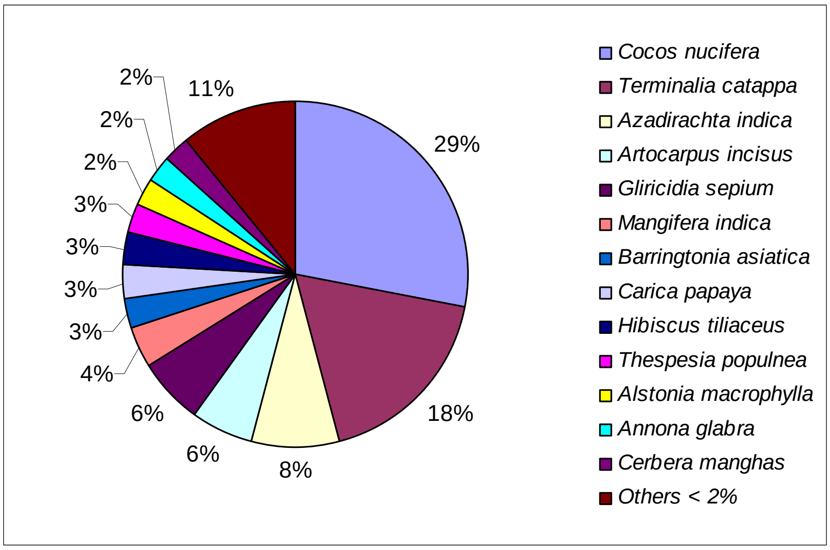

Figure 4.14: Trees which helped to save lives

4.2 Comparison of the present status (vegetation structure and composition) of tsunami affected homegardens with non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline

4.2.1 Floristic richness

A total of 484 individuals of woody perennial plants were recorded in the homegardens of the tsunami affected 100 m coastal belt study site. Figures for the homegardens in the tsunami affected 200 m belt, non-affected 100 m belt and non-affected 200 m belt were 353, 555 and 462 respectively (Table 4.1). These records from 60 homegardens (from one 10 m X 10 m quadrats in each homegarden) from each study site.

Table 4.1: Floristic data of woody perennials in 4 homegarden categories

Homegarden category	No. of individuals	No. of Families	No. of Genera	No. of Species
Affected within 100 m belt	484	19	23	24
Affected within 200 m belt	353	16	20	21
Non-affected within 100 m belt	555	14	16	16
Non-affected within 200 m belt	462	13	16	17

Floristic richness was highest in the homegardens of affected 100 m belt site followed by affected 200 m belt, non-affected 100 m belt and non-affected 200 m belt. The floristic richness is very similar in last two sites.

Twenty-four species of woody perennials (belong to 19 families and 23 genera) were recorded in the homegardens in affected 100 m belt and 21 species from the homegardens in affected 200 m belt (belong to 16 families and 20 genera), 16 species from the homegardens in non-affected 100 m belt (belong to 14 families and 16 genera) and 17 species from the homegardens in non-affected 200 m belt (belong to 13 families and 16 genera) were recorded (Table 4.1). A summary of woody perennial plant species distributed at different study sites is given in Table 4.2.

Table 4.2: Distribution of woody perennial plant species in 4 homegarden categories

Plant species	Family	Habitat			
		Affected within 100 m belt	Affected within 200 m belt	Non-affected within 100 m belt	Non-affected within 200 m belt
Accacia auriculiformis	Fabaceae		+	+	
Alstonia macrophylla	Apocynaceae	+	+	+	+
Annona sp.	Annonaceae	+			
Areca catechu	Arecaceae		+		+
Artocarpus heterophyllus	Moraceae		+		+
Artocarpus incisus	Moraceae		+		+
Averrhoa bilimbi	Oxalidaceae	+			
Azadirachta indica	Meliaceae	+	+	+	
Barringtonia asiatica	Lecythidaceae	+	+	+	
Calophyllum inophyllum	Clusiaceae	+	+	+	+
Cassia auriculata	Fabaceae	+			
Casuarina equisetifolia	Casuarinaceae			+	
Ceiba pentandra	Bombacaceae	+			
Cinchona sp.	Rubiaceae		+		
Citrus sp.	Rutaceae				+
Cocos nucifera	Arecaceae	+	+	+	+
Codiaeum variegatum	Euphorbiaceae		+		
Ficus sp. 1	Moraceae	+			
Ficus sp. 2	Moraceae	+			
Filicium decipiens	Sapindaceae		+		+
Hibiscus tiliaceus	Malvaceae	+	+	+	
Chrysophyllum roxburghii	Sapotaceae				+
Mangifera indica	Anacardiaceae	+	+	+	+
Manihot sp.	Euphorbiaceae	+			
Manilkara zapota	Sapotaceae	+	+	+	
Morinda citrifolia	Rubiaceae		+	+	+
Muntingia calabura	Tiliaceae	+			
Murraya koenigii	Rutaceae				+
Ochrosia oppositifolia	Apocynaceae			+	
Phyllanthus acidus	Euphorbiaceae	+			
Pisonia grandis	Nyctanthaceae	+		+	
Premna obtusifolia	Verbenaceae	+		+	
Psidium guajava	Myrtaceae	+	+		
Schleichera oleosa	Sapindaceae		+		
Sesbania grandiflora	Fabaceae				+
Spondias dulcis	Anacardiaceae				+
Swietenia macrophylla	Meliaceae				+
Syzygium jambos	Myrtaceae	+			
Tamarindus indica	Fabaceae	+			
Tectona grandis	Verbenaceae		+		
Terminalia catappa	Combretaceae	+	+	+	+
Thespesia populnea	Malvaceae	+	+	+	+
Total species		24	21	16	17

4.2.2 Phytosociological features

4.2.2.1 Plant density

Density of woody perennials in homegardens of affected 100 m belt was 807 ha^{-1}; and the density in the tsunami affected 200 m belt, non-affected 100 m belt and non-affected 200 m belt were 588 ha^{-1}, 925 ha^{-1} and 770 ha^{-1} respectively (Table 4.3). The analysis of variance (ANOVA) showed that the plant density of four sites was significantly different ($F_{3,236}$ = 18.15, P < 0.05). Outcome of the ANOVA is given in Table 4.4.

Table 4.3: Some phytosociological data in 4 homegarden categories

Homegarden category	No. of individuals	Plant density (ha^{-1})	Basal area (m^2 ha^{-1}) Mean ± SE	DBH (cm) Mean ± SE
Affected within the 100 m belt	484	807	0.04 ± 0.002	19.4 ± 0.52
Affected within the 200 m belt	353	588	0.03 ± 0.002	16.5 ± 0.57
Non-affected within the 100 m belt	555	925	0.03 ± 0.001	16.5 ± 0.44
Non-affected within the 200 m belt	462	770	0.03 ± 0.002	17.6 ± 0.49

Table 4.4: ANOVA results for plant density in 4 homegarden categories

Source	d.f.	SS	MS	*F*	*P*
Site	3	3500833	1166944	18.15	0,00000000012
Residual	236	15177667	64312		
Total	239				

4.2.2.2 Basal area and Diameter at breast height (DBH)

Highest mean basal area of a tree was observed in homegardens within the affected 100 m belt (0.04 m^2ha^{-1}) whereas it was similar (0.03 m^2ha^{-1}) for all other 3 categories (Table 4.3). Total basal area of tree were highest in homegardens of tsunami affected 100 m belt (19.38 m^2ha^{-1}) followed by non-affected 100 m belt (16.57 m^2ha^{-1}), non-affected 200 m belt (15.34 m^2ha^{-1}) and tsunami affected 200 m belt (10.74 m^2ha^{-1}).

The highest mean DBH of trees was observed in the homegardens of affected 100 m belt (19.4 cm) followed by homegardens in non-affected 200 m belt (17.6 cm) whereas in homegardens of affected 200 m belt and non-affected 100 m belt it was similar;16.5 cm (Table 4.3).

Diameter class distribution is shown in the Figure 4.15. According to the graphs it is very clear that the distribution of DBH classes has a very similar pattern in homegardens of the tsunami-affected 100 m belt, tsunami affected 200 m belt, non-affected 100 m belt whereas the graph for non-affected 200 m belt is somewhat left skewed.

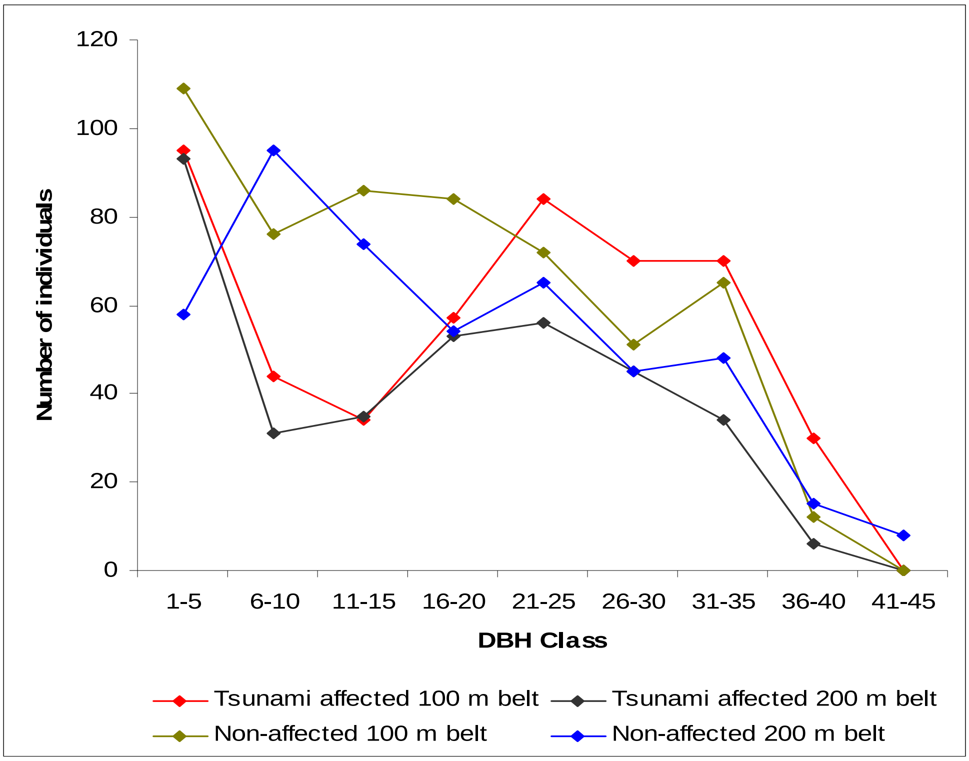

Figure 4.15: Diameter class distribution of trees in 4 homegarden categories

Figure 4.16 shows the DBH class distribution at four different sites in detail. Out of 484 individuals in the homegardens of affected 100 m belt, 95 (19.6%) was in the first diameter class (1-5 cm). Most of them were recently (after tsunami) planted small saplings. This character is also common in the homegardens of the tsunami affected 200 m belt as well as in the homegardens of the non-affected 100 m belt. Out of 353 individuals in the homegardens of the tsunami affected 200m belt, 93 (26.4%) were in the first diameter class (1-5 cm). Here too, most of these were recently planted small saplings. 109 plants (19.6%) out of 555 plants in the homegardens of non-affected 200 m belt were also in the first diameter class (1-5 cm). Most of these plants were also planted recently after tsunami. Relatively the distribution of small plants is lower in the homegardens of non-affected 200 m belt. It is important to note that the plants distribution were relatively low in the 6-10 cm, 11-15 cm and 16-20 cm classes in the homegardens of the affected 100 m and affected 200 m categories when compared with the two non-affected categories. Trees which belong to the last category (41-45 cm) were found only in the homegardens of the non-affected 200 m belt.

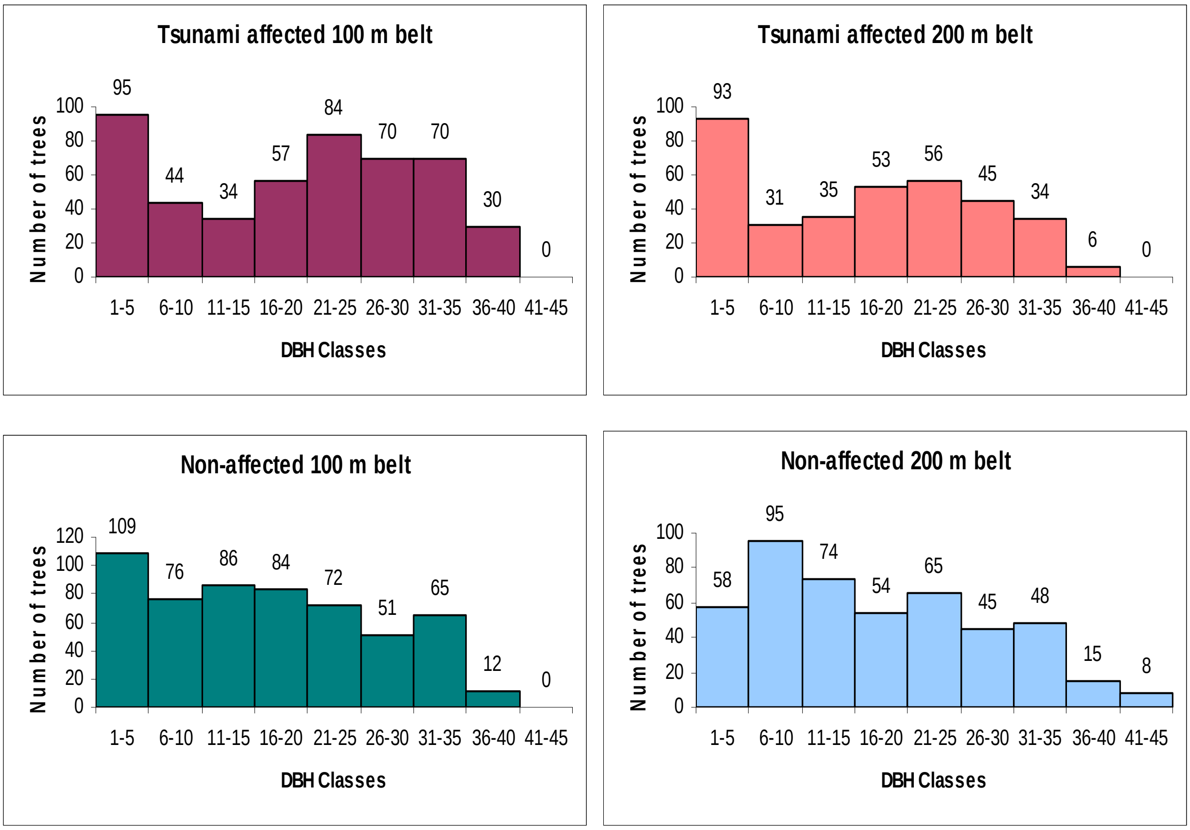

Figure 4.16: Detailed diameter class distribution of trees in the 4 homegarden categories

4.2.2.3 Dominance: Important Value Index (IVI)

Dominance in terms of Important Values of each species recorded from the homegardens in four different sites is given in Table 4.5 Table 4.6, Table 4.7 and in Table 4.8. *Cocos nucifera* was the most dominant species in all four sites. *Thespesia populnea*, *Barringtonia asiatica*, *Terminalia catappa*, *Calophyllum inophyllum* and *Alstonia macrophylla* were the other dominant species found in affected 100 m belt site. The first four species are climatic climax species of the coastal vegetation while the *Alstonia macrophylla* is an exotic timber species (Table 4.5).

Terminalia catappa, *Thespesia populnea*, *Mangifera indica*, *Calophyllum inophyllum*, *Barringtonia asiatica*, *Areca catechu* and *Morinda citrifolia* were the highly dominant species in the homegardens of affected 200m belt other than most dominant *Cocos nucifera*. Except *Mangifera indica* and *Cocos nucifera*, others were climatic climax species of the natural coastal vegetation (Table 4.6).

In the homegardens of non-affected 100 m belt *Terminalia catappa* was the second dominant species next to *Cocos nucifera* followed by *Thespesia populnea*, *Mangifera indica* *Calophyllum inophyllum*, *Barringtonia asiatica*, *Areca catechu* and *Morinda citrifolia*. Except

Mangifera indica and *Areca catechu*, others were climatic climax species of the coastal vegetation (Table 4.7).

Table 4.5: Plant species dominance in homegardens of the tsunami-affected 100 m belt

No.	Species	Important Value Index	No.	Species	Important Value Index
1	*Cocos nucifera*	118.56	13	*Syzygium jambos*	2.61
2	*Thespesia populnea*	47.35	14	*Pisonia grandis*	2.31
3	*Barringtonia asiatica*	34.19	15	*Tamarindus indica*	2.15
4	*Terminalia catappa*	30.72	16	*Ceiba pentandra*	2.11
5	*Calophyllum inophyllum*	17.19	17	*Annona sp.*	1.38
6	*Alstonia macrophylla*	9.59	18	*Hibiscus tiliaceus*	1.38
7	*Premna obtusifolia*	5.91	19	*Averrhoa bilimbi*	1.36
8	*Azadirachta indica*	5.77	20	*Cassia auriculata*	1.29
9	*Manilkara zapota*	3.53	21	*Phyllanthus acidus*	1.28
10	*Psidium guajava*	3.26	22	*Ficus sp. 1*	1.27
11	*Muntingia calabura*	2.80	23	*Manihot sp.*	0.69
12	*Mangifera indica*	2.63	24	*Ficus sp. 2*	0.68

Table 4.6: Plant species dominance in homegardens of the tsunami-affected 200 m belt

No.	Species	Important Value Index	No.	Species	Important Value Index
1	*Cocos nucifera*	127.94	12	*Hibiscus tiliaceus*	7.73
2	*Terminalia catappa*	22.00	13	*Alstonia macrophylla*	6.89
3	*Thespesia populnea*	15.54	14	*Filicium decipiens*	5.79
4	*Mangifera indica*	15.51	15	*Psidium guajava*	5.10
5	*Calophyllum inophyllum*	13.96	16	*Azadirachta indica*	4.36
6	*Barringtonia asiatica*	12.58	17	*Coeadium sp.*	3.68
7	*Areca catechu*	11.33	18	*Acacia auriculiformis*	3.56
8	*Morinda citrifolia*	10.78	19	*Cinchona sp.*	3.38
9	*Artocarpus incisus*	8.55	20	*Manilkara zapota*	2.43
10	*Artocarpus heterophyllus*	8.27	21	*Schleichera oleosa*	2.43
11	*Tectona grandis*	8.18			

Table 4.7: Plant species dominance in homegardens of non-affected 100 m belt

No.	Species	Important Value Index	No.	Species	Important Value Index
1	*Cocos nucifera*	95.59	9	*Mangifera indica*	12.80
2	*Barringtonia asiatica*	29.88	10	*Azadirachta indica*	10.51
3	*Alstonia macrophylla*	24.87	11	*Premna obtusifolia*	7.25
4	*Calophyllum inophyllum*	24.74	12	*Manilkara zapota*	4.85
5	*Thespesia populnea*	23.76	13	*Hibiscus tiliaceus*	4.23
6	*Ochrosia oppositifolia*	18.48	14	*Cassuarina*	4.00
7	*Terminalia catappa*	16.01	15	*Acacia auriculiformis*	3.93
8	*Morinda citrifolia*	15.53	16	*Pisonia grandis*	3.58

There were more dominant non-climatic climax species in the homegardens of the non-tsunami affected 200m belt. These are *Artocarpus incisus*, *Mangifera indica*, *Artocarpus heterophyllus*, *Filicium decipiens* and *Murraya koenigii*. *Thespesia populnea Terminalia catappa* and *Calophyllum inophyllum* were the dominant climatic climax species in these homegardens (Table 4.8).

