THE STATE
OF THE WORLD's
FOREST GENETIC RESOURCES
COUNTRY REPORT

SRI LANKA

This country report is prepared as a contribution to the FAO publication, The Report on the State of the World's Forest Genetic Resources. The content and the structure are in accordance with the recommendations and guidelines given by FAO in the document Guidelines for Preparation of Country Reports for the State of the World's Forest Genetic Resources (2010). These guidelines set out recommendations for the objective, scope and structure of the country reports. Countries were requested to consider the current state of knowledge of forest genetic diversity, including:

- Between and within species diversity
- List of priority species; their roles and values and importance
- List of threatened/endangered species
- Threats, opportunities and challenges for the conservation, use and development of forest genetic resources

These reports were submitted to FAO as official government documents. The report is presented on www. fao.org/documents as supportive and contextual information to be used in conjunction with other documentation on world forest genetic resources.

THE COUNTRY REPORT OF

FOREST GENETIC RESOURCES OF SRI LANKA

FOR

THE STATE OF THE
WORLD'S FOREST GENETIC RESOURCES (SOW_FGR)
FAO OF THE UNITED NATIONS

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PREPARATION OF THE COUNTRY REPORT

The country report of Sri Lanka for the World State of Forest genetic Resources (SoW-FGR) was prepared according to the guideline prepared by the Forestry Department and FAO of the United Nations. Details of the guideline are available at http://www.fao.org/forestry/21933-080bfbee5545985aa074d8330f9d 6e6d1.pdf. The country report preparation was over seen by the National Committee which was headed by the Conservator of Forest (Research and Education) of the Forest Department of Sri Lanka. The National Committee nominated the national consultant (Prof. DKNG Pushphakumara of the Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka who also served as ICRAF Country Liaison Scientist) to compile the information on Forest Genetic Resources through consultation of relevant stakeholders. After several meetings with group of individuals, the content of the first draft was presented at the workshop held at the Royal Botanic Gardens, Perdeniya, Sri Lanka on 19th December 2011 to finalize the Country Report of Forest Genetic Resources. The workshop was participated by 24 eminent personals from stakeholder organizations of the government, non-governmental and private sector organizations those who interested on forest genetic resources, genetic resources in general and biodiversity. The list of consulted stakeholders is given below. Almost all institutes involved with forest genetic resources conservation and management in Sri Lanka represented the workshop. The legal aspects of FGR was shared with Mr. Jagath Gunawardena, Environmental Lawyer of Sri Lanka. Once comments of the workshop participants have been addressed, the final report was compiled by Prof. DKNG Pushpakumara, Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka in collaboration with Dr. KMA Bandara and Dr. NDR Weerawardena, Forest Department, Sri Lanka which was then reviewed by the National Committee, and further reviewed by the stakeholders and finalized.

List of Participants of the Meeting to Finalize the Country Report of Forest genetic Resources of Sri Lanka for the State of the World's Forest Genetic Resources (SoW_FGR) FAO of the United Nations held at the Royal Botanic Gardens of Peradeniya, Sri Lanka on 19th December 2011.

1. Prof. Nimal Gunatilake, Department of Botany, Faculty of Science, University of Peradeniya, Sri Lanka.
2. Prof. DKNG Pushpakumara, Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka and served as the resource person to the workshop to introduce the draft report for the comment.
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4. Prof. IP Wikramasighe, Department of Agriculture Biology, Faculty of Agriculture, University of Peradeniya, Sri Lanka.
5. Dr. DSA Wijesundara, Director, Department of National Botanic Gardens, Peradeniya, Sri Lanka.
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7. Mr. Anura Sathurusighe, Forest Department, Rajamalwatta Road, Battaramulla, Sri Lanka.
8. Mr. Samantha Gunasekara, Department of Customs, Sri Lanka.

9. Dr. SDSS Sooriyapathirana, Department of Molecular Biology, Faculty of Science, University of Peradeniya, Sri Lanka.
10. Dr. GAD Perera, Department of Botany, Faculty of Science, University of Peradeniya, Sri Lanka.
11. Dr. T Sivananthawerl, Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka.
12. Dr. Mangali Alwis, University of Uva Wellassa, Sri Lanka.
13. Mr.Mahasen Ranathunga, Tea Research Institute, Thalawakele, Sri Lanka.
14. Dr. Samanthi Vithana, Rubber Research Institute, Agalawatta, Sri Lanka.
15. Dr. J Senavirathna, Department of Export Agriculture, Research Station, Mathale, Sri Lanka
16. Dr. G Samarasighe, Rice Research Institute, Bathalagoda, Sri Lanka.
17. Dr. Gamini Hitinayake, Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka.
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20. Ms. Deepani Alawathugoda, Forestry Research Institute, Forest Department, Kumbalpola.
21. Ms. SH Bandumala, Forestry Research Institute, Forest Department, Kumbalpola.
22. Dr. KMA Bandara, Forestry Research Institute, Forest Department, Badulla.
23. Mr. HWK Jayathilake, Forest Department, Sri Lanka.
24. Ms. SCJ Dissanayake, Plant Genetic Resources Centre, Gannoruwa, Peradeniya, Sri Lanka.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF PLATES

LIST OF ANNEXTURES

ACRONYMS

ADB	Asian Development Bank
AGA	Assistant Government Agent
APAFRI	Asia Pacific Association of Forestry Research Institution
APAN	Asia Pacific Agroforestry Network
AusAID	Australian Government Overseas Aid Program
BCAP	Biodiversity Conservation Action Plan
BFO	Beat Forest Officers
BGCI	Botanical Gardens Conservation International
BMARI	Bandaranayake Memorial Ayurvedic Research Institute
FD	Forest Department
CBD	Convention on Biological Diversity
CEA	Central Environmental Authority
CRI	Coconut Research Institute
CSIRO	Commonwealth Scientific and Industrial Research Organization
CITES	Convention on International Trade in Endangered species of Wild Fauna and Flora
CMS	Convention on the Conservation of Migratory Species
CTFS	Centre for Tropical Forest Science
CWR	Crop Wild Relatives
DBH	Diameter at Breast Height
DEAC	Department of Export Agriculture
DMEF	Dry Mixed Evergreen Forest
DNBG	Department of National Botanic Garden
DOA	Department of Agriculture
DWLC	Department of Wildlife Conservation
EIA	Environmental Impact Assessment
EPL	Environmental Pollution Licenses
EPA	Environment Protection Areas
FA	Faculty of Agriculture
FAO	Food and Agriculture Organization
FD	Forest Department
FDP	Forest Dynamics Plot
FGR	Forest Genetic Resources
FFPO	Fauna and Flora Protection Ordinance
FO	Forest Ordinance
FORTIP	Improvement Productivity of Man-made Forests through Application of Technological Advances in Tree Breeding and Propagation
FPU	Forestry Planning Unit
FRA	Forest Resources Assessment
FS	Faculty of Science
FSMP	Forestry Sector Master Plan
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GMO	Genetically Modified Oragnism
GN	Grama Niladari
GNP	Gross National Products
ICRAF	International Centre for Research in Agroforestry
IPGRI	International Plant Genetic Resources Institute

IUCN	International Union for Conservation of Nature
IUFRO	International Union for Forest Research Organizations
IVI	Importance Value Indices
JEDB	Janatha Estate Development Board
KDN	Kanneliya Dedioyagala and Nakiyadeniya
LMO	Living Modified Oragnismas
LWEF	Lowland Wet Evergreen Forest;
MAB	Man and Biosphere
MANF	Mangrove Forest
MASWL	Ministry of Agrarian Services and Wildlife
MAT	Mutually Agreed Terms
MDG	Millennium Development Goals
ME	Ministry of Environment
MEEF	Mid Elevational Evergreen Forest
MEF	Ministry of Environment and Forestry
MENR	Ministry of Environment and Natural Resources
MMEF	Moist Mixed Evergreen Forest
MOEF	Montane Evergreen Forest
MPCA	Medicinal Plant Conservation Area
MTA	Material Transfer Agreement
NARESA	Natural Resources, Energy and Science Authority
NCR	National Conservation Review
NFI	National Forest Inventory
NGO	Non Governmental Organization
NSCAG	National Species Conservation Advisory Group
NTFP	Non Timber Forest Product
PA	Protected Area
PAM&WCP	Protected Area Management and Wildlife Conservation Project
PGRC	Plant Genetic Resources Centre
PIC	Prior Inform Consent
RDA	Road Development Authority
REDD	Reducing Emissions from Deforestation and Forest Degradation
RFO	Range Forest Officer
RPC	Regional Plantation Company
RRI	Rubber Research Institute
SJP	Sri Jayawardena Pura
SLCSUMPP	Sri Lankan Conservation and Sustainable Use of Medicinal Plant Project
SLFI	Sri Lanka Forest Institute
SLSPC	Sri Lanka State Plantations Corporation
STRI	Smithsonian Tropical Research Institution
SRI	Sugarcane Research Institute
STC	State Timber Corporation
TRI	Tea Research Institute
TROF	Tree Resources outside Forests
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Education and Scientific and Cultural Organization

UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD	United Nations Collaborative Programme on REDD
USAID	United States Agency for International Development
WCMC	World Conservation Monitoring Centre
ZADI	German Centre for Documentation and Information in Agriculture

EXECUTIVE SUMMARY

The country report was prepared by the national committee using consultative process. The first section on introduction to Sri Lanka explains the basic information on climate, diversity and population of Sri Lanka along with its economy. It also explains the state of the forest genetic resources management. Sri Lanka is a small island located in the Indian Ocean which covers an area of 6.56 million ha. The country is divided to three distinct peneplains based on the elevation, namely low country (sea level to 300 m amsl), mid country (300 to 900 m amsl) and up country (over 900 m amsl). Based on the mean annual rainfall and its distribution, the country is classified into three major climatic zones: the dry zone (< 1,750 mm), intermediate zone with 1,750-2,500 mm rainfall and wet zone (over 2,500 mm rainfall). The dry, intermediate and wet zones of Sri Lanka cover 65%, 12% and 23% of the country. The seasonal variation of temperature throughout the island is minor. Sri Lanka divided into 15 floristic regions and 46 agro-ecological regions. Despite its small size, Sri Lanka has rich diversity of soils and nine out of the ten major soil orders based on the USDA soil taxonomic system are distributed throughout the country in a mosaic pattern. Sri Lanka is one of the most densely populated countries in Asia with current population of 20.653 million and population density of 329 people per square km. The wet zone occupying just 24% of the country is under great pressure because it is settled by 55% of the islands population with the average density of 650 persons per square km. Based on per capita income (US $ 2,014 in 2010), the country is now considered as a lower middle-income country.

Sri Lanka's forest cover is 29.6% of the land area, with closed canopy natural forest amounting to 22.4%. Eighty-six percent of the natural forest is located in the dry and intermediate zones of the country, and these areas contain about 85% of the closed canopy forests. The total extent of forest plantations is 79,941 ha. Almost all natural forests of Sri Lanka is owned, managed and protected by the Forest Department (FD) or Department of Wildlife Conservation (DWLC). The contribution of the forestry sector to the national economy was 1.4% of the GDP whereas the employment in the sector was at 170,000 people though the conservative estimate of indicated that 6% contribution to the GDP. Both FD and DWLC are engaged in conservation and management of several categories of natural forests. Plantations are managed by FD and state and privately owned Regional Plantation Companies. State Timber Cooperation (STC) is responsible for harvesting of forest plantations and their handling.

Due to the policy changes of the government of Sri Lanka on exploitation of natural forests, a logging ban in natural forests was imposed in 1990 and it is still continuing. Thus, production orientation of natural forests changed to protection orientation. During the last two decades, the extent of plantation forestry has increased but not in an accelerated manner. The wood production is a traditional concern of forestry and FD, and it continues to be so, even though the wood supply picture has changed greatly during the last few decades. Natural forests are no longer the most important source of wood and fuelwood in the country. In this respect, homegardens, coconut based, tea based and rubber based agroforestry systems, and other agricultural landscapes play a dominant role in management of FGRs and supply of products and services. This is important because the sawn wood demand from is projected to grow at the annual average rate of 2% and similar trends are projected for paper and paperboards, wood and non-wood forest products such as wooden poles and bamboo poles. Hence, effective and efficient management of FGRs outside forests is a priority in achieving timber, firewood and other environmental services and food security and livelihood improvement programmes in Sri Lanka.

Chapter 1 indicate the marked diversity of terrestrial forest and related ecosystems, coastal and marine ecosystems, inland wetland ecosystems and agricultural ecosystems. The terrestrial forest and related ecosystems that contain much of the biodiversity of Sri Lanka range from lowland, sub-montane and montane rainforests in the wet zone, to moist evergreen forests of the intermediate one, dry mixed evergreen forests of the dry zone. The high ecosystem diversity in the island has given rise to a large number of indigenous species, including a remarkably high percentage of endemics among both flora and fauna. Sri Lanka has over 3,771 angiosperms from 214 families and 1,522 genera, of which more than 28% are endemic to the country. The extraordinary endemicity occurring mainly at specific and intra-specific levels makes the Sri Lankan flora of outstanding interest. Further, Sri Lanka is unique because though the country is small it represents many orders and families recorded in the world. The wet zone rainforests harbor nearly all the country's woody endemic flora and all the endemic genera. The level of endemism in wet zone forests ranges from 37-64% for woody plants and 14-52% for animals, compared with 10-16% for species in the dry zone forests. Genetic diversity is relatively well known among only agricultural crops, which show a range of varieties and landraces, particularly among grains, cereals, vegetables and root, and tuber crops. Some of them show marked adaptations to various climatic conditions. In contrast, except for a few species, genetic diversity among wild species and forest trees is little known. However, a substantial genetic diversity is inferred in FGRs.

The forest cover in Sri Lanka declined drastically over the past century and continue. The closed canopy forest cover declined from about 84% of the land area in 1881, to 44% in 1956, to 27% in 1983, to 24% in 1992 and 22.4% in 1996. Effective management measures are reflected in relatively lower loss of forests through encroachment during the recent times. However, most of the natural forests and some of the forest plantations in the country have faced threats from the growing human population and their activities. These forests are gradually losing their quality in terms of species and stocking mainly due to illegal harvesting and clearing for agricultural activities. Sri Lanka has been engaged in the preparation of the red list of threatened fauna and flora of the country since 1987. In the recent national red listing exercise in 2007, the conservation status of about 1,099 species, which represent 35% of the angiosperm flora from 68 families, has been assessed. Of the total plant species evaluated, 72 species (6.5%) and 675 species (61%) are categorized as extinct and threatened species, respectively. Among the total threatened plant species, 412 species (61%) are endemic to the country. Among the extinct plant species, nearly 60% are endemic to the island. About 37% of threatened plant species are categorized as critically endangered. The family Orchidaceae had the highest number of threatened plant species (122 species) followed by Rubiaceae (99 species), Acanthaceae (51 species), Dipterocarpaceae (42 species) and Phyllanthaceae (31 species). These five families harbor more than 50% of the threatened species identified during this present study. An analysis of the geographical distribution of flora in different administrative districts in the island revealed that districts in the lowland wet zone (Galle, Matara, Rathnapura, Kaluthara, Kegalle) and the central highlands (Kandy, Matale, Nuwara Eliya, Badulla) harbor a higher number of threatened taxa.

In Sri Lanka, forest genetic resources are not actively managed in natural forests for human use. In contrast, genetic resources of forest trees and other species are actively and largely managed for human use in systems outside natural forests in forest plantations. In this respect, tea, rubber, coconut, export agriculture crop based agroforestry systems and homegardens play a dominant role. Sri Lanka is hence a unique example in forest product utilization in trees outside natural forests.

For plantation forestry species, such as *Tectona grandis, E. grandis* and some *E. microcorys* identification of seed stands, plus trees and establishment of seed orchards and assessment of variation of species based on growth and morphological characters are practised by the Forest Department. Seed requirement of the plantations established by FD is mainly met by the FD documented seed sources where as the seeds for the agroforestry sector of the country are mainly met by the unimproved seed sources. Though the genetic variations (at provenance and progeny level) have been tested for the main commercial exotic tree species, very limited studies have been conducted on the genetic variation/genetic characterization on the potentially important tree species for timber and fuel wood in the country which is of immediate importance to the country. Similarly, genetic characterization of threatened and endemic species has also not been investigated.

Chapter 2 indicated that despite some limitations, the National Conservation Review (NCR) carried out by FD is among the most detailed, comprehensive of its kind carried out in the country. The results of the NCR clearly demonstrate the importance of Sri Lanka's natural forests, both in terms of their role in maintaining ecosystem stability and functions and as a reservoir of high biodiversity. FD and DWLC are primarily responsible for the *in situ* conservation of biodiversity, through the designated protected areas network. It is significant that over 26% of the total land area of Sri Lanka is reserved and administrated by FD (11.5%) and DWLC (14.8%). None of these PAs exclusively made aiming conservation of FGRs but such PA network helps to conserve FGRs. Much of Sri Lanka's endemic and indigenous species exists in the PAs but except for a few species, their distribution and population sizes are little known. The biodiversity (also FGRs) of Sri Lanka under *in situ* state, however, continues to experience multiple threats such as loss of populations, loss of habitats, encroachment, unplanned development, pollution and over collection, hence categorized as one of 35 biodiversity hotspots in the world due to high diversity and endemism and threats to habitats. It is clear that though Sri Lanka has an extensive PA network, critical gaps exist in the context of biodiversity conservation. The level and extent of genetic erosion of the tree resources in natural forests and outside of the natural forest (i.e. homegardens) is uncertain. No baseline information or assessments have been carried out in this regard. Further, conservation of species is based on existing protected areas but not based on assessment of genetic information or effective population sizes. Research on reproductive biology and genetic variation and breeding systems should continue as a priority in *in situ* conservation of natural forests to understand their fate in the future. In *in situ* conservation, capacity building and strong collaborative programme with international institutes is immediately required. Almost all native species occurred in *in situ* conservation area. There is no dedicated programme for inclusion of threatened species into conservation programmes. It is also high time to carry out the next National Conservation Review to identify changes of species diversity in PAs.

Chapter 3 revealed that in Sri Lanka, *ex situ* conservation activities on various species of trees, crops and crop wild relatives are carried out by several organizations using (i) Seed Gene Banks (ii) Field Gene Banks, (iii) i*n vitro* Gene Banks and (iv) Arboreta. *Ex situ* conservation of genetic resources of forest plantation species is mainly carried out in the status of field collection and established of provenance collections, gene resources stands, establishment of seed stands and seed orchards of exotic commercial species such as *Eucalyptus grandis, E. microcorys, E. camaldulensis, E. teriticornis, Tectona grandis, Khaya senagalensis*. Other exotic and locally potential tree species are conserved *ex situ* in the arboreta of Forest Department and other institutes. The homegarden network of Sri Lanka

provides a complementary resource base for *circa situm* conservation of crop and forest genetic resources and acts as a complementary option to mediate *in situ - ex situ* gap and also a platform for continuation from natural vegetation to monoculture fields. However, adequate attention has not been paid on assessment of area under homegardens and their standing stocks and their contribution to FGRs and genetic resources conservation and food security in Sri Lanka. Several weaknesses of existing ex situ conservation options and priorities are identified.

Chapter 4 identified that a wide variety of indigenous plants have been used in Sri Lanka since prehistoric times. Non Timber Forest Products (NTFP) are a major income source for many rural communities adjacent to natural forests. Some instances harvesting techniques are non destructive, but other instances, the techniques used for harvesting are very destructive. Information on sustainable use of FGRs in natural forests are scanty which hampered the sustainable management of natural forests. With the shift in emphasis of forest policy from production to protection, steady growth in plantation forestry and improvement for timber production in other land use categories especially in homegardens is a must. With the rapid development of plantation forestry and other land uses for timber production, the introduction of exotic species, a need for genetic improvement was felt and activities leading to tree improvement have been initiated in FD. FD is responsible for production of quality planting material and their distribution to end users. Accordingly, the main objective of the tree breeding programmes of Sri Lanka is to support production of timber and fuelwood. Forest tree improvement programmes in Sri Lanka are mainly conducted for exotic species. *Tectona grandis* and *Eucalyptus grandis* are the two main species used for tree improvement programmes with 1st generation seed production. *Eucalyptus microcoys* and *Khaya senagalensis* are used up to a limited extent with identification of plus trees, seed stands and small units of seed orchards. *Swetenia macrophylla, Berrya cordiforlia, Artocarpus heterophyllus* have been used slightly in tree improvement programmes with identification of plus trees and seed stands. In addition, few local species have also been selected and less work been carried out because of the long rotation age of local species. Most of the local species are early or late successional climax species. The FD supplies seedlings of many timber species to farmers from departmental nurseries. In addition, a large number of seedlings are produced and supplied from farmer nurseries, school nurseries and NGO nurseries that are supported with technical assistance by the FD. However, due to the small-scale nature of these nurseries, it is not possible to produce sufficient amount of improved planting materials for commercial planting leaving a dearth of material for reforestation.

Chapter 5 indicated that several government institutes are actively engaged with use of FGRs. Sri Lanka has not established a national coordination mechanism to include different institutions or a national programme especially for FGRs. The Biodiversity Secretariat is responsible for it. The funding provided for tree improvement has not been changed but is inadequate for effective research programmes. The need for training and capacity building is strongly emphasized in all national development programmes including Biodiversity Conservation Action Plan. Education on FGRs are carried out at diploma (mainly by FD), undergraduate and postgraduate levels (both at master and doctoral levels) mainly by the national universities and postgraduate institutes of Sri Lanka. Priority requirements for training and research have been identified at the national level for FGRs. There is no separate national legislation for forest genetic resources conservation and use in Sri Lanka. The country has not established a legal framework for FGRs strategies, plans and programmes but existing legislations are used. The constitution of the country, the Fauna and Flora Protection Ordinance (FFPO), the Forest Ordinance and new Forest Conservation Act

form the direct legal framework pertaining to biological resources, including FGRs. While Sri Lanka has adequate legislation for protecting terrestrial biodiversity and threatened species, their enforcement is inadequate due to insufficient staff and facilities for effective monitoring and complicated legal procedures. At present, no special public awareness programmes are available for FGRs. In this regard, case studies are proposed make into make documentary programmes.

Chapter 6 identified that the government of Sri Lanka is party to 36 international conventions, agreements, treaties and protocols related to environment, forestry and related areas. The major convention related to the use of forest genetic resources is the Convention of Biological Diversity (CBD) which was signed in 1992 and ratified in 1999. Accordingly, Sri Lanka prepared the Biodiversity Conservation Action Plan (BCAP) in 1999 in response to article 6 of the CBD in consideration of the need to effectively conserve the island's valuable natural resources, including FGRs. It is noted here that the BCAP did not specifically state the conservation of FGRs, instead it identified the need for systematic approach of conservation. Provincial Ministries of Environment have a role to play in biodiversity conservation matters at the regional/local levels, and regional BCAP is already prepared allowing integration of biodiversity into regional strategic planning processes, too. The FD has been involved with several international collaborations and networking activities mainly in the area of exchanging information, development of technical guidelines and databases, establishment of genetic conservation strategies, germplasm exchange and training. Such activities generate a wealth of knowledge which is useful in management of FGR in Sri Lanka. However, though regional networks are in operation, exchange of FGRs (especially commercially important species) is extremely difficult, hence the need effective regional collaboration for sharing of information and FGRs for plantation species. This can be addressed through collaborative research programmes with regional countries such as India and Thailand. World Agroforestry Centre through its timber tree and fruit tree networks of the country provides opportunities for scientists to visit regional countries which yield sharing of knowledge and information and exchange of material among countries. Such programmes should be conducted frequently aiming species and capacity building. It is also proposed to conduct a national programme (seminar or workshop) for FGR and their activities to increase knowledge and awareness of the existing resources.

Chapter 7 revealed that policy on exchange of plant genetic resources are to be based on the Fauna and Flora Protection Ordinance (FFPO) although FGR is not specifically stated in the FFPO. Use of the material transfer agreement (MTA) and Prior Informed Consent (PIC) for exchange of plant genetic resources is suggested but not commonly practiced and such set up can be used for FGRs, too. Intellectual Property Rights (IPR) legislations are drafted as No. 36 of 2003 IPR laws. The country has not yet established mechanisms of sharing benefits arising out of the use of forest genetic resources. The Biodiversity Secretariat of Ministry of Forestry is expecting to act as an institution for such activities in due course.

Chapter 8 provide the information on how FGRs provide supportive role to plant genetic resources in Sri Lanka for achieving the food security, and support the sustenance of people in Sri Lanka by providing fruits, foods, raw material for food, weaving material, thatching material, timber, construction material, poles, paper and pulpwood, fuelwood, medicines, raw material for industries, raw material for extraction of biomedicines, resins, gums. It also indicated that if properly planned, FGRs could enhance economic development in several areas including sustainable land use, economics and trade, as well as public health and tourism.

INTRODUCTION TO SRI LANKA AND FORESTRY SECTOR

The Democratic Socialist Republic of Sri Lanka is one of the smallest but biologically most diverse countries in Asia. It is also recognized as a biodiversity hotspot of global importance. This chapter introduces physical characteristics of Sri Lanka, its floristic and agro-ecological regions, population and population trend, land use pattern, economy, forestry sector, tree resources management systems and organization and management of forestry sector in the country.

Sri Lanka – Physical Characteristics

Geography and Geology

Sri Lanka is located in the Indian Ocean at the southern point of the Indian sub-continent, between 5°54' to 9°52' north latitude and 79°39' to 81°53' east longitude. It is an elongated pear-shaped island with a maximum length of about 434 km and a maximum width of about 227 km. There are also a few small islands scattered along its coast. The country covers an area of 65,610 square km (6.56 million ha) of which 62,705 square km covers the land and 2,905 square km covers the inland water. The irregular coastline of the country is about 1,585 km in length (MENR, 2009; MENR and UNEP, 2009; MFE, 1999). Geologically, Sri Lanka shares with India, the south Asian tectonic plate, since the time of the breakup of the Gondwanaland. The separation of Sri Lanka from the peninsular India is believed to have occurred about 70 million years ago. Precambrian crystalline rocks form the underlying geological formations in 90% of the country. A narrow strip of miocene limestone extends from northern coast to over quarter of the northwestern coastal areas of the country (Cooray, 1984).

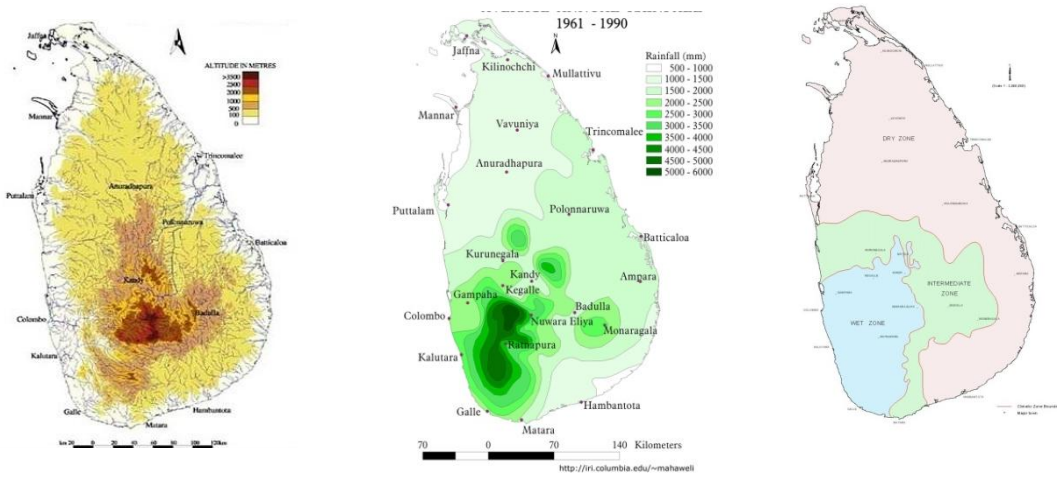
Three distinct peneplains are discernible in Sri Lanka based on the topography. The lowest of these, the flat lowland peneplain covers about 75% of the land consisting of the northern, southern halves of the country and the broad strip along east coast and the narrow strip along the west coast. This first peneplain is referred to as the low country with the altitude rising from sea level to 300 m above mean sea level (amsl). Towards the south central parts of the island, the land rises steeply on all sides and the second peneplain of mid country is identifiable from 300 to 900 m amsl. Further inland, the land rises very steeply to form the south central mountain massif with plateau like areas and has 162 peaks ranging from 1,000 - 2,500 m. This constitutes the third peneplain or up country (over 900 m amsl) (Map 1) (MFE, 1999).

Climate

The major determinants of the climate in Sri Lanka are rainfall and temperature (MFE, 1999). Sri Lanka receives rainfall from three types, namely monsoonal, convectional and depressional. There are four main rainfall seasons during the year, two monsoonal periods and two inter-monsoonal periods. The annual average rainfall varies from below 1,000 (at north west and south east parts of the country) to over 5,000 mm (mainly at south western slopes of the central hills) (Map 2), indicating that the local topography plays a major role in determining the rainfall distribution over the island. The two monsoonal periods, the southwest (May - September) and the north east (December - February) are responsible for major part of the annual precipitation of nearly 55%. The inter-monsoonal period following the southwest monsoon occurs from October to November whereas the inter-monsoonal

period following northeast monsoon occurs from March to April. The southwest monsoon provides rain mostly to southwestern quarter and the central hills, which exceeds 3,000 mm. The northeast monsoon provides rain (200 to over 1,200 mm rainfall) mostly to the eastern half of the country. The northeast monsoon along with inter-monsoonal depressional activity in October/November is stronger, and produces rain throughout the island and exceeds 500 mm. This period is considered as the rainiest period of the year. The other inter-monsoonal period in March/April produces less rainfall. Convectional rain occurs all over the country especially in the afternoons or evenings during inter-monsoonal periods. Depressional rain occurs during October - November inter-monsoonal period and southwest monsoon (MENR, 2009; MENR and UNEP, 2009; MFE, 1999; Punyawardena, 2010).

Based on the mean annual rainfall and its distribution, the country is classified into three major climatic zones: the dry zone (mean annual rainfall of less than 1,750 mm), intermediate zone (mean annual rainfall 1,750-2,500 mm with a short and less prominent dry season) and wet zone (mean annual rainfall over 2,500 mm without pronounced dry period) (Map 3). The dry zone experiences prolonged dry period from May to September with drought conditions prevailing from June to August. The presence of strong dry winds accentuates the harsh conditions during this period. The wet, intermediate and dry zones of Sri Lanka covers 23%, 12% and 65% of the country (Punyawardena, 2010).



Map 1: Topography of Sri Lanka. Source: MENR (2006)
Map 2: Mean annual rainfall of Sri Lanka.
Map 3: Major climatic zones of Sri Lanka. Source: MENR (2006)

Being located in the low altitudes and surrounded by the Indian Ocean, Sri Lanka shows very typical maritime-tropical temperature conditions. These conditiones are characterized by greater daily than annual temperature ranges and moderate average temperatures in comparison with the more continental tropics. Temperature conditions in Sri Lanka are also characterized by a significant temperature decrease in the central highlands according to vertical lapse rate of temperature, approximately around 5-6 °C for every 1,000 m rise in elevation (Map 4). However, descending southwest monsoon winds over the central hills towards lee side get warmer adiabatically causing ambient temperature to be increased along with decreased humidity. Hence, in this region, fall of temperature with rising altitude is not very distinct compared to the same elevations of the other side of the central hills wet zone.

The mean monthly temperature of the country over lowlands in the coastal areas below 150 m elevation is about 27.5 ℃ and it ranges from 15-28 ℃. The oceanic influence also helps to reduce temperature in the lowlands by sea breezes. In the montane region (above 1,500 m) the mean monthly temperatures varies from 13-16 ℃ with the night temperature occasionally dropping to around zero. The entire dry zone, which consists of lowland plains, except for a few isolated hills, has a mean annual temperature of 30 ℃, although the maximum temperature may occasionally even exceed 37 ℃. Diurnal variation of temperature is well marked and the range increases with altitude as well as with the distance from the sea. In general, the seasonal variation of temperature throughout the island is minor, but there is a general tendency for higher temperatures during the period of March to October while December to January are cooler (Punyawardena, 2010).

Relative Humidity

The relative humidity varies generally from about 70% during the day to about 90 to 95% during night. In the dry areas, these values are lower by about 5%. Most parts of the country is hot and humid (MFE, 1999).

Soils

Sri Lanka, despite its small size, has rich diversity of soils (Map 5). Nine out of the ten major soil orders based on the USDA soil taxonomic system are distributed throughout the country in a mosaic pattern. Fourteen of the great soil groups have been recognized within the country. In the dry zone, the predominant soil group is the well drained reddish brown earth in association with poorly drained humic gley alluvials and red yellow latosols. In the dry zone coastal areas non-calcic brown soil with sandy regosols, alkaline and saline soils, and grumosols are distributed in patches. In the wet zone, red yellow podzolic soils form the major soil group with bog, half bog soils, and sandy regosols along the south west coast. The intermediate zone displays a transition from reddish brown earth to red yellow podsolic soils, with non calcic brown loam in patches (MFE, 1999).

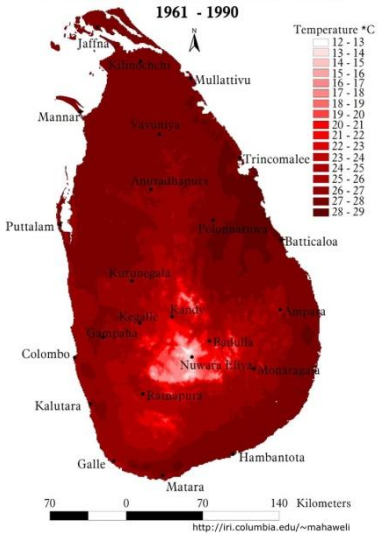
Surface Drainage

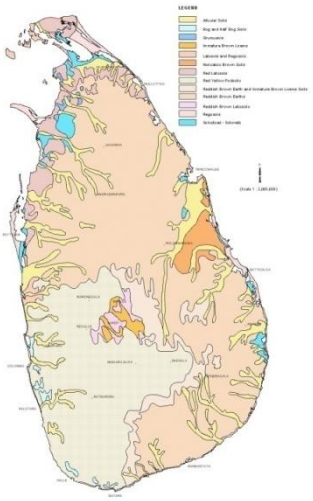
The centrally placed mountain mass encircled by coastal plains provides for radial pattern of surface drainage to all rivers except the river Mahaweli. The coastline is laced with 103 river basins, which end as sand bars, deltas, lagoons, marshes and mangrove swamps (Map 6).

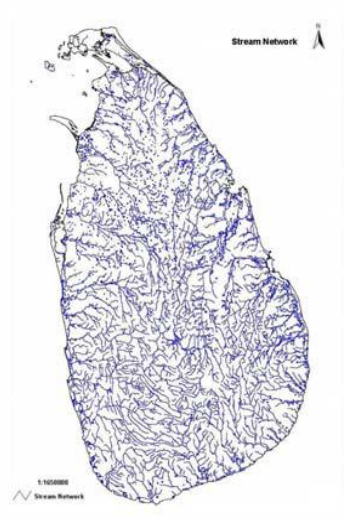
Population and Population Trend in Sri Lanka

The population of Sri Lanka in 2010 was 20.653 million and the natural increase in population is estimated at 1.1% annually. Sri Lanka is one of the most densely populated countries in Asia. Population density rose from 54 people per square km in 1900 to 139 people in 1956 and to 329 people per square km in 2010. The wet zone occupying just 24% of the country is under great pressure because it is settled by 55% of the islands population. Thus, population density in the wet zone is much higher (650 persons per square km) as compared to the dry zone (175 persons per square km). Over 72% of the country's population lives in rural areas, while less than 22% of the population is in the urban areas and 6% in upland plantation areas. Ethnic groups of the country include the Sinhalese (73.9%), Sri Lankan Tamil (12.7%), Indian Tamil (5.5%), Muslim (7.1%) and others (0.8%). Majority (69.3%) of the population is Buddhist while 15.5% is Hindu, 7.6% Islam, 7.6% Christian and

0.8% from other religions. The country has a high literacy rate of about 88% (CBSL, 2010). Details of social indicators of Sri Lanka are given in Annex 1.







Map 4: Mean annual air temperatures of Sri Lanka. Source: MENR (2006)
Map 5: Soils of Sri Lanka. Source: MENR (2006)
Map 6: Stream network of Sri Lanka. Source: MENR (2006)

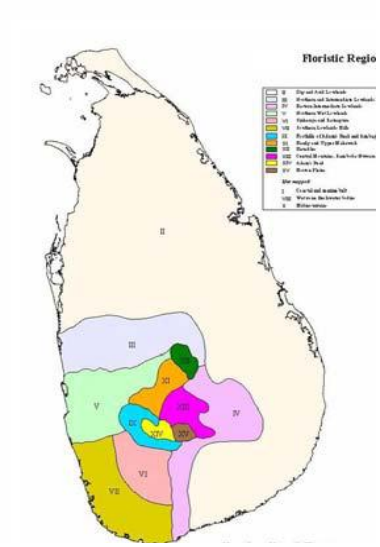
Bioclimatic and Floristic Regions and and Agro-Ecological Regions of Sri Lanka

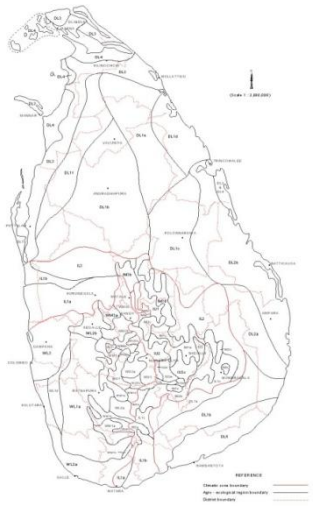
Taking the topography and the climate into consideration six bioclimatic zones have been recognized to describe the distribution of natural vegetation in the country. These are the low and mid country wet zone, montane wet zone, montane intermediate zone, low and mid country intermediate zone, dry zone and arid zone. Subsequently, through vegetational analysis, Ashton and Gunatilleke (1987) identified 15 floristic zones in the country. Map 7 shows the distribution of floristic regions in the country whereas Annex 2 shows the principal vegetation types and dominant plant communities of each floristic region. The majority of the floristic regions fall in the wet and intermediate zones. Superimposing the ecological parameters such as the climatic, topographic, edaphic, vegetational, cultural, land use, drainage and micro-climatic factors, the major climatic zones have been subdivided into 46 agro-ecological regions (Map 8). This classification is used to describe the distribution of crop plants in agricultural planning (Punyawardena, 2010).

Land Use Pattern in Relation to Forest Lands

The total land area of Sri Lanka besides the area occupied by inland waters is only 6.44 million ha. The land/man ratio is low and only 0.37 ha/person, however, after allowances are made for forest cover, steep and barren lands, urban and rural dwellings, only about 2.5 million ha (nearly 39% of the total land area) is available for further settlements and agricultural production. Thus, the per capita extent of croplands is as small as 0.14 ha. Majority of land area of the country is rainfed and is in the dry zone. This explains that the competition for land is severe among the sectors using it. The major land use sectors in the country are agriculture (paddy, tea, rubber, coconut and other perennials, non-perennial crops), close canopy and sparse forests, homegardens and others as illustrated in Figure 1 (DCS, 2010). Spatial differences of land use can be observed in Sri Lanka; in the dry zone

only 30% land is utilized. In contrast, in the wet zone utilized land has reached its peak with more than 80% and there is hardly any room for expansion. Forest covers around 9% of land area of the wet zone.





Map 7: Floristic regions of Sri Lanka. Source: MENR (2006)
Map 8: Agro-ecological regions of Sri Lanka. Source: MENR (2006)

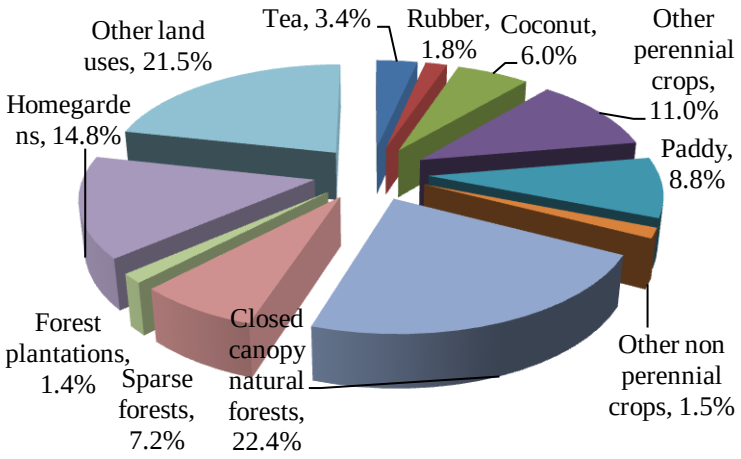


Figure 1: Forest lands in relation to agriculture and other land uses in Sri Lanka. Source: DCS (2010).

Economy of Sri Lanka

Before the adoption of open economic policies, Sri Lankan economy heavily depended on plantation crops such as tea, rubber and coconut. The private sector was relatively weak and the government owned most of the industries. Due to the policy changes, the private sector showed growth resulting in average annual growth rate of around 5% since 1990. During the last three decades, the country has steadily moved towards an industrialized economy with the development of textiles, apparel, telecommunications, finance and food processing. The Sri Lankan economy registered strong growth in the last ten years despite the long civil war (ended in 2009) and a major tsunami in 2004. GDP growth rate averaged 5% from 2000-

2009 and is estimated at 7% for 2010 (CBSL, 2010). In 2010, the total value of export was US $ 8.3 billion whilst the total value of imports was US$ 12.2 billion. The government promotes Sri Lanka as an economic hub in south Asia and the official national vision for the future is a Sri Lanka with a green environment, rapid development and a middle income economy (Mahinda Chintana, 2010). Currently, the service sector of the country contributes most to the GDP with 58% and employs 41% of the labour force. The industrial sector is responsible for 30% of the GDP and employs 26% of the labour force whilst the agriculture sector (including forestry sector) accounts for only 11.9% of GDP, but employs 33% of the labour force. Per capita income in 1994 was US $ 652 and it has reached US $ 2,014 in 2010 although high regional disparities remain. Based on per capita income, the country is now considered as a lower middle-income country. Between 1990 and 2002 the proportion of the population living below the poverty line (Rs. 3,087 or US$ 30.87/month) fluctuated around 25%, but by 2010, this figure was down to 9% (DCS, 2010). Poverty is more pronounced in the rural areas. Sri Lanka is ranked 91 out of 169 countries in the Development Index (CBSL, 2010; DCS, 2010).

Forestry Sector and Tree Resources Management Systems

According to most recent estimates, Sri Lanka's forest cover is 29.6% of the land area, with closed canopy natural forest amounting to 22.4% (ME, 2010b). The total area of dense natural forests in the country is 1,675,000 ha of which 167,000 ha are identified as primary forest, while the remaining area is categorized as naturally regenerated forests (Table 1). Eighty-six percent of the natural forest is located in the dry and intermediate zones of the country, and these areas contain about 85% of the closed canopy forests and 90% of sparse (open) forests in Sri Lanka. The total extent of forest plantations is 79,941 ha (FD, 2009). Almost all natural forests of Sri Lanka is owned, managed and protected by the state Forest Department (FD) or Department of Wildlife Conservation (DWLC). Forest resources owned by other sources are minute and negligible (Table 2).

Table 1: Area of primary, naturally regenerated and planted forests in Sri Lanka.

Main forest characteristics	Area (000 ha)			
	1990	**2000**	**2005**	**2010**
Primary forests	257	197	167	167
Naturally regenerated forests	1,851	1,664	1,571	1,508
Planted forests (forest plantations)*	-	-	-	79.4

Source: *FD (2009); FRA (2010).

Table 2: Ownership of forests of Sri Lanka.

Forest ownership	Area (000 ha)		
	1990	**2000**	**2005**
Public	2,167	1,925	1,804
Private	183	157	129
Others	Na	na	na

Source: FRA (2010).

The contribution of the forestry sector to the national economy was 1.4% of the GDP whereas the employment in the sector was at 170,000 people though the conservative estimate of FSMP (1995) indicated that 6% contribution to the GDP was mainly from the production of

timber, sawn wood and fuelwood. However, contribution of the forestry sector to the national economy is largely underestimated where only marketed products are included and household use of fuelwood, other products and environmental services are not documented. Hence, the true contribution of the forestry sector to the national economy may be much greater.

Due to the policy changes of the government of Sri Lanka on exploitation of natural forests, a logging ban in natural forests was imposed in 1990 and it is still continuing. The forests, which were subjected to felling prior to 1990, are now in an advanced regeneration stage and are managed purely as conservation forests. Land fragmentation and degradation, environmental concern of logging and consideration of conservation and sustainable use are the major driving forces behind the change of exploitation to conservation (FSMP, 1995). A change to this policy is not to be anticipated in the future. Natural forests are thus mainly used for nature conservation, ecotourism activities, REDD, and production orientation changed to protection orientation. During the last two decades, the extent of plantation forestry has increased but not in an accelerated manner. A new business oriented plantation establishment can be identified in the recent past where plantations of *Tectona grandis* and *Swietenia macrophylla* are established and managed by private companies. Their expansion is also relatively slow.

The wood production is a traditional concern of forestry and FD, and it continues to be so, even though the wood supply picture has changed greatly during the last few decades. Although forests and forest plantations still account for about 75% of the wood growing potential, most of this is inaccessible due to the ban on logging in natural forests. Hence, natural forests are no longer the most important source of wood and fuelwood in the country (Figures 2 and 3). The contribution of forest plantations to the timber supply (11%) and fulewood supply (4%) is also not the greatest in Sri Lanka (Figures 2 and 3). However, natural forests of Sri Lanka and forestry sector in the country mainly provide environmental services. In addition, forests provide food, fuel, fodder, fiber, thatching material, medicines, and biomedical materials, ornamental species of commercial value, raw material for industry such as rattan and areas for recreation and aesthetic enjoyment. Adjacent communities of natural forests depend to some extent in obtaining their food, fodder, fuelwood and income from natural forests; hence the importance for their food security and livelihood (FSMP, 1995).

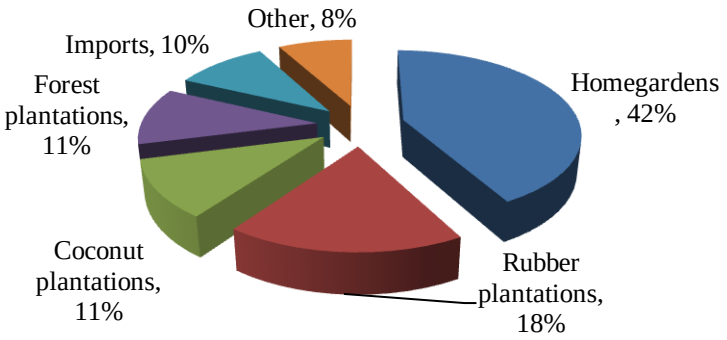


Figure 2: Contribution of wood supply of Sri Lanka by various sources.
Source: FD (2009).

In Sri Lanka, other than natural forests and forest plantations, genetic resources of forest trees are also managed outside natural forests. The presence of several systems in the agricultural

landscape will be an important place for conservation especially for *circ situm* conservation because it is reported that a number of trees in the forests are in a declining trend whereas the number of trees in farm lands are in increasing trend (World Agroforestry Centre, 2010). In this respect, homegardens, coconut based, tea based and rubber based agroforestry systems, and other agricultural landscapes play a dominant role (Ariyadasa, 2002; FSMP, 1995; Pushpakumara *et al*., 2010; 2011). These trees outside the natural forests have contributed substantially in terms of products and services and are now the major sources of timber and fuelwood (Figures 2 and 3). About 70% of the supply of construction and industrial wood comes from homegardens, rubber and coconut plantations, and trees planted along boundaries, on roadsides and urban areas indicating the importance of management of Forest Genetic Resources (FGRs) in trees outside forests in Sri Lanka (Figures 2 and 3; FSMP, 1995).

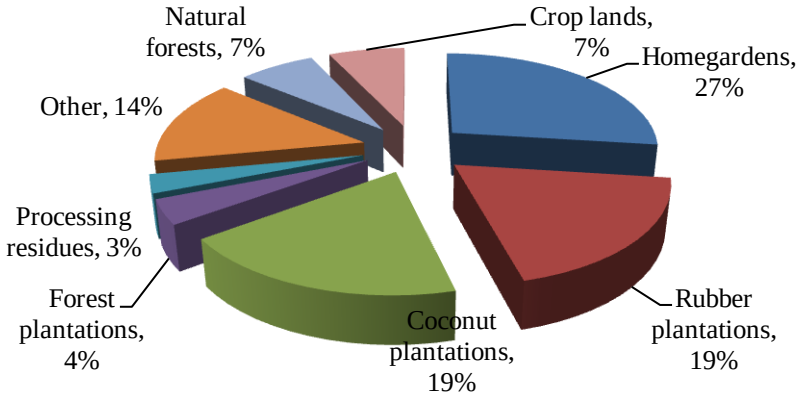


Figure 3: Contribution of fuelwood supply of Sri Lanka by various sources.
Source: FD (2009).

This is important because the sawn wood demand from 1993 to 2020 is projected to grow 12,600 cubic m/year, which corresponds to annual average growth rate of 2%. Similar trends are also projected for paper and paperboards, wood and non-wood forest products such as wooden poles and bamboo poles (Annex 3). Demand for fuelwood is also predicted to increase in the future (Annex 3), which is highest in the area of estate sector in the upcountry. All these indicate that in Sri Lanka, while conserving the remaining natural vegetations for biodiversity conservation and other environmental services, management of tree genetic resources outside forests is a priority for sustainability of the forestry sector. Because of the importance of trees outside forests, now there is a government policy even to expand and improve timber production and food production in areas outside forests such as homegardens (Mahinda Chintana, 2010).

However, this objective is somewhat hampered by fragmentation of homegardens and also logging ban imposed on some timber tree species those commonly grown in homegardens. This law needs to be revised if further expansion of timber production from homegardens and other sources outside forests are expected. Further, except Ariyadasa (2002) and Premakantha *et al*. (2008) systematic assessments of area of trees outside forests and their contribution on biodiversity and environmental conservation are hardly assessed in Sri Lanka despite the long history of preparing species inventories of homegardens. Availability of quality planting material for of timber trees of trees outside forests (except plantations managed by Forest Department) is generally poor. Thus, effective and efficient management of forest genetic resources outside forests must be a priority in achieving timber, firewood and other environmental services and food security and livelihood improvement programmes in Sri Lanka.

Organization and Management of Forestry Sector

At present, Ministry of Environment (ME) and Ministry of Agrarian Services and Wildlife (MASWL) are the two main ministries, which are responsible for policy planning, implementation, monitoring and resource mobilization related to state Forest Department (FD) and Department of Wildlife Conservation (DWLC), respectively. Both FD and DWLC are engaged in conservation and management of several categories of natural forests. Most forest plantations are managed according to working plans by FD. The other plantation forests are managed by state Janatha Estate Development Board and State Planation Cooperation and Regional Plantation Companies. State Timber Cooperation (STC) under the Ministry of Environment is responsible for harvesting of forest plantations of FD and other state timber resources and their handling. The FD releases selected plantations annually to the STC for felling or thinning operations. The Department of Sri Lanka Customs maintain statistics on import and export of wood and wood based products are classified according to the Harmonized System (HS 96) using standards codes based on declarations made by importers and exporters.

CHAPTER 1:

THE CURRENT STATUS OF FOREST GENETIC RESOURCES

Diversity of Ecosystem and Forest Ecosystems in Sri Lanka

Sri Lanka shows a marked diversity of terrestrial forest and related ecosystems, coastal and marine ecosystems, inland wetland ecosystems and agricultural ecosystems due to influencees by both natural (spatial distribution of rainfall, altitude and soil) and anthropogenic features (Table 1.1). The terrestrial forest and related ecosystems that contain much of the biodiversity of Sri Lanka range from lowland, sub-montane and montane rainforests in the wet zone, to moist evergreen forests of the intermediate one, dry mixed evergreen forests of the dry zone. The island also contains several types of grasslands in the wet and dry areas, at low to high elevations. There are ample wetlands associated with over a hundred major rivers that originate from the central mountains, and although there are no inland lakes, several thousand irrigation tanks and reservoirs dot the island. Together they provide habitats for a unique freshwater wetland fauna and flora, with a large complement of endemics. Being an island, Sri Lanka has a multitude of marine and coastal ecosystems, featuring several types of reefs, bays and lagoons, sandy beaches, mangrove habitats and coastal marshes. Considerable biodiversity exists in human modified habitats such as homegardens, agricultural lands, plantations, and even in built-up areas such as roadsides and urban environments (MFE, 1999; MENR, 2006; 2009, MENR and IUCN, 2007).

Table 1.1: Ecosystem Diversity in Sri Lanka

Ecosystems	Extent (ha)
Forest and related ecosystems (see Table 1.2 below)	
• tropical wet lowland evergreen forest (include lowland and mid elevation rain forest)	124,340.8
• tropical moist evergreen (monsoon) forest	221,977.0
• tropical dry mixed evergreen (monsoon) forest	1,027,544.1
• riverine dry forest	18,352.1
• tropical sub montane forest	65,792.3
• tropical montane forest	3,099.5
• grasslands (wet patana, dry patana, savannah)	>75,000
Inland wetland ecosystems	
• flood plains	na
• swamps	na
• lentic waters (tanks, reservoirs and ponds)	169,941
• river basins	5,924,500
• wet villu grasslands	12,500
Coastal and marine ecosystems	
• mangroves	6,080
• salt marshes	23,819
• sand dunes and beaches	19,394
• mud flats	9,754
• sea grass beds	na
• lagoons and basin estuaries	129,075
• coral reefs	68,000
Agricultural ecosystems	

• paddy lands	525,000
• fruit cultivations	97,000
• small crop holdings or other field crops (pulses, sesame etc)	128,000
• vegetables (including, root and tuber crops)	110,000
• crop plantations	772,000
• homegardens	367,800

Sources: CCD (2006); MENR (2003; 2009); Manchanayake and Maddumabandara (1999); IUCN and CEA (2006); CBSL (2010); DCS (2010).

Forest ecosystems of Sri Lanka consist of tropical lowland rainforests, tropical sub montane forests, tropical montane forests, tropical moist monsoon forests, tropical dry monsoon (mixed evergreen) forests, mangroves, riverine dry forests, sparse forests and grasslands (wet and dry patna and savannah. Table 1.2 shows the extent of each major forest ecosystem types and their characteristics and main species whereas Map 1.1 illustrates the distribution of different forest ecosystems in the country. Detailed account of history of research and the use of forest genetic resources of Singharaja forest is given in Annex 4.