Table 4.8: Plant species dominance in homegardens of non-affected 200 m belt

No.	Species	Important Value Index	No.	Species	Important Value Index
1	*Cocos nucifera L.*	71.51	10	*Areca catechu*	9.40
2	*Thespesia populnea*	30.36	11	*Spondias dulcis*	8.07
3	*Artocarpus incisus*	28.88	12	*Alstonia macrophylla*	7.41
4	*Mangifera indica*	28.40	13	*Morinda citrifolia*	6.42
5	*Artocarpus heterophyllus*	25.23	14	*Swietenia macrophylla*	6.27
6	*Terminalia catappa*	23.62	15	*Chrysophyllum roxburghii*	6.16
7	*Calophyllum inophyllum*	13.00	16	*Sesbania grandiflora*	6.16
8	*Filicium decipiens*	12.51	17	*Citrus sp.*	5.94
9	*Murraya koenigii*	10.65			

4.2.3 Diversity, Evenness and Similarity

According to the Shannon-Wiener Diversity Index, the woody perennial diversity was higher in the homegardens of the non-affected 200 m belt (1.127) followed by the homegardens in the tsunami affected 200 m belt (1.054), the non-affected 100 m belt (1.047) and the tsunami-affected 100 m belt (0.901). The lowest diversity was recorded in homegardens of the tsunami affected 100 m belt (Table 4.9).

Table 4.9: Species diversity and evenness in 4 homegarden categories

Index	Tsunami affected 100 m belt	Tsunami affected 200 m belt	Non-affected 100 m belt	Non-affected 200 m belt
Shannon H' (Log_{10}) Diversity	0.901	1.054	1.047	1.127
Shannon J' Evenness	0.653	0.797	0.870	0.916

Species distribution evenness is also higher in the homegardens of the non-affected 200 m belt (0.916) followed by the homegardens in the non-affected 100 m belt (0.870), the affected 200 m belt and the affected 100 m belt (0.797). Evenness is also lowest (0.653) in the homegardens of the affected 100 m belt (Table 4.9).

According to the Jaccard Coefficient of similarity, homegardens in the affected 100 m belt and non-affected 100 m belt show the highest similarity (23%) followed by the homegardens in the affected 200 m belt and the non-affected 200 m belt (22%) whereas the lowest similarity was found between the homegardens in the tsunami affected 100 m belt and the non-affected 200 m belt. The similarity between homegardens in the affected 100 m belt and the affected 200 m belt, the affected 200 m belt and the non-affected 100 m belt, and the non-affected 100 m belt and the non-affected 200 m belt is more or less similar (Table 4.10).

Table 4.10: Similarity half-matrix of Jaccard Coefficients for different homegarden categories

Site	Site			
	Affected 100 m belt	Affected 200 m belt	Non-affected 100 m belt	Non-affected 200 m belt
Tsunami affected 100 m belt	-	-	-	-
Tsunami affected 200 m belt	0.1509 (15%)	-	-	-
Non-affected 100 m belt	0.2308 (23%)	0.1897 (18%)	-	-
Non-affected 200 m belt	0.1277 (12%)	0.2245 (22%)	0.1750 (17%)	-

Rank abundance curves for the homegardens in all four categories showed the broken stick model and this expresses the more or less uniform distribution of species in homegardens of all four categories. However, the curve for the homegardens in the tsunami-affected 100 m belt shows the typical broken stick pattern just as, a little less pronounced, the tsunami affected 200 m belt whereas the curves obtained for the 2 non-affected categories somewhat deviate form the typical broken stick model. The number of species is lower and the individuals in the lower ranks are absent in these categories when compare to the tsunami affected categories (Figure 4.17).

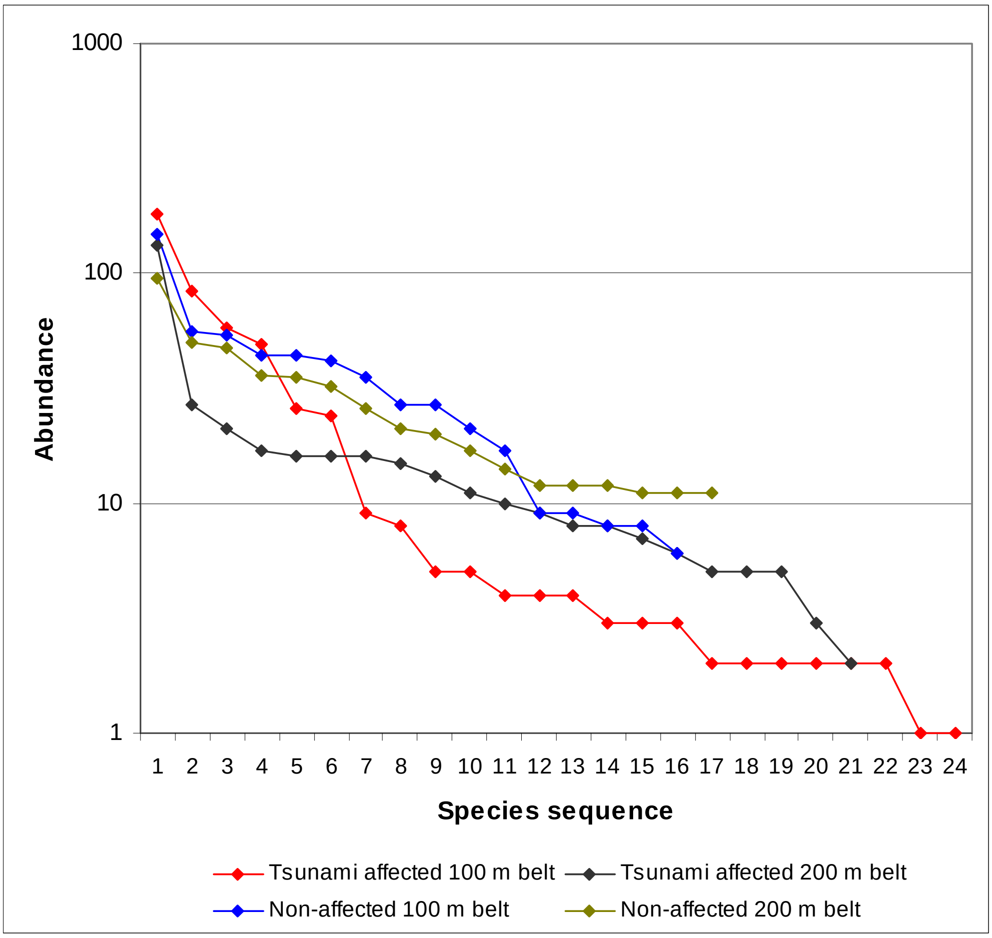

Figure 4.17: Rank abundance curves for the trees in 4 homegarden categories

4.3 Investigation of ground layer vegetation in order to study the regeneration of woody perennials in tsunami affected homegardens and non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline

4.3.1 Floristic richness and density

A total of 274 seedlings of woody perennial plants was recorded in the homegardens of tsunami affected 100 m coastal belt study site. Figures for the homegardens of the tsunami affected 200 m belt, non-affected 100 m belt and non-affected 200 m belt were 321, 173 and 203 respectively (Table 4.11). These records from 60 homegardens (from one 1 m X 1 m quadrats in each homegarden) from each study site.

Floristic richness was highest in the homegardens of the tsunami affected 100 m belt site followed by the non-affected 200 m belt, affected 200 m belt and non-affected 100 m belt. Ten species of woody perennials (belong to 10 families and 10 genera) were recorded in the homegardens in affected 100 m belt and 6 species from the homegardens in affected 200 m belt (belong to 6 families and 6 genera), 5 species from the homegardens in non-affected 100 m belt (belong to 5 families and 5 genera) and 7 species from the homegardens in non-affected 200 m belt (belong to 6 families and 7 genera) were recorded (Table 4.11). Seedlings of some different woody perennial plant species found in the homegardens of the present study are shown in Figure 4.18. A summary of seedlings of woody perennial plant species distributed at different study sites is given in Table 4.12.

Table 4.11: Floristic data of seedlings of woody perennial species in 4 homegarden categories

Homegarden category	No. of individuals	Density ha^{-1}	No. of Families	No. of Genera	No. of Species
Tsunami affected within 100 m belt	274	45667	10	10	10
Tsunami affected within 200 m belt	321	53500	6	6	6
Non-affected within 100 m belt	173	28833	5	5	5
Non-affected within 200 m belt	203	33833	6	7	7

Figure 4.18: Seedlings of woody perennial species in homegardens: Galle District, Sri Lanka: (a) *Calophyllum inophyllum* and *Terminalia catappa*, (b) *Barringtonia asiatica* (c) *Alstonia macrophylla* and *Calophyllum inophyllum* and (d) *Thespesia populnea*

Table 4.12: Distribution of seedlings of woody perennial species in the 4 homegarden categories

Species	Family	Habitat			
		Tsunami affected 100 m	Tsunami affected 200 m	Non-affected 100 m	Non-affected 200 m
Areca catechu	Arecaceae		+		+
Barringtonia asiatica	Lecythidaceae	+		+	
Calophyllum inophyllum	Cluciaceae	+	+	+	+
Calotropis gigantea	Asclepiadacea	+			
Ficus racemosa	Moraceae		+		
Macaranga peltata	Euphorbiaceae	+			
Morinda citrifolia	Rubiaceae	+	+		+
Murraya koenigii	Rutaceae				+
Ochrosia oppositifolia	Apocynaceae	+		+	+
Pandanus sp.	Pandanaceae	+			
Pagiantha dichotoma	Apocynaceae				+
Scaevola taccada	Goodianaceae	+			
Sterculia balanghas	Sterculiaceae		+		
Terminalia catappa	Combretaceae	+	+	+	+
Thespesia populnea	Malvaceae	+		+	
Total species		10	6	5	7

Density of seedlings of woody perennial plants were highest (Table 4.12) in the homegardens of affected 200 m belt (53500 ha^{-1}) followed by the homegardens of affected 100 m belt (45667 ha^{-1}), non-affected 200 m belt (33833 ha^{-1}) and non-affected 100 m belt (28833 ha^{-1}).

4.3.2 Diversity, Evenness and Similarity

According to the Shannon-Wiener Diversity Index, diversity of the seedlings of woody perennial was higher in the homegardens of the non-affected 200 m belt (0.752) followed by the homegardens in the tsunami affected 100 m belt (0.749), the non-affected 100 m belt (0.680) and the tsunami affected 200 m belt (0.487). The lowest diversity was recorded in homegardens of the tsunami affected 100 m belt (Table 4.13).

Table 4.13: Species diversity and evenness in 4 homegarden categories

Index	Tsunami affected 100 m belt	Tsunami affected 200 m belt	Non-affected 100 m belt	Non-affected 200 m belt
Shannon H' (Log_{10}) Diversity	0.749	0.487	0.680	0.752
Shannon J' Evenness	0.749	0.626	0.973	0.890

Species distribution evenness was higher in the homegardens of the non-affected 100 m belt followed by the homegardens in the non-affected 200 m belt, affected 100 m belt and affected 200 m belt. Evenness was lowest in the homegardens of affected 200 m belt (Table 4.13).

According to the Jaccard Coefficient of similarity, homegardens in affected 100 m belt and non-affected 100 m belt has been shown the highest similarity (25%) whereas the lowest similarity has been shown between the homegardens in affected 100 m belt and affected 200 m belt (15%) as well as between affected 200 m belt and non-affected 100 m belt (15%). The similarities between other categories were more or less similar (Table 4.14).

Table 4.14: Similarity half-matrix of Jaccard Coefficients for the 4 different homegarden categories

Site	Site			
	Tsunami affected 100 m belt	Tsunami affected 200 m belt	Non-affected 100 m belt	Non-affected 200 m belt
Tsunami Affected 100 m belt	-	-	-	-
Tsunami Affected 200 m belt	0.1579 (15%)	-	-	-
Non-affected 100 m belt	0.2500 (25%)	0.1538 (15%)	-	-
Non-affected 200 m belt	0.1905 (19%)	0.1875 (18%)	0.2000 (20%)	-

Rank abundance curves for the seedlings in home gardens of all four categories showed the broken stick model and this express the more or less uniform distribution of seedlings of woody perennial species in homegardens of all four categories. However, the curves are somewhat deviant form the typical broken stick model except one for the affected 100 m belt (Figure 4.19).

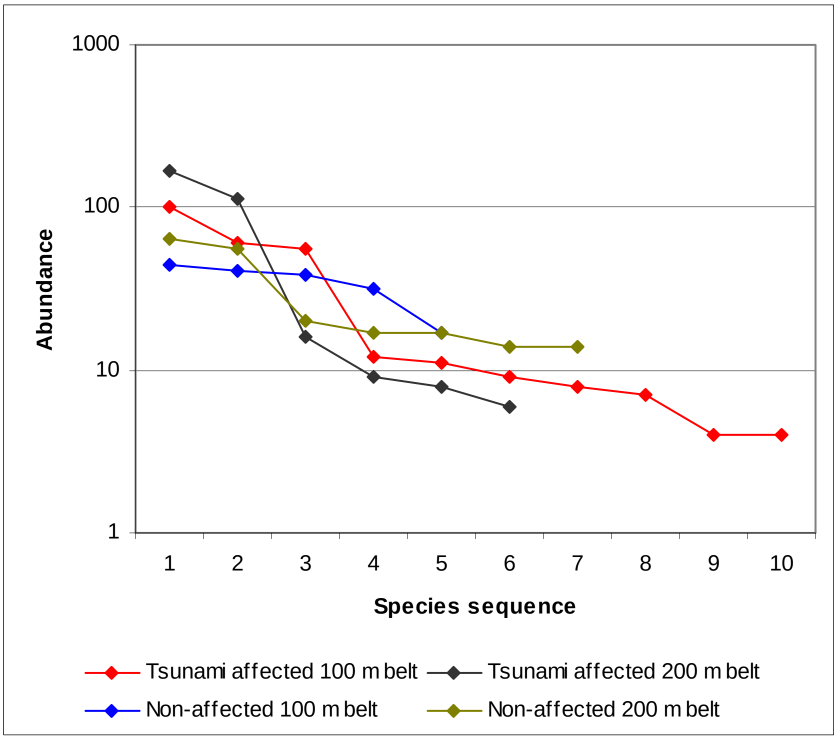

Figure 4.19: Rank abundance curves for the seedlings of woody perennials in 4 homegarden categories

4.4 Survey of the live fence species in tsunami affected homegardens and non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline

The results of the survey of live fence species in selected homegardens (60 homegardens from each category) are given in Table 4.15. The highest number of species (10) found in the live fences around the homegardens of the tsunami affected 100 m belt and the non-tsunami affected 200 m belt followed by the tsunami affected 200 m belt (8 species) and the non-tsunami affected 100 m belt (4 species).

Gliricidia sepium, *Hibiscus tiliaceus* and *Thespesia populnea* were found in live fences around the homegardens of all four categories whereas *Barringtonia asiatica* was found in the live fences around the homegardens of first 3 categories but not in the last, the non-affected 200 m category.

Figure 4.20 presents the frequency occurrence of live fence species in the 4 homegarden categories. According to the results as given in the figure, *Thespesia populnea Hibiscus tiliaceus* and *Gliricidia sepium* were the most frequently found species in live fences of all four categories.