Table 1.2: Major forest type categories, their extent and main tree species.

Major forest types	Area covered by forest type (ha)		Distribution and main tree species for each type
	1992	1996	
Tropical lowland rainforests	141,549	124,340	Tropical lowland rainforests are restricted to the south west of the island. Dominant communities or species in this forest type are *Mesua-Doona-Shorea* (mid altitudes), and *Vitex-Dillenia(Wormia)-Chaetocarpus-Anisophyllea* (low altitudes). Canopy is usually dominated by two species of *Dipterocarpus* (in low and mid altitudes), *Mesua* and *Shorea* species. Major subcanopy species are *Cullenia* and *Myristica* whilst understorey is from largely *Xylopia* and *Garcinia*. Most commonly occurring species in the lowland forests are *Vitex pinnata, Palaqium petiolare, Artocarpus nobilis, Dipterocarpus zeylanicus, Shorea sp., Syzygium makul, Dellinia retusa, Annisophyllea cinnamonoides, Cheatocarpus castanocarpus, Dillenia triquetra, Mangifera zeylanica, Myristica dactyloides* (FSMP, 1995). In these forests, 60–75% of tree species are endemic.
Tropical sub montane forests	68,838	65,792	Tropical sub montane forests are mainly confined to middle elevations of the hill ranges. *Shorea, Calophyllum, Cryptocarya, Myristica* and *Syzygium* species are dominate in these forests. The endemic genus *Stemonoporus* shows a much localized distribution. The endemism of tree species is about 50%.
Tropical montane forests	3,108	3,099	Tropical montane forests are restricted to the uppermost elevations and dominated by *Calophyllum, Syzygium, Symplocos, Neolitsea, Cinnamomum, Litsea* and *Actinodaphne*. Understorey dominated by *Strobilanthes* and *Coleus*. About 50% of the species are endemic.
Tropical moist monsoon forests	243,877	221,977	Tropical moist evergreen forests represent an ecotone between the aseasonal and seasonal forests. Forests are dominated by *Mangifera, Canarium, Filicium,*

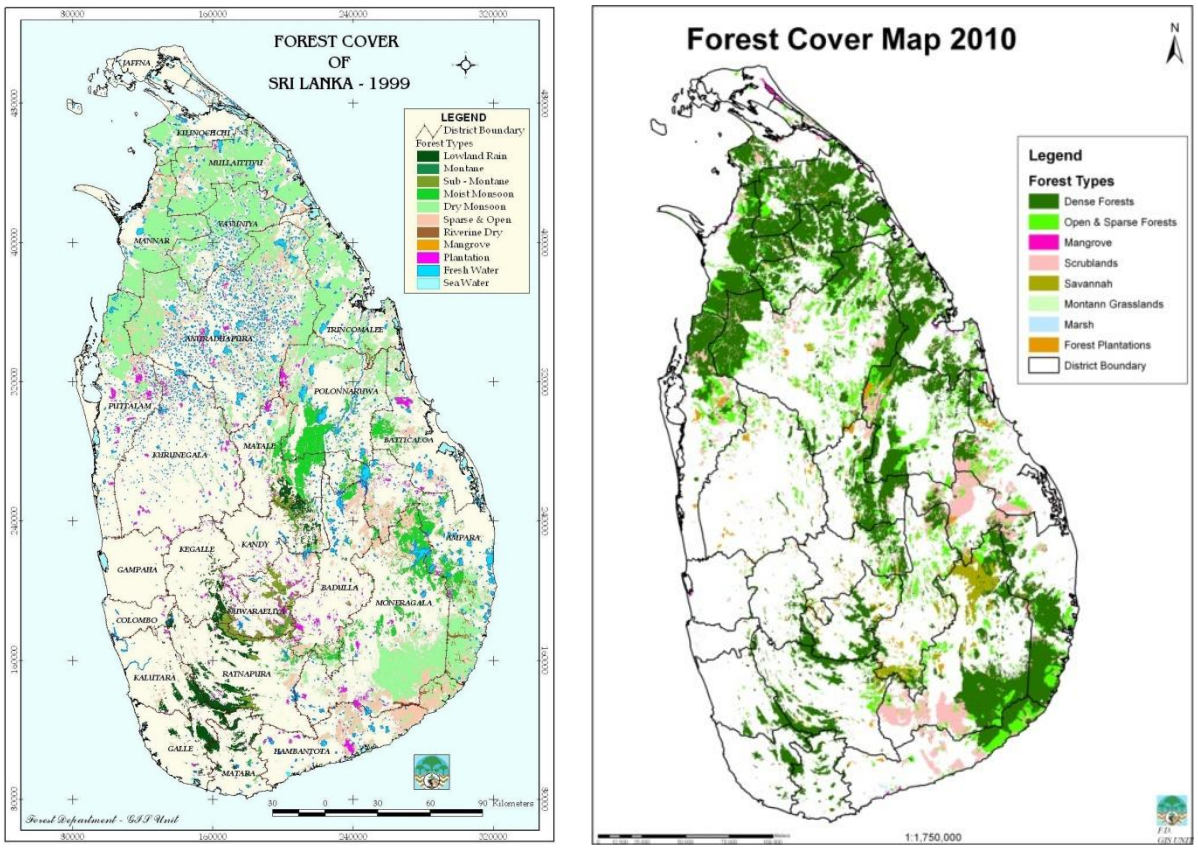
			Euphorbia, Nothopegia and *Gironniera* species in the system. Only about 17%t of the tree species in these forests are endemic. Frequent anthropogenic fires in these areas have given way to parkland-like savannas with fire-tolerant medicinal tree species dominated by *Careya, Phyllanthus* and *Terminalia*. Most commonly occurring 10 species in the dry monsoon forests are *Chloroxylon swietenia, Vitex pinnata, Pterocarpus canescens, Syzygium gardneri, Grewia damine, Drypetes sepiaria, Euphoria longana, Tetrameles nudiflora, Macaranga peltata* (FSMP, 1995).
Tropical dry monsoon (mixed evergreen) forests	1,094,287	1,027,544	Tropical dry monsoon (mixed evergreen) forests are distributed in the country's dry zone in the north, eastern, north central and southern provinces. It is the most widespread of all the forest types in the island. Dominant canopy species here are *Manilkara, Chloroxylon, Schleichera,* and *Pleurostylia* and in the understorey tree layer they are *Pterospermum, Drypetes* and *Dimorphocalyx*. Significant proportion of this flora is similar to that of India and only about 13% of the tree species in these forests are endemic. Most commonly occurring 12 species in the dry monsoon forests are *Diospyros quaesita, Chloroxylon swietenia, Vitex pinnata, Pterospermum canescens, Manilkara hexandra, Bridelia retusa, Diospyros sp., Grewia damine, Careya arborea, Drypetes sepiaria* (FSMP, 1995).
Mangroves	8,687	9,530	Mangroves are dominated by species of *Rhizophora, Ceriops, Bruguiera, Lumnitzera* and *Avicennia*.
Riverine dry forests	22,411	18,352	Dominated by *Terminalia arjuna* and *Barringtonia* sp.
Sparse and open forests		> 75,000	Dominated by *Phyllanthus emblica, Terminalia chebula, T. belerica, Diospyros melanoxylon*

Source: FD (2009); FRA (2010); FSMP (1995).

Plant Species in Sri Lanka: Diversity and Endemism

The high ecosystem diversity in the island has given rise to a large number of indigenous species, including a remarkably high percentage of endemics among both flora and fauna. Not surprisingly, Sri Lanka is identified as the biodiversity richest per unit area in the Asian region with regard to mammals, reptiles, amphibians, fish and flowering plants, and is only second to Malaysia and Taiwan with regard to the density of bird and pteridophyte species per unit area, respectively (MFE, 1999; Ranil *et al*., 2008). Much of the endemic species of Sri Lanka are concentrated in the rainforests of the wet zone, which are heavily dependent on rainfall and humidity to maintain their structure and function. A unique feature is that Sri Lanka has many endemic rainforest species among both plants and animals that are point endemics restricted to extremely small areas within a single forest. Further, the various geo-evolutionary and geological processes in Sri Lanka, coupled with spatial variations in climate and topography, have also promoted isolation of species resulting in a large number of geographically relict species. Further, due to a long history of agriculture, Sri Lanka has a wide range of agricultural systems and cultivated species. In addition, there are also many wild relatives of crops that occur in forests and other wild habitats that can contribute positively to national and global food security (IUCN and MENR, 2007; MFE, 1999; MENR, 2009). Species richness and endemism of different groups of flora of Sri Lanka is given in

Table 1.3. Sri Lanka has over 3,771 angiosperms (Table 1.3) from 214 families and 1,522 genera, of which more than 28% are endemic to the country (Seneratne, 2001; Figure 1.2). The extraordinary endemicity occurring mainly at specific and intra-specific levels makes the Sri Lankan flora of outstanding interest (Ashton and Gunatilleke, 1987). Further, Sri Lanka is unique because though the country is small it represents many orders and families recorded in the world (Table 1.4).



Map 1.1: Map of Sri Lanka showing the forest cover in different districts in 1999 (left) and 2010 (right). Source: FD (2000; 2012).

All 58 species of *Dipterocarpus* in Sri Lanka, which form the dominant structural and floristic component in wet zone rainforests, are endemic; with 26 species of *Stemonoporus* occurring throughout the full elevation range of the wet zone (MENR, 2008). These *Dipterocarps* also share a common Gondwanic ancestry with Sarcolaenaceae, which is now endemic to Madagascar (MENR, 2008). The wet zone rainforests harbor nearly all the country's woody endemic flora and all the endemic genera (MFE, 1999). The level of endemism in wet zone forests ranges from 37-64% for woody plants and 14-52% for animals, compared with 10-16% for species in the dry zone forests (MFE, 1999). Annex 5 provides a list of endemic plant species in Sri Lanka based on Bandaranaike and Sultanbawa (1991), Ashton *et al*. (1997) and Senaratne (2001).

Genetic diversity is relatively well known among only agricultural crops, which show a range of varieties and landraces, particularly among grains, cereals, vegetables and root, and tuber crops. Some of them show marked adaptations to various climatic conditions. Several local crops varieties are also resistant to pests and disease, and in the case of some traditional varieties of rice, to adverse climatic conditions such as droughts, high soil salinity, and

submergence. In contrast, except for a few species, genetic diversity among wild species and forest trees is little known. However, a substantial genetic diversity is inferred in forest genetic resources from the variations in morphological features that are seen and also due to out-breeding and long-lived nature of tropical tree flora (Gunatilleke, 1999).

Table 1.3: Species richness, and endemism of various plant groups in Sri Lanka.

Plant group	Number of species	Number of endemics	Sources
Angiosperms (flowering plants)	3,771	927 (28.3%)	Dassanayake and Clayton (1995-2000); Dassanayake and Fosberg (1980-1991); Dassanayake *et al*. (1994); Senarathne (2001)
Gymnosperms	1	-	
Pteridophytes (ferns)	350	48+	Sledge (1982); Shaffer-Fehre, (2006), Ranil *et al*. (2011)
Mosses	566	63+	O'Shea (2002; 2003); Tan (2005)
Algae	896		MFE (1994)
Fungi	1,920		MFE (1994)
Liverworts	303		Abeywickrama and Jensen (1978); MENR (2006)
Lichens	661		MENR (2006)

Table 1.4: Taxic diversity and occurrences of selected plant orders and families in Sri Lanka.

Sub class	**No of Orders in the world**	**No of Orders in Sri Lanka**	**%**	**No of Families in the world**	**No of Families in Sri Lanka**	**%**
Magnoliidae	8	8	100	38	18	47
Hamamelidae	11	2	18	24	4	17
Caryophyllidae	3	3	100	14	12	86
Dilleniidae	13	10	77	78	34	44
Rosidae	18	17	94	112	57	51
Asteridae	11	10	91	47	30	64
Alismatidae	4	4	100	16	7	44
Arecidae	4	3	75	5	4	80
Commelinidae	7	6	86	16	8	50
Zingiberidae	2	2	100	8	5	63
Liliidae	2	2	100	19	10	53
Total	83	67	81	377	189	50

Source: Dr. S. Wijesundera (Personal Communication).

Trends in Forest Cover – Still on the Decline?

The forest cover in Sri Lanka declined drastically over the past century. Early forest inventories suggest that Sri Lanka's closed canopy forest cover declined from about 84% of the land area in 1881, to 44% in 1956 and to 27% in 1983 (FSMP, 1995). Closed canopy

forest cover declined further to 24% in 1992 and 22.4% in 1996 (Bandaratillake and Fernando, 2003). Bandaratillake and Fernando (2003) suggest that closed canopy forests declined by 42,000 ha per year on average from 1956 to 1992, and 17,000 ha per year from 1992 to 1999. However, the district-level analysis suggests that closed-canopy forest cover increased subsequent to this period but accuracy of this data is unclear. Natural forest cover overall declined by 26,095 ha per annum from 1992 to 1996, at a rate of 1.27%. Adding in plantations reduces the rate of decline to 1.1%. FRA (2010) provides the following estimations of forest cover for 1990 to 2010 based on best available information and expert consultations. These estimates indicate the trend in forest cover loss has considerably slowed down during the recent past but is still continuing and now increasing (Table 1.5; FRA, 2010; MENR, 2009). However, the data is based purely on extrapolation. Further, level of forest degradation is not clearly identifiable and addressed. Further, after liberation of north and east, such area is rapidly changing and forest cover assessment in such area will add value to the information. To obtain actual figures on forest cover trends over the last decade, the results of the nationwide forest cover assessment are being finalized by the Forest Department and needs analysis.

Table 1.5: Trends in total and closed canopy forest cover, reforestation and deforestation.

Year	Total forest cover (000 ha)	Closed canopy forest cover (000 ha)	Sparse forest (000 ha)	Area reforested (ha)	Extent deforested (ha)
2001	2,119	1,583	464	840	314
2002	1,942	1,471	464	661	511
2003	1,942	1,471	472	1,057	950
2004	1,942	1,471	472	805	442
2005	1,942	1,461	472	1,229	358
2006	2,035	1,458	472	1,848	173
2007	1,422	1,046	367	893	873
2008	1,422	1,046	367	732	744
2009	1,422	1,046	367	877	877
2010	1,934	1,501	417	873	Na

Source: CBSL (2010).

It is reported that forest encroachments and illegal felling have been largely eradiated in the biologically rich wet zone forests due to improved management, management as conservation forests, boundary marking of forest reserves and a move towards participatory conservation with the aid of local communities in some of these forests (MENR, 2009). Effective management measures are reflected in relatively lower loss of forests through encroachment between 2002-2007, and trends in deforestation. However, most of the natural forests and some of the forest plantations in the country have faced threats from the growing human population and their activities. These forests are gradually losing their quality in terms of species and stocking mainly due to illegal harvesting and clearing for agricultural activities. Considerable attempts are being made to protect, enrich and reforest those forest areas. The attempts made towards conservation of forest resources by the Forest Department include enactment of forest ordinance, revision of forest policies, imposing logging bans in natural forests, establishment of biosphere reserves and other protected areas, implementing programmes of reforestation and forest management, forest protection, forestry research, social forestry and environmental management. In the dry zone, damages caused by forest

fires and cattle and elephants are also significant. Fire lines are opened in fire-prone areas as a measure of protection, but there are occasions where the fire has spread during acute dry weather in spite of fire lines.

Despite adequate natural regeneration, mature trees of several valuable timber species such as satin wood and ebony are now very rare, due to selective removal. The nature and extent of forest resource use varies according to location and socio-economic level of the local communities. However, depletion of non-timber forest resources occurred in all climatic zones due to over exploitation of species of commercial or subsistence value. This demand for forest products such as wood for poles and posts, food items, resins, rattan and bamboo, biomass for fuelwood and medicinal plants was a major cause of forest degradation through to the 1990s. As a result, all ten species of rattans in the country, and several bamboo and medicinal plants of commercial value, are now nationally threatened (IUCN and MENR, 2007). Fuelwood collection has been particularly damaging to forests, due to debarking of trees to increase dead wood for collection, and this is continuing in some regions even now. Alien invasive species have been identified to reach threatening proportions in several natural forests, such as *Lantana* sp. at Uda Walawe National Park; *Ulex europeus* at Horton Plains National Park, *Prosopis julifolra* at the Bundala National Park and Myroxylon balsamum at Udawatta kele sanctuary (Munasinghe, 2005).

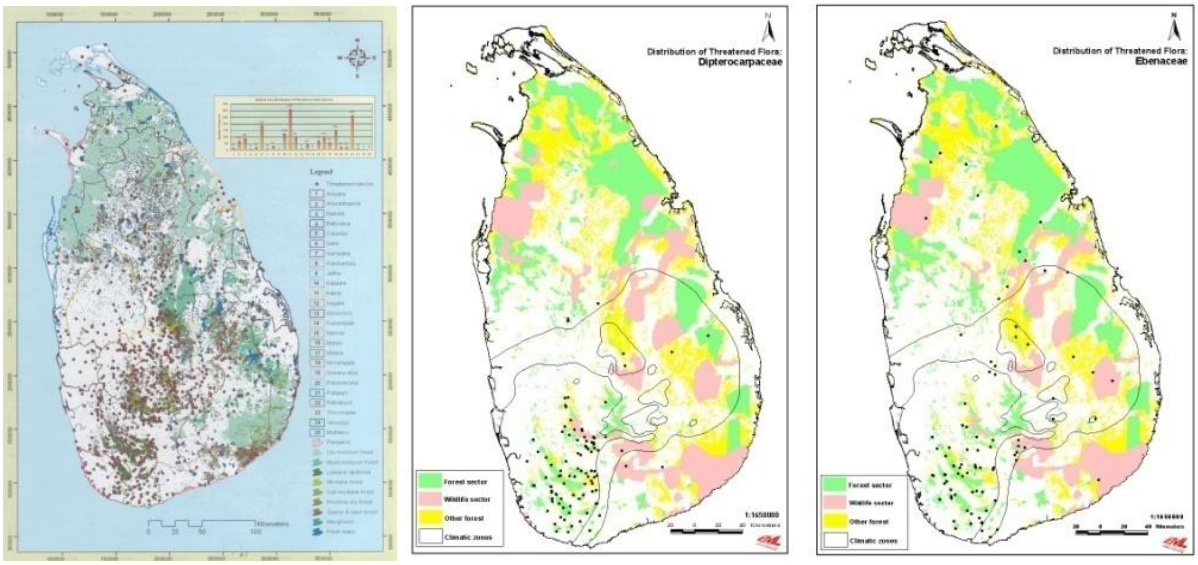
Plant Species of Sri Lanka: Threatened Status

Sri Lanka has been engaged in the preparation of the red list of threatened fauna and flora of the country since 1987 (Abeywickrama, 1987; Wijesinghe *et al*., 1993; IUCN, 2000; IUCN and MENR, 2007) and the first list of nationally threatened plants was compiled in 1987 (Abeywickrama, 1987). The list reproduced in 1989 was updated using data obtained from NCR in 1993 (Wijesinghe *et al*., 1993). However, the application of objectively and scientifically defined criteria was used only in the 1999 list of threatened fauna and flora of Sri Lanka (IUCN, 2000). In the recent national red listing exercise in 2007, the conservation status of about 1,099 species, which represent 35% of the angiosperm flora from 68 families, has been assessed. Of the total plant species evaluated, 72 species (6.5%) and 675 species (61%) are categorized as extinct and threatened species, respectively. Among the total threatened plant species, 412 species (61%) are endemic to the country. Among the extinct plant species, nearly 60% are endemic to the island. About 37% of threatened plant species are categorized as critically endangered (IUCN and MENR, 2007).

The family Orchidaceae had the highest number of threatened plant species (122 species) followed by Rubiaceae (99 species), Acanthaceae (51 species), Dipterocarpaceae (42 species) and Phyllanthaceae (31 species). These five families harbor more than 50% of the threatened species identified during this present study. As a plant family, the Dipterocarpacea in Sri Lanka are with a remarkable level of endemicity of 100%. Out of 58 species assessed, 42 species (72%) are categorized as threatened. This represents 6.5% of the threatened plants in the list, with one extinct species (IUCN and MENR, 2007). Most of the threatened Dipterocarps are also confined to the highly fragmented wet zone areas of the country (Map 1.3). *Diospyros* being the main genus of the family Ebenaceae with 32 species, of which 19 species are endemic while 23 species are threatened. Although the bulk of the species are distributed in the wet zone, some extend into the intermediate and dry zones (Map 1.4).

An analysis of the geographical distribution of flora in different administrative districts in the island revealed that districts in the lowland wet zone (Galle, Matara, Rathnapura, Kaluthara,

Kegalle) and the central highlands (Kandy, Matale, Nuwara Eliya, Badulla) harbor a higher number of threatened taxa (Table 1.6 and Map 1.2) (IUCN and MENR, 2007). Annex 6 provides the list of threatened plant species of Sri Lanka based on IUCN and MENR (2007). The list of species with data deficient in assessment of threatened status of plants based on IUCN and MENR (2007) is given in Annex 7. The IUCN global list of threatened species contains 280 plant species found within Sri Lanka. The National Species Conservation Advisory Group (NSCAG), the Biodiversity Secretariat of the Ministry of Environment and the Department of National Botanic Gardens are currently updating the 1999 red list.



Map 1.2: Distribution of threatened plant species in relation to forest cover and administrative districts. Source: IUCN and MENR (2007).

Map 1.3: Distribution of Dipterocarpaceae in Sri Lanka in relation to protected area network of the country. Source: MENR (2006).

Map 1.4: Distribution of Ebanaceae in Sri Lanka in relation to protected area Network of the country. Source: MENR (2006).

Table 1.6: Statistics on threatened plants, forest cover, population density and area of administrative districts of Sri Lanka.

District	Area (sq km)	Population density (per sq km)	Forest cover (%)	Threatened plants (number)
Ampara	4,318	143	37.5	15
Anuradhapura	7,034	111	35.0	68
Batticaloa	2,686	204	21.0	9
Hambantota	2,579	210	20.5	32
Jaffna	2,218	337	1.1	7
Kurunegala	4,813	311	5.0	44
Mannar	1,985	50	60.0	5
Moneragala	5,545	75	40.5	56
Mullativ	2,517	56	60.0	0
Polonnaruwa	3,224	117	38.0	26
Puttalam	3,013	245	25.0	21
Vavunia	1,967	74	51.0	1

Trincomalee	2,631	147	48.0	10
Badulla	2,803	294	19.0	90
Colombo	656	3,631	2.8	22
Galle	1,635	629	13.0	187
Gampaha	1,386	1,523	0.3	10
Kalutara	1,588	688	13.0	126
Kandy	1,906	704	17.0	310
Kegalle	1,693	468	9.5	98
Nuwara Eliya	1,720	423	24.5	150
Rathnapura	3,255	325	20	264
Sri Lanka	65,610	314	23.5	675

Source: IUCN and MENR, 2007.
Note: Districts in the wet zone and central highlands of Sri Lanka are highlighted.

Management of Species for Human Use

In Sri Lanka, forest genetic resources are not actively managed in natural forests for human use. In contrast, genetic resources of forest trees and other species are actively and largely managed for human use in systems outside natural forests (Table 1.7).

Table 1.7: Tree resource management systems in Sri Lanka outside natural forests.

System	Ownership(s)	Extent (ha)	Remarks
Forest Plantations	FD	76,469	Only the inventoried and mapped extent is given, the records give the total as 135,622 ha for 2000.
	DWLC	2,352	No timber harvesting is being undertaken.
	Village communities	9,771	Farmers woodlots established under the participatory forestry project (1993-2000)
	RPC/State	12,784	Tea, rubber and coconut estates leased to private sector by the government.
	JEDB/SLSPC	1,795	Government statutory bodies
	Others	6,000	Newly established private sector forest plantations
Home Gardens	Private family holdings	858,490	Stocking of utilizable timber trees varies considerable according to many factors such as agro-ecology, population density etc.
Rubber based agroforestry	RPC, JEDB/SLSPC and small holders	193,000	Timber often used as fuelwood, for furniture and as support material in the construction industry
Coconut based agroforestry	RPC, JEDB/SLSPC and small holders	300,700	Timber has gained importance as a material for roof construction
Orchards of horticultural crops	DOA, private	--	Mainly mango, cashew, rambutan, durian, jackfruit,
Other	Mostly small	45,300	Includes cinnamon, cocoa, coffee and

perennial croplands	holders		palmyra plantations mixed with timber trees
Roadside plantings	RDA	18,288 km	1,288 km complete with community participation under the participatory forestry project (1993-2000)

Sources: FD (2009), CBSL (2010).
Note: FD=Forest Department; DWLC=Department of Wildlife Conservation; RPC=Regional Plantation Companies; JEDB=Janataha Estate Development Board; SLSPC=Sri Lanka State Plantations Cooperation; RDA=Road Development Authority.

Monoculture Forest Plantations

The country is actively managed mainly exotic forest tree species. They are *Tectona grandis, Pinus* species (*P. caribaea* and *P. patula*), *Eucalyptus* species (mainly *E. grandis, E. microcorys, E. camaldulensis, E. tereticornis, E. globulus*), *Kayha senagalensis, Swietenia macrophylla, Artocarpus heterophyllus* and *Gliricidia sepium.* These tree species are mainly used for production of timber and fulewood along with other environmental services. Table 1.8 shows the major forest plantation species in Sri Lanka and their extent in 2009 whereas Table 1.10 shows major uses and system of management. Based on ownership and establishment methods, forest plantations in Sri Lanka can be categorized into several groups, namely plantations owned by Forest Department, Department of Wildlife Conservation, Communities (community forests), two state owned plantation crop organizations (Janatha Estate Development Board (JEDB) and Sri Lanka State Plantation Corporation (SLSPC), and privately owned Regional Plantation Companies.

Table 1.8: Major plantation forest species and their extent in 2009.

Species of Forest Plantation	**Extent (ha)**	**Area (%)**
Tectona grandis	26,333	32.9
Eucalyptus sp.	22,268	27.9
Pinus sp.	9,954	12.5
Swietenia sp.	5,505	6.9
Khaya senagalensis	1,765	2.2
Others	14,116	17.6
Total	**79,941**	**100.0**

Source: FD (2009).

The total extent of forest plantations currently inventoried mapped and managed by the FD amounts to 79,941 ha which has not changed rapidly during the last decade. The major species comprise *Tectona grandis*, Eucalyptus (*Eucalyptus grandis, E. microcorys* and others), *Swietenia macrophylla, Khaya senagalensis* and tropical pines (mainly *Pinus caribaea*). The participatory Forestry Project, implemented by the FD between 1993 and 2000 with the assistance of the Asian Development Bank, has established farmers' woodlots (Community forests) in difference parts of the country totaling 9,771 ha. The majority of trees planted were teak with an area of 3,398 ha being planted in total. The extent of forest plantations owned by DWLC has been estimated as 2,352 ha. Although the FD established the plantations, they ended up within wildlife reserves as a result of boundary realignment or declaration of new wildlife conservation areas. Considering the environmental and wildlife

management criteria, the plantations, most of which are teak, are not being harvested at present.