Table 4.15: Live fence species in 4 homegarden categories

Species	Habitat			
	Tsunami affected 100 m belt	Tsunami affected 200 m belt	Non-affected 100 m belt	Non-affected 200 m belt
Alstonia macrophylla				+
Annona glabra	+			
Areca catechu				+
Barringtonia asiatica	+	+	+	
Calophyllum inophyllum		+		+
Cerbera manghas	+	+		
Gliricidia sepium	+	+	+	+
Hibiscus rosa-sinensis	+	+		+
Hibiscus tiliaceus	+	+	+	+
Polyscias sp.				+
Manihot sp.	+			
Morinda citrifolia	+			
Moringa oleifera				+
Terminalia catappa	+	+		+
Thespesia populnea	+	+	+	+
Total	10	8	4	10

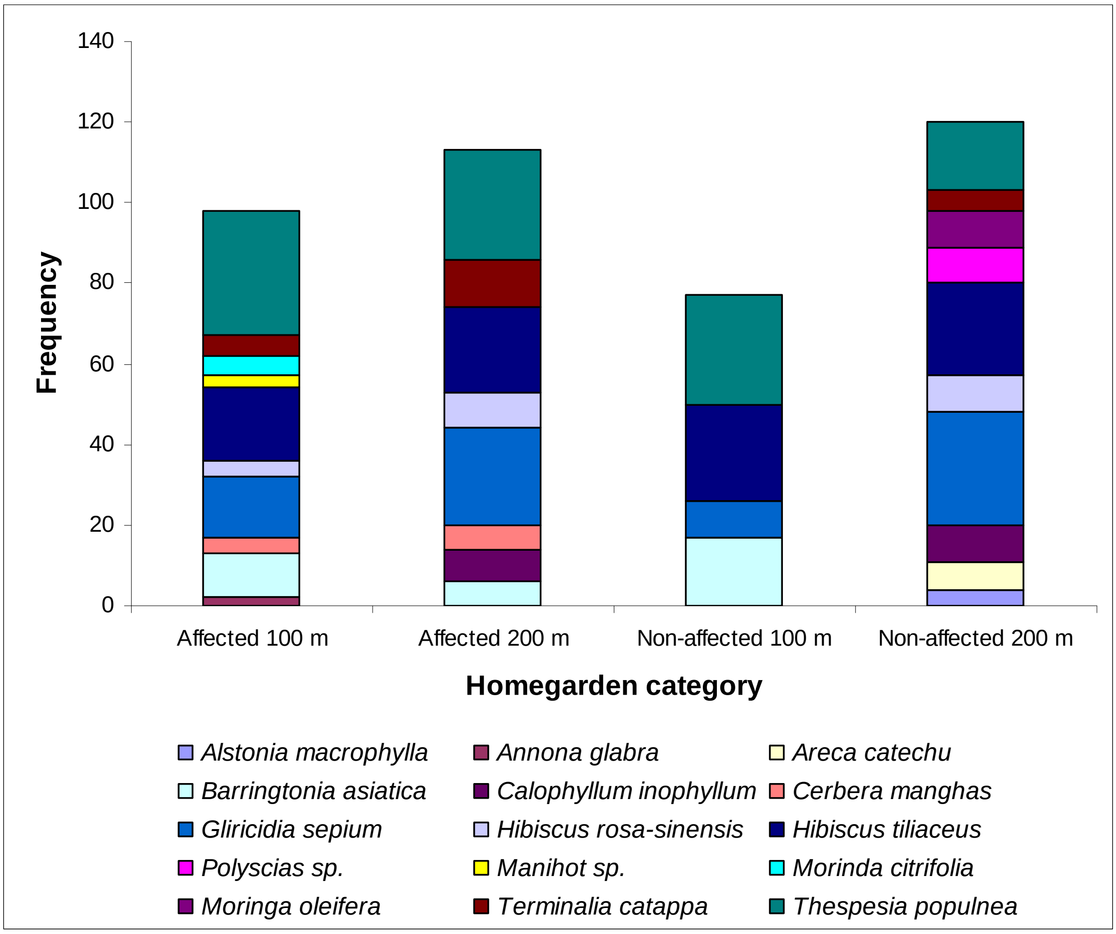

Figure 4.20: Frequency occurrence of live fence species in 4 homegarden categories

The highest number of occurrence of live fence species was recorded around the fences around the homegardens in non-affected 200 m belt category followed by affected 200 m belt, affected 100 m belt and non-affected 100 m belt categories.

The use of climatic climax species found in the coastal vegetation is a noticeable feature. However some people in the study sites do not like to have live fences and sometime they do not like to have any kind of fence around there homegardens due to various reasons. Fences around there homegardens were obstructions to safe escape during the tsunami and the aftermath flooding, and problems encountered in demarcation of boundaries after the tsunami were some reasons behind that.

4.5 Survey of the uses of 15 selected plant species by the coastal community

Results of the survey on the uses of 15 selected plants revealed that some plant species were salient for the coastal community whereas a few of them were not very important or under exploited (Figure 4.21).

4.5.1 Uses of *Alstonia macrophylla*

This is a very valuable timber tree for the coastal community as a source of timber for construction. 92% of the respondents used this as a timber and only 8% of them did not use it for timber. Except as a source of timber this species is not used for any other purposes by the community, very rarely for fuel wood.

4.5.2 Uses of *Barringtonia asiatica*

This tree was used by 32% of the respondents as a shade tree (Figure 4.22). 11% of the respondents used it as a source of timber and 7% used it in their live fences. 29% of the respondents stated that they do not get any benefit from this plant. However it is very interesting to note that, 20% of the respondents identified *Barringtonia asiatica* as asuitable species for coast conservation.

4.5.3 Uses of *Calophyllum inophyllum*

This tree is a very good and valuable source of timber. 52% of the respondents used *C. inophyllum* as timber. Timber of this plant is especially used in various parts of fishing boats (as floats, outriggers and masts) due to the water resistant and long lasting quality. 49% of the respondents of the community used it for boat construction. 5% of the community used the seeds of this plant for medicinal purposes and 5% of the community mentioned this as a suitable tree for coast conservation.

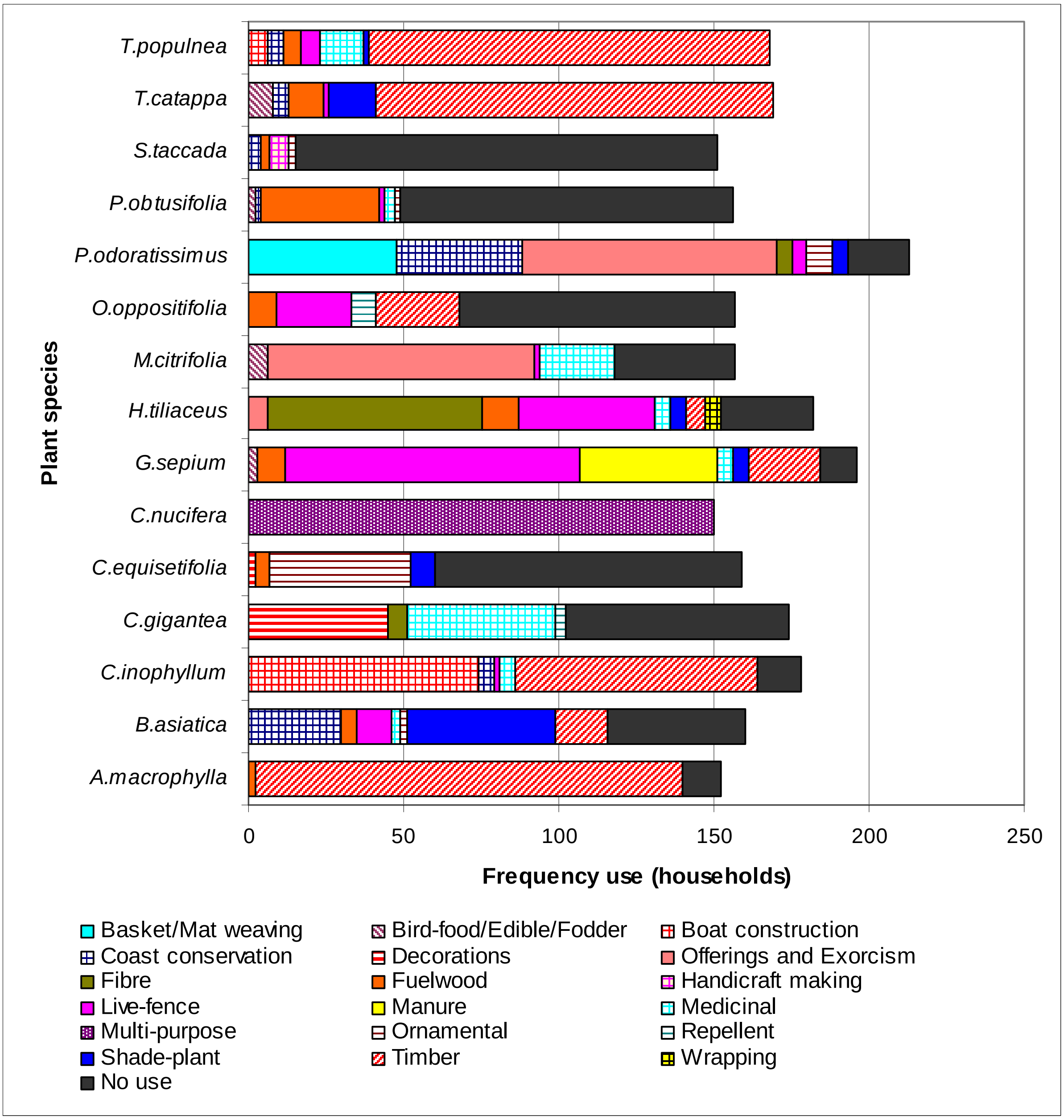

Figure 4.21: Utilisation of selected 15 plants by the coastal community

4.5.4 Uses of *Calotropis gigantea*

This species was reported as of use in local medicine by 32% of the respondents, especially to treat snake-bites and as an anthelmintic to treat worms in domestic animals (dogs). Eye-catching flowers of this plant are used to decorate funeral houses in the coastal region and 30% of the respondents mentioned this special utility. A fine fiber obtained from the stem is used in traditional fishery (fishing-rod) to catch a particular fish species, *Katsuwonus pelamis* (Balaya in Sinhala), belongs to family Tunidae. Only 4% of the respondents mentioned this utility. Roots of *C. gigantea* are used as a repellant (only 2% of respondents), especially the roots of the white-flowered variety, to repel snakes (in particular cobras).

Figure 4.22: Use of *Barringtonia asiatica* trees for shade in homegardens: Sea Spray Terrace Restaurant, Akurala, Galle, Sri Lanka

4.5.5 Uses of *Casuarina equisetifolia*

Casuarina equisetifolia is mainly planted as an ornamental tree and has reported by 35% of the respondents. A very few people used this for fuel wood and for decorations. However 66% of the respondents mentioned that they do not use this plant for any purpose.

4.5.6 Uses of *Cocos nucifera*

Coconut is the most important tree for the coastal community as a multipurpose tree. The uses were not specifically reported by the respondents. Instead reporting specific uses, they have only mentioned that it was a very useful tree for them in many ways (100% of the respondents). Coir production is one of the main household industries in the coastal area (Figure 4.23).

4.5.7 Uses of *Gliricidia sepium*

Gliricidia sepium was used as a live fence species by 63% of the respondents and 29% of the respondents used the leaves of this leguminous plant as a green manure. 23% of the respondents had mentioned that the mature trees can be used as a source of timber and 6%

of the respondents used this for fuel wood. Freshly crushed leaves are sometimes applied on wounds (only by 3% of the respondents - not a very popular practice).

Figure 4.23: Coir (fibres from coconut husks) production in Kahawa, Galle, Sri Lanka

4.5.8 Uses of *Hibiscus tiliaceus*

Hibiscus tiliaceus was reported by 49% of respondents mainly as a source of bark fiber for cordage to tie the poles in fences, to tie the structures of the Lanterns made for the Vesak festival (a Buddhist festival) and also to tie the structures used in exorcism. 29% of the respondents used *H. tilacaeus* in the live fences around their homegardens (Figure 4.24) and 8% of respondents used it as a source of fuel wood, whereas 20% of respondents do not use this plant for any purpose.

4.5.9 Uses of *Morinda citrifolia*

Morinda citrifolia is mainly used in exorcism among the coastal community (57%); fruits as a substitute for lime fruits. This species was mentioned as a medicinal plant (16% of respondents) and also as a food plant for a particular kind of bird (4% of respondents) known as Indian (or Asian) Koel (*Eudynamys scolopacea*).

4.5.10 Uses of *Ochrosia oppositifolia*

This species is mainly used as a live fence species (16% of respondents), as a very low quality timber (poles for mud-huts) and as fuel wood (18% and 6% of respondents respectively). It is remarkable to note that, some people (only 5% of respondents) burn dried seeds of this plant to repel mosquitoes. However, this was not a very popular species in terms of utilization by 59 % of the coastal community.

Figure 4.24: ***Hibiscus tiliaceus*** **in a live fence around a homegarden in Akurala, Galle, Sri Lanka**

4.5.11 Uses of *Pandanus odoratissimus*

Pandanus odoratissimus is very a popular plant for the community; especially the inflorescences (Figure 4.25) are used in offerings at Buddhist temples and in exorcism (55% of respondents). The leaves of *Pandanus* spp. are used by the community (32% of respondents) to make baskets, bags, mats and ornaments (Figure 4.25). This plant is used as an ornamental plant in some homegardens and also in live fences. Considerable number of respondents (27%) had mentioned *P. odoratissimus* as a suitable plant for coast conservation. Some people used aerial prop roots to make brushes for painting their houses.

4.5.12 Uses of *Premna obtusifolia*

Premna obtusifolia is also not very popular among the community as 71% of the respondents had mentioned that they do not use it for any purpose. However the use of it as fuel wood in special functions (in some rituals) was mentioned by respondents (25%), and also the use as a medicinal plant.

Figure 4.25: *Pandanus odoratissimus*: Inflorescence and baskets made of *Pandanus* leaves (Basket weaving, homestead industry: Thelwatte, Galle, Sri Lanka).

4.5.13 Uses of *Scaevola taccada*

This was not a very popular species among the community. This was the least useful plant among the 15 plants tested. 90.6% of the respondents have mentioned that they do not use it for any purpose. However some people use the stem pith to make some handicrafts, especially to make artificial flowers. A very few had mentioned as a suitable plant for coast conservation.

4.5.14 Uses of *Terminalia catappa*

Terminalia catappa is mainly used as a good source of timber for construction (85% of the respondents) and also as a shade tree, for fuel wood. The nuts and the fruit peels are eaten by some people and it very useful food source for birds and bats. This species had also been mentioned by some respondents as a suitable tree for coast conservation.

4.5.15 Uses of *Thespesia populnea*

Thespesia populnea is mainly used as a good quality timber tree for furniture (86% of the respondents) and construction and also as timber for boat construction. Use of various parts for medicinal purposes has also been mentioned. This tree is also used as a live fence species (Figure 4.26) and as a source of fuel wood. Some respondents had mentioned that *T. populnea* is suitable for coast conservation.

Figure 4.26: *Thespesia populnea* in a live fence around a homegarden in Uduwaragoda, Galle, Sri Lanka

4.6 Investigation on the preference of 15 selected plant species to integrate in the coastal homegardens

The results of the investigation on the preference of 15 selected plants species to integrate in the coastal homegardens reveal remarkable and important information. Figure 4.27 shows the average scores gained for the 15 selected plants species in terms of preference to integrate them in their homegardens. *Cocos nucifera* reached the highest average score of 14.72 whereas *Scaevola taccada* had the lowest average score of 2.16. *Alstonia macrophylla* scored second highest with 12.89, followed by *Calophyllum inophyllum* (12.74), *Thespesia populnea* (12.57), *Terminalia catappa* (12.25), *Gliricidia sepium* (11.58), *Barringtonia asiatica* (10.50), *Casuarina equisetifolia* (10.14), *Hibiscus tiliaceus* (9.39), *Pandanus odoratissimus* (8.17), *Ochrosia oppositifolia* (7.74), *Calotropis gigantea* (6.50), *Morinda citrifolia* (5.75) and *Premna* obtusifolia (5.33).

The results of this survey reveales further that *Cocos nucifera* obtained the highest number of first preference; it reached 126 first preferences out of 150 households surveyed, followed by *Calophyllum inophyllum* (14), *Alstonia macrophylla* (6), *Terminalia catappa* (2) and *Casuarina equisetifolia* (2). Other species were not selected as first preference. The lowest (i.e. 15th) preference has been given to *Scaevola taccada* by 17 out of 150 households surveyed. The highest number of second preference reached *Alstonia macrophylla*; 40 out of 150 households surveyed, followed by *Thespesia populnea* (39), *Calophyllum inophyllum* (29), *Gliricidia sepium* (13), *Barringtonia asiatica* (6) and *Terminalia catappa* (5). Other species were not given second preference status. Preferences (1-15) gained by 15 selected plant species are provided in Figure 4.28 for further reference.

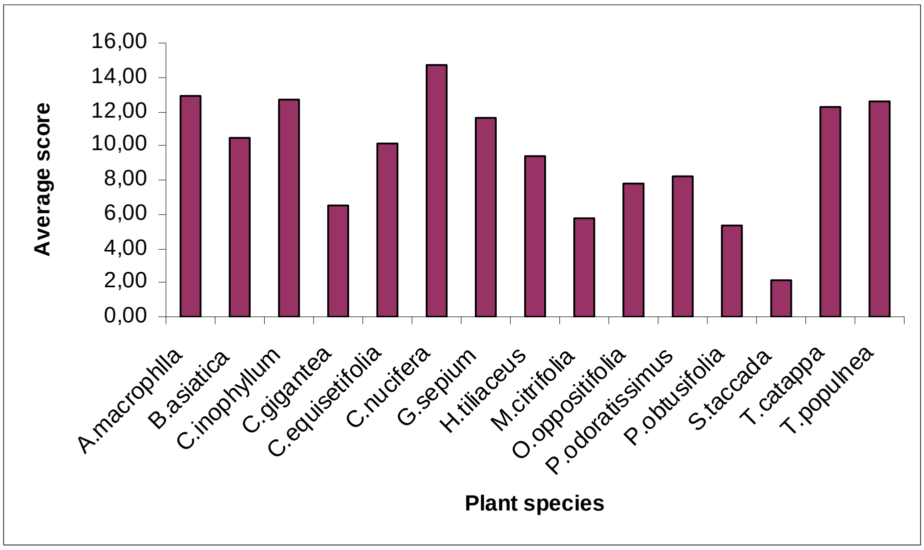

Figure 4.27: Average scores gained for the 15 selected plants species in terms of preference to integrate them in homegardens

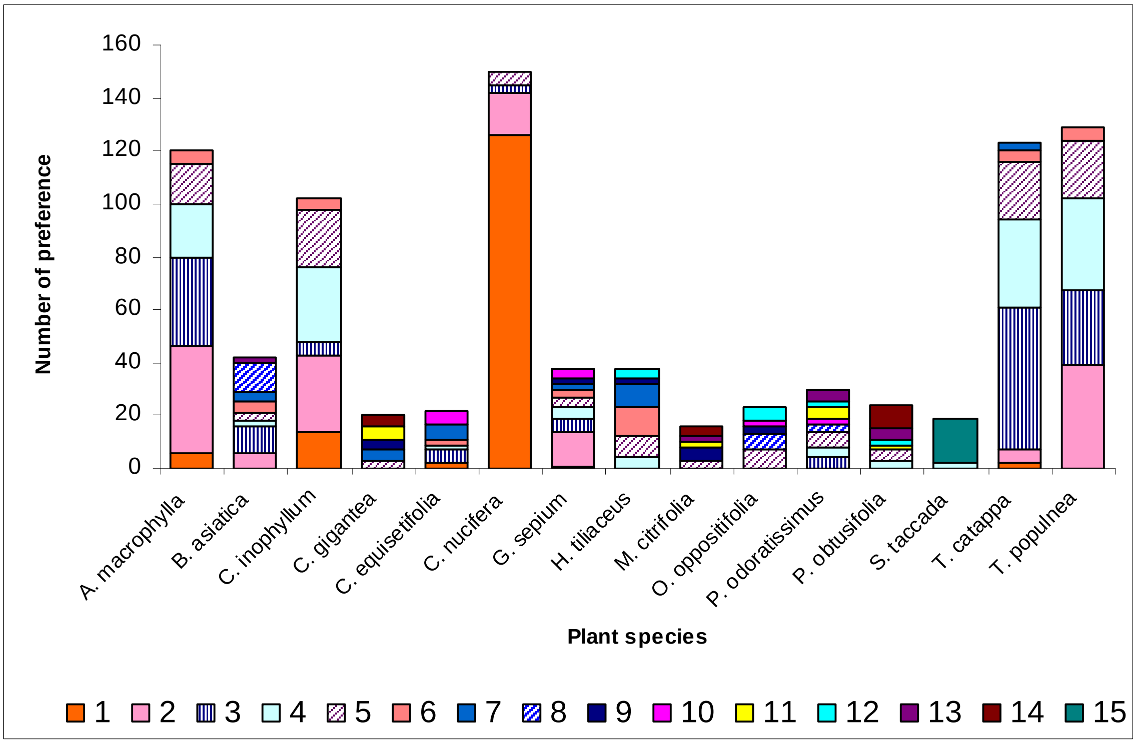

Figure 4.28: Details of the preferences (1-15) allotted to 15 selected plants species by the local community

According to the overall results of the preference query, *Cocos nucifera* is the most preferred plant to be integrated in the homegardens by the coastal community followed by *Alstonia macrophylla*, *Calophyllum inophyllum*, *Thespesia populnea*, *Terminalia catappa*, *Gliricidia sepium*, *Barringtonia asiatica*, *Casuarina equisetifolia*, *Hibiscus tiliaceus*, *Pandanus odoratissimus*, *Ochrosia oppositifolia*, *Calotropis gigantea*, *Morinda citrifolia*, *Premna* obtusifolia and *Scaevola taccada* is the least preferred.