Tea, Rubber, Coconut Export Agriculture Crop Based Agroforestry

Sri Lanka also has a well-developed export oriented plantation crop industries, comprising tea, rubber, coconut and export agricultural crops. Trees are grown in association with these crops, especially on tea estates in the central highlands and the south west of the country. The stock on tea consists mainly of eucalyptus species (*Eucalyptus grandis, E. microcorys*) although *Grevillea robusta, Gliricidia sepium* and *Albizia* sp. are also planted as common shade trees. Tea planters started planting eucalyptus as fuel crops in the 19th century and the estates use the timber as fuel for processing of tea leaves and for domestic construction work. Timber is also sold to third parties through special arrangements with the government. On rubber and coconut plantations in lowland areas, valuable timber species such as teak and mahogany are commonly planted for commercial purposes.

Forest plantations in the plantation crop sector either are managed by one of two state owned organizations, the Janatha Estate Development Board (JEDB) and the Sri Lanka State Plantations Corporation (SLSPC), or are leased by theses organizations to Regional Plantation Companies. The JEDB and the SLSPC manage tea plantations amounting to 10,703 ha and 13,345 ha, respectively. The JEDB manages 17 estates with 755.6 ha of planted forests and the SLSPC have 1,039 ha of forest plantation. Both enterprises are currently engaged in commercial forestry activities, which mainly comprise harvesting and selling mature tree (mainly eucalyptus). Most timber extraction is contracted to privately owned enterprises rather than the STC. During the recent restructuring of estates owned by the two aforementioned organizations, nearly 400 tea, rubber and coconut estates were leased to 23 privately owned Regional Plantation Companies. The total extent of leased plantation cropland amounts to 340,000 ha. Although an estimate of the extent of forest plantations on these lands has been made (12,784 ha) the exact figure is not known. Timber is also extracted from other sources such as perennial croplands other than tea, rubber and coconut. These include lands planted with coffee, cinnamon and cocoa. Total area of these croplands has been estimated as 45,300 ha with a production potential of 0.69 m^3 of sawlogs and 0.48 m^3 poles per hectare per year (FSMP, 1995).

Private Sector Forest Plantations

Sri Lanka does not have a large area of private forests or private forest plantations. However, as per the National Forestry Policy (FSMP, 1995), the government of Sri Lanka planned to establish large areas of new forest plantations with the private sector involvement to meet increased timber demand. The government has since been awarding long-term land leases to the private sector to establish commercial forest plantations and aims to provide adequate policy, legislative and financial support. So far, several such agreements have been signed between the Forest Department and private sector investors (including foreign investors) to develop commercial scale plantations. At present, the extent of such establishments is small but it is emerging as an important business venture.

One model of private sector involvement is planting fast-growing species such as Eucalyptus and Acacia for timber and fuelwood in barren and abandoned lands in tea and rubber estates. The companies raise their own funds. Another model is a private company planting of timber species such as Teak, Mahogany, Agarwood and Sandalwood. The public can invest in these

plantations and the company manages the trees on their behalf until harvest, which is usually 20 or more years after which they derive income from timber sales. Examples of companies adopting this model are Touchwood Investments, Sadaharitha Plantations Limited and Help Green. Touchwood Investments has about 1,400 ha of plantations of seven species including Mahogany, Bamboo, Agarwood, Sandalwood whereas Sadaharitha Plantations has over 405 ha of Teak and 30 ha of Sandalwood at present and plans to establish 80 ha of Teak and 80 ha of Sandalwood per year over the next 10 years. Help Green had established 1,909 ha of Teak plantations in the dry zone of Sri Lanka but currently is not functioning.

The precise area in private sector plantations and in different models, species and investment sources is unknown at present. The private sector indicated that their plantation operations were constrained by lack of suitable land (sizeable areas for cost-effective operation), unclear land titles and complicated tax regulations.

Table 1.9: Plantation forest species currently used in Sri Lanka.

Species (Scientific name)	Native (N) or exotic (E)	Current uses	If managed, type of management system	Area managed if known (ha)
Tectona grandis	E	Wood products agroforestry	PL, AF,	33,000+
Pinus caribaea and *P. patula**	E	Wood products	PL	18,400+
Eucalyptus sp. (mainly *E. grandis* and some *E. microcorys, E. camaldulensis, E. teriticornis*)	E	Wood products	PL, AF	11,900+
Switenia macrophylla	E	Wood products	PL, AF	3,200+
Artocarpus heterophyllus	E	Wood, fodder, food, energy, agroforestry	PL, AF	Nk
Gliricidia sepium	E	Energy, agroforestry,	PL, AF	Nk

Notes: * Currently not used as a plantation species. PL=Plantation; AF=Agroforestry systems. nk=not known.

Homegardens

Homegardens of varied sorts are found all over the country providing economic, environmental and aesthetic benefits to their owners and to the community at large. They are also cultural markers of indigenous knowledge that have spread through time and space. Several studies have identified homegardens as an important source of timber (over 70% of the country's supply of construction and industrial wood) and fuelwood in the country (Ariyadasa, 2002; FSMP, 1995; Pushpakumara *et al*., 2010) and in 1995 homegardens produced 551,000 m^3 of saw logs nationally. This is considerably higher than the total quantity of sawlogs produced by State Timber Coperation (STC) in 2001 (109,032 m^3) and in upcountry areas, medium size saw mills are heavily reliant on timber from homegardens. In recent years, there has been an increasing trend of timber tree planting in homegardens and it

has been estimated that during the next 15 years, total annual production of timber from homegardens will be 1.2 million m^3 (FSMP, 1995). The extent of homegardens increased from 918,000 ha in 1995 to 977,700 in 2005 at a rate of 1% per annum (FSMP, 1995).

Roadside Plantations

Tree planting by main roads is a common sight in Sri Lanka and the FSMP (1995) has qualified 2.5 trees per kilometer of road. The total length of roads planted with trees is about 17,000 km (FSMP, 1995). In addition, the Participatory Forestry Project (1993-2000) assisted in establishing 1,288 km of roadside tree plantings, the survival of which varied according to agro-ecological zones. Trees are occasionally felled at maturity, for safety reasons or for development work. STC is normally responsible for felling of timber trees.

Assessment of Genetic Variation of Plantation Species

Provenance variations of exotic *Eucalyptus* species (*E. grandis, E. microcorys, E. cloeziana, E. urophylla, E. camaldulensis*) have been tested under Sri Lankan conditions for a long time, and significant variation have been reported (Bandara, 2006; Bandara, 1999; Bandara, 1998; Tilakaratne and Dayananda, 1994; Connelly, 1990; Phillips and Weerawardane 1991a; 19 Weerawardena and Phillips, 1991). Further, the genetic variation of growth and wood traits among families of *E. grandis* that have been tested in the higher elevations of the country reveals higher genetic variation within the *E. grandis* breeding population (Bandara, 1999; Bandara, 2006). Genetic evaluations of Sri Lankan *Tectona grandis* germplasm (Bandara, 2007) and *Khaya senagalensis* (23 introduced provenances from Western Africa) are in progress under the Forest Departmental tree improvement programmes.

Seed requirement of the plantations established by Forest Department is mainly met by the Forest Department documented seed sources (progeny tested/untested seed orchards and seed stands). Forest Department required approximately 5,000 kg, 5 kg and 100 kg of *Tectona grandis, Eucalyptus* species and *Khaya senagalensis* seeds for its annual planting programmes. However, the magnitude of the forest seed requirement of the country for all tree planting sectors (including homegardens and private plantation sectors etc) should be very high but no records are available. The seeds for the agroforestry sector of the country are mainly met by the unimproved seed sources.

For plantation forestry species, such as *Tectona grandis, E. grandis* and some *E. microcorys* identification of seed stands, plus trees and establishment of seed orchards and assessment of variation of species based on growth and morphological characters are practised by the Forest Department.

Though the genetic variations (at provenance and progeny level) have been tested for the main commercial exotic tree species, very limited studies have been conducted on the genetic variation/genetic characterization on the potentially important tree species for timber and fuel wood in the country (Table 1.10) which is of immediate importance to the country. Similarly, genetic characterization of threatened and endemic species (see Annexs 5 and 6) have also not been investigated.

Only recently, assessment of genetic variation of woody timber and fruit tree species have been started for *Artocarpus heterophyllus, Phyllanthus emblica* (Pushpakumara and Harris, 2007), natural forest species in the lowland rainforest such as *Shorea* sp. and *Stemnoporous*

sp. (Murawski *et al*., 1994a; 1994b; 1994c) and selected tropical dry monsoon forest (Dhammika Perera, Personal Communication). Due to lack of such information, species level conservation strategies/programmes have not been developed in the country. Lack of expertise, lack of facilities and funds hindered generating within species genetic information. Except for *Cinnamomum capparu-kurundo*, there are no species management programmes under the natural forests. However, based on the National Species Conservation Advisory Group's (NSCAG) recommendations, Species Conservation Profiles have been developed for all threatened flora of Sri Lanka. Annex 8 provides an example of Species Conservation Profile prepared. Hence, in Sri Lanka assessment of genetic variation of timber trees using molecular markers is an immediate priority research area for future tree improvement programmes.

Priority Tree Species

Prioritized plantation species are given in Table 1.10. No formal priority setting process has been carried out for natural forest or homegarden agroforestry species. Homegarden species can be prioritized based on the frequency of occurrence and imporatance to timber production and included in the Table 1.10. Natural forest species can be prioritized based on species at the level of emergent or canopy layers, endemism and threatened status. Accordingly, all threatened, endemic emergent and canopy species of all forest types can be listed as priority tree species under natural forest category.

Table 1.10: Priority species for timber and fuel wood production in Sri Lanka.

Site quality and priority	Tree or Other	Native or Exotic	Priority
Priority 1			
High quality sites			
Tectona grandis	T	E	1
Khaya senagalensis	T	E	1
Berrya cordifolia	T	E	
Azadirachta indica	T	E	
Swetinea macrophylla	T	E	1
Gravel low quality sites			
Eucalyptus teriticornis	T	E	1
Acacia auriculiformis	T	E	
Holoptelea intregrifolia	T	E	
Inundation sites			
Meduca longifolia	T	E	
Priority 2			
Native species			
Chukrasia tabularis	T	N	2
Pterocarpus marsupium	T	N	2
Mila dubia	T	N	2
Adina cordifolia	T	N	2
Bredelia retiusa	T	N	2
Vitex pinnata	T	N	2
Schleichera oleosa	T	N	2
Pterocarpuscanescens	T	N	2

Albizia odoratissima	T	N	2
Bauhinia resimosa	T	N	2
Samania saman	T	N	2
Calamus rotang	V	N	2
Exotic species			
Swetenia mahogany	T	E	2
Artocarpus heterophylla			
Dalbergia sisso	T	E	2
Acacia crassicarpa	T	E	2
Acacia mangium	T	E	2
Eucalyptus cloeziana	T	E	2
Eucalyptus urophylla	T	E	2
Eucalyptus camaldulensis	T	E	2
Eucalyptus pellita	T	E	2
Pinus caribaea var hondurensis	T	E	2
Pinus caribaea var caribaea	T	E	2
Pinus tecumanii	T	E	2
Pinus oocarpa	T	E	2
Up country			
Eucalyptus grandis	T	E	1
Eucalyptus microcorys	T	E	1
Eucalyptus cloeziana	T	E	2
E. urophylla	T	E	2
E. toraliana	T	E	2
E. piliularis	T	E	2
Michelia champaka	T	E	2
Albizia molucana	T	E	2
Gravellia rubusta	T	E	3
Acacia melanoxylon			

Source: REFORGEN; http://foris.fao.org/reforgen/byCountry.jsp?g=37&t=-

CHAPTER 2:
THE STATE OF *IN SITU* GENETIC CONSERVATION

National Conservation Review (NCR)

National Conservation Review (NCR) was carried out by FD with technical assistance from IUCN which constituted a systematic assessment of biodiversity in the natural forests of the country with overriding objective of defining a national system of protected areas in which watersheds important for soil conservation and hydrology are protected and forest biodiversity is fully represented while maintaining the cultural economic and social needs of the country (MENR, 2006; 2009). The review covered a total of 281 (including 204 legally designated forests and other state forests of 200 ha or more) natural forests in the country except in northern and eastern provinces. A total of 1,725 plots (100 m x 5 m) have been inventoried for woody plants, vertebrates, mollusks and butterflies along 310 gradient-directed transects in 204 forests. Forests were assessed, using existing data, with respect to their importance for soil and water conservation, e.g. soil erosion, headwaters protection, flood hazard and fog interception at higher altitudes. The results of the NCR clearly demonstrates the importance of Sri Lanka's natural forests, both in terms of their role in maintaining ecosystem stability and functions and as a reservoir of high biodiversity. The NCR survey resulted in the compilation of 70,548 records of plants of which 69,405 are identified as forest plants. These records were represented by 1,195 plant species of which 1,153 are identified as forest woody plant species and 455 are identified as endemic woody plant species (MENR, 2006). Despite some limitations, the NCR is among the most detailed, comprehensive and innovative evaluation of its kind carried out in the country (IUCN and WCMC 1997).

Present Status of Protected Area (PA) Network

In Sri Lanka, Forest Department (FD) and Department of Wildlife Conservation (DWLC) are primarily responsible for the conservation of biodiversity. Central Environmental Authority (CEA), departments dealing with Archeology, Fisheries and Coast Conservation, Urban Development Authority, Agriculture Department, Mahaweli Authority, Town Councils and Tourist Board, Divisional Secretaries and local authorities play a supplementary role for *in situ* conservation of forest biodiversity. Whenever the *in situ* conservation option is practised, the protected area (PA) concept becomes important. *In situ* conservation of forest biodiversity is carried out through the establishment of legally designated protected areas representative of high biodiversity.

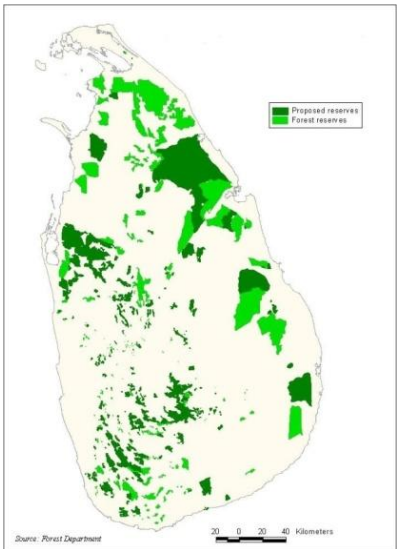
It is significant that over 26% of the total land area of Sri Lanka is reserved and administrated by FD and DWLC. FT manages 11.5% of natural habitats in the form of National heritage and wilderness area, international biosphere reserve, conservation forests and reserved forests whereas DWLC manages 14.8% natural habitats in the form of jungle corridors, national parks, nature reserves, sanctuary, strict nature reserve. Table 2.1 illustrates the details of extent, ownership and designation of PAs whereas Maps 2.1 and 2.2 illustrate the distribution of protected area network in Sri Lanka based on the ownership. A new category of protected areas is administrated by the Central Environmental Authority (CEA) termed Environmental Protection Areas (EPA) gazette under the provisions of the National Environmental Act. There are currently eight EPAs and two more are proposed (MENR, 2009; Padmalal *et al*., 2006). More than 60% of closed canopy natural forest, or 55% of all natural forests, lie within the PAs of these two departments (Table 2.2) (IUCN and WCMC, 1997). None of

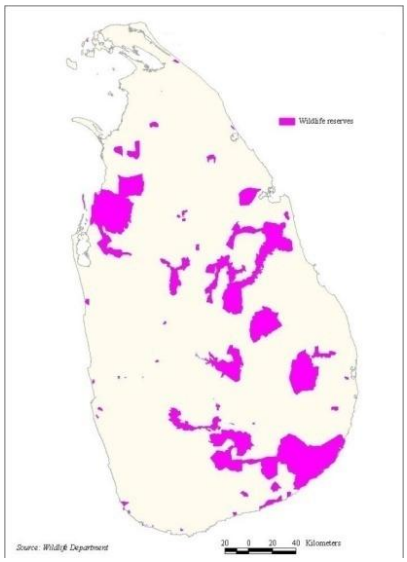
these PAs exclusively made aiming conservation of FGRs but such PA network helps to conserve FGRs. Much of Sri Lanka's endemic and indigenous species exists in the PAs but except for a few species, their distribution and population sizes are little known.

Table 2.1: Extent and type of protected areas administrated by two state departments.

Ownership and national designation of reserves	Number	Area (ha)
Reserves under the Forest Department (FD)		
National heritage and wilderness area (also a world heritage area)	1	11,127
International biosphere reserves	3	42,768
Conservation forests including 20 mangroves area	53	91,859
Reserved forests		612,396
Sub total	***57***	***758,150***
Reserves under the Department of Wildlife Conservation (DWLC)		
Jungle corridors (Kaudulla-Minneriya)	1	8,777
National parks	20	526,156
Nature reserves	5	57,059
Sanctuary	61	349,105
Strict natural reserve	3	31,575
Sub total	***90***	***972,669***

Source: ME (2010).





Maps 2.1: Distribution of protected area network of Sri Lanka under Forest Department. Sources: MENR (2006; 2009); MENR and UNEP (2009).
Maps 2.2: Distribution of protected area network of Sri Lanka under Department of Wildlife Conservation. Sources: MENR (2006; 2009); MENR and UNEP (2009).

Threats to *In Situ* Conservation Area

The biodiversity (also FGRs) of Sri Lanka, however, continues to experience multiple threats such as loss of populations, loss of habitats, encroachment, unplanned development, pollution and over collection (Padmalal *et al*., 2006), hence categorized as one of 35 biodiversity hotspots in the world due to high diversity and endemism and threats to habitats (Mittermeier

et al., 2004). Much of the biodiversity lies within Sri Lanka's tropical rainforests located in 3.1% of the island's land area where forest cover represented about 9.5%. Such forests area are heavily fragmented. Further, only about 18% of total protected area falls within the biologically rich wet zone (Padmalal *et al*., 2006). Thus, it is clear that though Sri Lanka has an extensive PA network, critical gaps exist in the context of biodiversity conservation, (for example some PA network does not adequately represent floristically rich wet zone areas of the country. Another threats to *in situ* conservation areas is the shift in the boundaries of major climatic zones due to climate change on the premise that the dry zone will spread into the intermediate zone, and the later will spread into the wet zone (ME, 2010). ME (2010) suggests that monatane wet zone forests, several lowland forests and reserves and national parks in the intermediate zone could be affected. Further, several districts are highly vulnerable to natural disasters such as floods and landslides.

Table 2.2: Percentage of each forest type in protected areas of Sri Lanka.

Forest type	**Extent in forest reserves or PAs (%)**
Lowland rainforest	51
Moist monsoon forest	53
Dry monsoon	63
Sub montane	65
Montane	85
Sub total of closed canopy forests	***61***
Mangrove	8
Dry reverine	79
Open sparse	37
Total natural forests	**55**

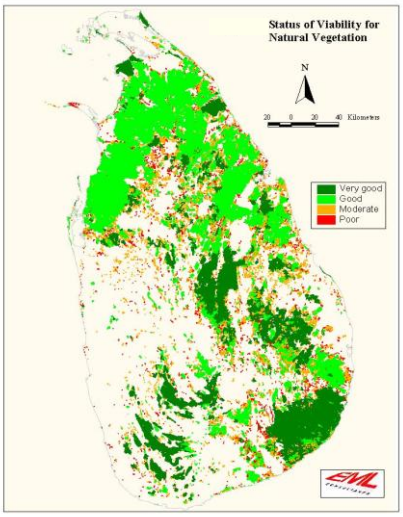
Source: FSMP (1995)

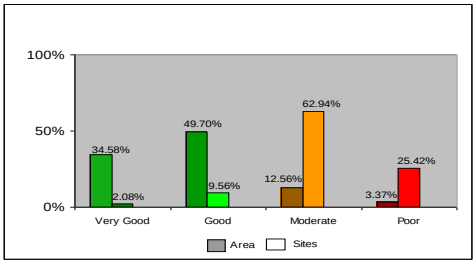
Further, though the protected area network of Sri Lanka consists of 26%, assessment of the viability of natural vegetation in Sri Lanka through the 'GAP analysis' of the existing protected area network showed that a considerable percentage of forests in the island are of the condition categories of moderate or poor (Map 2.3; Figure 2.1). The viability status of different forest categories are also in the same trend as given in Annex 9 (MENR, 2006).

In trees, as with other plants, mating patterns vary depending on the attributes of a particular species' reproductive biology and spatial structure, which combine to influence the levels and dynamics of genetic diversity. Consequently achievement of both short-term and long-term goals of effective resource management and maintenance of evolutionary flexibility, through the design and implementation of species-based conservation strategies, require an understanding of the basic process of tree reproductive biology (sexual system, incompatibility mechanisms, flowering patterns, pollination processes), and how they combine to produce observed patterns of gene flow and genetic variation (Gunatilleke, 1999; Young *et al*., 2000).

Plants have a diverse array of systems that influence their reproduction and, hence, evolution. Such systems are controlled genetically and are therefore not constant, but have the flexibility to respond to changing conditions. The maintenance of genetic variation, enabling adaptability to a range of environmental conditions over both space and time, is an important part of the reproductive process itself and hence of any conservation efforts. Generally, trees

have been shown to carry a heavy genetic load of deleterious recessive alleles such that inbreeding, in particular selfing, may lead to reduced fertility and slower growth rates in progeny. The need to reduce the possibility or effect of inbreeding and maintain diversity in naturally out crossing species is evident, while maintenance of breeding system flexibility will be a priority for species that naturally combine outcrossing and inbreeding. Whatever the situation, information on actual levels of outcrossing or inbreeding will be important for natural or managed ecosystems, and to the success of forestry breeding programmes (Gunatilleke, 1999; Pushpakumara *et al*. 1997). Similarly, it is essential for effective and representative seed collections, for *ex situ* conservation or for reforestation and breeding, to have a knowledge of the genetic base being sampled (Young *et al*., 2000).





Maps 2.3: Status of viability for 14 natural vegetations in Sri Lanka.
Figure 2.1: Distribution of viability categories in 14 vegetations in Sri Lanka. Source: MENR (2006).

However, only recently, Gunatilleke (1999), Murawski *et al*. (1994a; 1994b) reported reduction of outcrossing rates in *Shorea megistophylla* and other *Shorea* (Dipterocarpaceae) in a selectively logged over forest (about 20 years) compared to undisturbed forests in Sri Lanka, indicating inbreeding despite that the area is morphologically recovering with the same species.

The number and extent of protected area network of the country is given in Table 2.1. At the moment logging in the natural forests in Sri Lanka has been completely banned and all natural forests are protected for biodiversity, soil and water conservation, and that will hopefully reduce the genetic erosion within the natural forests. The level and extent of genetic erosion of the tree resources in natural forests and outside of the natural forest (i.e. homegardens) is uncertain. No baseline information or assessments have been carried out in this regard. Further, conservation of species is based on existing protected areas but not based on assessment of genetic information or effective population sizes. Conservation of genetic diversity of wild species has received little attention, as the focus has been on conservation of threatened species and maintenance of species diversity.

Gunatilleke (1999) reported that for outbreeding tree species, only large areas of contiguous forests ensure their genepool conservation, in small isolated populations as in the case of wet zone of Sri Lanka, genetic diversity declines through inbreeding and genetic drift, hence

relative fitness of resulting individuals may progressively reduce, to conserve the genetic diversity in small forests, they must be linked through gene corridors to larger protected areas or forest clusters. Further, in *S. trapezifolia* populations, 18% of total alleles sampled were outside the Singharaja MAB reserve signifying the importance of understanding the distribution of genetic diversity in conservation and management planning of natural forests (i.e. in selecting conservation forests in the future (Gunatilleke, 1999). Further, he also suggested conversion or enrichment of monoculture *Pinus* plantations around fragmented natural forests into indigenous mixed species plantations of *Shorea* species, *Dipterocarpus* species, *Caryota urens* as small blocks that could provide genetic bridges at least for key rainforest species. As Gunatilleke (1999) pioneered and suggested, these research should continue as a priority in *in situ* conservation of natural forests to understand their fate in the future.

Despite the long history of research, no genetic based analysis has been carried out to evaluate the conservation value of PAs. Further, no analysis has been carried out to identify the viable population sizes of priority or endemic tree species of FGR. Similarly, no analysis has been carried out for identification of genecological zonation for any species in Sri Lanka. These aspects are priority in research in *in situ* conservation of FGRs in Sri Lanka. At present, lack of knowledge and lack of capacity hampered such kinds of assessment. Hence, capacity building and strong collaborative programme with international institutes is immediately required. Almost all native species occurred in *in situ* conservation area. There is no dedicated programme for inclusion of threatened species into conservation programmes. However, priorities have been paced to collect and propagate a few threatened species in nurseries of Forest Department. It is also high time to carry out the next National Conservation Review to identify changes of species diversity in PAs.

CHAPTER 3:
THE STATE OF *EX SITU* GENETIC CONSERVATION

In Sri Lanka, *ex situ* conservation activities (i.e. the collection, handling and management of germplasm, its storage, regeneration, characterization/evaluation, documentation and dissemination to users) on various species of trees, crops and crop wild relatives are carried out by several organizations using (i) Seed Gene Banks (Plant Genetic Resources Centre (PGRC), Gannoruwa, Peradeniya; Rice Research and Development Institute (RRDI), Bathalagoda; Horticultural Crops Research and Development Institute (HORDI), Gannoruwa, Peradeniya; Regional Agricultural Research and Development Centers (RARDC) at Makandura, Bandarawela, Bombuwela; (ii) Field Gene Banks at PGRC, HORDI, Bandaranayake Memorial Ayurvedic Research Institute (BMARI) at Navinna, Maharagama, Tea Research Institute (TRI) at Thalawakele, Coconut Research Institute (CRI) at Lunuwila, Rubber Research Institute (RRI) at Agalawatta, Field Crops Research and Development Centre (FCRDC), Department of Export Agriculture (DEA), Sugarcane Research Institute (SRI), Regional Agricultural Research and Development Centers (RARDC) at Makandura, Bandarawela, Aralaganwila, Bombuwela, TRI, Department of National Botanic Gardens (DNBG), Chemical Industries of Colombo (CIC) farm at Pelwehera mainly *Mangifera indica* collection; experimental stations of universities of Sri Lanka, (iii) i*n vitro* Gene Banks at PGRC, DNBG; and (iv) Arboreta (BMARI, DNBG, Pophem arboretum, Forest Department). *Ex situ* conservation of genetic resources of forest plantation species is mainly carried out in the status of field collection and established of provenance collections, gene resources stands, establishment of seed stands and seed orchards.

National Botanic Gardens Network

Department of National Botanic Gardens (DNBG) is mandated with the *ex situ* conservation of the flora of Sri Lanka and currently holds over 8,000 plant species. The DNBG has five botanic gardens to represent all major climatic zones of Sri Lanka and located at Peradeniya (representing the mid country wet zone), Hakgala (representing the montane zone), Henerathgoda - Gampaha (representing the low country wet zone), Sitawake – Awissawella (representing the low country wet zone) and Mirijjawila - Hambantota District (representing the dry zone). Individuals of many exotic, and a relatively few native and endemic trees, shrubs and understory species have been established as arboreta and plots in the Royal Botanical Garden Peradeniya established in 1821, now consists of over 5,000 accessions of plant species (of which 90% are exotic) in 60 ha, Botanical Gardens of Gampaha, established in 1876 contains over 1,000 accession of plant species in 13 ha, Botanical Gardens of Hakgala, established in 1861 with over 2,000 accessions of plant species in 20 ha. Botanic gardens of Sitawake and Mirijjawila are recent additions to the network. The medicinal garden at Ganewatta located in the dry and intermediate zone was established in 1951 with over 500 accessions of mainly medicinal plants in 20 ha (Wijesundara *et al*., 2006). The Biodiversity Complex of Ambuluwawa, Gampola also functioned under the DNBG and later was handed to Ambuluwawa Trust.