Figure 4.29: Profiles of some affected homegardens in Galle District, Sri Lanka

5 Discussion

This chapter is comprised of 7 main sections. Section 5.1 presents the discussion on the survey of damage to vegetation: Investigation of the impact of the tsunami on homegarden vegetation, exploration of the surviving vegetation; the role of vegetation during the tsunami and in the aftermath of flooding. Results of the comparison of the present status (vegetation structure and composition) of tsunami affected homegardens with non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline is discussed in Section 5.2. In Section 5.3, results of the investigation of ground layer vegetation in order to study the regeneration of woody perennials in tsunami affected homegardens and non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline is discussed. Live fence species in the surveyed homegardens are discussed in Section 5.4, whereas in Section 5.5 the results of the survey of the uses of 15 selected plant species by the coastal community is discussed. Results of the investigation on the preference of 15 selected plant species to integrate in the coastal homegardens are discussed in Section 5.6.

5.1 Vegetation damage survey: Investigation of the impact of the tsunami on homegarden vegetation, exploration of the survived vegetation; the role of vegetation during the tsunami and in the aftermath of flooding

5.1.1 Uprooted and/or inclined tree species

Though Banana (*Musa* x *paradisiaca*) and Papaya (*Carica papaya*) are perennial species, they are not woody and do not have deep root systems and therefore, most of these plants had been uprooted due to the wave force of tsunami. Coconut (*Cocos nucifera*) is an essential multipurpose tree species of the coastal homegardens in Sri Lanka. The root system of *C. nucifera* is well developed and adapted for the coastal environment for better anchorage. It has a root zone of more than 10 m growing to a depth of 0.3–0.4 m. (TANAKA et al. 2007). However, 11% of the surveyed household records indicate that a considerable amount of *C. nucifera* trees have been uprooted too (Figure 5.1) as a result of the tsunami. According to TANAKA et al. (2007), the roots were undercut by erosion and strong drag forces by a tsunami of more than 5 m in height; even though they have well developed root systems. Root system of *Artocarpus incisus* (Breadfruit) is wide spread but not deep enough for a better anchorage in a coastal terrain. Most of the *A. incisus* trees had been uprooted in the tsunami affected near shore homegardens. It is interesting in this context that even most of the mature Breadfruit trees in the inlands of Sri Lanka had been uprooted during the cyclone of November 1978 (K.W.M. WIJEKOON, Personal Communication 2008). The relatively large leaves and the well spreading crown (sometimes with low laying branches) seem to absorb more of the wave and wind energy of tsunamis and cyclones respectively than the root system can tolerate. Most of the other uprooted plants were deliberately planted food plants, timber species, ornamental plants and various kinds of herbaceous plants. Most of them are exotics and not adapted to coastal environments. It is very important to note that, climatic climax species such as *Barringtonia asiatica* (Figure 5.1) and *Calophyllum inophyllum* have not been reported as uprooted in the surveyed homegardens and it is evident that these species are well adapted to withstand destructive coastal conditions.

Figure 5.1: Impacts of tsunami on *Cocos nucifera*, exposed root systems (a), uprooted young plants (b), uprooted mature trees (c) and survived *Barringtonia asiatica* tree (d) (Photos by Samantha Bogahapitiya)

5.1.2 Tree species with broken branches

Branches of *Artocarpus incisus* have been broken due to the tsunami, damage very noticed by the coastal community as *A. incisus* is a very important and useful plant for them. The tree architecture with low laying branches is very vulnerable to damage. Also the branches as well as the main trunk of this species are not very hard and liable to break easily. Even though they have high volume of wood it is not used as a source of timber because of the poor quality. The low laying branches of *Alstonia macrophylla*, *Mangifera indica* and *Terminalia catappa* have also been damaged severely. There were a number of other species reported those with broken branches. However, it is obvious that the surveyed coastal community has overlooked the damage to unimportant wild trees because their emphasis was on useful and important trees. Even damage to the compound leaves (called "branches" by local people even though they are leaves and not branches) of coconut palms (*Cocos nucifera*) were reported by the community. However, only 2% of the surveyed community reported that *B. asiatica* trees had broken branches. Most of the other climatic climax species were not reported with broken branches as a result of tsunami the reason may be overlooking damage to less used plants.

5.1.3 Tree species with broken trunks

Plants with broken trunks as an affect of tsunami were also reported by the coastal community. Damage to the pseudo stems (trunks) of *Musa x paradisiaca* (Banana) was reported from 19% (highest frequency) of the surveyed community. Damage to the trunks of *Cocos nucifera* (Coconut), *Alstonia macrophylla*, *Carica papaya*, *Mangifera indica*, *Artocarpus incisus* was also reported by the community. *Carica papaya* has a very delicate stem and therefore the damage is obvious. It is important to note the damage to the trunks of *Artocarpus incisus*. Other species reported with broken trunks as an affect of tsunami were *Areca catechu*, *Artocarpus heterophyllus*, *Azadirachta indica, Citrus aurantifolia, Persea americana, Syzygium jambos,* and *Terminalia catappa*. Except *Terminalia catappa,* no other naturally available coastal tree species was recorded with broken trunks by the community. Earlier, I had assumed this was also due to overlooking. However, informal interviews held with some households (SANJAYA DILSHAN et al., Personal Communication 2006, 2007 and 2008) in the study area after the questionnaire survey reveals that the damage to the trunks of species such as *Barringtonia asiatica and Calophyllum inophyllum* was very rare (almost no damage).

5.1.4 Tree species with broken tops (apical branches)

Fifteen pant species and ornamental plants (species had not been mentioned) had been reported with broken tops due to the tsunami by the coastal community. Though *Cocos nucifera*, *Areca catechu* and *Musa* x *paradisiaca* do not have the apical branches, the respondents considered the topmost unopened leaves as branches. *Artocarpus incisus*, *Alstonia macrophylla*, *Cocos nucifera*, *Areca catechu, Artocarpus heterophyllus, Swietenia macrophylla* and *Terminalia catappa* usually grown taller in the coastal area when compare with other species reported (viz. *Carica papaya*, *Mangifera indica*, *Musa* x *paradisiaca*, *Persea americana*, *Codiaeum variegatum*, *Filicium decipiens*, *Hibiscus tiliaceus* and *Spondias dulcis*). WIJETUNGE (2006) suggests that the mean possible tsunami height was about 5 m at Galle and Matara (Sri Lanka). However, it was more than 10 m in some areas (Peraliya village) selected for the present study (WIJETUNGE 2006). Therefore, most of the trees with broken tops may be probably below 5 m in their height and may be around 10 m in the areas like Peraliya village. Species such as *Barringtonia asiatica and Calophyllum inophyllum* (the climatic climax species) had not been reported with broken tops and this is most probably due to overlooking (villagers not had paid much attention to them).

5.1.5 Plant death and defoliation due to tsunami

The results obtained from the questionnaire survey on plant death after a few of tsunami, plants surviving after defoliation and plant death after one month or later due to tsunami are discussed in this section under 3 separate headings as follows.

5.1.5.1 Plant death within a few days of after the tsunami

Altogether 44 woody species, vegetables, ornamentals and grasses / weeds had been reported as having died within a few days after the tsunami. Almost all of them were deliberately planted species in the coastal homegardens and most of them were exotics (non-native). These species are not adapted to tolerate high salinity levels and increased salinity level of the soil (due to the aftermath flooding of tsunami) may be the main reason for the quick death of these salt intolerant species. However, a few numbers of individuals of *Cocos nucifera, Terminalia catappa, Calophyllum inophyllum, Hibiscus tiliaceus and Thespesia populnea* were also in the list. These species can tolerate normal inundated salinity levels as well as or increased (excess) salinity levels during the high tides (monthly and annual). Therefore, the probable cause of death of these species may be physical injures due debris or may be some other reason like anaerobic conditions of the flooded soil or the combination of several causes.

5.1.5.2 Plants surviving after defoliation by the tsunami

Some plants had been defoliated as an immediate respond to the tsunami and later on they grew new leaves and survived. Fifteen out of 30 the species reported were either deciduous species or species with compound leaves (Table 5.1). Species with compound leaves usually defoliate immediately as a response to the unfavourable condition like drought. By doing this it is possible to mitigate the further damage. *Terminalia catappa* deciduous species; shed their leaves twice a year. It is very abundant in coastal areas. *Azadirachta indica*, *Asparagus* spp. and *Swietenia macrophylla* are the other deciduous species. *Azadirachta indica* and *Asparagus* spp. are also abundant in coastal areas especially in dry and intermediate zones whereas *Swietenia macrophylla* (Mahogany) is not a common coastal plant in Sri Lanka. It is important to note that some *Artocarpus heterophyllus* and *Artocarpus incisus* individuals also were among the survivors after defoliation.

Table 5.1: Some characteristics of the plants surviving after defoliation

No.	Plant species	Deciduous	Compound leaves
1	*Alstonia macrophylla*		
2	*Annona sp.*		
3	*Artocarpus heterophyllus*		
4	*Artocarpus incisus*		
5	*Asparagus sp.*	+	
6	*Averrhoa bilimbi*		+
7	*Azadirachta indica*	+	+
8	*Bambusa sp.*		
9	*Barringtonia asiatica*		
10	*Calophyllum inophyllum*		
11	*Cerbera manghas*		
12	*Chrysophyllum roxburghii*		
13	*Citrus sinensis*		
14	*Cynometra cauliflora*		+
15	*Delonix regia*		+
16	*Erythrina variegata*		+
17	*Ficus religiosa*		
18	*Gliricidia sepium*		+
19	*Hibiscus tiliaceus*		
20	*Jasminum sp.*		+
21	*Mangifera indica*		
22	*Pericopsis mooniana*		+
23	*Psidium guajava*		
24	*Punica granatum*		
25	*Sesbania grandiflora*		+
26	*Spondias dulcis*		+
27	*Swietenia macrophylla*	+	+
28	*Tabernaemontana divaricata*		
29	*Terminalia catappa*	+	
30	*Thespesia populnea*		

5.1.5.3 Plant death later than one month after the tsunami

Twenty three species were reported by the surveyed households, which died after one month or later due to the tsunami. Most of them were deliberately planted and some of them were exotics, except of a few common coastal species such as *Calophyllum inophyllum*, *Hibiscus tiliaceus*, *Terminalia catappa* and *Cocos nucifera*. *Cinnamomum verum* (Cinnamon) was also reported. This is a very important agricultural export crop of Sri Lanka. Salinity and anaerobic conditions due to the aftermath flooding may be the reason for this dieback. Salinity level of the soil usually increase for some time due to the evaporation and this may aggravate the condition and this may be the reason behind the death of above mentioned common coastal species. Later on, however, the salinity levels decrease when monsoon rain sets in and the soil gradually recovered.

5.1.6 Alien plant species germinated (found) in homegardens after the tsunami

Most of the alien plants (species not present in the homegardens before the tsunami) recorded from the tsunami affected homegardens were food plants, mostly vegetable species belonging to the families Cucurbitaceae and Solanaceae. Some ornamental species, medicinal species as well as some weedy species were also reported as aliens. All these species have relatively small, light seeds and therefore were easily dispersed by the flood waters. They may have come from nearby affected hotels, neighbouring households and garbage dumps to the affected homegardens. In addition to the species dispersed by seeds, there were some species like *Musa x paradisiaca* and *Colocasia esculenta* among the aliens. They had emerged from dispersed rhizome fragments (those damaged during the tsunami). Though the invasive alien problem is a critical one in Sri Lanka, it is important to note that there were no invasive alien plant species among the reported species at that time.

5.1.7 Species planted after the tsunami with and without the advice of institutions

Replanting of tsunami affected homegardens was done in two ways; some households with advice from governmental and/or nongovernmental institutions and others without advice from any of these institutions. There is no remarkable difference between the plants selected by these two methods. However, lot of ornamental plants had been grown in the homegardens of the families who selected plants without advice. On the other hand, there were more newly planted Coconut trees in the homegardens of the families who selected plants with the advice and they also have been provided by some institutions with exotic timber species such as *Swietenia macrophylla* and *Tectona grandis.* In general it is clear that much attention has been laid on food plants rather than on other species. This makes clear that the demand of the community on their homegardens is often to satisfy day to day requirements.

5.1.8 Permanently surviving plants in homegardens after the tsunami

The highest number of surviving individuals in the affected homegardens was found to be *Cocos nucifera* according to the records of the questionnaire survey, followed by *Terminalia catappa*, *Azadirachta indica*, *Mangifera indica* etc. In this instance too, some trees were overlooked by the community. Some species were totally neglected when the people responded to the questionnaire, especially *Barringtonia asiatica*. There were a number of mature *B. asiatica* trees which survived in the affected homegardens. Community tend to pay more attention to very useful plants than to other, rarely used plants. There were many salt intolerant species among the survivors but at the same time there were individuals belonging to the same species among the plants which died within a few days after the tsunami such as *Mangifera indica*, *Cocos nucifera*, *Artocarpus incisus* and *Musa* x *paradisiaca*.

5.1.9 Desired plants for growing in affected homegardens, as suggested by the community

Cocos nucifera and *Musa* x *paradisiaca* have been suggested as suitable by 17% of the households surveyed. Other than these 2 species, the community likes to grow food plants (fruit and vegetable species) and timber species in their affected homegardens. Food species are to meet their daily needs, whereas timber species to use in future construction work as well as a source of income. However a very few households reported that they like to grow naturally grown coastal species such as *Terminalia catappa*, *Barringtonia asiatica*, *Calophyllum inophyllum*, *Hibiscus tiliaceus* and *Thespesia populnea*.

5.1.10 Plants suitable for coast conservation, as suggested by the coastal community

Pandanus spp., *Cocos nucifera*, *Barringtonia asiatica*, *Terminalia catappa*, *Ipomoea pes-caprae* and *Calophyllum inophyllum* had been suggested as plants suitable for coast conservation by the majority of the households surveyed. It is very clear that the coastal community was well informed about suitable species for coastal conservation. *Pandanus* spp., *Cocos nucifera*, *Barringtonia asiatica* and *Terminalia catappa* are the species recommended by the Coast Conservation Department of the Sri Lankan Government for the selected study sites in the Galle District. *Ipomoea pes-caprae* (Figure 5.2) is one of the common perennial herbaceous species found along the coasts of Sri Lanka on sandy soil and it naturally prevents the coast from erosion. It is a luxuriantly growing runner on sandy seashores and commonly associates with *Spinifex littoraria* on the beaches of dry, intermediate and arid zones and form thickets. *Calophyllum inophyllum* is a common climatic climax species in the coastal woodlands and it is a suitable species for coast conservation.

5.1.11 Trees which helped to save lives

Most people saved their lives by climbing or clasping to Coconut (*Cocos nucifera*) trees and *Terminalia catappa* trees and a number of some other trees also in the listing. However, people not purposely select these tree species to escape, whatever the tree that they found by chance during the tsunami disaster they climbed or clasped. *Carica papaya* has a very delicate trunk and people never climbed to Papaya trees even to pluck the fruits. However some people have tried to save their lives by climbing on Papaya plants during the tsunami. In general, it is obvious that an important role has been played by plants in this manner.

Figure 5.2: *Ipomoea pes-caprae,* runners with a flower (left) and invading an affected homegarden (right, circled) in Kahawa, Galle, Sri Lanka

5.2 Comparison of the present status (vegetation structure and composition) of tsunami affected homegardens with non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline

5.2.1 Floristic richness

Floristic richness of woody perennial trees was higher in the tsunami affected homegardens than in the non-affected homegardens. The highest number of families, genera and species was recorded from the homegardens of the tsunami affected 100 m belt category followed by the tsunami affected 200m belt. There were plenty of recently introduced plants in the tsunami affected homegardens (both 100 m belt and 200 m belt categories) whereas in non-affected categories there were not as many. Plants such as *Annona sp.*, *Averrhoa bilimbi*, *Cassia auriculata*, *Ceiba pentandra*, *Cinchona sp.*, *Codiaeum variegatum*, *Manihot sp.*, *Muntingia calabura*, *Phyllanthus acidus*, *Psidium guajava, Schleichera oleosa*, *Syzygium jambos*, *Tamarindus indica* and one species of *Ficus* were only recorded from tsunami affected homegardens and therefore the floristic richness was higher in the affected homegardens than non-affected. *Murraya koenigii*, *Ochrosia oppositifolia*, *Casuarina equisetifolia*, *Sesbania grandiflora*, *Spondias dulcis*, *Swietenia macrophylla* and one species of *Citrus* were recorded only from non-affected homegardens.