Until recently, botanic gardens have been underutilized in maintenance of threatened species and conservation of genetic resources. Analysis of species revealed that only a fraction of the species in the Botanic gardens at present are endemic to Sri Lanka, and the role of this institution as reservoirs of indigenous biodiversity is not well established due to historical reasons (Wijesundara *et al*., 2006). This trend has been reversed somewhat in recent times and the Royal Botanical Gardens now has 1,471 specimens from local species, while the

more recently developed herbarium at the Hakgala Botanic Gardens has about 2,000 specimens from local species. While most species in the older NBGs are exotics, the NBG has recently commenced propagation of endemic species-such as orchids, that is of direct use for conservation of threatened species. The new botanic gardens at Marijjawila and Awissawella will focus on conservation of indigenous plants (MENR, 2009). One of the other objectives of the DNBG now is for development of technologies related to exploitation of lesser known and under-utilized plants and development of ornamental and amenity horticulture which help to *ex situ* conservation of FGRs.

Popham Arboretum

This was a private land owned by a British conservationist (Sam Popham), and later donated to the Institute of Fundamental Studies, Kandy, Sri Lanka to be used for research and education. The land is located in Kandalama, Dambulla in Matale District at an altitude of 178 m and belongs to the dry zone of Sri Lanka. The initial thorn scrub vegetation was converted into a high stature forest with primary species through a natural process of succession, natured by human involvement. This model finally created a patch of dry mixed evergreen forest (DMEF) , the main climax vegetation type of the area, in a degraded site in the dry zone (Popham, 1997). The Popham's concept of nature under human supervision involves preliminary slashing of undesired species, strict rejection of fire to clean the slashed litter, but allowing natural decomposition to enrich the soil, leaving plant litter *in situ* without sweeping or displacing them, preference of spontaneous seedlings over replanting of seedlings, regular weeding, caring of the young during climatic stresses (watering during difficult early stages), encouraging early growth by stem-pruning and crown-lifting for dominant tree species and controlled thinning of excess saplings. The nature trails help visitors to observe various plants and bird life within the arboretum. Cramer (1993) has recorded 426 plant species (of which 10 species are endemic) in 167 genera and 56 families that belong to many life forms, such as trees, shrubs, lianas, creepers and herbs in the site.

It is evident that in the dry zone, degraded lands can be successfully converted to the status of a self-sustaining forest through Popham's concept of forest restoration in 25 years. This is proof that there is potential to rehabilitate what appears at first to be less useful land, which has been over-cultivated, perhaps regularly burnt, and is no longer able to produce crops. An important factor in this, however, is the availability of mother trees that can introduce new seed into such degraded level (Popham and Neil, 1994). The Popham model of forest restoration has been recommended to establish genetic corridors between forest sites in the dry zone, especially for resurrecting privately owned degraded scrublands that lie within designated corridors (MENR, 2006). Further, since more than one individual of the same species are conserved in the arboretum, this is an important addition to the forest conservation network of Sri Lanka. *Vitex pinnata, Strychnos nux-vomica, Drypetes sepiaria, Berrya cordifolia, Chloroxylon swietenia, Manilkara hexandra, Diospyros ebanum* are some of the common species in the arboreta. Many of these important timber trees in the dry zone of Sri Lanka add value to the genepool of timber trees (Cramer, 1993). However, no genetic characterization of timber trees has been carried out on any tree species.

Menikdena Archaeological Reserve and Arboretum

Menikdena Archaeological Reserve and Arboretum is located in the Matale District and consists of 16.2 ha accommodating mostly natural forest, in which remains of a monastery dating back to the 6th Century AD. This reserve and the arboretum is considered as a unique

model of an integrated biodiversity and archaeological conservation project conducted by a school of Sri Lanka (Trinity College) in 1998 with the permission of the Departments of Archeology and technical guidance and support from PGRC, Gannoruwa and the National Herbarium, Peradeniya. Presently, the site is managed by the Department of Archeology. The arboretum covers the total area of the archeological reserve in which a network of nature trails have been made and about 450 trees, lianas and large shrubs have been identified (Jayasuriya 1998, Jayasuriya *et al*., 1997).

Plant Genetic Resources Centre (PGRC)

The Plant Genetic Resources Centre (PGRC) was established in 1988 with a mandate of plant exploration, collection, introduction, evaluation, documentation and conservation of genetic diversity of food crops and their wild relatives. It is the focal point of national programmes on *ex situ* conservation of plant genetic resources. Over 10,950 accessions of more than 125 plant species is presently conserved in the PGRC seed gene banks. The major collection conserved include rice and wild relatives (3,919), other cereals (1,054), grain legumes and related species (1,772), vegetable legumes and related species (1,064), solanaceous vegetables (1,121), cucurbits (662), leafy vegetables (135), other vegetables (327), spices and condiments (292), *Brassica* species (22), *Allium* species (17), oil crops (99), fruits (160), fiber crops (66), and miscellaneous plants (221). Accessions of 160 germplasm are also conserved in *in vitro* conservation. Sixteen cold storage modules (4 units at 1 ^{0}C and 12 units at 5 ^{0}C) are available for the conservation of seeds of orthodox species. However, at the moment, clone banks, seed banks and in vitro cryo-preservation of FGRs are not practiced in Sri Lanka (Jayasuriya *et al*., 2006).

Field Gene Banks of Tree Crops/Crops

In addition to Ganewatta, field gene banks of medicinal plants belonging to the BMARI are available in Haldummulla (7 ha), Pattipola (7 ha), Nawinna (20 ha), Girandurukotte (45 ha). Several Orchards of fruit crops such as *Mangifera indica, Persia americana, Garcinia mangostana, Garcinia cambogia, Artocarpus heterophyllus* are located in various agro-climatic regions owned and maintained by DOA. Crop specific research institutes such as Coconut Research Institute, Tea Research Institute and Rubber Research Institutes are also holding field gene banks of their respective species (Table 3.1). Universities are also holding field gene banks of several species but details are not available. Field gene banks belonging to Department of Export Agricultural Crops (DEAC) located in the low country wet zone in Matara consists of 255 accessions of *Cinnamomum* sp. and 25 species of *Cymbopogon* sp., located in Matale in the mid country intermediate zone consists of 12 accessions of *Elettaria cardamomum*, 167 accessions of *Piper nigrum*, 65 accessions of *Theabroma cacao*, 18 accessions of *Coffee* sp., and 65 accessions of *Areca catechu*.

Field Gene Banks of Forest Plantation Species

Ex situ conservation of forest genetic resources of plantation species is mainly in the status of field collections and establishment of seed stands, seed orchards and resource stands. Genetic resources of exotic commercial species such as *Eucalyptus grandis, E. microcorys, E. camaldulensis, E. teriticornis, Tectona grandis, Khaya senagalensis* are well conserved in provenance trials, provenance resource stands, seed stands and seed orchards by the Forest Department. Broad collections of natural provenances of *E. grandis* have been established at Gurutalawa and Kadapola in the high elevations of the country. Further, three seed stands at

Kinigama, Gurutalawa and Ohiya, one provenance resource stand at Erabedda and one seedling seed orchard at Erabedda also serve as *ex situ* gene conservation for *E. grandis* (Table 3.2).

Table 3.1: Germplasm collection in different research centers of Sri Lanka.

Crop and Research Centers	No. of accessions
Rubber (Rubber Research Institute)	8,664
Tea (Tea Research Institute)	435
Coconut (Coconut Research Institute)	115
Cinnamon related wild species	255
Black pepper	175
Black pepper wild species	10
Cardamom	12
Coffee	20
Areca nut	70
Betel	20
Fruit crops	670

Source: Wijesundera *et al*. (2006).

Table 3.2: List forest species included in *ex situ* conservation programmes in Sri Lanka.

Species		Field Collections		
Scientific name	N or E	Collections, provenance or progeny tests, arboreta or conservation stands		
		No stands	No accessions	Area (ha)
T. grandis	E	5 Seed stands	--	60
		4 Orchards	200+	30
E. grandis	E	3 Seed stands	--	9
		1 Orchards	100+	2.5
		Provenance stand	20	3
		2 Resource stands	10	10
E. microcorys	E	2 Seed stands	--	5
		Provenance stand	10	1
S. macrophylla	E	1 Seed stand	--	5
K. senagalensis	E	3 Seed stands	--	12
		1 Orchard	30	2
Many species	E/N	Arboreta of NBGs		
Many species		Other Arboreta		

Two provenance trials at Erabedda and Nuwara Eliya, two seed stands extent of five (5) ha at Dansinan and Diyatalawa and one-provenance resources stands of *E. microcorys* have been established in the high altitudes of the country which conserve the *E. microcorys* germplams in the country (Table 3.2). The growth performance of the *Eucalyptus* sp. in the dry and intermediate low lands is poor; hence, the establishment of eucalypts plantations in the dry lowlands is limited. However, exotic genetic materials of *E. camaldulensis* and *E. teriticornis* are conserved in the field provenance collections (Connely, 1990; Bandara, 1998).

The initial introduction of the germplasm of *T. grandis* to the country is uncertain, however, the available Sri Lankan forest genetic resource of *T. grandis* is conserved in seed stands (60 ha), clonal seed orchards (30 hectares) and progeny trials in the dry (Wellawaya, 5 ha) and the intermediate zones (Kurunegalla, 5 ha). As *T. grandis* is the main timber tree species of the country widening of the genetic base is a major requirement for future improvement of this species (Table 3.2).

Genetic materials of *Khaya senagalensis* (newly introduced species for the dry and intermediate lowlands) are conserved in the broad provenance collections (23 provenances from Western African countries) at Wellawaya and Nikavehera, two seed stand at Horakele and one clonal seed orchard at Ethgala. Other lesser used tree and biofuel species (*Jatropha curcus*) are conserved in genetic resource stands and small provenance/progeny trials.

Other exotic and locally potential tree species are conserved in the arboreta of Forest Department. Mainly subtropical Eucalypts and other Myrtaceae species (i.e. *Tristania conferta, Melaluca* species) have been planted in the upcountry arboreta at Haputale, Ohiya and Erabedda. Many arboreta in the dry and intermediate zones (i.e. Korakahawewa, Mudunpita, Horakele, Manikdena) conserve genetic materials of the tropical exotic tree species and locally potential tree species.

Circa situm Conservation of FGRs in homegardens

Circa situm conservation refers to the conservation of plants or their genetic resources through extensive utilization. Importantly, *circa situm* conservation lays between *in situ* and *ex situ* conditions. In this respect, homegarden network in Sri Lanka offers a highly diversified and economically viable form of agroforestry landuse system. Like natural forest; homegardens are dominated by trees and woody perennials and produce a variety of products such as food, fruits, medicine, spices, fuelwood and timber (Pushpakumara *et al*., 2010). There are more than 400 different woody species in homegardens and 120 of these species are common where some species are planted and the others are naturally regenerated. Traditionally, *Cocos nucifera, Artocarpus heterophyllus, Mangifera indica* are commonly found species. In the recent past, species composition has changed with the inclusion of commercially valuable exotic timber species such as *Tectona grandis, Swietenia macrophylla, Alstonia scholaris, Albizia* sp. and *Eucalyptus* species. These five species are among the top 10 species in the order of frequency of occurrence and account for 15% of the total number of trees recorded and produce over 40% of the volume of total timber produced. Importantly, the most important tree species found in homegardens in terms of producing food and timber are well distributed across the climatic zones. Twenty-two such species are distributed in excess of 50% of the land area. The majority of tree species, especially the ones that are grown traditionally, has more trees in lower diameter classes showing the sustainable nature of homegardens. Although there are some variations (from 20 to 475), the average density is about 200 trees per ha. Tree density is highest in the wet zone districts followed by the intermediate and dry zones (Ariyadasa, 2002). The homegarden network of Sri Lanka provides a complementary resource base for conservation of crop and forest genetic resources and acts as a complementary option to mediate *in situ - ex situ* gap and also a platform for continuation from natural vegetation to monoculture fields. However, adequate attention has not been paid on assessment of area under homegardens and their standing stocks and their contribution to FGRs and genetic resources conservation and food security in Sri Lanka. Such assessments have been carried out only recently for fragmented area (see Premakantha *et al*., 2010).

Homegardens are a source of economically and culturally important bio-resources, both wild and cultivated. Sri Lanka's agricultural habitats and homegardens have evolved over many centuries, and hence conserved a rich diversity of cultivated species (BCAP, 2005). Homegardens are commonly found in many rural areas of Sri Lanka. However, the concept of Garden's is used to indicate this *in situ* conservation method. The size of a normal home garden plot varies from 100 - 1,000 m^2. As altitude increases, the homegardens become smaller with greater density of plants and plant species and lesser diversity within a species. A well-defined plant association and canopy structure that reflect a variety of complimentary functions are displayed in the system. At the perimeter, coconut and fruit trees predominate and canopy is progressively reduced with the occurrence of spice trees. Vegetables occupy the core areas around the dwelling. Near the well or open drainage areas, aroids and yams are grown. Medicinal plants are frequently grown in the shade while ornamental plants occupy the front portion near the house.

For several perennial fruit crops like banana, mango, jackfruit, citrus, rambutan, durian, guava, avocado, papaya and mangosteen, the bulk of the genetic diversity is conserved in homegardens. Fuelwood is also an essential component of the self sustaining system. Therefore, the homegardens provide a valuable system for the conservation of agro-biodiversity. Nevertheless the importance of homegardens has still not been widely recognized and little inventory work has been done so far.

Tree Seed centers

Tree seed banks have been established within the Forest Department premises at Kumbalpola and Badulla with the objective of storing seeds for the plantation establishment programmes. However, at present, due to lack of trained staff and facilities, the centers are not catering as a method of *ex situ* genetic conservation facility, which has to be improved in the future.

The gaps of *ex situ* conservation and Constraints for *ex situ* conservation of FGRs

Most of the field gene banks of Forest Department are scattered throughout the country. Therefore, the management and protection of them from biotic and abiotic factors is an enormous concern. Lack of trained human resource, lack of equipment and technology are the major constraints in conservation of seeds and pollen of commercial tree species of the country. In order to satisfy the growing demand for genetic resources of plantation species especially in the area of homegardens and tea plantation area, the tree seed centers and seed production process must be improved. Hence, capacity building is a priority in this area. Further, an analysis of *ex situ* collections in various places and their database is also a requirement. In addition, threatened endemic species should be propagated and included into the network of DNBGs.

Identification of *ex situ* conservation options of FGRs as a part of overall integrated conservation programme, compiling a directory of all *ex situ* options to identify institutionally held collections of FGRs including critically endangered species into conservation programmes, coordination of *in situ* and *ex situ* conservation options are considered as priority area for *ex situ* conservation. The geographical representation of the collections of many forest plantation species is not adequate. Poor institutional collaboration and lack of integrated approach, resource availability and awareness are some of the obstacles hindering the expansion of *ex situ* collections. Inadequate co-ordination among institutions

involved in *in situ* and *ex situ* activities is a major constraint. The other constraints include, (a) lack of financial and human resources to launch realistic *ex situ* conservation activities; (b) shortage of public awareness programmes, and; (c) lack of monitoring programmes.

Infrastructure facilities at all *ex situ* centers need upgrading. Institutional policies need to be changed to accommodate *ex situ* conservation. Staff training, upgraded facilities for long term preservation are essential. In some institutes, such as CRI, expansion is limited due to lack of land. Due to inadequate characterization facilities, it has become a problem to detect duplications at some *ex situ* conservations centers. Therefore, it is vital to introduce molecular technology for characterization.

Better cold room facilities, data base development, proper maintenance (protection) standards, improved irrigation methods, and cryopreservation techniques can also be immensely helpful.

At present there is no clearly defined policy legal framework (only a draft legal framework is available) to regulate access to genetic resources. Failure to identify agencies to assist farmers in accessing genetic resources and the lack of widespread awareness of available mechanisms to promote utilization of genetic resources for economic benefits are some of the issues that need to be addressed.

Policies and programmes to promote farm-based participatory research are lacking. Absence of the recognition to incorporate traditional knowledge on biological resources into IPR systems or legislative systems is also hindering research and development on genetic resources. Many obstacles remain in the quest to provide a secure source of germplasm. First is a lack of information. Secondly, the high cost of *ex situ* collections, particularly when seed is stored at very low temperatures it can force some seed banks to cut back or shut down. The high storage costs mean that funds for describing the germplasm present in the banks, a necessity for making the germplasm useful to plant breeders, can be minimal. Thirdly, a serious problem associated with *ex situ* collections involves gaps in coverage of important species, particularly those of threatened and endangered habitats. The most worrisome gaps are in the coverage of species with recalcitrant seeds and wild species.

The PGRC‘s gene bank facilities are for only medium and short-term seed storage at +1° C and 35% relative humidity, and + 5 °C and 35% relative humidity respectively, which are far below international standards. it is recommended that PGRC should obtain the necessary equipment to conserve in original samples at least in one or two gene bank modules at -20°C. it is also advisable to strengthen smaller *ex situ* conservation facilities as safeguards.

CHAPTER 4:

THE STATE OF USE AND SUSTAINABLE MANAGEMENT OF FOREST GENETIC RESOURCES

Sustainable Use of FGR and Need for Coordinated Efforts for Plantation Forestry and Trees Outside Forests

A wide variety of indigenous plants have been used in Sri Lanka since prehistoric times. Non Timber Forest Products (NTFP) are a major income source for many rural communities adjacent to natural forests. For this reason, several forest species are also routinely harvested from the wild by local communities. The collection of fruits of *Garcinia* sp., *Limonia accidissima, Dialium ovoideum, Phyllanthus emblica, Vateria copallifera,* extraction of oil from *Dipterocarpus glandulosus,* are some examples from different forest reserves. More than 60% of villages in some parts of Sri Lanka (i.e. Bibila and Nilgala medicinal plant conservation areas) are engaged in harvesting medicinal plants from the wild (Bandaratilleke, 1995; FSMP, 1995). Some instances harvesting techniques are non destructive, i.e. collection of fallen fruits of *Garcinia quaesita*, but other instances, the techniques used for harvesting are very destructive as in the case of *Dipterocarpus glandulosus* (making galleries to the main trunk and setting fire inside), *Dialium ovoideum* and *Phyllanthus emblica* (branch felling).

All ten species of rattans in Sri Lanka have been over-collected and are now threatened. Likewise, many species of medicinal plants of commercial value, such as *Rauvolfia serpentina, Saraca asoca, Capparis moonii, Withania somnifera* and *Munronia pinnata* have become rare in the wild due to heavy collections (MFE, 1994; FSMP, 1995). Several valuable timber species such as *Chloroxylon swietenia, Diospyros ebenum, Diospyros quaesita* are also now listed as threatened due to selective removal of mature trees; similarly, *Cleistanthus collinus* has been so heavily exploited that it is suspected to have become extinct during the latter half of the past century (FSMP, 1995). As in many of the medicinal plants, demand is clearly greater than supply with regard to the ayurvedic pharmacopoeia allow over exploitation, or depend on import to meet its requirements. Hence, over exploitation has been a major determinant of species loss in Sri Lanka.

Further, many forest plants related to food and medicinal uses are linked with associated traditional knowledge (i.e. preparation of *Vateria copallifera*) and in the case of other species propagation require unique systems. Some of these knowledge systems are already documented and many are to be explored. In some instances, economic analysis of contribution of NTFP to income generation has been assessed of up to some level (see Gunathilake, 1995) but has not fully captured the real economic contribution due to difficulties in obtaining relevant information of collections and trading.

In this regard, domestication and genetic improvement of heavily used FGRs is one of the options to safeguard the uses as well as conservation of the species, hence sustainable use. *Cinnamomum verum* in Sri Lanka's is one example, which is highly domesticated and widely cultivated with 8 species wild relatives conserved in natural forests. Further, although many forest products are harvested for ages from various forests, no study has been made of the sustainability of the associated wild collection practices and their impacts on natural populations (Pethiyagoda *et al*., 2006). Sri Lanka Conservation and Sustainable Use of Medicinal Plants project provides some information in this regard, but there is a dearth of

knowledge on the level of sustainability (SLCSUMPP, 2000). These aspects need urgent attention in this regard.

With the shift in emphasis of forest policy from production to protection, forest plantations have become particularly important for the supply of timber and other small wood requirements. Further, with growing prosperity of the country, annual demand for sawn wood is likely to grow steadily from the present level of 35 cubic m per 1,000 population, resulting in an estimated national demand of 45 cubic m per 1,000 population by 2020 (FSMP, 1995).

Further, it is estimated that wood products accounts for more than 50% of Sri Lanka's energy requirements (FSMP, 1995). While many rural communities harvest brushwood from homegardens and associated agricultural lands for their cooking needs, families living close to forests tend to depend entirely on this resource for their fuel requirements. This problem is particularly acute in the case of forest reserves such as Peak Wilderness and Piduruthalagala where workers on adjacent tea plantations depend entirely on firewood harvested illegally from forests. This pressure has led to the degradation of vast tracts of montane and sub montane wet zone forests facilitation in turn succession by invasive alien species (Pethiyagoda *et al*., 2006).

Addressing all these problems requires steady growth in plantation forestry and improvement for timber production in other land use categories especially in homegardens since harvesting of timber from natural forests is already suspended. Activities of forest plantations in Sri Lanka started as far back as 1680 with the introduction of teak. During 1680-1890, several exotic species have been used in planting programmes. During the subsequent years, a substantial area was planted with of exotic species to compensate the loss of timber production from natural forests. With the rapid development of plantation forestry and the introduction of exotic species, a need for genetic improvement was felt and activities leading to tree improvement have been initiated in Forest Department (FD). Early tree improvement work was carried out on four species widely used in plantation establishment, namely *Tectona grandis, Pinus caribaea, Eucalyptus grandis* and *E. microcorys* and later *Khaya senagalensis*.

FD is responsible for production of quality planting material and their distribution to end users. Accordingly, the main objective of the tree breeding programmes of Sri Lanka is to support production of timber and fuelwood. Forest tree improvement programmes in Sri Lanka are mainly conducted for exotic species. *Tectona grandis* and *Eucalyptus grandis* are the two main species used for tree improvement programmes with 1st generation seed production. *Eucalyptus microcoys* and *Khaya senagalensis* are used up to a limited extent with identification of plus trees, seed stands and small units of seed orchards.

Tree improvement programmes with propagation methods have been started for the main tree species in the recent past. *E. grandis* breeding programme was initiated with 100+ natural families and consequently converted the progeny trials to a first generation breeding seedling seed orchards to produce comparatively improved seeds (Table 4.1). Further, second generation breeding work was started in 2007. Establishment of clonal seed orchards with the selected clones and the clonal multiplication programmes were also in progress. Therefore, the planting materials requirement of *E. grandis* of the country will be replaced with improved seed sources in the future. Teak seeds for the FD plantation programme are mainly derived by the old clonal seed orchards established in 1970s (approximately 30 ha) and from the selected seed stands (Table 4.2). Systematic teak breeding work and expansion of the

extent of first generation clonal seed orchard development is in progress. Teak breeding programme in Sri Lanka is based on the genetic materials from the Sri Lankan landrace. However, a narrow genetic base has been identified for Sri Lankan landraces. Therefore, infusion of exotic teak genetic resources to the current breeding programme is very much needed.

Table 4.1: Status of forest improvement trials in Sri Lanka.

Species		Plus trees	Provenance trial		Progenies trials	
Scientific name	**N or E**	**No**	**No of trials**	**No of provi**	**No of trials**	**No of families**
Tectona grandis	E	300	1	5	2	250
Eucalyptus grandis	E	80	3	19	2	140
Eucalyptus microcoys	E	-	2	8		
Kaya senagalensis	E	24	2	24		

Note: E=Exotic

Table 4.2: Status of seed orchards in Sri Lanka.

Species (Scientific name)	Seed orchards*		
	Number	**Generation****	**Area (ha)**
Tectona grandis	4	1	30
Eucalyptus grandis	1	1	2.5

Limited tree breeding work has been conducted in the past on *E. microcorys* and *K. senagalensis*. Mainly the seed requirement of both species is met by the selected seed stands. *E. microcorys* breeding work is hindered due to the species nature (difficulty of grafting, difficulty of clonal multiplication and long age for flowering). *Khaya* was introduced very recently and the seeds for the plantation establishment of FD were met by importation from Africa until 2011. Breeding programme for *Khaya senagalensis* was started in 2008 through establishment of provenance trials (23 provenances from West Africa and 2 local land races) and identification of plus trees for long term breeding programme by FD. Clonal seed orchard (progeny untested) establishment is in progress.

Swetenia macrophylla, Berrya cordiforlia, Artocarpus heterophyllus have been used slightly in tree improvement programmes with identification of plus trees and seed stands. In addition, few local species have also been selected and less work been carried out because of the long rotation age of local species. Most of the local species are early or late successional climax species. Some examples are *Berrya cordifolia, Pterocarpus marsupium, Pericopsis mooniana* and *Chukrasia tabularis.*

To a limited extent, locally collected genetic resources of forest trees from wild are established at homegardens and other agroforestry systems adjacent to natural forests. The seeds of indigenous tree species, such as *Terminalia arjuna, Holoptelea integrifolia, Terminalia belerica, Madhuca longifolia, Diospyros ebenum, Chloroxylon swietenia, Lagerstroemia speciosa, Pericopsis mooniana* are collected locally by farmers as well as by the FD. The FD supplies seedlings of many timber species to farmers from departmental nurseries. In addition, a large number of seedlings are produced and supplied from farmer nurseries, school nurseries and NGO nurseries that are supported with technical assistance by

the FD. However, due to the small-scale nature of these nurseries, it is not possible to produce sufficient amount of improved planting materials for commercial planting leaving a dearth of material for reforestation. Further, the total area of forest plantations maintained by the Forest Department in 1999 was around 135,623 ha**,** but records indicate about 72,350 ha of viable forest plantations in 2000 (MENR, 2002) indicating that further expansion of forest plantations are difficult.

Addressing these problems requires an appropriate framework of incentives to achieve the required goal of establishment of plantations from suitable species, improvement of timber production from homegardens and other land use systems thereby reducing pressure on natural forests as a result of illegal logging and reduce the burden on national budget for importing timber. In this respect, private and public sector partnership is a must for production of quality planting material of FGRs and their utilization in appropriate scale and levels.

CHAPTER 5:
THE STATE OF NATIONAL PROGRAMMES, RESEARCH, EDUCATION, TRAINING AND LEGISLATION

National Initiatives

Institutional actively engaged with sustainable use of FGRs in Sri Lanka are mainly government institutions. Table 5.1 shows the institutions and their activities related to *ex situ* and *in situ* conservation and sustainable use of FGRs.

Table 5.1: Institutions involved with conservation and use of forest genetic resources.