Annona sp., *Cassia auriculata*, *Filicium decipiens, Phyllanthus acidus*, *Psidium guajava* and *Syzygium jambos* recorded from the tsunami affected homegardens were provided to tsunami affected people by governmental and nongovernmental organizations and planted within the last 3 years, after the December 26, 2004 tsunami. *Ochrosia oppositifolia* is a very abundant coastal plant of the region (south and southwestern Sri Lanka) and mature plants were not recorded from the tsunami affected homegardens; however is was recorded from non-affected homegardens. Most of the mature individuals had been uprooted during the tsunami (SANJAYA DILSHAN, Personal Communication 2006).

Indigenous species such as *Azadirachta indica*, *Barringtonia asiatica*, *Calophyllum inophyllum*, *Cocos nucifera*, *Hibiscus tiliaceus*, *Mangifera indica*, *Manilkara zapota*, *Morinda citrifolia*, *Premna obtusifolia*, *Terminalia catappa* and *Thespesia populnea* and exotic species such as *Accacia auriculiformis* and *Alstonia macrophylla* were reported from tsunami affected homegardens as well as from non-affected homegardens. Out of selected 15 plants considered to investigate the preference of the community to integrate these in their affected homegardens, *Alstonia macrophylla, Barringtonia asiatica, Calophyllum inophyllum, Cocos nucifera, Hibiscus tiliaceus, Morinda citrifolia, Premna obtusifolia, Terminalia catappa* and *Thespesia populnea* were recorded from both tsunami affected and non-affected homegardens; whereas, *Calotropis gigantea*, *Gliricidia sepium*, *Pandanus odoratissimus* and *Scaevola taccada* were not recorded from the surveyed homegardens (in 10 m x 10 m plots, *Gliricidia sepium* was recorded in live fences of all categories). *Ochrosia oppositifolia* and *Casuarina equisetifolia* was recorded only in non-affected homegardens. However *Casuarina equisetifolia* is not a commonly available plant in the present study area. Accordingly it is clear that the most of the indigenous plant species were abundant in homegardens of tsunami affected as well as in non-affected categories and this is a positive feature for the future regreening programmes.

5.2.2 Phytosociological features

Results of phytosociological features such as plant density, basal area, diameter at breast height (DBH), diameter class distribution and dominance in terms of important value index (IVI) are discussed in this section separately under 3 headings as follows.

5.2.2.1 Plant density

The highest plant density of woody perennial plants was recorded in the homegardens of non-affected 100 m belt category followed by the tsunami affected 100 m belt, then non-affected 200 m belt and the lowest was observed in the homegardens of the tsunami affected 200 m belt. Many recently planted individuals were reported in both 100 m categories. These plants had been provided through rehabilitation programmes by different organisations. However, homegardens in both affected and non-affected 200 m belts had been less treated in this manner. This may have led to the higher density in 100 m categories than in the 200 m categories. However, if we consider only the tsunami affected and non-affected plots, the density is higher in non-affected categories than affected categories. This is most likely due to the damage caused by the tsunami. When we consider the overall densities of these coastal homegardens (both tsunami affected and non-affected), it is very low when we compare it with homegardens of central parts of the country. According to HOCHEGGER (1998) it was from 11,000 to 16,000 trees per hectare.

5.2.2.2 Basal area and Diameter at breast height (DBH)

The total basal area was highest in the homegardens of the tsunami affected 100 m belt (19.38 m^2ha^{-1}) followed by the non-affected 100 m belt (16.57 m^2ha^{-1}), the non-affected 200 m belt (15.34 m^2ha^{-1}) and the affected 200 m (10,74 m^2ha^{-1}). The mean basal area of a tree was 0.04 m^2ha^{-1} in the homegardens of tsunami affected 100 m belt and in all other 3 categories it was 0.03 m^2ha^{-1}. The highest basal area in the tsunami affected 100 m category was mainly due to the highest number of Coconut (*Cocos nucifera*) trees recorded in that category. There were 182 Coconut trees in that category and only 133, 148 and 95 in the tsunami affected 200 m, non-affected 100 m and non-affected 200 m belt respectively. Usually the density of *C. nucifera* trees in the homegardens decreases with the increasing distance from the coast. Therefore, it is not possible to state that this difference is merely due to the impact of tsunami.

The mean DBH was also highest in the homegardens of tsunami affected 100 m belt (19.4 cm) followed by non-affected 200 m belt (17.6 cm), tsunami affected 200 m (16.5 cm) and non-affected 100 m (16.5 cm). Highest DBH in the tsunami affected 100 m category was also mainly due to the highest number of Coconut (*Cocos nucifera*) trees recorded in that category.

5.2.2.3 Diameter class distribution

Except in the homegardens of non-affected 200 m belt, distribution of DBH classes has a very similar pattern in the homegardens of the tsunami-affected 100 m belt, tsunami-affected 200 m belt, and non-affected 100 m belt. Whereas the graph of DBH class distribution for the homegardens of non-affected 200 m has been somewhat left skewed (Please refer Figure 4.15).

Out of 484 individuals in the homegardens of the affected 100 m belt, 95 (19.6%) were in the first diameter class (1-5 cm). Most of them were recently (after tsunami) planted small saplings. This character is also common in the homegardens of the affected 200 m belt as well as in the homegardens of the non-affected 100 m belt. Out of the 353 individuals in the homegardens of the affected 200 m belt, 93 (26.4%) were in the first diameter class (1-5 cm). Here too, most of these were recently planted small saplings. 109 plants (19.6%) out of 555 plants in the homegardens of the non-affected 200 m belt were also in the first diameter class (1-5 cm). Most of these plants were also planted recently after the tsunami. Relatively seen the distribution of small plants is lower in the homegardens of the non-affected 200 m belt. Only 58 individuals (12.5%) belong to the 1-5 cm DBH class. It is important to note that the frequency was were relatively low in the 6-10 cm, 11-15 cm and 16-20 cm classes in the homegardens of the affected 100 m and affected 200 m categories when compared with the two non-affected categories. (Please refer Figure 4.16). Accordingly it was clear that the smaller trees have been destroyed due to the impact of tsunami whereas the larger trees left. Vulnerability of smaller tress for the damage was higher than that of larger trees during the tsunami (TANAKA et al. 2007; FORBES and BROADHEAD 2007).

Out of 95 individuals in the 1-5 cm DBH class in the homegardens of the tsunami affected100 m belt, most of the individuals were saplings of *Alstonia macrophylla, Barringtonia asiatica*, *Calophyllum inophyllum, Terminalia catappa* and *Thespesia populnea*. In higher DBH classes such as 31-35 cm and 36-40 cm, *Cocos nucifera* is the main component.

Out of 93 individuals in the first diameter class (1-5 cm) in the homegardens of the affected 200 m belt, there are a number of small plants belong to several species such as *Artocarpus heterophyllus*, *Artocarpus incisus*, *Barringtonia asiatica, Calophyllum inophyllum, Filicium decipiens, Morinda citrifolia, Mangifera indica, Psidium guajava, Terminalia catappa* and *Tectona grandis*. As in the tsunami affected 100 m category, here also *Cocos nucifera* is the main component of higher DBH classes.

Out of 109 individuals, saplings of species such as *Alstonia macrophylla, Azadirachta indica, Barringtonia asiatica, Calophyllum inophyllum, Morinda citriflolia, Mangifera indica, Ochrosia oppositifolia Premna obtusifolia, Terminalia catappa* and *Thespesia populnea* were in the lowest DBH class 1-5 cm whereas here also the prominent member in higher DBH classes was *Cocos nucifera* in the homegardens of non-affected 100 m belt.

Out of 58 individuals, saplings of *Artocarpus incisus, Calophyllum inophyllum, Filicium decipiens, Murraya koenigii, Mangifera indica, Sesbania grandiflor, Terminalia catappa* and *Thespesia populnea* were in the lowest DBH class (1-5 cm) in the non-affected 200 m belt. Here, members of the higher DBH class not mainly occupied by *Cocos nucifera*; *Artocarpus incisus, Artocarpus heterophyllus, Terminalia catappa* and *Thespesia populnea* also found in the higher DBH classes. In this homegarden category there were only 8 members in the highest DBH class 41-45 cm, whereas in other 3 categories there were no individuals in this class.

Accordingly, it is very clear that a considerable amount of young woody plants can be found in the homegardens of the tsunami affected 100 m belt, in homegardens of the tsunami affected 200 m belt and the non-affected 100 m belt. This is probably due to artificial regeneration; whereas it seemed mainly by natural regeneration in the homegardens of the non-affected 200 m category. The occurrence of young individuals was comparatively low in this category. If this regeneration process will continue without disturbances, it would be a better way to restore the affected homegardens without a great deal of effort. However, it is feasible to introduce more important species into the affected homegardens through community participation.

5.2.2.4 Dominance: Important Value Index (IVI)

Cocos nucifera was the most dominant species in all 4 categories of homegardens in terms of Important Value Index (IVI). Since the IVI calculated for each species in each category by adding up the relative frequency, relative density and relative basal area of each species, *C. nucifera* had the highest frequency, highest density and highest basal area in all four categories. This is a due to the abundance of Coconut trees in homegardens of coastal region. It is very difficult to find a single homegarden without a Coconut tree. Coconut is a part and parcel of many tropical coastal communities.

There were 7 native coastal species among the first 10 dominant species in the non-affected 100 m belt, 6 in the homegardens of tsunami affected 100 m belt as well as in the homegardens of non-affected 200 m belt, and 4 in the homegardens of non-affected 200 m belt (Table 5.2).

Table 5.2: First 10 dominant species in four homegarden categories (*native coastal species)

No.	Tsunami affected 100 m belt	Tsunami affected 200 m belt	Non-affected 100 m belt	Non-affected 200 m belt
1	*Cocos nucifera**	*Cocos nucifera**	*Cocos nucifera**	*Cocos nucifera**
2	*Thespesia populnea**	*Terminalia catappa**	*Barringtonia asiatica**	*Thespesia populnea**
3	*Barringtonia asiatica**	*Thespesia populnea**	*Alstonia macrophylla*	*Artocarpus incisus*
4	*Terminalia catappa**	*Mangifera indica*	*Calophyllum inophyllum**	*Mangifera indica*
5	*Calophyllum inophyllum**	*Calophyllum inophyllum**	*Thespesia populnea**	*Artocarpus heterophyllus*
6	*Alstonia macrophylla*	*Barringtonia asiatica**	*Ochrosia oppositifolia**	*Terminalia catappa**
7	*Premna obtusifolia**	*Areca catechu*	*Terminalia catappa**	*Calophyllum inophyllum**
8	*Azadirachta indica*	*Morinda citrifolia**	*Morinda citrifolia**	*Filicium decipiens*
9	*Manilkara zapota*	*Artocarpus incisus*	*Mangifera indica*	*Murraya koenigii*
10	*Psidium guajava*	*Artocarpus heterophyllus*	*Azadirachta indica*	*Areca catechu*

Dominance of more native coastal species in all categories is a very important feature, especially in affected categories. Exotic *Alstonia macrophylla* was found among the first 10 dominant species in both tsunami affected and non-affected100 m categories. *Calophyllum inophyllum, Terminalia catappa* and *Thespesia populnea* is among the first 10 dominants in all four categories, whereas *Barringtonia asiatica* is not in the non-affected 100 m category. It has not been recorded from the surveyed homegardens. *Psidium guajava* was the 10th dominant species in the homegardens of tsunami affected 100 m belt. There a number of recently introduces Guava plant could be found in the affected homegardens those were recently introduced. *Areca catechu* is found among the first 10 dominants in both 200 m categories. At a glance, almost all the coastal homegardens can be mistaken as parts of a continuum of Coconut plantation due to the dominance of *Cocos nucifera* in all 4 categories. Accordingly it is clear that a number of the indigenous plant species were dominant in the homegardens of tsunami affected as well as in non-affected categories and this is a positive feature for the future regreening programmes.

5.2.3 Diversity, Evenness and Similarity

According to Shannon H' (Log_{10}), woody perennial plant diversity is lowest in the homegardens of the tsunami affected 100 m belt and highest in the homegardens of the non-affected 200 m belt. This was one of my assumptions at the onset of the study. The diversity had been reduced due to the impacts of tsunami; even though the floristic richness is highest in the homegardens of the affected 100 m belt. The diversity is slightly higher in the homegardens of the tsunami affected 200 m than in those of the non-affected 100 m belt.

It is very interesting to note that the evenness abided the expected result. Evenness is highest in the homegardens of the non-affected 200 m belt followed by the non-affected 100 m belt, the affected 200 m belt and the affected 100 m belt. Accordingly, evenness is lowest in the homegardens of the tsunami affected 100 m belt. Though the floristic richness is highest and the density is second highest in this category, the evenness is lowest. This explains that the individuals of different woody perennial species not distributed evenly in the homegardens of tsunami affected 100 m belt. However, according to the typical broken stick model rank abundance curves it is clear that the species more or less uniformly distributed in homegardens.

According to the Jaccard Coefficient of similarity, the highest dissimilarity was detected between the homegardens of the affected 100 m belt and the homegardens of the non-affected 200 m belt. This was an expected result. The lowest dissimilarity or highest similarity was observed between the homegardens of tsunami affected 100 m belt and the non-affected 100 m belt followed by homegardens of tsunami affected 200 m belt and non-affected 200m belt. This indicates the similarity of homegardens in the same distance categories. According to the overall results, it is possible to state that there is a remarkable difference between the homegardens of tsunami affected100 m belt and non-affected 200 m belt. However it is difficult to argue that this difference is only due the impacts of tsunami; because the distance from the shore line to the homegardens is also a possible reason for this dissimilarity. Similarity between categories of the same distance is apparent to support this assumption.

5.3 Investigation of ground layer vegetation in order to study the regeneration of woody perennials in tsunami affected homegardens and non-affected homegardens, in the 100 m belt and the 100-200 m belt from the shoreline

5.3.1 Floristic richness and density

Floristic richness (number of families, genera and species) of seedlings and saplings of woody perennials is somewhat higher in the homegardens of the affected 100 m belt when compare with the other 3 categories of homegardens. However this is not a very remarkable. Seedlings of *Calotropis gigantea*, *Pandanus odoratissimus* and *Scaevola taccada* and *Macaranga peltata* were recorded only from the homegardens of the affected 100 m belt and the reason for this relatively high richness is due to these. Obviously these species except *M. peltata* are commonly available in the near-shore area and rare in other areas. However these species were not reported from the homegardens of the non-affected 100 m belt. The possible reason for this difference is due to the degree of management of the homegardens. Non-affected homegardens in the 100 m belt had been managed well compare to the affected homegardens in the 100 m belt. Some of the homegardens in the affected 100 m belt were almost neglected and *C. gigantea*, *P. odoratissimus* and *S. taccada* established in these homegardens. *M. peltata* is a common pioneer species (first colonizers in the succession) in disturbed sites in the wet zone of Sri Lanka; however mature plants were not recorded during the survey from any category of homegardens. Seedlings and saplings of woody perennial species recorded form other categories (the tsunami affected 200 m belt, non-affected 100 m belt and non-affected 200 m belt) were mainly climatic climax species of the coastal area except a few such as *Areca catechu* (Areca-nut or beetle-nut) *Ficus racemosa*, *Murraya koenigii*, *Pagiantha dichotoma* and *Sterculia balanghas*.

The seedling and sapling density of woody perennials was highest in the homegardens of the tsunami affected 200 m belt category and lowest in the homegardens of the non-affected 100 m belt. If we consider only the distance from the seashore, density was lower in 100 m belt and if we consider only the tsunami affect, density was lower in non-affected regions. Accordingly the lowest density was recorded from the homegardens of non-affected 100 m belt. Affected homegardens contain still some debris and this provides additional microhabitats for the regeneration of woody perennials as compared with non-affected ones. Additionally weeding was practised more intensely in the non-affected than in affected homegardens at that time of the survey. The impact of wind velocity and tidal actions on the survival of young immigrants may be the reason for the lower seedling density in the 100 m belt than in the 200 m belt. However, the main threat on survival is mainly the anthropogenic activities. Most of the households do not like to have large woody perennials in their homegardens, except timber and important fruit trees. They use to uproot or weed the seedlings and saplings of common coastal plants that they think not useful and unimportant for them. Most of the mature trees were accidentally escaped individuals of these native species, except when individuals had been allowed to grow in live fences or in edges of the homegardens.

According to the results, it is clear that considerable amount of natural regeneration of woody perennials (native coastal) takes place in the coastal homegardens (Please refer Figure 4.18); however they encountered some problems in the process of surviving and maturing in to adults.

5.3.2 Diversity, Evenness and Similarity

Seedling and sapling diversity of woody perennials [according to Shannon H' (Log_{10})] was highest in the homegardens of the non-affected 200 m belt and the tsunami affected 100 m belt followed by the non-affected 200m belt and lowest in the tsunami affected 200 m belt. The comparatively high diversity in non-affected 200 m belt and tsunami affected 100 m belt is due to the high number of species and the high number of individuals occurring in both categories and the reason for the lowest diversify in tsunami affected 200 m belt is due to the lowest no of species and lowest number of individuals in the homegardens.

According to Shannon J' calculations seedlings and saplings of woody perennials are more evenly distributed in the non-affected 100 m followed by the non-affected 200 m than affected categories. When we compare the affected homegardens with the non-affected ones, the affected ones were more disturbed than the non-affected ones and this may have affects on the evenness.

According to the Jaccard Coefficient, the homegardens in the 4 categories do not show considerable difference among them due to the abundance of seedlings and saplings of woody perennials. However, homegardens in the affected 100 m category and homegardens in the non-affected 100 m category showed the highest similarity. The rank abundance curves explain this low dissimilarity further. Curves for the seedlings in home gardens of all four categories showed the broken stick model and this express the more or less uniform distribution of seedlings of woody perennial species in homegardens of all four categories.

According to the overall results of diversity, evenness and similarity and rank abundance curves it is evident that there is no remarkable difference in regeneration of woody perennial among the four homegarden categories.

5.4 Live fence species in the surveyed homegardens

According to my personal observations, the use of both indigenous (native) and exotic species in live fences around the homegardens in central parts of Sri Lanka is a regular practice. In many cases, the number of exotic species is higher than the natives in mixed live fences. The desire for ornamental foliage and/or flowers is the reason for this selection. Easy propagation by stem cuttings is an additional advantage of these exotics.