Name of institution	Type of Institution	Activities or programmes
Forest Department	Government	Tree improvement; *in situ* and *ex situ* conservation; monitoring
Department of Wildlife Conservation	Government	*In situ* conservation, monitoring
State Timber Cooperation	Government	Harvesting of timber
Department of National Botanic Gardens	Government	*Ex situ* conservation
Universities (Peradeniya – FA, FS; Ruhuna – FA, FS; SJP; Rajarata, Wayamba,	University	Assessment of species and genetic diversity, taxonomy
Department of Agriculture Plant Genetic Resource Centre (PGRC)	Government	Crop improvement, *ex situ* conservation, multiplication
Bandaranayake Memorial Ayurvedic Research Institute (BMARI)	Government	*Ex situ* conservation
Department of Export Agricultural Crops (DEAC)	Government	Selection and breeding, *ex situ* conservation
Coconut Research Institute (CRI), Tea Research Institute (TRI), Rubber Research Institute (RRI), Sugarcane Research Institute (SRI)	Government	Breeding, *ex situ* conservation, multiplication
NGOs	Private	Multiplication of FGR
Private Nurseries	Private	Multiplication of FGR
Regional plantation companies	Private	Establishment of plantation stands
Government plantation Companies (JEDB and SLSPC)	Private	Establishment of plantation and stands

Preparation of management plans for all forests managed by the FD and the DWLC are underway, and will be a mandatory requirement. Overall, 16 Management Plans have been prepared for several forests managed by the FD and plans are being prepared for the others (See DWLC, 2005a; 2005b; 2005c; 2005d; 2005e; 2005g; 2005h; 2005i). Management Plans were prepared for nine cluster PAs managed by the DWLC; subsequently some were revised

and management plans with operational plans have been prepared for eight PAs; management plans are being prepared for three other national parks. They include plans for tourism development and participatory management involving local people. Institutional capacity has been built for preparation of management plans for PAs managed by the DWLC under the PAM&WC project.

Sri Lanka has not established a national coordination mechanism to include different institutions or a national programme especially for forest genetic resources. The Biodiversity Secretariat is responsible for it. The funding provided for tree improvement has not been changed but is inadequate for effective research programmes. The need for training and capacity building is strongly emphasized in all national development programmes including Biodiversity Conservation Action Plan. In addition, government is committed to carry out training and capacity building to fulfill the obligations of international conventions and agreement ratified subject to the relevant focal points.

Education on FGRs at Different Levels

Diploma education in FGRs

The technical staff of the FD is mostly the holders of two-year diploma in forests offered by Forestry College at Sandathenna, which discusses about tree improvement and quality planting material production and their management through silviculture. These middle level technical staff is the backbone of the forestry extension services. This level of education need to be strengthened and improved through improvement of diploma education at Forestry College. Further, there is great demand for training of farmers and plantation managers for use of FGRs for improvement of quality timber production which needs offering of several short courses and training programmes that can be offered through collaboration of Forestry College with national universities which is national level priority for efficient use of FGRs in Sri Lanka. In addition, officers at the Department of Wildlife Conservation should also be trained for FGRs especially for identification of important plus trees.

Undergraduate education in FGRs

Respective faculties of agriculture, science and applied sciences are responsible for undergraduate level training on FGRs. BSc degree programme on Agricultural Technology and Management degree of Faculty of Agriculture, University of Peradeniya address FGR under Tree Diversity and Improvement course in their advanced module of plantation management and forestry. This course mainly addresses fundamentals of genetic diversity of trees and their potential in tree domestication. In addition, basic forest ecology and plantation silviculture are also discussed under this programme. BSc degree programmes in other agricultural faculties generally discuss the importance of forestry and FGRs under subjects of forest ecology, silviculture and tree improvement. A BSc degree programme in Botany at Faculties of Sciences address issues related to forest ecology, species diversity and genetic diversity of forests and their taxonomy and phylogeny. The Department of Forestry and Environmental Sciences of Faculty of Botany of University of Sri Jayawardenapura is the only Institute which offers BSc in Forestry and Environmental Science with tree improvement, forest ecology, silviculture etc. BSc programmes of other universities also offer several courses related to forestry.

Masters level

MSc programme on Environmental Forestry at Postgraduate Institute of Agriculture (PGIA) explicitly discuss tree improvement and applied forest genetic conservation whereas MSc

programmes on (i) Biodiversity Conservation and Management and (ii) Biodiversity, Ecotourism and Environment Management at Postgraduate Institute of Science, (iii) Environmental Science (PGIS) discuss issues related to biodiversity and their conservation. The University of Sri Jayawardenapura (SJP) offers MSc in Forestry and Environmental Management and discusses most issues related to forestry and environmental management including tree improvement (see also respective websites).

PhD level

PGIA, PGIS, SJP, University of Ruhuna and other national universities offers PhD level training for postgraduates to address various issues related to biodiversity, taxonomy and systematic, silviculture, remote sensing, molecular biology etc. However, the number of students in this category is limited compared to MSc programmes, hence new knowledge is generating slowly.

Priorities for research, education and training to support the conservation and sustainable use of forest genetic resources?

Training

The following PhD/Master level training programmes have been identified as priority:

1. training on breeding and including molecular marker assisted selection for timber trees/ genetic characterization
2. training on taxonomy and forest systematic
3. training of assessment of forest and non forest resources using advanced technologies
4. training on monitoring of genetic diversity in natural forests using model species

Research

The following research areas have been identified as priority:

1. Genetic characterization of model forest trees
2. Natural products/bio prospecting research on key forest species
3. Genetic improvement/domestication of local FGRs
4. Taxonomy and systematic studies on forest trees
5. Reproductive biology/genetic diversity/conservation genetics of key forest tree species
6. Population viability analysis of key forest tree species
7. Effects of community participation in FGR management
8. Ecological restoration using key FGR species
9. Impacts and adaptation strategies of climatic change on FGRs

National Legislation:

There is no separate national legislation for forest genetic resources conservation and use in Sri Lanka. However, there are substantial numbers of laws enacted to conserve Sri Lanka's environment and its biodiversity. Many of these are of directly or indirectly relevant to the conservation and sustainable use of biological diversity including FGRs.

In general, ownership of the genetic resources is protected in the Constitution of the Democratic Socialist Republic of Sri Lanka in both Articles 27 and 28. The Fauna and Flora Protection Ordinance of 1937 and its amendments also announced that the state holds responsibility over all genetic resources and holds ownership of such resources. The Fauna and Flora Protection Ordinance No. 2 of 1937, and subsequent amendments including Act No. 49 of 1993, Act of 2009 and the Forest Ordinance No. 16 of 1907, and its subsequent amendments, including Act no 23 of 1995, and No. 56 of 2009 Forest Conservation Act form the direct legal framework pertaining to biological resources, including genetic resources, as at present. Environmental impact Assessments (EIAs) for prescribed projects was introduced in 1984 under the National Environmental Act (NEA) No. 47 of 1980 which can be considered as the first comprehensive legislation on environmental management in Sri Lanka.

Felling of Trees Control Act No. 9 of 1951; the National Heritage Wilderness Area Act No. 3 of 1988; Soil Conservation Act, No. 25 of 1951, amended in 1996; Coast Conservation Act No. 57 of 1981, and the amendment Act No.64 of 1988; Plant Protection Act No. 35 of 1999 (replacing Plant Protection Ordinance No.10 of 1924); the Botanic Gardens Ordinance No. 31 of 1928; the National Environmental Act No. 47 of 1980 and the amendment No. 56 of 1988 (a new National Environmental Protection Act is being drafted); Seed Act No 22 of 2003. Several other acts enacted for plant protection are also of relevance for the conservation of genetic resources of forest trees, indigenous crops and their wild relatives.

With regard to the access and movement/exchange of genetic resources in line with the Convention on Biological Diversity Article 15 including the regime of Prior Inform Consent (PIC) and Mutually Agreed Terms (MAT), the main laws governing are the Fauna and Flora Protection Ordinance (FFPO) as amended and the Forest Ordinance (FO) as amended. These laws can adequately control the access to genetic resources; prevent illegal access and protection against commercial exploitation.

The National Heritage Wilderness Area Act No. 3 of 1988 and the Fisheries and Aquatic Resources Act No. 2 of 1996 also have provisions to protect wild genetic resources.

However, the above laws are not consistent with equitable sharing of benefits from genetic resources. There is a gap in the absence of a Cabinet approved policy on Access to Genetic Resources to strengthen the national legal framework on Access to Genetic Resources and Benefit Sharing (AGR&BS) regime in the country especially. However, proposed National Policy on Access to Genetic Resources and Benefit Sharing and the proposed act on Plant Breeders Right will be necessary to ensure fair and equitable benefit-sharing and secure farmers'/ breeders' rights. Material Transfer Agreements (MTAs) (bi-lateral) are used to exchange of genetic materials by the relevant institutions (PGRC) for their development work.

Recent expertise idea on the MTAs reveals that the common MTA should be in place, operating through a central governing body.

The Plant Protection Act No. 35 of 1999 makes provision against the introduction and spread of any organism harmful to or injurious to plants or destructive to plants found in Sri Lanka. This act can be used to prevent the import of any GMO that could be potentially cause damage cause to native plants or crops. Similarly the Water Hyacinth Ordinance No 09 of 1909 can be used to control any noxious weed or plant that could be harmful to native plants in Sri Lanka. These laws facilitate the national quarantine service to implement the national

quarantine regulations. The Plant Quarantine Service fulfils the Quarantine and Phytosantary requirements of imported and exported plants and plant products and seeds.

National Seed Policy 1996 and the National Seed Act of 2003 focus on enhancing the production and marketing of high quality seeds. The Agrarian Services Act No. 58 of 1979 has made provisions to enhance the scope of agricultural insurance activities for assisting farmers in disaster situations. This Act can be used to regularize ownership of land and to create better ownership of land among farmers, and to empower local farmer organizations involved in the agricultural sector. Sri Lanka has also enacted the intellectual Property Act No. 36 of 2003. This law relates to all the different types of intellectual property rights in Sri Lanka and provides the procedures of registration, control and administration of such rights. It is also relevant for granting IPR protection in the use of genetic resources and for genetic engineering techniques and their products. This can be used for the protection of IPR over use of genetic resources of indigenous species. However, IPR issues over genetic resources and associated traditional knowledge need to be further covered. In parallel to the agreement on WTO-TRIPS, intellectual Property Office in Sri Lanka has decided to introduce new enactment to the existing law. Details of these acts and their authority are given in Annex 10.

The country has not established a legal framework for forest genetic resources strategies, plans and programmes but existing legislations are used. While Sri Lanka has adequate legislation for protecting terrestrial biodiversity and threatened species, their enforcement is inadequate due to insufficient staff and facilities for effective monitoring and complicated legal procedures (Table 5.2).

Table 5.2: Needs for developing forest genetic resources legislation.

Needs	Level of priority			
	NA	Low	Medium	High
Improve FGR legislation				1
Improve reporting requirements				1
Consider sanctions for non compliance				1
Create FGR target regulations		1		
Improve effectiveness of FGR regulations				1
Enhance cooperation between FGR national authorities				1
Create permanent national commission for conservation and management of FGRs				

Administrative procedures for removal of timber produced in private lands

Removal of timber from private lands, including homegardens, is governed by restricted felling regulations and transport permits. In restricted felling, due to their nutritional or economic significance, the government restricts felling of *Artocarpus heterophyllus*, *Artocarpus nobilis* and female *Borassus flabellifer*. These trees may be felled only under special circumstances on special approval granted by Divisional Secretaries. Timber transport permit have been made obligatory for many important timber species. Authority is required from the Conservator General of Forests for removal of the following eight tree species from private or government leased lands: *Diospyros ebenum*, *Diospyros quesita*, *Chloroxylon swetenia*, *Chukrasia tabularis*, *Pterocarpus marsupium*, *Vitex altissima*, *Pterospermum canescens* and *Pleurostylia opposita*. The Divisional Forest Officers may

grant permission for removal of the following species from private or government-leased lands. *Manilkara hexandra, Albizzia lebbeck, Berya cordifolia, Terminalia arjuna, Azadirachta indica, Madhuca longifolia.* All species mentioned above are classified as class I, special class or luxury timber by the STC. For other tree species not mentioned above or not needing a transport permit, according to Gazette Extraordinary No. 1129/13 of 28/04/2000 or subsequent regulations, approval for removal from private or government-leased lands may be granted by the Divisional Secretaries. Major commercial species raised in plantation or on private lands, such as Teak, eucalyptus, pine mahogany, etc. and most natural forests species, still require transport permits and deregulation is unlikely.

Public Awareness:

No special public awareness programmes are available for FGRs, but understanding the contribution of FGRs to achieve millennium development goals is necessary to address through coordination between line agencies (FD and DWLC). Only leaflets on timber resources their utilization and biodiversity in Sri Lanka has been prepared but not specifically on FGRs. It is necessary to prepare target FGR information communications such as popularization of success cases in achieving food security, livelihood improvement and environmental conservation. In this regard, two case studies are proposed to make documentary programmes: (a) case of true cinnamon (*Cinnamomum verum*) linking to the use and improvement needs of wild relative of FGRs *Cinnamomum capparu-corondo* and (b) case study on the use of FGR in ecological restoration and 25 ha plot information of Sinharaja and how such information help in sustainable management. Awarness raising needs of FGRs is given in Table 5.3.

Table 5.3: Awareness raising needs.

Needs	**Priority level**			
	NA	**Low**	**Medium**	**High**
Prepare target FGR information				1
Prepare target FGR communication strategy				1
Improve access to FGR information				1
Enhance FGR training and education				1
Improve understanding of benefits and values of FGR				1

CHAPTER 6:
THE STATE OF REGIONAL AND INTERNATIONAL AGREEMENTS AND COLLABORATION

International Agreements

The government of Sri Lanka is party to a number of related international conventions, agreements, treaties and protocols related to environment, forestry and related areas. The country has ratified 36 such initiatives (MENR, 2009), and a list of the most relevant international conventions, agreements, treaties and protocols related to forest genetic resources are given in Table 6.1. The major convention related to the use of forest genetic resources is the Convention of Biological Diversity (CBD) which was signed in 1992 and ratified in 1999. Accordingly, Sri Lanka prepared the Biodiversity Conservation Action Plan (BCAP) in 1999 in response to article 6 of the CBD in consideration of the need to effectively conserve the island's valuable natural resources, including FGRs. It is noted here that the BCAP did not specifically state the conservation of FGRs, instead it identified the need for systematic approach of conservation. Despite the lack of a coordinated holistic mechanism to implement the BCAP, much of its recommendations with regard to *in situ* and *ex situ* conservation as well as some cross-cutting areas have been implemented by the institutions with a mandate to conserve forest and agro biodiversity. This has occurred in various ways. In some instances, those involved with BCAP preparation have included the relevant recommendations in subsequent plans and programmes they were involved with. Further, the Biodiversity Secretariat, the Department of Forest and the Department of Wildlife Conservation and conservation NGOs are represented in most fora that deal with habitat or species conservation, so that it has been possible to include *in situ* and *ex situ* biodiversity conservation considerations into the plans, programmes and projects of the forestry. Further, there is awareness about the need for biodiversity conservation among sectoral institutions and the conservation community (MFE, 1999). Furthermore, Provincial Ministries of Environment have a role to play in biodiversity conservation matters at the regional/local levels, and regional BCAP is already prepared allowing integration of biodiversity into regional strategic planning processes, too (Bambaradeniya, 2008; Jayasingham, 2008; Jayasuriya, 2008a; 2008b).

Table 6.1: International conventions, agreements, treaties and protocols related to biodiversity and ratified by Sri Lanka.

Name of Convention, agreement, convention, treaty and protocol	Date adopted	Date ratified
Vienna Convention on Protection of Ozone layer	22.03.1985	15.12.1989
United Nations framework Convention on Climate Change (UNFCCC)	09.05.1992	23.11.1993
Convention on Biological Diversity	22.05.1992	23.03.1994
United Nations Convention to Combat Desertification (UNCCD)	17.06.1994	09.12.1998
The Ramsar Convention on Wetlands	02.02.1971	15.06.1990
Convention on International Trade in Endangered species of Wild Fauna and Flora (CITES)	03.03.1973	04.05.1979
Convention on the Conservation of Migratory Species (CMS)	23.06.1979	06.06.1990
International Plant Protection Convention	06.12.1952	12.02.1952

Convention Concerning the protection of World cultural and Natural Heritage	16.11.1972	06.06.1980
Rotterdam Convention	10.09.1998	10.01.2006
Plant protection Agreement for Asia and Pacific Region	27.02.1956	27.02.1956
Montreal Protocol on Substances that deplete Ozone layer	16.09.1987	15.12.1989
Kyoto Protocol	11.12.1997	03.09.2002
Cartagena Protocol on Biosafety	29.01.2000	28.04.2004

Sources: MENR (2009); MENR and UNEP (2009).

International Collaboration

The FD has implemented reforestation activities under the ADB-funded Forest Resources Management Project. The main species that is being planted in the dry zone was teak, while eucalypts are planted in the upcountry as commercial timbers. Planting efforts implemented directly by the FD are involved mostly in regeneration cutting areas of mature forest plantations, while afforestation of degraded areas is mostly implemented through local people's participation. Relatively large blocks of land of over 25 ha are leased out to private companies to establish commercial plantations, while farmer participation is sought in establishing plantations in smaller blocks of land.

The ministry of Environment and the Forest Department are executing several collaborative donor - funded projects and programmes on conservation and use. The government of Sri Lanka is also committed to develop national programmes for conservation and sustainable use in adopting Agenda 21 and Rio Principles, implementing the Millennium Development Goals (MDGs), Biodiversity 2010 Target, Ecosystem Approach and Precautionary Principles and monitoring at a national level with the support of various Ministries Departments and UN agencies.

Sinharaja rainforest was one of the ten programme sites for the tropical soil biology and fertility programme of UNESCO/IUBS. It also continues to be a member of the long term forest dynamics programme across the tropics launched by the Centre for Tropical Forest Science (CTFS) of the Smithsonian Tropical Research Institution (Gunatilleke *et al*., 2004). A wealth of knowledge is generated through such projects (Annex 4).

Networking

Sri Lanka is involved in a number of regional and international collaborative initiatives, such as the TeakNet, TSC CSIRO, Aus Aid Small Grant, Asia Pacific Agroforestry Network (APAN), UNDP/FAO Regional Project on improved productivity of man-made forests in tree breeding and propagation (FORTIP), IUFRO, Asia Pacific Association of Forestry Research Institution (APAFRI) (Table 6.2). Some of them are currently functioning whereas the others are not active at present or the projects have been completed. However, FD continues to be a member of such initiatives (if functions at present). The main emphasis of such networks is information exchanges, development of technical guidelines, development of shared databases, establishment of genetic conservation strategies and germplasm exchange. ICRAF (World Agroforestry Centre) Sri Lanka programme is involved with tree domestication and networking of researchers of fruit trees and timber trees and also facilitate exchange of information, material and knowledge within Sri Lanka and among south Asian region

(species includes are *Artocarpus heterophyllus, Tectona grandis, Mangifera indica, Phyllanthus emblica, Aegle marmelos*.

Table 6.2: Overview of the main activities carried out through networks and their outputs.

Network name	Activities*	Genus/species involved (Scientific names)
Teak net	1, 2,	*Tectona grandis*
International Neem network (at present not functional)	1, 2, 3, 4, 5	*Azadiracta indica*
TSC CSIRO	2, 5	*Eucalyptus* sp.
AUSAID Small grant	2, 5	*Eucalyptus* sp. Established seed production areas for *Eucalyptus grandis* and *Eucalyptus microcorys*, and clonal seed orchards
FORTIP – FAO	1, 2,7	
APAN Network	1, 2	Agroforestry trees
Winrock – MPTS Network (locally functional but not globally)	1, 2, 5	Agroforestry species such as *Gliricidia, Leucaena, Calliandra*
APFORGEN	1, 2, 3	Multiple
CTFS Network	1, 2, 3, 4, 6	Centre for Tropical Forest Science (CTFS) of the Smithsonian Tropical Research Institute (STRI) is a global initiative in long-term tropical forest research. This established 25 ha Forest Dynamic Plot Programme at the Sinharaja forest
ICRAF (World Agroforestry Centre) Sri Lanka programme	1, 2, 3, 6	Agroforestry tree domestication. Operating timber tree and fruit tree networks for sharing information, material and knowledge within Sri Lanka and within the south Asia region.

Note: Examples of activities: 1- Information exchanges; 2- Development of technical guidelines; 3- Development of shared databases; 4- Establishment of genetic conservation strategies; 5- Germplasm exchange; 6- Elaboration, submission and execution of joint research projects; 7-Training.

Although regional networks are in operation, exchange of FGRs (especially commercially important species) is extremely difficult, hence the need effective regional collaboration for sharing of information and FGRs for plantation species. This can be addressed through collaborative research programmes with regional countries such as India and Thailand. World Agroforestry Centre through its timber tree and fruit tree networks of the country provides opportunities for scientists to visit regional countries which yield sharing of knowledge and information and exchange of material among countries. Such programmes should be conducted frequently aiming species and capacity building.

It is also proposed to conduct a national programme (seminar or workshop) for FGR and their activities to increase knowledge and awareness of the existing resources. It is important to

note here that the testing of provenance of *G. sepium* makes the way to identify the correct provenance for fuelwood, fodder, and higher yield (Gunasena *et al*., 1998; Thattil *et al*., 1995). Within the country, a network can be established to share knowledge and information with respect to current use of FGRs. It is also suggested that public and private sector partnership be built for quality planting material production. The level of priority for future international collaborations are given in Table 6.3. Outcomes of selected international collaborations are given in Annex 11.

Table 6.3: Awareness raising needs/needs for international collaboration and networking.

Needs	Level of priority			
	NA	Low	Medium	High
Understanding the state of diversity				1
Enhancing *in situ* management and conservation				1
Enhancing *ex situ* management and conservation				1
Enhancing use of forest genetic resources				1
Enhancing research				1
Enhancing education and training				1
Enhancing legislation (existing law low priority but regulations high priority)				1
Enhancing information management and early warning systems for FGR				1
Enhancing public awareness				1

CHAPTER 7:
ACCESS TO FOREST GENETIC RESOURCES AND SHARING BENEFITS ARISING OF FOREST GENETIC RESOURCES OUT OF THEIR USE

Access to forest genetic resources:

Policy on exchange of plant genetic resources are to be based on the Fauna and Flora Protection Ordinance (FFPO). FGR is not specifically stated in the FFPO. Jayasuriya *et al.* (2006) documented the material transfer agreement (MTA) and Prior Informed Consent (PIC) for exchange of genetic resources. According to Jayasuriya *et al*. (2006) only PGRC and Field Crops Research and Development Institute at Mahailuppllama used MTA and PIC in exchanging genetic resources, especially on food crop plants. This set up can be used for FGRs, too.

FFPO, Forest Ordinance, Seed Act, Quarantine Law and Plant Protection are the main legislations related to FGRs but none of these specifically mentioned the FGRs. Quarantine laws allow the international transfer of seeds and *in vitro* materials. National laws restrict unregulated collection and export of flora, as well as planting out of certain imported genetic resources to comply with quarantine regulations. The protection of flora outside National Reserves and Sanctuaries is also covered by Section 42 of the Fauna and Flora Protection Ordinance. The number of protected species of plants has been increased from nine to over 450 through the FFPO (Amendment Act of 1993). Much of these legislations are generally meant for conservation purpose, but not for utilization or regulating the access to the resources. There is a need to develop an efficient and effective system to regulate the access to genetic resources, and to ensure fair and equitable sharing of the benefits arising from the use of forest genetic resources particularly genetic resources of plantation forest species.

Sharing of benefits arising out of the use of forest genetic resources:

In Sri Lanka, Intellectual Property Rights (IPR) legislations are drafted as No. 36 of 2003 IPR laws. The country has not yet established mechanisms of sharing benefits arising out of the use of forest genetic resources. The Biodiversity Secretariat of Ministry of Forestry is expecting to act as an institution for such activities in due course.

CHAPTER 8:

CONTRIBUTION OF FOREST GENETIC RESOURCES TO FOOD SECURITY AND POVERTY REDUCTION

Forest Genetic Resources (FGRs) consist of an inter- and intra-specific diversity of the genetic material of species in natural forests and established plantations and homegardens. They consists of within and between variation of species. These FGRs provide supportive role to plant genetic resources in Sri Lanka for achieving the food security, and support the sustenance of people on earth because they are capable of providing fruits, foods, raw material for food, weaving material, thatching material, timber, construction material, poles, paper and pulpwood, fuelwood, medicines, raw material for industries, raw material for extraction of biomedicines, resins, gums. Hence, FGRs can be used directly to achieve food and nutritional security of rural communities. Timber is a direct source of income and asset for many rural communities. Raw material can be sold to obtain income and develop industries as in the case of sap of *Caryota urenus*. FGRs can be incorporated into the diverse ecosystems based on their adaptability, and also in attempts to diversify the farming strategies in the agroecosystems. These diversities can also be improved genetically and used to establish superior plantations. Thus, it is clear that if properly planned, FGRs could enhance economic development in several areas including sustainable land use, economics and trade, as well as public health and tourism. The importance of these resources to the economy, the basis of and source of livelihood for most of the country's people as well as being a source of substantial foreign exchange, cannot be underestimated. The use of FGR in the field of medicine and public health is probably placed at the highest profile. Knowledge of those plants of medicinal importance plays a major role in generating revenue and in some cases earning foreign exchange. Novel approaches to develop medicinal products through sustainable utilization of the FGRs, improvement and product development activities and in bioremediation and environmental pollution control would add to the economic benefits of this precious natural resource bases found in the country. Table 8.1 shows a list of forest tree species that are important in Sri Lanka for food security and livelihood improvement whereas Table 8.2 shows a list of agroforest tree species that are important in Sri Lanka for food security and livelihood improvement.

Table 8.1: List of forest tree species that are important in Sri Lanka for food security and livelihood improvement.

Scientific name	Family	Food and medicinal properties
Semecapus gardener	Anacardiaceae	Fruits are claimed to be of clinical relief to cancer. Oil from nuts a vesicant in rheumatism and sprains. Seeds after removal of toxicity by boiling used for treating haemorrhoids, urinary diseases, nervous disorders, skin diseases, sexual debility and diseases of liver and spleen.
S. marginata	Anacardiaceae	Fruits formed by expanded receptacle are sweet and edible.
S. subpeltata	Anacardiaceae	fruits and seed used as substitutes for *S. gardneri*.
Mangifera zeylanica	Anacardiaceae	Ripe fruits are edible although fibrous, plant parts used for skeletal fractures, snake bites, bee plant.
Amaranthus tricolor	Amaranthaceae	Used as a green vegetable akin to spinach.
Aerva lanata	Amaranthaceae	Herbal or medicinal tea. Juice extracted after crushing the whole plant is made into "green porridge" mixed with rice and coconut milk.
Alternanthera sessilis	Amaranthaceae	Eaten as a vegetable or plant extract made into "green

		porridge"
Enicosanthum acuminata	Annonaceae	Anticancer (?) compounds
Xypolia championii	Annonaceae	Perianth parts taken as a masticatory together with betel leaves and areca nut.
Aponogeton rigidifolius	Aponogetonaceae	Leaves, inflorescences and rhizome are eaten as a vegetable curry
Amorphophallus sylvaticus	Araceae	Corms used as a source of starch, leaves as a vegetable.
Cryptocoryne thawaitesii	Araceae	Medicinal
Rhaphidophora pertusa	Araceae	Medicinal value in treatment of jaundice or hepatitis, and snake bites.
Schefflera emarginata	Araliaceae	Leaves edible
Apama siliquosa	Aristolochiaceae	Substitute for betel leaves
Aristolochia indica	Aristolochiaceae	Decoction used to treat worms in children.
Eclipta prostrate	Asteraceae	Treats skin ailments, fractures, snake bites; leaves edible.
Vernonia cinerea	Asteraceae	Plant extract added to rice porridge – health food.
Balanophora fungosa ssp. indica	Balanophoraceae	Medicinal, used in neurological disorders.
Blechnum orientale	Blechnaceae	young unopened leaves cooked as a vegetable
Canarium zeylanicum	Burseraceae	Decoction of bark used a gargel for bleeding and inflamed gums and in treatment of diabetes. Seeds edible.
Salacia reticulate	Celasteraceae	Fruits edible, medicinal tonic made from seeds, stem and roots in treating diabetes.
Garcinia quaesita	Clusiaceae	The acidic fruits produce a kind of gamboge.
Garcinia zeylanica	Clusiaceae	The fruit segments are dried and sold in local market for curry preparations. In fish preparations it is added to brine.
Garcinia Morella	Clusiaceae	Gamboge possesses anthelmintic properties and is used for dropsy and chronic constipation and as a vermifuge.
Dioscorea bulbifera	Dioscoreaceae	Yams edible
Dioscorea spicata		Yams edible
Dioscorea koyamae		Yams edible
Shorea megistophylla	Dipterocarpaceae	Cotyledons used in food preparations; against alimentary disorders
Shorea disticha	Dipterocarpaceae	
Shorea cordifolia	Dipterocarpaceae	
Vateria copallifera	Dipterocarpaceae	Fruits used in a range of carbohydrate food preparations.
Eriocaulon brownianum	Eriocaulaceae	Health food. Plant extracts used in porridge. Cooked as a vegetable.
Eriocaulon cinereum	Eriocaulaceae	
Eriocaulon quinquangulare	Eriocaulaceae	
Eriocaulon sexangulare	Eriocaulaceae	"
Macaranga peltata	Euphorbiaceae	Leaves used as wrappers for steam-cooked food preparations.
Aporosa lindleyana	Euphorbiaceae	young leaves used in vegetable curries.
Casearia zeylanica	Flacourtiaceae	Used as a purgative. Also in treatment of diabetes.
Trichadenia zeylanica	Flacourtiaceae	Seeds made into curry or roasted and eaten.
Leucas zeylanica	Lamiaceae	Leaves used as a vegetable.
Cinnamomum verum	Lauraceae	Bark widely used as a spice and a medicine against dysentery, vomiting and bronchitis. Oil against toothaches.

Erythrina sp.	Leguminosae	Leaves cooked as a vegetable and used against worms in children.
Caesalpinia bonduc		Against internal parasites including worms.
Asparagus falcatus	Liliaceae	Tubers cooked and eaten. Leaf extract made into a porridge, a health food.
Amoora rohituka	Meliaceae	Bark astringent and used in treatment of enlarged liver and spleen.
Walsura trifoliolata	Meliaceae	Pulpy aril of the seed is edible, bark a powerful emmenagogue and acts as a violent emetic, fruit an expectorant.
Osbeckia octandra	Melastomataceae	Leaf extract used as a porridge – health food for those recovering from hepatitis.
Artocarpus nobilis	Moraceae	Seeds roasted and eaten
Cassampelos paapeira	Menispermaceae	used as a medicine
Coscinium fenestratum		Decoction of woody stem used in treatment of rheumatic fever, effective against tetanus.
Myristica dactyloides	Myristicaceae	Wild relative of nutmeg (*M. fragrans*)
Embelia ribes	Myrsinaceae	Used as a mild vermifuge in children.
Syzygium caryophyllatum	Myrtaceae	Fruits sweet and edible.
Nepenthes distillatoria	Nepenthaceae	Liquid in unopened pitcher used in treatment of whooping cough.
Caryota urens	Arecaceae	Phloem sap: sugar candy, alcoholic beverage; vinegar; palm heart: vegetable. Pith flour: food against alimentary tract disorders.
Oncosperma fasciculatum	Arecaceae	Palm heart eaten as a vegetable made into a curry. Pith of older parts made into flour for foods.
Piper sylvestre	Piperaceae	Wild relative of cultivated pepper, medicinal.
Piper trineuron	Piperaceae	Wild relative of cultivated pepper, medicinal.
Portulaca oleracea	Portulacaceae	Used as a cooked vegetable curry.
Zizyphus rugosa	Rhamnaceae	Fruits edible
Anthocephalus chinensis	Rubiaceae	Fruits edible.
Mussaenda glabrata	Rubiaceae	Leaves cooked as a vegetable.
Hedyotis fruticosa	Rubiaceae	Leaves as health food.
Pavetta indica	Rubiaceae	Used in herbal tea.
Nauclea orientalis	Rubiaceae	Fruits edible.
Dimocarpus longan	Sapindaceae	Aril of the seed is very sweet and edible.
Cardiospermum halicacabum	Sapindaceae	Made into porridge.
Chrysophyllum roxburghii	Sapotaceae	Fruits edible.
Bacopa monnieri	Scrophulariaceae	Health food. Cooked as vegetable
Torenia travancorica	Scrophulariaceae	Herbal tea.
Costus speciosus	Zingiberaceae	Leaves eaten as a vegetable; medicinal
Curcuma zedoaria	Zingiberaceae	Medicinal
Elettaria cardamomum	Zingiberaceae	Wild cardamom, medicinal and spice

Source: Gunatilleke and Gunatilleke, (1993).

Table 8.2: List of agroforest woody tree species that are important in Sri Lanka for food security and livelihood improvement.

Scientific name	Family	Scientific name	Family
Cocos nucifera	Palme	*Aegle marmelos*	Myrtaceae
Hevea brasiliensis	Euphorbiaceae	*Careya arborea*	Lecythidaceae
Artocarpus heterophyllus	Moraceae	*Alseodaphne semicarpifolia*	Lauraceae
Areca catechu	Palme	*Lannea coromandelica*	Anacardiaceae

Swietenia macrophylla	Meliaceae	*Holoptelea integrifolia*	Ulmaceae
Alstonia macrophylla	Apocynaceae	*Cassia fistula*	Fabaceae
Mangifera indica	Anacardiaceae	*Chukrasia tabularis*	Meliaceae
Albizia molucana	Fabaceae	*Borrasus flabellifer*	Palme
Eucalyptus sp.	Myrtaceae	*Phyllanthus emblica*	Euphorbiaceae
Tectona grandis	Verbenaceae	*Ceiba pentandra*	Bombacaceae
Azadirachta indica	Meliaceae	*Syzygium cumini*	Tiliaceae
Anacardium occidentale	Anacardiaceae	*Cassia siamea*	Fabaceae
Citrus aurantifolia	Rutaceae	*Spondias dulcis*	Anacardiaceae
Melia dubia	Meliaceae	*Diospyros malabarica*	Ebenaceae
Drypetes sepiaria	Euphorbiaceae	*Diplodiscus verrucosus*	Tiliaceae
Psidium guajva	Myrtaceae	*Morinda citrifolia*	Rubiaceae
Caryota urens	Palme	*Carallia brachiata*	Rhizophoraceae
Chloroxylon swietenia	Rutaceae	*Albizzia lebbeck*	Fabaceaea
Citrus cinensis	Rutaceae	*Acacia spp*	Fabaceae
Grevillea robusta	Proteaceae	*Homalium zeylanicum*	Flacourtiaceae
Bambusa vulgaris	Bambusaceae	*Calophyllum walkeri*	Clusiaceae
Gliricidia sepium	Euphorbiaceae	*Dialium ovoideum*	Fabaceae
Berrya cordifolia	Tiliaceae	*Sterculia foetida*	Sterculiaceae
Nephelium lappaceum	Sapindaceae	*Mangifera zeylanica*	Anacardiaceae
Toona sinensis	Meliaceae	*Phyllanthus indicus*	Euphorbiaceae
Grewia damine	Tiliaceae	*Bauhinia racemosa*	Fabaceae
Persea americana	Lauraceae	*Xylopia nigricans*	Annonaceae
Limonia acidissima	Rutaceae	*Coffea Arabica*	Rubiaceae
Artocarpus altilis	Moraceae	*Salmalia malabarica*	Bombacaceae
Dipterocarpus zeylanicus	Dipterocarpaceae	*Chrysophyllum roxburghi*	Sapotaceae
Vitex altissima	Verbenaceae	*Diospyros chaetocarpa*	Ebenaceae
Bridelia retusa	Euphorbiaceae	*Grewia rothii*	Tiliaceae
Tamarindus indica	Fabaceae	*Syzygium aromaticum*	Myrtaceae
Terminalia arjuna	Combritaceae	*Sesbania grandiflora*	Fabaceae
Schleichera oleosa	Sapindaceae	*Manilkara zapota*	Sapotaceae
Syzygium assimile	Myrtaceae	*Pongamia pinnata*	Fabaceae
Moringa oleifera	Moringaceae	*Helicteres isora*	Sterculiaceae
Manilkara hexandra	Sapotaceae	*Samanea saman*	Fabaceae
Mitragyma parvifolia	Rubiaceae	*Ficus racemosa*	Moraceae
Pterospermum suberifolium	Sterculiaceae	*Calotropis gigantean*	Asclepiadaceae
Adina cordifolia	Rubiaceae	*Gmelina asiatica*	Verbenaceae
Albizia odoratissima	Fabaceae	*Garcinia Morella*	Guttiferae
Pericopsis mooniana	Fabaceae	*Averrhoa bilinbi*	Oxalidaceae
Syzygium malaccensis	Myrtaceae	*Artocarpus heterophyllus*	Moraceae
Terminalia chebula	Combritaceae	*Canarium zeylanicum*	Burseraceae
Michelia champaca	Magnoliaceae	*Kurrimia ceylanica*	Celastraceae
Thevetia peruviana	Apocynaceae	*Myristica dactyloides*	Myristicaceae
Leucaena leucocephala	Fabaceae	*Durio zibethinus*	Bombacaceae
Pterocarpus marsupium	Fabaceae	*Semecarpus gardneri*	Anacardiaceae
Anona cherimolia	Annonaceae	*Anona muricata*	Annonaceae
Madhuca longifolia	Sapotaceae	*Strychnos potatorum*	Loganiaceae
Theobroma cacao	Sterculiaceae	*Neolitsea cassia*	Lauraceae
Dimocarpus longana	Sapindaceae	*Nauclea orientalis*	Rubaceae
Macaranga peltat a	Euphorbiaceae		
Elaeocarpus serratus	Elaeocarpaceae		
Thespesia populnea	Malvaceae		

Punica granatum	Panicaceae
Terminalia catappa	Combritaceae
Filicium decipiens	Sapindaceae
Terminalia bellirica	Combritaceae
Diospyros ebenum	Ebenaceae
Dillenia retusa	Dilleniaceae
Calophyllum inophyllum	Clusiaceae

Sources: Pushpakumara *et al.*, 2010; Ariyadasa, 2002

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ANNEXTURES

Annex 1: Key Social Indicators of Sri Lanka.

Social indicator	Value in 2010
1. Midyear population (million people)	20.01
2. Population growth rate	1.1
3. Population density (persons per square km)	319
4. Crude birth and death rate (per 1,000)	19.0, 5.8
5. Infant mortality (per 1,000 live birth)	12
6. Dependency ratio (%)	49.3
7. Life expectation at birth for male and female (years)	71.7, 77
8. Literacy rate; overall, male and female (%)	92.5, 94.5, 90.6
9. Population below US $ 1 and 2 a day	5.6, 41.6
10. Mean and median household income (US $/month)	243.39, 154.95
11. Average daily caloric intake	2,118
12. Poverty head count index	15.2
14. Employed persons in agriculture (%)	31.3
15. Per capita GNP (US $/month)	2,014

Source: CBSL (2010).

Annex 2: Floristic regions of Sri Lanka with their principal vegetation types and dominant plant communities.

No	Floristic Region	Characteristic natural vegetation types (dominant plant communities
I	Coastal and marine belt	Marine mangroves, salt marsh, and dunes, and strand Vegetation
II	Dry and arid lowlands	Tropical dry mixed evergreen forests *Manilkara* Community Mixed community (*Chloroxylon-Vitex-Berrya-Schleichera* series) Tropical thron forests (*Manilkara-Chloroxylon-Salvadora-Randia* series) Damana and Villu grasslands Flood-plain wetlands, Riverine and gallery forests
III	Northern intermediate lowlands	Tropical moist semi-evergreen forests (*Filicium-Euphoria-Artocarpus- Myristica* series)
IV	Eastern intermediate lowlands	Tropical moist semi-evergreen forests Savannah forests
V	Northern Wet lowlands	Tropical wet evergreen forests
VI	Sinharaja and Ratnapura	Tropical wet evergreen forests - (lowland hill Dipterocarp forests – *Mesua-Doona* community, Talawa –grasslands, Fernlands)
VII	Southern lowland hills	Tropical wet evergreen forests (*Dipterocarpus* community, *Mesua-Doona* Community)
VIII	Wetzone freshwater bodies	Streams, rivers and other freshwater bodies
IX	Foothills of Adam's Peak and Ambagamuwa	Tropical wet evergreen forests
X	Mid-mountains	Submontane forests (*Shorea –Calophyllum –Syzgium* series)
XI	Kandy and Upper Mahaweli	Tropical wet Evergreen forests Humid zone dry patana grasslands
XII	Knuckles	Tropical submontane forests (*Myristica-Cullenia-Aglaia-Litsea* Community Tropical montane forests (*Calophyllum* zone)
XIII	Central Mountains Ramboda, Nuwara Eliya	Tropical montane forests *(Calophyllum walkeri - Syzgium* community, wet patana grasslands)
XIV	Adam's Peak	Tropical montane forests Tropical submontane evergreen forests
XV	Horton Plains	Tropical montane forests Upper wet patana grasslands

Source: Ashton and Gunatilleke (1997).

Annex 3: The predicted demand for wood based products in Sri Lanka.

Annex 3.1: Predicted sawn wood and plywood consumption and supply.

Product	Amount (000 cubic m)			
	2005	2010	2015	2020
Sawn wood				
Consumption	688	753	820	885
Production	585	640	646	646
Imports	103	113	174	239
Plywood and other wood based panels				
Consumption	49	58	70	82
Production	5	5	5	5
Imports	44	53	65	77

Source: FSMP (1995).

Annex 3.2: Projected annual demnds for timber based products in Sri Lanka.

Product	Quantity				
	2000	2005	2010	2015	2020
Sawnwood (million cu. m)	0.626	0.688	0.753	0.820	0.889
Plywood (000 cu. m)	34	39	45	52	59
Fibre board (000 cu. m)	4	6	9	12	16
Particle board (000 cu. m)	2.5	3.3	4.3	5.5	7.0
Wooden poles (million cu. m)	0.411	0.432	0.453	0.471	0.486
Bamboo poles (million cu. m)	0.081	0.085	0.085	0.085	0.085
Biomass energy (million cu. m)	0.626	0.688	0.753	0.820	0.889

Source: FSMP (1995).

Annex 3.3: Projected area and wood production of homegardens in Sri Lanka.

Category	Quantity				
	2000	2005	2010	2015	2020
Area of homegardens (000 ha)					
Current trend	949.4	977.7	1,005.1	1,030.7	1,053.0
FSMP	970.5	1,019.2	1,067.1	1,112.7	1,153.0
Total wood production (000 cu. m)					
Current trend	2,501.0	2,552.1	2,526.4	2,429.3	2,411.1
FSMP	2,531.8	2,612.6	2,616.8	2,548.8	2,556.9

Source: FSMP (1995).

Annex 4: History of research and use of forest genetic resources in Sinharaja forest.

Sinharaja World heritage site (Plate 4.1) hereafter called as Sinharaja forest is the largest relatively undisturbed lowland rainforest in Sri Lanka. It is one of the most popular lowland rain forests for nature-based tourism in the country. Sinharaja forest is a major contributor to a hotspot of diversity because of its bio-geographic value and abundance of endemic species with restricted distributions. Its status over the years has changed from a wilderness area protected by traditional veneration to a production forest exploited for timber and back to a legally protected nature reserve. Before 1972, it was protected largely by its inaccessibility. Between 1972 and 1977, the western part of Sinharaja forest was a production forest, selectively logged for flywood. Concurrently, 40 ha at Warukandeniya in the south and central part and 1,800 ha in the eastern part were designated as National Man and Bisophere reserves. In 1978, logging at Sinharaja forest was stopped and the whole extent of 8,500 ha, comprising 65% high forest, 34% fern lands and secondary forests was declared as International Man and Bisophere Reserve. In 1980's an additional 2,687 ha of lower montane forests were included making a total of 11,187 ha. In 1988 the forest was declared as a National Heritage Wilderness Area whereas in 1990, UNESCO recognized it as a Natural World Heritage site (FD, 1988; 1993).

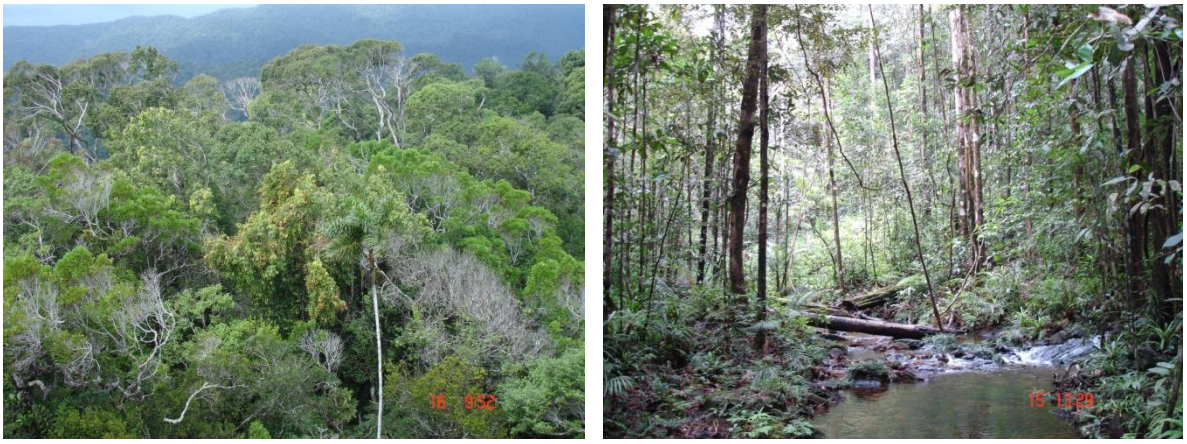


Plate 4.1: Canopy layer (left) and inside (right) of Sinharaja forest of Sri Lanka.
Photo: D.K.N.G. Pushpakumara.

The first systematic research at Sinharaja forest was dated back to 1950 where timber content was estimated from plot samples and aerial photographs (Meritt and Ranatunga 1959). This formed the basis for the Sinharaja logging project in the early 1970s. When logging was stopped in 1977, biological research was initiated to examine the richness and distribution of biodiversity for effective conservation management of the forest followed by a steadily developed interdisciplinary research programs. The next phase emphasized targeted research on the regeneration of timber and non-timber species in selectively logged sites, reproductive biology of economically important plants harvested directly from the wild, genetic diversity of Dipterocarps, eco-physiology and silvics of selected canopy dominant species, restoration and rehabilitation ecology, natural resource economics and ethnobotany and rural sociology of the surrounding villages. In the early 1990s, long-term forest dynamic studies in the primary forests and mixed species trails in a buffer zone *Pinus caribaea* plantation were initiated. Sinharaja forest was one of the ten program sites for the Tropical Soil Biology and Fertility Program of UNESCO/IUBS. It is a member of the long-term Forest Dynamics Plot

(FDP) across the tropics launched by the Centre for Tropical Forest Science of the Smithsonian Tropical Research Institution (Gunatilleke *et al*., 2004). Research information generated so far has not only enhanced the conservation value of this forest but also contributed towards its management for multiple uses including management of forest genetic resources.

The following is a brief discussion on some of the research outputs. Studies conducted by variation in number of trees per ha (594-769 individuals/ha), their basal area (36-41 m^2/ha), species richness of trees (115-144) and degree of dominance in different parts of the forest; contributions to species richness and dominance from different forest strata; and the contribution of endemic species to density (75-93%), basal area (87-93%), and tree species richness (64-75%) were reported by Gunathilake and Gunathilake (1983; 1985). They also assessed the populations sized of selected species and such work laid the foundation for subsequent floristic studies on the distribution and conservation of threatened woody endemic species of Sri Lanka and underutilized plant resources of Sinharaja (Gunathilake *et al*., 1987; Gunathilake and Gunathilake, 1993); a phyto-sociological comparison of neighboring modified rain forest sites with varying levels of disturbance (a selectively logged site, an abandoned skid trail and an abandoned shifting cultivated sites) with an undisturbed forest (de Zoysa *et al*., 1990). This latter study recorded 9-11% of pioneer species in the undisturbed and selectively logged sites compared to 29-32% in the highly degraded sites. The proportion of endemic species was shown to decrease from 62% to 44% with increasing disturbance and gap size. It also found that 77% of the species performed better in the primary forest and selectively logged sites.

Studies on non-timber forest species (NTFP) were initiated to understand their potential for domestication in buffer zones of the Sinharaja reserve, so that their products could be obtained from the agroforestry systems in the buffer zone instead of from the undisturbed forest from where they were traditionally gathered. Results revealed that most often used species are rattans, *Coscinium fenestratum* (medicinal vine), *Caryota urens* (palm) whose sugary sap is tapped from the inflorescence, and wild cardamom, which is used both as a spice and as a medicine. All these species grew better and were more abundant in selectively logged forests than in unlogged forests, where they grew slowly if they were present at all. Some of the canopy *Dipterocarps* such as *Shorea megistophylla, Shorea distica, Shorea cordifolia* and *Vateria copallifera*, provided a source of carbohydrate from their cotyledons, which also had medicinal properties. Some of these species also yielded resin. The reproductive biology of most of these species and a few others (*Shorea congestiflora, Shorea trapezifolia, Shorea affinis*) was studied to understand their pollination ecology, breeding biology, seed germination and seedling ecology (Senerath, 1990; Dayanandan *et al.,* 1990; Murawski *et al*., 1994a; 1994b; 1994c; Gunatilleke *et al.*, 1996; Kathriarachchi *et al*., 2000).

Murawski *et al*. (1994a, 1994b, 1994c) reported that the mating system of *Shorea congestiflora* was predominantly out-crossing (87%) while *S. trapezifolia* and *S. magistophylla* from the selectively logged areas exhibited a mixed mating strategy (54%-71% out-crossed). The out-crossing rate of *S. megistophylla* was significantly lower in a selectively logged population, where there was a ten-fold decrease in adult stem density compared to that of an unlogged forest. This provides evidence for enhanced inbreeding through selfing and kin mating subsequent to selective logging (Muruwski *et al*. 1994c). This research was pioneer research on mating system analysis of forest genetic resources.

Dayanandan (1989) studied the total genetic variation among ten sub-populations of *S. trapezifolia* from in and around the Sinharaja and revealed that 11.1% of it was due to differences among sub-populations. The distances among these populations ranged from 0.5-40 km. Stacey *et al*. (2001) report that in *Shorea cordifolia* and *Syzygium rubicundum* out-crossing between trees from the same forest significantly increases fruit set. Fruit set is highest for trees between one and ten km apart. On the other hand, crosses between trees from different forests causes outbreeding depression as manifested by a dramatic drop in fruit set compared to within-forest crosses. This suggests the existence of some degree of reproductive isolation resulting from natural selection and genetic drift among separate forest reserves of the aseasonal region of south-west of Sri Lanka. Consequently, each forest represents a distinct genetic resource worthy of conservation.

Anthropological surveys at Sinharaja forest focus on the interaction between people living around the reserve and the forest (Kariyawasam, 1999; Werahera and Abeygunawardena, 1993; Kathriarachchi, 2002). Households around Sinharaja forest depend on the forest both for their subsistence and for products to sell. The main commodities extracted are fuelwood for home use and sap tapped from *Caryota urens*, for commercial purposes. Kariyawasam (1999) using the method of participatory rural appraisal, studied three villages and found that low income households earned 32% of their income from NTFPs and over 40% from labour. In contrast, the richest households earned over 35% of their income from employment and over 45% of their income from the cultivation of tea. In Sinharaja and surrounding forests, 179 forest species, of which 33% are endemic, provide forest products gathered by villagers (Gunathileke *et al*., 1993). Folk knowledge of the uses of different forest products were gathered by surveying people in two villages reveal that the knowledge of the uses of forest products varies according to age, gender, distance to forest and social participation.

Kathriarachchi (2002) has also surveyed, through personal visits and informal discussions, 50% of the households in two peripheral villages (Kudawa and Pitakelle) to find out the views of villagers on the initiation of a community-based participatory management programme within the Sinharaja buffer zone for planting native non-timber forest species. This survey revealed that of the households surveyed, 95-100% had tea as a commercial crop, 46-59% had homegardens ranging from 0.1-0.4 ha, 61-85% extracted resources from the forest, 29-77% tapped *Caryota urens* as an income generating cottage industry, 33-46% gathered the medicinal vine *Coscinium fenestratum* for their home consumption. In addition, many of the households were eager to grow *Caryota urens* and *Elettaria cardamom*.

Sinharaja is an important site for training and environmental education. Since 1988, visitors to Sinharaja have increased almost exponentially. This increase is due to publicity through the mass media, tour guidebooks on Sri Lanka, and the inclusion of Sinharaja forest in ecology curricula of pre-university and university courses.

Floristic richness and life form variation

In the 25 ha FDP, the trees enumerated represented 46 families, 115 genera and 205 known species and 5 unidentified species representing five life form categories, namely (a) canopy species, which reach the uppermost layer of the forest and have umbrella shaped crowns, which are directly exposed to light; this life form group corresponds to the emergent layer of Southeast Asian mixed Dipterocarp forests as Sri Lankan rain forests like Sinharaja forest have no clear emergent layer, possibly due to strong wind experienced by these forests; (b) sub-canopy species which are found immediately below the uppermost stratum and typically

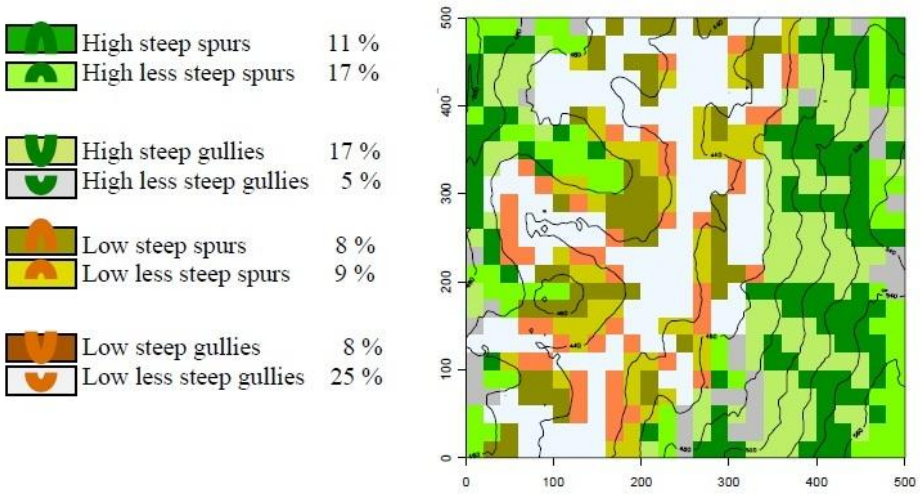
are able to grow in high light conditions; (c) understorey tree species, which have narrow but deep crowns and grow under shade and not in direct sunlight; (d) treelets and shrubs which include the smaller diameter species, most of whose adults are < 10 cm dbh; and (e) the lianas. The proportion of species among these different life forms was found to be a high 37% for treelet and shrub species, 24%, 22% and 13% for understorey tree species, subcanopy and canopy species, respectively, and a low of 5% for liana species (Gunatilleke *et al*., 2004). It has been also reported that the number of species representing a life-form group declined with increasing elevation. The largest decrease was observed for the treelet and shrub species and smallest for the canopy species.