The live fences around the coastal homegardens are also comprised of both native and exotic plant species. However, in mixed live fences, the proportion of exotics is lower than that of natives in many cases. Monoculture live fences of *Hibiscus tiliaceus* and *Thespesia populnea* is a common feature of coastal homegardens of the present study sites. Individuals in these monoculture live fences are planted in a very congested way to protect the homegardens from feral cattle. According to the general information provided by some households, during the tsunami and aftermath floods, these live fences were at problematic obstacle for some of them as they hindered easy escaping. Therefore, some villagers are still hesitant to construct any type of fence around their homegardens.

According to our experience, the size of the homegardens in the near shore coastal areas is relatively small when compared to the homegardens of a bit inland and this is mainly due to the land scarcity as a result of high population density. Therefore, instead of integration of trees in homegardens, the people integrate them in live fences around their homegardens as a reasonable option in this particular situation.

Though there are some variations in the occurrence of species in the 4 categories of homegardens studied, native naturally grown coastal species such as *Thespesia populnea, Terminalia catappa Hibiscus tiliaceus*, *Barringtonia asiatica* and *Calophyllum inophyllum* had already been integrated in the live fences of the surveyed homegardens. *Gliricidia sepium* was the most frequently recorded species from the live fences of all four categories. This is a very popular multipurpose tree species in the live fences of Sri Lanka.

The highest numbers of species (10 species) was recorded from the live fences around the homegardens in the tsunami affected 100 m belt and in the non-affected 200 m belt. However, the species composition is dissimilar in both categories. In the tsunami affected

100 m belt, there were a number of recently planted plants in the live fences; whereas in the non-affected 200 m belt there were a number of non-affected old trees in the live fences. Even in the tsunami affected 200 m belt, there were 8 different plant species in live fences, but only 4 species were recorded in the live fences form the non-affected 100 m belt. Even though there was a number of recently introduced plants in the homegardens of this category (non-affected 100 m belt), there were only a few recently created live fences around these homegardens, as they were not affected by the tsunami.

Occurrence of climatic climax species in live fences around the coastal homegardens is an attractive important feature and this clearly indicates the feasibility of further integration of these species in future restoration programmes.

5.5 Survey of the uses of 15 selected plant species by the coastal community

Some plants had a high demand for various purposes and at the same time some plants were considered as less important by the community.

Coconut (*Cocos nucifera*) is the most important among the 15 surveyed species. As a multipurpose tree, this serves so many purposes in day to day lives of the community. The households lost some of the mature productive individuals of this species as an impact of the tsunami (either uprooted or died). Most of the young trees have been damaged severely. Therefore the demand has been increased further. Frequently recently planted (around 2 or 3 years old) Coconut plants can be seen as an indication for this.

Thespesia populnea, *Terminalia catappa*, *Calophyllum inophyllum* and *Alstonia macrophylla* are used as timber for various purposes. *Thespesia populnea* mainly is used to make superior quality furniture and there is a high demand on this species due to the lack of enough mature trees. *Terminalia catappa* is used mainly for light construction, especially for door and window frames. Even though it is an exotic species; there is a very high demand on *Alstonia macrophylla* as a timber species especially used in light construction work and mainly for the rafters and panelling. *Calophyllum inophyllum* has a special demand as a timber species especially in boat construction. Though nowadays most of the fishermen use fibreglass boats, they like to have some parts of there fishing boats (floats, outriggers and masts) made out of *Calophyllum inophyllum* wood due to the water resistance and the long lasting quality. This has not yet been substituted by any other sources and therefore the community totally depends on this species for these purposes.

Demand on the naturally growing native coastal species such as *Calotropis gigantea*, *Ochrosia oppositifolia*, *Premna obtusifolia*, *Scaevola taccada* and on exotic species *Casuarina equisetifolia* is comparatively small. Few people had been reported some uses while others considered them as not very useful. According to JAYAWEERA (1981a) and

JAYAWEERA (1982b) *Calotropis gigantea* and *Premna obtusifolia* are important medicinal plants in Sri Lankan local medicine. The medicinal purposes of these species have nowadays been substituted by easily available pharmaceuticals and the community tends to depend on these.

DE ZOYSA (2008) reports that the city dwellers in Hambantota (another District of the Sothern Province of Sri Lanka) have not recognized the economic importance of *Casuarina* timber but are impressed with the increase of fuel wood supply from the shelterbelt. The author further states a number of advantages and disadvantages of *Casuarina* coastal shelterbelts of Hambantota city, implemented during 1986–1997 under a forestry development project funded by the Norwegian Agency for Development Cooperation (NORAD).

Morinda citrifolia is an essential tree in the indigenous exorcism. However it is also used by a relatively low percentage of the community only. This is also a medicinal plant (JAYAWEERA 1982a).

Barringtonia asiatica and *Hibiscus tiliaceus* are native coastal plants and *Gliricidia sepium* is an exotic multipurpose species. However, *B. asiatica* is used by a minority of the community; it is popular among them as an ornamental shade tree. This species had been reported as a suitable species for coast conservation by the households. *H. tiliaceus* is very popular among the community as a fibre plant for cordage in various purposes, as a fast growing live fence species. The use of this plant as a fibre has still not been substituted by synthetics. The leaves of *H. tiliaceus* is used by some local community in preparation (to wrap and steam) of a kind of indigenous sweetmeat known as Kurakkan-helapa (S), as a substitute for *Macaranga peltata* and *Berrya cordifolia* leaves. *M. peltata* and *B. cordifolia* trees are not very abundant in this coastal belt.

Pandanus odoratissimus is a very popular tree among the community for two special purposes. Leaves used to make baskets, bags, mats and ornaments and flowers as a special offering at Buddhist Temples and for exorcism. *P. odoratissimus* had also been reported as a suitable species for coast conservation by the households. They had been eye witnessed the mitigation of tsunami by *P. odoratissimus* belts along the coast (Figure 5.3).

Three species were exotics out of selected 15 plants surveyed to investigate the uses. *Alstonia macrophylla* and *Gliricidia sepium* were very popular among the households, whereas *Casuarina equisetifolia* is not popular among them. This is not yet introduced as a species for coast conservation in the present study sites, Galle district of Sri Lanka.

Figure 5.3: *Pandanus odoratissimus* belts along the affected southwest coast of Sri Lanka (Photos by Samantha Bogahapitiya)

Twelve were native or naturalised out of 15 plants surveyed to investigate the uses. *Cocos nucifera*, *Thespesia populnea, Terminalia catappa, Calophyllum inophyllum, Pandanus odoratissimus* and *Hibiscus tiliaceus* were very popular among the community as useful plants; *Barringtonia asiatica* and *Morinda citrifolia* were moderately popular, whereas *Calotropis gigantea, Ochrosia oppositifolia, Premna obtusifolia* and *Scaevola taccada* were less popular among the community as useful plants.

5.6 Investigation on the preference of 15 selected plant species to integrate in the coastal homegardens

According to the results obtained from the investigation on the preference of 15 selected plant species to integrate in affected coastal homegardens, *Cocos nucifera* (Coconut) reached the highest preference (Figure 5.4). Next highest preferences reached by timber species such as *Alstonia macrophylla, Calophyllum inophyllum, Thespesia populnea* and *Terminalia catappa* (arranged according to the preferred order) and next *Gliricidia sepium*, *Barringtonia asiatica, Casuarina equisetifolia, Hibiscus tiliaceus*, *Pandanus odoratissimus* and *Ochrosia oppositifolia* (arranged according to the preferred order). *Calotropis gigantea, Morinda citrifolia, Premna obtusifolia* and *Scaevola taccada* (arranged according to the preferred order) reached lower preferences. Accordingly *Scaevola taccada* reached the lowest preference.

The results of this investigation comparatively tally with the results obtained for the survey on uses of these plants. Households prefer to integrate the timber species, next to Coconut in their affected homegardens as there is a high demand on timber. Then they like to integrate multipurpose tree species and some other species.

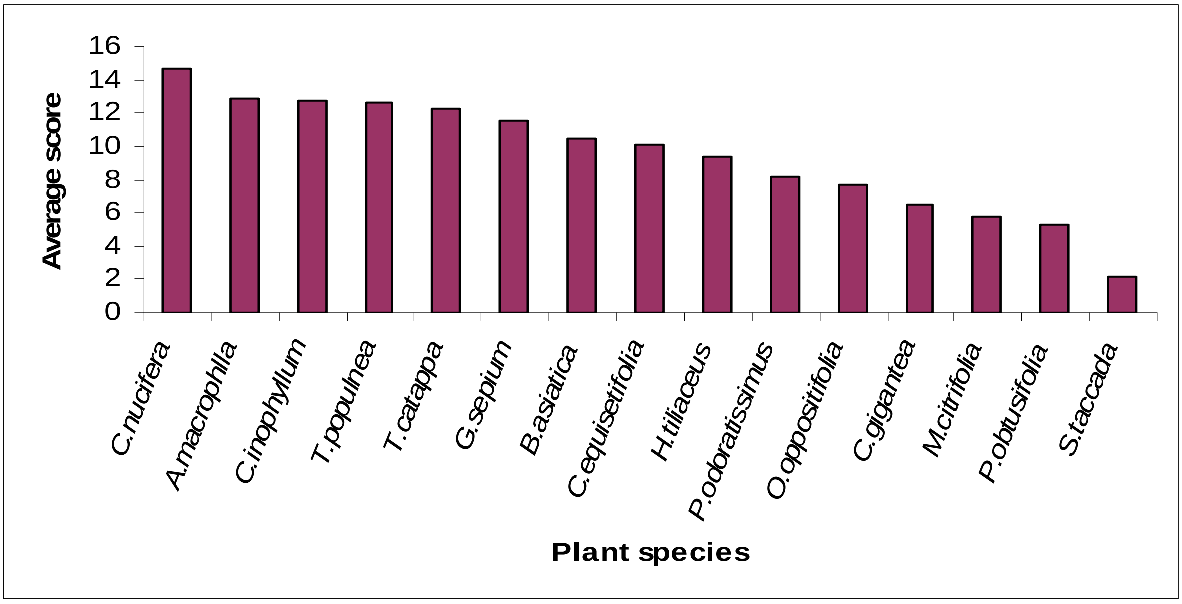

Figure 5.4: Average scores gained for the 15 selected plants species in terms of preference to integrate them in homegardens, species arranged according to highest preference to lowest

The preference on non-timber plants was at a remarkably low level, even though they are medicinal. However it is clear that the community prefers to integrate both indigenous and exotic species in their tsunami affected homegardens. Everybody likes to have Coconut trees in their homegardens even when they are very small in extent. Naturally growing *C. inophyllum*, *T. populnea* and *T. catappa* would be integrated in homegardens in future restoration programmes without major conflicts with the community. Introduction of *B. asiatica* and *P. odoratissimus* into homegardens would most probably be problematic as both species occupy considerable amount of homegarden space with the maturity. Therefore, these two species are more suitable to integrate in the live fences of the seaward side of near-shore homegardens. *H. tiliaceus* also can be integrated in live fences as it takes less space in managerial cultivations, whereas *O. oppositifolia* will not be possible to integrate as easily as *H. tiliaceus*. However, some households prefer to integrate them also in their live fences considering the straight nature of the trunks of these trees suitable for live fence poles.

Exotic species *A. macrophylla* and *G. sepium* are also easy to integrate due to the timber demand of *A. macrophylla* and multipurpose nature of *G. sepium.* However *C. equisetifolia* will not be accepted easily by the community as they are not well informed the uses of this species, especially as a coast conservation agent. *Calotropis gigantea* and *Scaevola taccada* are more suitable for the near-shore homegardens whereas *Morinda citrifolia* and *Premna obtusifolia* are suitable for the others a little away from the shore according to the personal observations, there is a clear zonation of their distribution. However it will not be an easy task to introduce them into the affected homegardens. Because these species are considered as weedy plants by the community and also they suppose that there is no need to plant them deliberately in their homegardens due to the common abundance. Hence, the need of proper dissemination of the information to the community on the species suitable for coast conservation, species suitable to mitigate the impact of sea-borne natural disasters and species suitable to serve the various purposes during natural disasters is highlighted and recommended.

6 Conclusions and Recommendations

6.1 Conclusions

The homegardens in the coastal belt of Sri Lanka were affected by the Asian Tsunami of December 26, 2004. The vegetation of the homegardens in the selected coastal belt from Ambalangoda to Boossa in Galle District of the Southern Province, Sri Lanka had been affected severely. Some trees had been uprooted and/or inclined and had died later on. Some had died within a few days after the tsunami and some after one month or later due to the various impacts of the tsunami. Some trees had recovered from defoliation as a result of the tsunami and survive to date. There was also considerable damage to branches and tree tops, while the trunks of some trees had been broken due to the impacts of the tsunami.

A number of alien species (species not present in the homegardens before the tsunami) are now present in the affected homegardens; however, invasive alien species are not among them. A considerable amount of restoration was done in the affected homegardens by the households, either with or without the advices of governmental or nongovernmental organisations. Even after the immediate direct and the subsequent indirect impact of the tsunami, a great amount of trees survived in the affected homegardens, particularly *Cocos nucifera*, *Barringtonia asiatica*, *Calophyllum inophyllum*, *Terminalia catappa* and *Thespesia populnea*.

The coastal community mainly suggested *Cocos nucifera*, fruit trees and vegetables as suitable plants for growing in their affected homegardens; less attention had been paid on common coastal plants. Community was found to be well informed on the use of *Barringtonia asiatica*, *Calophyllum inophyllum*, *Terminalia catappa* and *Pandanus odoratissimus* as suitable plants for coast conservation.

Even though people did not look for particular trees to climb or hold on during the tusunami wave, *Cocos nucifera* (Coconut) played a significant role in saving lives during the impact of the first tsunami wave and the subsequent flooding. The role of *Terminalia catappa* was also remarkable in this manner, next to Coconut. However, it is interesting to note that some people had saved their lives by clinging to very delicate plants such as *Carica papaya* (Papaw).

Floristic richness of woody perennials was higher in the tsunami affected homegardens than in the non-affected homegardens mainly due to the recently integrated (after the tsunami within last 3 years) plants. Various organizations provided affected households with a number of plants to grow in their damaged homegardens. Density of woody perennials was higher in the homegardens of the 100 m belt (in both tsunami affected and non-affected) than in the homegardens of 200 m belt. Total basal area and mean DBH of woody perennials were highest in the homegardens of tsunami-affected 100 m belt. This is due to the highest number of mature *Cocos nucifera* trees found in the homegardens of this category.

A higher number of individual woody perennials were found in the lowest diameter (DBH) class (1-5 cm) in the homegardens of the tsunami affected 100 m belt, the tsunami affected 200 m belt and the non-affected 100 m belt due to plants integrated within the 3 years after tsunami; whereas the number of individuals was relatively low in the lowest DBH classes in the homegardens of the non-affected 200 m belt as this category was neglected by the rehabilitation organizations. According to the DBH class distribution it was clear that the smaller trees have been destroyed due to the impact of tsunami whereas the larger trees left. It is evident that the vulnerability of smaller tress for the damage was higher than that of larger trees during the tsunami

Cocos nucifera (Coconut) was the most dominant woody perennial in all 4 categories of homegardens. Native coastal species *Calophyllum inophyllum*, *Terminalia catappa* and *Thespesia populnea* were among the first 10 dominant species in all 4 categories of homegardens.

Diversity and evenness of woody perennial species were lowest in the homegardens of the tsunami affected 100 m belt category and both indices were highest in the homegardens of the non-affected 200 m belt category. Even though the density and floristic richness of woody perennials were highest in the homegardens of the tsunami affected 100 m belt category, diversity and evenness of distribution of species was reduced due to the impacts of the tsunami. This has been further verified by finding the highest dissimilarity between these two categories.

There was a substantial amount of natural regeneration of woody perennial species in the homegardens of the non-affected categories as well as in the tsunami-affected categories. However extensive anthropogenic activities at a problematic level for these for thriving and growing up to maturity levels. According to the overall results of diversity, evenness and similarity, it was found that there was no remarkable difference in regeneration of woody perennials among the 4 homegarden categories.

Live fences around the coastal homegardens were comprised of both indigenous and exotic species and remarkably the proportional integration of indigenous species was higher in the live fences of coastal homegardens when compare them with the live fences around the homegardens of the central part of the country. The occurrence of naturally growing coastal species in live fences around the coastal homegardens is an attractive important feature and this clearly indicates the feasibility of further integration of these species in future restoration programmes.

Survey of the uses of 15 selected plants reveals that some plants are in high demand for various purposes and some plants are considered as less important by the community. *Cocos nucifera* was found to be the most important useful plant for the community out of 15 species tested. Demand of timber species was at a very high level. There was a high demand on the naturally growing native coastal species *Thespesia populnea*, *Terminalia catappa* and *Calophyllum inophyllum*. However, some important coastal species were not utilised by the community very frequently. Even they have properties useful for coast conservation and sometimes medicinal values, some coastal species have been considered as useless species by the community.

According to the results obtained from the investigation on the preference of 15 selected plant species to integrate in affected coastal homegardens, *Cocos nucifera* (Coconut) reached the highest preference. Next highest preferences reached by timber species such as *Alstonia macrophylla, Calophyllum inophyllum, Thespesia populnea* and *Terminalia catappa*. *Scaevola taccada* reached the lowest preference. The preference on non-timber plants was at a remarkably low level; even some of them are very useful. It was clear that the community prefers to integrate both indigenous and exotic species in their tsunami affected homegardens. Every household likes to grow Coconut trees in their affected homegardens even they are very small in extent. Naturally growing *C. inophyllum*, *T. populnea* and *T. catappa* could be integrated in the homegardens in future restoration programmes without major conflicts with the community. However it will not be an easy target to introduce some plant species into the affected homegardens as they were considered as weedy plants by the community.

According to the overall outcome of the present study, it can be confirmed that the impacts of tsunami on homegardens were severe and the affected homegardens are presently being recovered gradually. There were some structural and compositional differences between tsunami affected and non-affected homegardens due to the impacts of tsunami and aftermath flooding. It is evident that there is a substantial amount of natural regeneration of woody perennials occurred in the coastal homegardens. Useful naturally growing coastal plants could be integrated into homegardens as well as in live fence around the coastal homegardens without much difficulty. The other important plants which suitable for coastal management could be integrated through proper community participation in future restoration programmes.

6.2 Recommendations

The use of timber, fruit and multipurpose trees which comprise the characters suitable for the coast conservation, suitable to mitigate the impact of sea-borne natural hazards and suitable to serve the various purposes during natural disasters is highlighted and recommended.

The knowledge gained on the selected plant species should properly be disseminated to the community through participatory work shops and media to minimise the conflicts in the future restoration programmes of the tsunami affected homegardens.

Use of *Barringtonia asiatica, Calophyllum inophyllum, Cocos nucifera*, *Hibiscus tiliaceus, Pandanus odoratissimus, Terminalia catappa* and *Thespesia populnea* in coastal regreening programmes is highly recommended and I would like to pay a special emphasis on *Barringtonia asiatica* and *Calophyllum inophyllum* according to my personal observations.

Necessary precautions should be taken to minimize problematic anthropogenic activities that influence the natural regeneration in coastal zone.

The use of multipurpose trees and trees suitable for coastal conditions in live fences is a suitable remedy for the small homegardens. Use of various species in live fences instead of present monocultures like *Hibiscus tiliaceus* and *Thespesia populnea* is recommended as they will be more economical and more ecological in future. Use of indigenous coastal species should be promoted.

The use of various species in coastal regreening instead of monocultures in proper ratios and spacing to blend with the natural environment is very important to maintain the aesthetic value of the coastal zone, with a special emphasis on ecotourism.

The evacuation of people from their native coastal area in order to establish green belt along the coast is not recommended, as it will generate serious socioeconomic problems on dwellers, especially on fishermen communities. Instead of evacuation, regreening with the community participation and the need of a proper disaster management programme and an early warning system is recommended.

Community participation and the integration of local knowledge in all coastal restoration programmes is highlighted and recommended in order to improve the quality and to mitigate the consequential social problems.

Importance of further studies on screening of suitable species for the different coastal zones of the country is suggested.

7 References

ABEYWICKRAMA, B.A. (1996): Casuarinaceae. In: Dassanayake, M.D., and Clayton, W.D. (Eds.): Revised handbook to the flora of Ceylon – Volume X. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd., 72-74.

ALONGI, D. M. (2008): Mangrove forests: Resilience, protection from tsunamis, and responses to global climate change. Estuarine, Coastal and Shelf Science 76: 1-13.

ANONYMOUS (2005): Rebuilding Sri Lanka, Action Plan, Discussion Draft. Department of National Planning; Ministry of Finance and Planning, Presidental Secretariat, Task Force for Rebuilding the Nation (TAFREN), Sri Lanka.

ANONYMOUS (2006): Sri Lanka component of forestry programme for early rehabilitation in Asian tsunami affected countries.

APPANAH, S. (2005): Assessment of forestry-related requirements for rehabilitation and reconstruction of tsunami-affected areas of Sri Lanka, mission report, 10 – 24 March 2005. Food and Agriculture Organization of the United Nations (FAO).

ASHTON, M.S.; GUNATILLEKE, S.; DE ZOYSA, N.; DASSANAYAKE, M.D.; GUNATILLEKE, N.; WIJESUNDERA, S. (1997): A field guide to the common trees and shrubs of Sri Lanka. Sri Lanka: WHT Publications (Pvt.) Ltd.

ASIAN DEVELOPMENT BANK; JAPAN BANK FOR INTERNATIONAL COOPERATION; WORLD BANK (2005): Sri Lanka: 2005 Post-tsunami recovery program, preliminary damage and needs assessment.

BABBIE, E. (2004): The practice of social research; 10th Edition. USA: Wadsworth, Thomson Learning.

BAMBARADENIYA, C.; SENGUPTA, S.; PERERA, S.; TAMELANDER, J.; MEYNELL, M.; RUST, M.; VIDANAGE, S.; PERERA, S. (2005): Rapid environmental and socio-economic assessment of tsunami-damage in terrestrial and marine coastal ecosystems of Ampara and Batticaloa districts of eastern Sri Lanka. IUCN post-tsunami rapid environmental assessment in Ampara and Batticaloa districts, Sri Lanka.

BANDARATILLEKE, H.M. (1997): Forests. In: Somasekaram, T., Perera, M.P., De Silva, M.B.G. and Godellawatta, H. (Eds.): Arjuna's atlas of Sri Lanka. Dehiwala, Sri Lanka: Arjuna Consulting Co Ltd.

BERNINGHAUSEN, W. H. (1966): Tsunamis and Seismic Seiches reported from regions adjacent to the Indian Ocean. Bull. Seism. Soc. Am., 56 (1): 69-74.

BIRD, M.; COWIE, S.; HAWKES, A.; HORTON, B.; MACGREGOR, C.; ONG, J.E.; TAN, A.; HWAI, S.; SA, T.T.; YASIN, Z. (2007). Indian Ocean tsunamis: environmental and socio-economic impacts in Langkawi, Malaysia. The Geographical Journal 173(2): 103–117.

BIRKELAND, P.W.; LARSON, E.E. (1989): Putnam's geology. New York, Oxford: Oxford University Press, Inc.

BIRKMANN, J.; FERNANDO, N.; HETTIGE, S.; AMARASINGHE, S.; JAYASINGAM, T.; RAVI, M.; PARANAGAMA, D.; NANDANA, M.; NASSEL, M.; VOIGT, S.; WOLFERTS, J. (2005): Summary UNU-EHS vulnerability study, measuring revealed vulnerability in Sri Lanka at the local level.

BURGESS, T. F. (2001): Guide to the Design of Questionnaires, a general introduction to the design of questionnaires for survey research. University of Leeds: Information Systems Services. Available online.

CARPENTER, S. R.; FOLKE, C. (2006): Ecology for transformation. Trends in Ecology and Evolution 21(6): 309-315.

CHANDRASEKAR, N.; SARAVANAN, S.; IMMANUEL, J. L.; RAJAMANICKAM, M.; RAJAMANICKAM, G.V. (2006): Classification of tsunami hazard along the southern coast of India: an initiative to safeguard the coastal environment from similar debacle. Science of Tsunami Hazards 24(1): 3-23.

CHATENOUX, B.; PEDUZZI, P. (2007): Impacts from the 2004 Indian Ocean Tsunami: analysing the potential protecting role of environmental features. Nat. Hazards 40: 289–304.

CHERRY, S.D.; FERNANDES, E.C.M. (1997): Live Fences. http://www.ppath.cornell.edu/mba_project/livefence.html. Last access on 11.08.2008

COCHARD, R., RANAMUKHAARACHCHI, S.L., SHIVAKOTI, G.P., SHIPIN, O.V., EDWARDS, P.J., SEELAND, K.T. (2008): The 2004 tsunami in Aceh and Southern Thailand: A review on coastal ecosystems, wave hazards and vulnerability. Perspectives in Plant Ecology, Evolution and Systematics 10: 3–40.

COMMONWEALTH SECRETARIAT, SRI LANKA (2007): http://www.thecommonwealth.org/YearbookHomeInternal/139452/. Last access on 30.06.2008.

COORAY, P.G. (1997): Geology. In: Somasekaram, T., Perera, M.P., De Silva, M.B.G. and Godellawatta, H. (Eds.): Arjuna's atlas of Sri Lanka. Dehiwala, Sri Lanka: Arjuna Consulting Co Ltd.

DAHDOUH-GUEBAS, F. (2006): Mangrove forests and tsunami protection. Ecological communities; forest management; mangrove; tsunami in the McGraw-Hill encyclopedia of Science & Technology: 187-191.

DAHDOUH-GUEBAS, F.; JAYATISSA, L.P.; NITTO, D. D.; BOSIRE, J.O.; SEEN, D. L.; KOEDAM, N. (2005): How effective were mangroves as a defence against the recent tsunami? Current Biology 15(12): R443-R447.

DAHDOUH-GUEBAS, F.; KOEDAM, N. (2006): Coastal Vegetation and the Asian Tsunami. Science 311: 37-38.

DANIELSEN, F.; SØRENSEN, M.K.; OLWIG, M.F.; SELVAM, V.; PARISH, F.; BURGESS, N.D.; HIRAISHI, T.; KARUNAGARAN, V.M.; RASMUSSEN, M.S.; HANSEN, L.B.; QUARTO, A.; SURYADIPUTRA, N. (2005): The Asian tsunami: A protective role for coastal vegetation. Science 310 (5748): 643.

DAWSON, A. G.; LOCKETT, P.; SHI, S. (2004): Tsunami hazards in Europe. Environment International 30: 577– 585.

DE ALWIS, L (1997): Fauna. In: Somasekaram, T., Perera, M.P., De Silva, M.B.G. and Godellawatta, H. (Eds.): Arjuna's atlas of Sri Lanka. Dehiwala, Sri Lanka: Arjuna Consulting Co Ltd.

DEPARTMENT OF CENSUS AND STATISTICS, SRI LANKA (2008): Census of Population and Housing 2001. http://www.statistics.gov.lk/PopHouSat/PDF/Population/p9p1%20Growth.pdf. Last access on 30.06.2008.

DE SILVA, M.B.G. and FERNANDO, T.K. (1997): Climate. In: Somasekaram, T., Perera, M.P., De Silva, M.B.G. and Godellawatta, H. (Eds.): Arjuna's atlas of Sri Lanka. Dehiwala, Sri Lanka: Arjuna Consulting Co Ltd.

DE SILVA, P.K.; DE SILVA, M. (2006): A guide to the mangrove flora of Sri Lanka. Sri Lanka: WHT Publications (Pvt.) Ltd.

DE TISSERA, C.H. (1997): Natural Hazards. In: Somasekaram, T., Perera, M.P., De Silva, M.B.G. and Godellawatta, H. (Eds.): Arjuna's atlas of Sri Lanka. Dehiwala, Sri Lanka: Arjuna Consulting Co Ltd.

DE ZOYSA, M. (2008): Casuarina coastal forest shelterbelts in Hambantota City, Sri Lanka: assessment of impacts. Small-scale Forestry 7: 17–27.

DE ZOYSA, N. (2000): Arecaceae. In: Dassanayake, M.D., and Clayton, W.D. (Eds.): Revised handbook to the flora of Ceylon – Volume XIV. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd., 33-93.

DEHERAGODA, C.K.M.; TANTRIGAMA, G. (1997): Tourism. In: Somasekaram, T., Perera, M.P., De Silva, M.B.G. and Godellawatta, H. (Eds.): Arjuna's atlas of Sri Lanka. Dehiwala, Sri Lanka: Arjuna Consulting Co Ltd.

DOERNER, K. F.; GUTJAHR, W.J.; NOLZ, P.C. (2008): Multi-criteria location planning for public facilities in tsunami-prone coastal areas. OR Spectrum: Springer Verlag.

DYTHAM, C. (2003): Choosing and using statistics, a biologist's guide (2nd Ed.). USA: Blackwell Publishing Company.

FAGHERAZZI, S.; DU, X., (2007): Tsunamigenic incisions produced by the December 2004 earthquake along the coasts of Thailand, Indonesia and Sri Lanka. Geomorphology.

FERNANDO, P.; WIKRAMANAYAKE, E.D.; PASTORINI, J. (2006): Impact of tsunami on terrestrial ecosystems of Yala National Park, Sri Lanka. Current Science 90 (11): 1531-1534.

FORBES, K.; BROADHEAD, B. (2007): The role of coastal forests in the mitigation of tsunami impacts. RAP Publication 2007/1, Food and Agriculture Organization of the United Nations.

FOSBERG, F.R. (1997): Goodeniaceae. In: Dassanayake, M.D., and Clayton, W.D. (Eds.): Revised handbook to the flora of Ceylon – Volume XI. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd., 284-286.

GIRI, C.; ZHU, Z.; TIESZEN, L. L.; SINGH, A.; GILLETTE, S.; KELMELIS, J. A. (2008): Mangrove forest distributions and dynamics (1975–2005) of the tsunami-affected region of Asia. Journal of Biogeography 35: 519–528.

GUNAWARDENA, M.; ROWAN, J. S. (2005): Economic Valuation of a Mangrove Ecosystem Threatened by Shrimp Aquaculture in Sri Lanka. Environmental Management 36(4): 535–550.

HALLÉ, F.; OLDEMAN, R.A.A.; TOMLINSON, P.B. (1978): Tropical trees and forests, an architectural analysis. Berlin, Heidelberg, New York: Springer-Verlag.

HARADA, K.; IMAMURA, F. (2003): Study on the evaluation of tsunami reducing by coastal control forest for actual conditions, Proc. APAC 2003, Makuhari, Japan.

HARADA, K.; KAWATA, Y. (2005): Study on tsunami reduction effect of coastal forest due to forest growth. Annuals of Disaster Prevention Research Institute, Kyoto Univ., Kyoto.

HARINARAYANA, T.; HIRATA, N. (2005): Destructive Earthquake and Disastrous Tsunami in the Indian Ocean, What Next? Gondwana Research 8(2): 246-257.

HEWAPATHIRANE, D. (2005): History of tsunamis in Sri Lanka. Online edition of Sunday Observer; Business. http://www.sundayobserver.lk/2005/01/02/fea29.html. Last access on 11.08.2008.

HOCHEGGER, K. (1998): Farming like the forest, traditional home garden systems in Sri Lanka. Tropical Agroecology 9. Germany: Margraf Verlag.

HUBER, H. (1983a): Apocynaceae. In: Dassanayake, M.D. and Fosberg, F.R. (Eds.): Revised handbook to the flora of Ceylon – Volume IV. New Delhi: Amerind Publishing Co. Pvt. Ltd., 25-72.

HUBER, H. (1983b): Asclepiadaceae. In: Dassanayake, M.D. and Fosberg, F.R. (Eds.): Revised handbook to the flora of Ceylon – Volume IV. New Delhi: Amerind Publishing Co. Pvt. Ltd., 73-124.

INGRAM, J. C.; FRANCO, G.; RUMBAITIS-DEL RIO, C.; KHAZAI, B. (2006): Post-disaster recovery dilemmas: challenges in balancing short-term and long-term needs for vulnerability reduction. Environmental Science & Policy 9: 607-613.

INOUE, S.; WIJEYEWICKREMA, A.C.; MATSUMOTO, H.; MIURA, H.; GUNARATNA, P.; MADURAPPERUMA, M.; SEKIGUCHI, T. (2007): Field survey of tsunami effects in Sri Lanka due to the Sumatra-Andaman earthquake of December 26, 2004. Pure appl. geophys. 164: 395–411.

JAYASEKERA, R. (1997): Flora. In: Somasekaram, T., Perera, M.P., De Silva, M.B.G. and Godellawatta, H. (Eds.): Arjuna's atlas of Sri Lanka. Dehiwala, Sri Lanka: Arjuna Consulting Co Ltd.

JAYATISSA, L. P.; DAHDOUH-GUEBAS, F.; KOEDAM, N. (2002): A review of the floral composition and distribution of mangroves in Sri Lanka. Botanical Journal of the Linnean Society 138: 29–43.

JAYATISSA, L. P.; HETTIARACHI, S.; SAMARAKOON, S.P. (2006): Nature's protection against nature's fury: a post tsunami assessment of non-mangrove plants as elements to build a green belt against tsunami. Abstract: Ruhuna Journal of Science I.

JAYAWEERA, D.M.A. (1980): Medicinal plants (indigenous and exotic) used in Ceylon, Part II, Cactaceae-Fagaceae. Colombo: The National Science Council of Sri Lanka.

JAYAWEERA, D.M.A. (1981a): Medicinal plants (indigenous and exotic) used in Ceylon, Part I, Acanthaceae-Burseraceae. Colombo: The National Science Council of Sri Lanka.

JAYAWEERA, D.M.A. (1981b): Medicinal plants (indigenous and exotic) used in Ceylon, Part III, Flacourtiaceae-Lythraceae. Colombo: The National Science Council of Sri Lanka.

JAYAWEERA, D.M.A. (1982a): Medicinal plants (indigenous and exotic) used in Ceylon, Part IV, Magnoliaceae-Rubiaceae. Colombo: The National Science Council of Sri Lanka.

JAYAWEERA, D.M.A. (1982b): Medicinal plants (indigenous and exotic) used in Ceylon, Part V, Rutaceae-Zygophyllaceae. Colombo: The National Science Council of Sri Lanka.

KARIYAWASAM, D. (2005): Impact of the tsunami on natural ecosystems of Sri Lanka: Lessons learned. Online edition of Sunday Observer - Features: Monday, March 07, 2005, Serving Sri Lanka. http://servesrilanka.blogspot.com/2005/03/impact-of-tsunami-on-natural.html. Last access on 04.06.2008.

KATHIRESAN, K., RAJENDRAN, N. (2005): Coastal mangrove forests mitigated tsunami. Estuarine, Coastal and Shelf Science 65: 601-606.

KATHIRESAN, K.; RAJENDRAN, N. (2006): Reply to comments of Kerr et al. on ‘‘Coastal mangrove forests mitigated tsunami’’ [Estuar. Coast. Shelf Sci. 65 (2005): 601-606]. Estuarine, Coastal and Shelf Science 67: 542.

KEATING, B. H. (2006): 2006: Status of tsunami science research and future directions of research. Science of Tsunami Hazards 24 (5): 385-395.

KEATING, B. H.; HELSLEY, C. (2005): 2004 INDIAN OCEAN TSUNAMI ON THE MALDIVES ISLANDS: INITIAL OBSERVATIONS. Science of Tsunami Hazards 23(2): 19-70.

KENT, M.; COKER, P. (1996): Vegetation description and analysis, a practical approach. England: John Wiley & Sons Ltd.

KERR, A. M.; BAIRD, A.H.; CAMPBELL, S.J. (2006): Comments on ‘‘Coastal mangrove forests mitigated tsunami’’ by K. Kathiresan and N. Rajendran [Estuar. Coast. Shelf Sci. 65 (2005): 601-606]. Estuarine, Coastal and Shelf Science 67: 539-541.

KOSTERMANS, A.J.G.H. (1980): Cluciaceae. In: Dassanayake, M.D. and Fosberg, F.R. (Eds.): Revised handbook to the flora of Ceylon – Volume I. New Delhi: Amerind Publishing Co. Pvt. Ltd., 72-110.

KOTHARI, C.R. (2004): Research methodology, methods and techniques. New Delhi: New Age International Publishers.

KRISHNA, K. S. (2005): Science plan for coastal hazard preparedness. Current Science 89 (8):1339-1347.

LATIEF, H.; HADI, S., (2006): The role of forests and trees in protecting coastal areas against tsunamis, Coastal protection in the aftermath of the Indian Ocean tsunami: What role for forests and trees? FAO/RAPO, Khao Lak, Thailand. Food and Agriculture Organization of the United Nations, Bangkok.

LEITAN, G.R.T. (1997): Administrative divisions. In: Somasekaram, T., Perera, M.P., De Silva, M.B.G. and Godellawatta, H. (Eds.): Arjuna's atlas of Sri Lanka. Dehiwala, Sri Lanka: Arjuna Consulting Co Ltd.

LEROY, S. A. G. (2006): From natural hazard to environmental catastrophe: Past and present. Quaternary International 158: 4–12.

MACNAE, W.; FOSBERG, F.R. (1981): Lecythidaceae. In: Dassanayake, M.D. and Fosberg, F.R. (Eds.): Revised handbook to the flora of Ceylon – Volume III. New Delhi: Amerind Publishing Co. Pvt. Ltd., 195-201.

MAGURRAN, A.E. (1998): Ecological diversity and its measurements. Princeton, New Jersey: Princeton University Press.

MAGURRAN, A.E. (2004): Measuring biological diversity. USA: Blackwell Publishing Company.

MATTSSON, E. (2006): The potential of using clean development mechanism in land and vegetation recovery after the 2004 tsunami, Hambantota District, Sri Lanka. Department of Physical Geography, Earth Sciences Centre, Göteborg University.

McCONNELL, D.J. (1992): The forest-garden farms of Kandy, Sri Lanka. Farm System Management Series 3. Rome: FAO.

McCONNELL, D.J. (2003): The forest farms of Kandy and other gardens of complete design. England: Ashgate.

MINISTRY OF URBAN DEVELOPMENT AND WATER SUPPLY, MINISTRY OF HOUSING AND CONSTRUCTION INDUSTRY AND TASK FORCE FOR REBUILDING THE NATION (2005): Assistance Policy and Implementation Guidelines, Housing & Township Development. http://www.recoverlanka.net/data/tafrenhousing.doc. Last access on 28.07.2008.

MOLDENKE, H.N.; MOLDENKE, A.L. (1983): Verbenaceae. In: Dassanayake, M.D. and Fosberg, F.R. (Eds.): Revised handbook to the flora of Ceylon – Volume IV. New Delhi: Amerind Publishing Co. Pvt. Ltd., 196-487.

MORTON, R. A.; GOFF, J.R.; NICHOL, S.L. (2007): Impacts of the 2004 Indian Ocean Tsunami on the Southwest Coasts of Sri Lanka. Proceedings of the Sixth International Symposium on Coastal Engineering and Science of Coastal Sediment Processes, May 13–17, 2007, New Orleans, Louisiana.

MUELLER-DOMBOIS, D.; ELLENBERG, H. (1974): Aims and methods of vegetation ecology. New York: John Wiley & Sons, Inc.

MUNASINGHE, M. (2007): The importance of social capital: Comparing the impacts of the 2004 Asian Tsunami on Sri Lanka, and Hurricane Katrina 2005 on New Orleans. Ecological Economics 64: 9-11.

MURCK, B.W.; SKINNER, B.J.; PORTER, S.C. (1996): Environmental geology. New York: John Wiley & Sons, Inc.

NARAYAN, J. P.; SHARMA, M.L.; MAHESHWARI, B.K. (2005a): Effects of Medu and coastal topography on the damage pattern during the recent Indian Ocean tsunami along the coast of Tamilnadu. Science of Tsunami Hazards 23(2): 9-18.

NARAYAN, J. P.; SHARMA, M.L.; MAHESHWARI, B.K. (2005b): Run-up and Inundation pattern developed during the Indian Ocean tsunami of December 26, 2004 along the coast of Tamilnadu (India). Gondwana Research 8(4): 611-616.

PANABOKKE, C.R. (1997a): Soils. In: Somasekaram, T., Perera, M.P., De Silva, M.B.G. and Godellawatta, H. (Eds.): Arjuna's atlas of Sri Lanka. Dehiwala, Sri Lanka: Arjuna Consulting Co Ltd.

PANABOKKE, C.R. (1997b): Agro Ecological Regions. In: Somasekaram, T., Perera, M.P., De Silva, M.B.G. and Godellawatta, H. (Eds.): Arjuna's atlas of Sri Lanka. Dehiwala, Sri Lanka: Arjuna Consulting Co Ltd.

PANABOKKE, C.R. and KANNANGARA, R. (1975): An identification and demarcation of the distinctive agro-ecological regions of Sri Lanka. Proceedings of Sri Lanka Association for the Advancement of Science (SLASS), Colombo. 31 (1).

PANAGODA, D.; WITHANAGE, H. (2005): Tsunami swept away. BANKWATCH, the Official Publication of the NGO Forum on the ADB, Inc., Special Tsunami Edition, January 2005.

PARARAS-CARAYANNIS, G. (2006): Alexander the great - impact of the 325 BC tsunami in the north Arabian Sea upon his fleet. http://www.drgeorgepc.com/Tsunami325BCIndiaAlexander.html. Last access on 11.08.2008.

PÉREZ-MAQUEO, O.; INTRALAWAN, A.; MARTÍNEZ, M.L. (2007): Coastal disasters from the perspective of ecological economics. Ecological Economics.

PHILCOX, D. (1995): Combretaceae. In: Dassanayake, M.D., Fosberg, F.R. and Clayton, W.D. (Eds.): Revised handbook to the flora of Ceylon – Volume IX. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd., 28-46.

PHILCOX, D. (1997): Malvaceae. In: Dassanayake, M.D., and Clayton, W.D. (Eds.): Revised handbook to the flora of Ceylon – Volume XI. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd., 287-360.

PIYADASA, R. U. K.; WEERASINGHE, K.D.N.; LAKMAL, H.K.C.S.; MAIER, D. (2006): Groundwater quality changes in the tsunami affected coastal belt – Southern Sri Lanka. 32nd WEDC International Conference, Sustainable Development of Water Resources, Water Supply and Environmental Sanitation, Colombo, Sri Lanka.

PREMASIRI, H.M.R.; ABEYSINGHE, A.M.K.B. (2005): In: De Silva, R.P. (Ed.) Tsunami in Sri Lanka: genesis, impact and response (2nd Ed.). Sri Lanka: Postgraduate Institute of Agriculture.

RAMACHANDRAN, S.; ANITHA, S.; BALAMURUGAN, V.; DHARANIRAJAN, K.; VENDHAN, K.E.; DIVIEN, M.I.P.; VEL, A.S.; HUSSAIN, I. S.; UDAYARAJ, A. (2005): Ecological impact of tsunami on Nicobar Islands (Camorta, Katchal, Nancowry and Trinkat). Current Science 89(1): 195-200.

RANASINGHE, H. (2006): Assessment of Tsunami damage to coastal vegetation & Development of Guidelines for integrated coastal area management, Koh Lak.

RAO, D. V. S.; RAO, K.S.; IYER, C.S.P.; CHITTIBABU, P. (2008): Possible ecological consequences from the Sethu Samudram Canal Project, India. Marine Pollution Bulletin 56: 170–186.

RASHEED, K. A. A.; DAS, V.K.; REVICHANDRAN, C.; VIJAYAN, P. R.; THOTTAM, T.J. (2006): Tsunami impacts on morphology of beaches along south Kerala coast, west coast of India. Science of Tsunami Hazards 24(1): 24-34.

RASTOGI, B. K., JAISWAL, R. K. (2006): A catalog of tsunamis in the Indian Ocean. Science of Tsunami Hazards 25 (3): 128-143.

RIDSDALE, C.E. (1998): Rubiaceae (in part). In: Dassanayake, M.D., and Clayton, W.D. (Eds.): Revised handbook to the flora of Ceylon – Volume XII. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd., 141-343.

ROSSETTO, T.; PEIRIS, N.; POMONIS, A.; WILKINSON, S. M.; RE, D.D., KOO, R.; GALLOCHER, S. (2007): The Indian Ocean tsunami of December 26, 2004: observations in Sri Lanka and Thailand. Nat Hazards 42: 105–124.

RUDD, V.E. (1991): Fabaceae (in part) - Papilionoideae. In: Dassanayake, M.D. and Fosberg, F.R. (Eds.): Revised handbook to the flora of Ceylon – Volume VII. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd., 108-381.

SENARATNE, L.K. (2001): A Checklist of the Flowering Plants of Sri Lanka. Sri Lanka: National Science Foundation of Sri Lanka.

SOMASEKARAM, T (1997): Land Use. In: Somasekaram, T., Perera, M.P., De Silva, M.B.G. and Godellawatta, H. (Eds.): Arjuna's atlas of Sri Lanka. Dehiwala, Sri Lanka: Arjuna Consulting Co Ltd.

SONAK, S.; PANGAM, P.; GIRIYAN, A. (2007): Green reconstruction of the tsunami-affected areas in India using the integrated coastal zone management concept. Journal of Environmental Management.

SRINIVAS, H.; NAKAGAWA, Y. (2007): Environmental implications for disaster preparedness: Lessons Learnt from the Indian Ocean Tsunami. Journal of Environmental Management.

STONE, B.C. (1981): Pandanaceae. In: Dassanayake, M.D. and Fosberg, F.R. (Eds.): Revised handbook to the flora of Ceylon – Volume III. New Delhi: Amerind Publishing Co. Pvt. Ltd., 293-320.

STONE, R. (2006): A rescue effort for tsunami-ravaged mangrove forests. Science 314: 404.

SURVEY DEPARTMENT OF SRI LANKA (1996): Road atlas of Sri Lanka. Sri Lanka: Survey Department of Sri Lanka.

TANAKA, N.; SASAKI, Y.; MOWJOOD, M. I. M.; JINADASA, K. B. S. N.; HOMCHUEN, S. (2007): Coastal vegetation structures and their functions in tsunami protection: experience of the recent Indian Ocean tsunami. Landscape Ecol Eng 3: 33–45.

TISSEVERASINGHE, A.E.K. (1971): A manual of timber utilisation for Ceylon. Colombo: The Ceylon Forest Department.

VERMAAT, J. E.; THAMPANYA, U. (2006): Mangroves mitigate tsunami damage: A further response. Estuarine, Coastal and Shelf Science 69: 1-3.

VILLHOLTH, K. G.; AMERASINGHE, P.H.; JEYAKUMAR, P.; PANABOKKE, C.R.; WOOLLEY, O.; WEERASINGHE, M.D.; AMALRAJ, N.; PRATHEPAAN, S.; BÜRGI, N.; LIONELRATHNE, D.M.D.S.; INDRAJITH, N.G.; PATHIRANA, S.R.K. (2005): Tsunami Impacts on Shallow Groundwater and Associated Water Supply on the East Coast of Sri Lanka. International Water Management Institute (IWMI), Colombo, Sri Lanka.

VITHANAGE, P.W. (1997): Relief and drainage. In: Somasekaram, T., Perera, M.P., De Silva, M.B.G. and Godellawatta, H. (Eds.): Arjuna's atlas of Sri Lanka. Dehiwala, Sri Lanka: Arjuna Consulting Co Ltd.

WICKREMERATNE; H.J.M.; SAMARAKONE, J.I. (1997): Wetlands. In: Somasekaram, T., Perera, M.P., De Silva, M.B.G. and Godellawatta, H. (Eds.): Arjuna's atlas of Sri Lanka. Dehiwala, Sri Lanka: Arjuna Consulting Co Ltd.

WIEGEL, R. L. (2006a): Tsunami information sources. Science of Tsunami Hazards 24 (2): 58-167.

WIEGEL, R. L. (2006b): Tsunami information sources - Part 2. Science of Tsunami Hazards 25 (2): 67-125.

WIJESINGHE, Y. (1994): Checklist of woody perennial plants of Sri Lanka. Sri Lanka: The Sri Lanka Forest Department.

WIJETUNGE, J. J. (2006): Tsunami on 26 December 2004: Spatial distribution of tsunami height and the extent of inundation in Sri Lanka. Science of Tsunami Hazards 24 (3): 225-239.

WIKIPEDIA (2008a): http://en.wikipedia.org/wiki/2004_Indian_Ocean_earthquake. 2004 Indian Ocean earthquake. Last access on 28.07.2008.

WIKIPEDIA (2008b): http://en.wikipedia.org/wiki/Natural_disaster. Natural disaster. Last access on 28.07.2008.

WIKIPEDIA (2008c): http://en.wikipedia.org/wiki/September_2007_Sumatra_earthquakes. September 2007 Sumatra earthquakes. Last access on 28.07.2008.

WIKIPEDIA (2008d): http://en.wikipedia.org/wiki/Tsunami. Tsunami. Last access on 28.07.2008.

WORTHINGTON, T.B. (1959): Ceylon trees. Colombo: The Colombo Apothecaries' Co., Ltd.

http://en.wikipedia.org/wiki/Cocos_nucifera. Cocos nucifera: Last access on 13.06.2008

http://www.agrolanka.net/Agro-ecology%20of%20Sri%20Lanka.htm. Agro-ecology of Sri Lanka. Last access on 30.06.2008.

http://www.analytictech.com/mb313/principl.htm. Principles of Questionnaire Construction. Anonymous. Last access on 31.01.2006.

http://www.cc.gatech.edu/classes/cs6751_97_winter/Topics/quest-design/. Questionnaire Design. Last access on 31.01.2006.

http://www.fao.org/forestry/media/13416/1/0/. Bibliography on the protective functions of trees and forests against tsunamis. Last access on 15.03.2008.

http://www.statpac.com/surveys/index.htm#toc. Survey & Questionnaire Design. Last access on 31.01.2006.

http://www.surveysystem.com/sscalc.htm. Survey Design, The Survey System's Tutorial - Creative Research Systems. Last access on 31.01.2006.

8 Index of Tables

9 Table of Figures

10 Appendix

Questionnaire: Vegetation damage survey

Serial No:

Survey on Effects of December 26, 2004 Tsunami on Homegarden Vegetation

(1) Date: 2006 / …… / ……

(2) Identification of Place:

2.1 District: …………………………………………………………………………………….

2.2 Name of the Village/Grama Niladhari Division: …………………………………….

2.3 Name (if you like to mention): Rev./Mr/Mrs/Miss……………………………….

2.4 Address and/or Telephone Number (if you like to mention): ……………………..

……………………………………………………………………………………

(3) Describe the damage caused by tsunami to you, your family and property: ……………………………………………………………………………………

……………………………………………………………………………………

(4) Was there any damage to the vegetation in your land? (Yes / No)

(5) 5.1 Were any trees uprooted / slanted? (Yes / No)

5.2 Name those trees. …………………………………………………………………..

(6) 6.1 Were there any trees with broken trunks? (Yes / No)

6.2 Name those trees. …………………………………………………………………..

6.3 Were there any trees with broken tips? (Yes / No)

6.4 Name those trees. …………………………………………………………………..

6.5 Were there any trees with broken branches? (Yes / No)

6.6 Name those trees. …………………………………………………………………..

(7) 7.1 Did any trees in your land die immediately after Tsunami? (Yes / No)

7.2 Name those trees. …………………………………………………………………..

7.3 Did any trees survived after defoliation? (Yes / No)

7.4 Name those trees. …………………………………………………………………..

7.5 Did any trees die after 1 month or later? (Yes / No)

7.6 Name those trees. …………………………………………………………………..

(8) 8.1 Do you find any new plants after the tsunami, which were not in your garden before tsunami? (Yes / No)

8.2 What are those plants? …………………………………………………………..

……………………………………………………………………………………

(9) 9.1 Did you plant any trees in your land after the Tsunami? (Yes / No)

9.2 What are those trees? ……………………………………………………………

……………………………………………………………………………………..

……………………………………………………………………………………

9.3 Did you select those plants or get any advice from someone else? ………………..

…………………………………………………………………………………………

9.4 Plants selected by you: Plants selected on advice:

………………………………….	………………………………….
………………………………….	………………………………….
………………………………….	………………………………….
………………………………….	………………………………….

(10) If there are any trees in your home garden which survived after the Tsunami, what are those trees? ……………………………………………………………………..

…………………………………………………………………………………………

(11) If there are any trees which you like to grow or you think it is suitable to grow in your land which was under the effects of Tsunami, what are those? ……………..

…………………………………………………………………………………………

…………………………………………………………………………………………

(12) What are the trees that you think are suitable for the conservation of coast?

…………………………………………………………………………………………

…………………………………………………………………………………………

(13) 13.1 Are there any people among you who climbed on to the trees and survived their lives during Tsunami? (Yes / No)

13.2 What are those trees helped to survive lives? ………………………………..

…………………………………………………………………………………………

…………………………………………………………………………………………

(14) After 2 years of Tsunami do you still have any problems which were not solved?

…………………………………………………………………………………………

…………………………………………………………………………………………

(15) If you have any information you would like to mention about Tsunami:

…………………………………………………………………………………………

…………………………………………………………………………………………

The information given by you may help to protect your environment!

Thank you so much for your kind cooperation.

11 Table of Abbreviations

E	English
S	Sinhala
SK	Sanskrit
T	Tamil

12 Curriculum Vitae

Personal data:

Name: Wijetunga Mudiyanselage Gamagedara Asanga Sanjeeva Tikiri Bandara Wijetunga

Date of Birth: December 02, 1969

Place of Birth: Matale, Sri Lanka

Country: Sri Lanka

Nationality: Sri Lankan, Sinhala

Parents: Mother-Mrs K.W.M.M. Karuna Wijetunge, Father-Mr W.M.G. Somathilaka Wijetunga

Marital status: Married, wife Achini, with two sons Haritha Chayana and Asitha Rawana

Permanent Address: Wijaya Nivasa, Galwadukumbura, Kavudupelella - 21072, Sri Lanka

University: University of Peradeniya, Peradeniya, Sri Lanka and University of Natural Resources and Applied Life Sciences (BOKU), Vienna, Austria

Education:

Bachelor of Science (B.Sc.) in Natural Sciences, Open University of Sri Lanka (OUSL): Valid from November 01, 1996.

Master of Science (M.Sc.) in Agriculture, Postgraduate Institute of Agriculture (PGIA), University of Peradeniya, Sri Lanka: Valid from March 27, 2003.

Doctoral Studies at the Institute of Forest Ecology, Department of Forest and Soil Sciences, University of Natural Resources and Applied Life Sciences (BOKU), Vienna, Austria: From November 2005 to November 2008.

Professional experience:

Technical Assistant, Department of Pre-Clinical Studies, Faculty of Veterinary Medicine, University of Peradeniya, Sri Lanka: In 1990.

Technical Officer, Department of Botany, Faculty of Science, University of Peradeniya, Sri Lanka: From October 15, 1991 to date.

Visiting Demonstrator, M.Sc. Programme in Science Education, Postgraduate Institute of Science, University of Peradeniya, Sri Lanka: In 2000.

Vienna, Austria November 2008