The families with the most stems $\geq$ 1 cm dbh in the plot were the Euphorbiaceae with 19% of all stems, followed by the Clusiaceae 15%, Dipterocarpaceae 14% and Fabaceae 11%. Of the individuals in the FDP, 59% belonged to these four families, while 41% individuals represented the remaining 42 families. Based on Importance Value Indices (IVI), the leading families were Clusiaceae, Euphorbiaceae and Dipterocarpaceae, with Rubiaceae the fourth leading family.

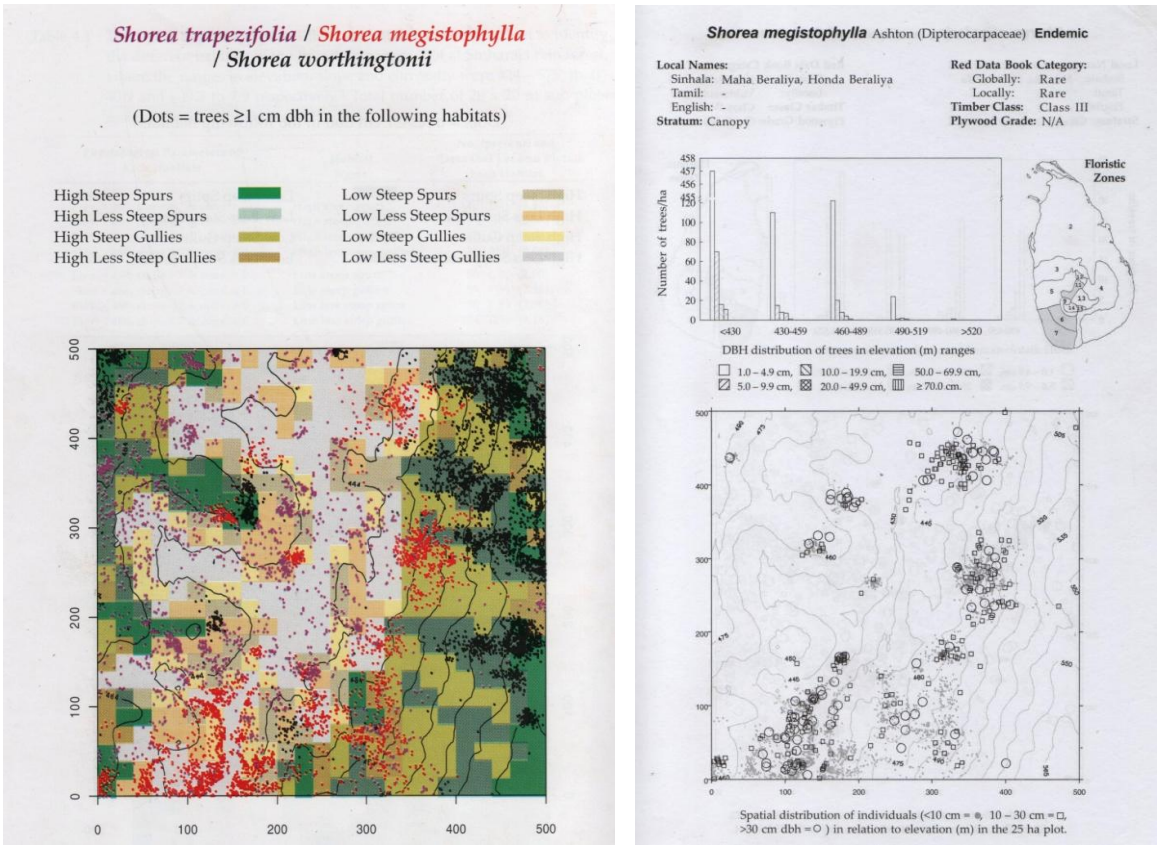
Although, lowland rain forest in Sri Lanka are fragmented, degraded, isolated and reduced to about 141,549 ha (Legg and Jewell 1995, based on interpretation of 1992 Landsat imagery), they remain a repository of much of the biological wealth of the country. Furthermore, the high local endemism in the island calls for sustainable management of not only the conservation forests that have been identified, but also those that would be assigned for production. With the wealth of information accrued since 1977 in Sinharaja forest and other rainforests, as well as that emerging from the Sinharaja FDP, it is opportune to formulate scientific guidelines, both for protection and production forests. Towards this end, Ashton *et al*. (1993) have already proposed a shelterwood regeneration method for sustained timber production in place of the more detrimental polycyclic system practiced in Sri Lanka in the recent past.

A field trial has also been initiated to restore monoculture *Pinus* plantations in the buffer zone of the Sinharaja forest to mixed species stands using primary forest canopy species and non-timber species (Ashton *et al*., 1997; Ashton, 1998). There is no doubt that information on growth, gap regeneration and spatial patterns of species emerging from the Sinharaja FDP will greatly contribute to the scientific understanding of the endemic-species rich rain forests of Sri Lanka and consequently to their sustainable management.

The diameter at breast height (DBH) distribution, population structure and spatial distribution patterns of individuals in relation to elevation of 144 abundant species represented by more than 50 individuals in the 25 ha plot are given in Gunatilleke *et al*. (2004). Annex Map 1 shows the spatial distribution of eight habitats based on elevation, slope and convexity identified in the Sinharaja 25 ha forest dynamics plot. The spatial distributions of three *Shorea* sp. of family Dipterocarpaceae is given in Annex Map 2. Accordingly, *S. megistophylla* and *S. trapezifolia*, among the leading canopy dominants in the valley, show an over representation of individuals in the low elevation steep and less steep habitats wheras *S. worthingtonii* is restricted and specialized to grow at the high elevation steep and less steep spurs. An example of species map of *S. trapezifolia* showing the distribution of individuals in three-diameter classess in the forest dynamics plot is given in Annex Map 3 (see Gunatilleke *et al*., 2004 for details).



Annex Map 1: The spatial distribution of eight habitats based on elevation, slope and convexity identified in the Sinharaja 25 ha forest dynamics plot.
Source: Gunatilleke *et al*. (2004).



Annex Map 2: The spatial distributions of three *Shorea* sp. of family Dipterocarpaceae in the forest dynamics plot of Sinharaja.
Source: Gunatilleke *et al*. (2004)

Annex Map 3: Species map of *S. trapezifolia* showing the distribution of individuals in three-diameter classess in the forest dynamics plot of Sinharaja.
Source: Gunatilleke *et al*. (2004)

Annex 5: List of endemic plant species in Sri Lanka.

ACANTHACEAE

- Barleria L
  - *B. nutans* Nees
  - *B. vestita* T. Anders.
- Gymnostachyum Nees
  - *G. ceylanicum* Arn. & Nees
  - *G. hirsutum* T. Anders.
  - *G. paniculatum* T. Anders.
  - *G. sanguinolentum* (Vahl) T. Anders.
  - *G. thwaitesii* T. Anders.
- Justicia L.
  - *J. ceylanica* (Nees) T. Anders.
  - *J. hookerana* (Nees) T. Anders.
  - *J. royeniana* (Nees) C.B. Clarke
- Lepidagathis Willd.
  - *L. ceylanica* Nees
  - *L. incurva* var. lophostachyoides (Nees) Abeywick
  - *L. walkeriana* Nees
- Plaesianthera (C.B. Clarke) Livera
  - *P. thwaitesii* (T. Anders.) Livera
  - *P tvssiglottis* T. Anders.
  - *P. radicosa* (Nees) T. Anders.
- Strobilanthes Blume
  - *S. arnottiana* Nees
  - *S. asperrima* Nees
  - *S. calycina* Nees
  - *S. deflexa* T. Anders.
  - *S. diandra* (Nees) Alston
  - *S. exserta* C.B. Clarke
  - *S. gardneriana* (Nees) T. Anders.
  - *S. helicoides* (Nees) T. Anders.
  - *S. hookeri* Nees
  - *S. lanceolata* Hook, ex Nees
  - *S. laxa* T. Anders.
  - *S. nigrescens* T. Anders.
  - *S. nockii* Trimen
  - *S. paniculata* T. Anders.
  - *S. pulcherrima* T. Anders.
  - *S. punctata* Nees
  - *S. rhamnifolia* (Nees) T. Anders.
  - *S. rhytisperma* C.B. Clarke
  - *S. stenodon* C.B. Clarke
  - *S. thwaitesii* T. Anders.
  - *S. trifida* Nees
  - *S. vestita* Nees
  - *S. viscosa* (Nees) T. Anders.
  - *S. walked* Arn. ex Nees
  - *S. zeylanica* T. Anders.

ALANGIACEAE

- Alangium Lam.
  - *A. salvifolium* (L. f.) Wangerin subsp. *Sundanum* (Miq.) Blombergen

AMARANTHACEAE

- Achyranthes L.
  - *A. diandra* Roxb.

ANACARDIACEAE

- Campnosperma Thw.
  - *C. zeylanicum* Thw.
- Mancifera L.
  - *M. zeylanica*
- Semecarpus L. f.
  - *S. acuminata* Thw.
  - *S. coriacea* Thw.
  - *S. gardneri* Thw.
  - *S. marginata* Thw.
  - *S. moonii* Thw.
  - *S. nigro-viridis* Thw.
  - *S. obovata* Moon
  - *S. parvifolia* Thw.
  - *S. pubescens* Thw.
  - *S. subpeltata* Thw.
  - *S. walkeri* Hook. f.

ANCISTROCLADACEAE

- Ancistrocladus Wall.
  - *A. hamatus* (Vahl) Gilg

ANNONACEAE

- Alphonsea Hook. f. & Thorns.
  - *A. hortensis* H. Huber
- Desmos Lour.
  - *D. elegans* (Thw.) Safford
  - *D. zeylanica* (Hook. f. & Thorns.) Safford
- Enicosanthum Becc.
  - *E.acuminata* (Thw.) Airy-Shaw
- Goniothalamus Hook. f. & Thorns.
  - *G. gardneri* Hook. f. & Thorns.
  - *G. hookeri* Thw.
  - *G. salicina* Hook. f. & Thorns. subsp. *reticulata* (Thw.) Huber subsp. *salicina*
  - *G. thomsonii* Thw.
- Miliusa Leschen. ex A. DC.
  - *M. zeylanica* Gardn. ex Hook. f. & Thorns.
- Phoenicanthus Alston (Endemic genus)
  - *P. coriacea* (Thw.) H. Huber
  - *P. obliqua* (Hook. f. & Thorns.) Alston in Trimen
- Polyalthia Blume
  - *P. moonii* Thw.
  - *P. persicaefolia* (Hook. f. & Thorns.) Thw.
- Sageraea Dalz.
  - *S. thwaitesii* Hook. f. & Thorns.
- Uvaria L.
  - *U. semecarpifolia* Hook. f. & Thorns.
  - *U. sphenocarpa* Hook. f. & Thorns.

Xylopia L
X. championii Hook. f. & Thorns.
X. nigricans Hook. f. & Thorns.

APOCYNACEAE
Anodendron A. DC.
A. rhinosporum Thw.
Cleghornia Wight
C. acuminata Wight
Walidda (A. DC.) M. Pichon
W. antidysenterica (L.) M. Pichon
Wrightia R. Br.
W. angustifolia Thw.
W. flavido-rosea Trimen
W. puberula (Thw.) Ngan
Holarrhena R. Br.
H. mitis (Vahl) Roem. & Schult.
Petchia Livera
P. ceylanica (Wight) Livera
Willughbeia Roxb.
W. cirrhifera Abeywick.

APONOGETONACEAE
Aponogeton Agardh
A. jacobsenii Bruggen in De Wit
A. rigidifolius Bruggen

AQUIFOLIACEAE
Ilex L.
I. zeylanica (Hook, f.) Maxim.

ARACEAE
Arisaema Mart.
A. constrictum Barnes
Cryptocoryne Fischer
C. alba de Wit
C. beckettii Trimen
C. parva de Wit
C. bogneri Rataj
C. nevillii Trimen
C. thwaitesii Schott
C. undulata Wendt
C. walkeri Schott
C. wendtii de Wit
C. x willisii Reitz
Lagenandra Dalz.
L. bogneri de Wit
L. jacobsenii de Wit
L. koenigii (Schott) Thw.
L. lancifolia (Schott) Thw.
L. praetermissa de Wit
L. thwaitesii Engler in DC.
Pothos L.
P. hookeri Schott
P. parvispadix Nicolson
P.remotiflorus Hook.

ARALIACEAE
Schefflera J.R. & G. Forst.
S. emarginata (Seem.) Harms.

ASCLEPIADACEAE
Brachystelma R. Br.
B. lankana Dassanayake & Jayasuriya
Ceropegia L.
C. elegans Wall. var. gardneri (Thw.) Huber
C.parviflora Trimen
C.tabrobanica Huber
Bidaria (Endl.) Decne
B. cuspidata (Thunb.) Huber in Abeywick.
var. *cuspidata*
var. *stenoloba* (Hook, f.) Huber in Abeywick.
B. celsicola Huber in Abeywick.
Gymnema R. Br.
G. lactiferum (L.) R. Br. ex Schult.
var. *thwaitesii* Hook. f.
G. rotundatum Thw.

BALANOPHORACEAE
Balanophora J.R. & G. Forst.
B. thwaitesii Eichl.

BALSAMINACEAE
Impatiens L.
I. appendiculata Arn.
I. arnottii Thw.
I. ciliifolia Grey-Wilson
subsp. *ciliifolia*
subsp. *sinharajensis* Grey-Wilson
I. cornigera Arn.
I. cuspidata Wight & Arn.
subsp. *bipartita* (Wight & Arn.) Grey-Wilson
I. elongata Arn.
I. janthina Thw.
I. leptopoda Arn.
I. leucantha Thw.
I. linearis Arn.
I. macrophylla Gardner
I. repens Moon
I. subcordata Arn.
I.taprobanica Hiern.
I. thwaitesii Hook. f. ex Grey-Wiison
I. truncata Thw.
I. walkeri Hook.

BAMBUSACEAE
Indocalamus Nakai
I. debilis (Thw.) Alston
I. floribundus (Thw.) Nakai
Ochlandra Thw.
O. stridula Thw.
var. *maculata* Gamble
Teinostachyum Munro
T. attenuatum (Thw.) Munro

BEGONIACEAE

Begonia L.

B. tenera Dry.
var. *tenera*
var. *thwaitesii* (Hook.) Jayasuriya

BOMBACACEAE

Cullenia Wight

C. ceylanica (Gardn.) K. Schum.
C. rosayroana Kosterm. emend A. Robyns

BORAGINACEAE

Cordia L.

C. oblongifolia Thw.

Tournefortia L.

T. tetrandra var. *walkerae* (C.B. Clarke) I.M. Johnston

BURMANNIACEAE

Thismia W. Griff.

T. gardneriana Hook. f. ex Thw.

BURSERACEAE

Canarium L.

C. zeylanicum (Retz.) Blume

Scutinanthe Thw. (Endemic genus)

S. brunnea Thw.

CELASTRACEAE

Euonymus L.

E. revolutus Wight
E. thwaitesii Laws.
E. walkeri Wight

Gymnosporia (Wight & Arn.) Hook. f.

C. emarginata (Willd.) Hook. f. ex Thw.

Kurrimia Wall.

K. ceylanica Arn. & Palen

CLUSIACEAE (GUTTIFERAE)

Calophyllum L.

C. bracteatum Thw.
C. calaba L *gurukina,*
C. cordato-oblongum Thw.
C. cuneifolium Thw.
C.moonii Wight
C. tomentosum Wight
C. trapezifolium Thw.
C. *walkeri* Wight
C. zeylanicum Kosterm.

Garcinia L**.**

G. hermonii Kosterm.
G. quaesita Pierre
G. terpnophylla (Thw.) Thw.
var. *terpnophylla*
var. *acuminata* Thw.
G. thwaitesii Pierre
G. zeylanica Roxb.

Mesua L**.**

M. ferrea L. (doubtfully endemic)
M. stylosa (Thw.) Kosterm.

COMBRETACEAE

Terminalia L.

T. parviflora Thw.

COMMELINACEAE

Commelina L.

C. thwaitesii Hook. f.

Cyanotis D. Don

C. ceylanica Hassk.
C. obtusa (Trimen) Trimen

COMPOSITAE

Anaphalis DC**.**

A. fruticosa Hook. f.
A. pelliculata Trimen
A. sulphurea (Trimen) Grierson
A. thwaitesii C.B Clarke
var. *thwaitesii*
var. *glabrescens* Grierson \
A. zeylanica C.B. Clarke in Hook. f.

Blumea DC. in Guill.

B.angustifolia Thw.
B. crinita Arn.
B. heiracifolia (D. Don) DC. in Wight
var. *flexuosa* (C.B. Clarke) Randeria
B. zeylanica (Hook, f.) Grierson

Helichrysum P. Mill.

H. buddleioides DC. var. *hookerianum* (Wight & Arn)Hook.f.

Youngia Cass.

Y. fuscipappa Thw.

Emilia Cass.

E. alstonii Fosberg
E. baldwinii Fosberg
E. exserta Fosberg
E. speeseae Fosberg
E. zeylanica C.B. Clarke
var. *zeylanica*
var. *walkeri* (Hook, f.) Trimen

Gynura Cass.

G. hispida Thw.
G. zeylanica Trimen

Senecio L.

S. gardneri (Thw.) C.B. Clarke

Vernonia Schreb.

V. anceps C.B. Clarke in Hook. f.
V. gardneri Thw.
var. *gardneri*
var. *brevior* Crierson
V. *hookeriana A*rn.
V. *lankana* Grierson
var. *lankana*
var. *crassa* (Thw.) Grierson
V. *nemoralis* Thw.
V. *pectiniformis* (DC.) subsp. *puncticulata* (DC.) Grierson
V. *setigera* Arn.
V. *thwaitesii* C.B. Clarke
V. *wightiana* Arn.

V. *zeylanica* (L.) Less.

CONNARACEAE

Connarus L.

C. championii Thw.

Ellipanthus Hook. f.

E. unifoliatus (Thw.) Thw.

CONVOLVULACEAE

Argyreia Lour.

A. hancorniaefolia Gardner in Thw.

A. populifolia Choisy in DC.

A. thwaitesii (Clarke) D. Austin

Ipomoea L.

I. jucunda Thw.

CORNACEAE

Mastixia Blume

M. tetrandra (Wight ex Thw.) C.B. Clarke

CUCURBITACEAE

Momordica L.

M. denudata (Thw.) C.B. Clarke

Trichosanthes L.

T. integrifolia Thw.

CYPERACEAE

Carex L

C. arnottiana Nees ex Drejer

C. filicina Nees in Wight subsp. *ceylanica* (Boeckeler) T. koyama

C. lobulirostris Drejer

C. rara Boott subsp. *patanicola* T. Koyama

C. spicigera Nees in Wight subsp. *spicigera*

f. *spicigera*

f. *rostrata* (Boeckeler) T. Koyama

f. *rubella* (Boott) T. Koyama

subsp. *minor* (Boott) T. Koyama

C. taprobanensis T. Koyama

Eleocharis R. Br.

E. lankana T. Koyama

Fimbristylis Vahl

F. fusca (Nees) Clarke in Hook. f. subsp. *fulvescens* (Thw.) T. Koyama

F. zeylanica T. Koyama

Hypolytrum L.C. Rich.

H. longirostre Thw.

H. turgidum Clarke in Hook. f.

Mapania Aubl.

M. immersa (Thw.) Benth. ex Clarke in Hook. f.

Scleria Berg.

S. multilacunosa T. Koyama

S. pilosa Boeckeler

DILLENIACEAE

Acrotrema Jack.

A. dissectum Thw. ex Hook. f.

A. gardneri Thw.

A. intermedium Thw.

A. lanceolatum Hook.

A. lyratum Thw. ex Hook. f.

A. thwaitesii Hook. f. & Thorns.

A. uniflorum Hook.

Dillenia L.

D. retusa Thunb.

Schumacheria Vahl (Endemic genus)

S. alnifolia Hook. f. & Thorns.

S. angustifolia Hook. f. & Thorns.

S. castaneaefolia Vahl

Wormia Rottb.

W. triquetra Rottb.

DIOSCOREACEAE

Dioscorea L.

D. trimenii Prain & Burkill

DIPSACACEAE

Dipsacus L.

D. walkeri Arn.

DIPTEROCARPACEAE

Cotylelobium Pierre

C. lewisianum (Trimen ex Hook, f.) Ashton

C.scabriusculum (Thw.) Brandis

Dipterocarpus Gaertn. f.

D. glandulosus Thw.

D.hispidus Thw.

D. insignis Thw.

D. zeylanicus Thw.

Hopea Roxb.

H. brevipetiolaris (Thw.) Ashton

H. cordifolia (Thw.) Trimen

H. discolor Thw.

H. jucunda Thw.

subsp. *jucunda*

subsp. *modesta* DC.

Shorea Roxb. ex Gaertn. f

S. stipularis Thw.

S. affinis (Thw.) Ashton

S. congestiflora (Thw.) Ashton

S. cordifolia (Thw.) Ashton

S. disticha (Thw.) Ashton

S. gardneri (Thw.) Ashton

S. megistophylla Ashton

S. ovalifolia (Thw.) Ashton

S. trapezifolia (Thw.) Ashton

S. worthingtonii Ashton

S. zeylanica (Thw.) Ashton

S. dyeri Thw. in Trimen

S. lissophylla Thw.

S. oblongifolia Thw.

S. pallescens Ashton

Stemonoporus Thw., Hook. (Endemic genus)

S. acuminatus (Thw.) Beddome

S. affinis Thw.

S. canaliculars Thw.

S. ceylanicus (Wight) Alston in Trimen

S. cordifolius (Thw.) Alston in Trimen

S. elegans (Thw.) Alston in Trimen

S. gardneri Thw.

S. lanceolatus Thw.

S. lancifolius (Thw.) Ashton

S. nitidus Thw.
S. oblongifolius Thw.
S. petiolaris Thw.
S. reticulatus Thw.
S. revolutus Trimen ex Hook. f.
S. rigidus Thw.

Vateria L.
V. copallifera (Retz.) Alston ex Trimen

Vatica L.
V. affinis Thw.
V. obscura Trimen

EBENACEAE

Diospyros L.
D. acuminata (Thw.) Kosterm.
D. acuta Thw.
D. albiflora Alston in Trimen
D. atrata Alston in Trimen
D. attenuata Thw
D. chaetocarpa Kosterm.
D. hirsuta L. f.
D. ebenoides Kosterm.
D. koenigii Kosterm.
D. moonii Thw.
D. oblongifolia (Thw.) Kosterm.
D. opaca Clarke
D. oppositifolia Thw.
D. quaesita Thw.
D. rheophytica Kosterm.
D. thwaitesii Beddome
D. trichophylla Alston in Trimen
D. walked (Wight) Cuerke

ELAEOCARPACEAE

Elaeocarpus L.
E. ceylanicus (Arn.) Mast.
E. glandulifer (Hook. ex Wight) Mast.
E. montanus Thw.
E. obovatus Arn.

ERIOCAULACEAE

Eriocaulon L.
E. atratum Koern.
E. ceylanicum Koern.
E. longiocuspis Hook. f.
E. philippo-coburghii Szy.
E. subglaucum Ruhl
E. trimenii Hook. f.
E. walkeri Hook. f.

ERYTHROXYLACEAE

Erythroxylum Browne
E. obtusifolium (Wight) Hook. f.
E. zeylanicum O.E. Schuitz

EUPHORBIACEAE

Adenochlaena Boiv. ex Baill.
A. zeylanica (Baill.) Thw.

Agrostistachys Dalz.
A. coriacea Alston
A. hookeri (Thw.) Hook. f.

Antidesma L.
A. pyrifolium Muell. Arg.

Aporosa Blume
A. cardiosperma (Gaertn.) Merr.
A. lanceolata (Tul.) Thw.

Bridelia Willd.
B. moonii Thw.

Chaetocarpus Thw.
C. coriaceus Thw.
C. pubescens (Thw.) Hook. f.

Cleistanthus Hook. f.
C. acuminatus (Thw.) Muell. Arg.
C. ferrugineus (Thw.) Muell. Arg.
C. pallidus (Thw.) Muell. Arg.
C. robustus Muell. Arg.

Croton L.
C. moonii Thw.
C.nigroviridis Thw.

Drypetes Vahl
D. gardneri (Thw.) Pax & Hoffm.
D. lanceolata (Thw.) Pax & Hoffm.

Glochidion J.R. & G. Forst.
G. acutifolium Alston
G. coriaceum Thw.
G. gardneri Thw.
G. montanum Thw.
G. moonii Thw.
G.nemorale Thw.
G. pachycarpum Alston
G.pycnocarpum (Muell. Arg.) Bedd
G. stellatum (Retz.) Bedd.

Macaranga Thou.
M. digyna (Wight) Muell. Arg.

Mallotus Lour.
M. eriocarpus (Thw.) Muell. Arg.
M. fuscescens (Thw.) Muell. Arg.
M. walkerae Hook. f.

Micrococca Benth.
M. oligandra (Muell. Arg.) Prain

Ostodes Blume
O. minor (Thw.) Muell. Arg.

Phyllanthus L.
P. affinis Muell. Arg.
P. baillonianus Muell. Arg.
P. cinereus Muell. Arg.
P. cyanospermus (Gaertn.) Muell. Arg.
P. dealbatus Alston
P. hakgalensis Thw. ex Trimen
P. myrtifolius (Wight) Thw.
P. oreophilus Muell. Arg.
P. thwaitesianus Muell. Arg.

Podadenia Thw. (Endemic genus)
P. thwaitesii (Baill.) Muell. Arg.

Putranjiva Wall.
P. zeylanica (Thw.) Muell. Arg.

Sauropus Blume
S. assimilis Thw.
S. retroversus Wight
S. rigidus Thw.

Trigonostemon Blume
T. diplopetalus Thw.

FABACEAE

Sophora L.

S. violacea Thw.

S. zeylanica Trimen

FLACOURTIACEAE

Chlorocarpa Alston (Endemic genus)

C. pentachista Alston

Dovyalis E. Mey. ex Arn

D. hebercarpa (Gardn.) Warb.

Erythrospermum Lam.

E. zeylanicum (Gaertn.) Alston

Hydimocarpus Gaertn.

H. octandra Thw.

Osmelia Thw.

O. gardneri Thw.

Scolopia Schreb.

S. acuminata Clos.

S. crassipes Clos.

S. pusilla (Gaertn.) Willd.

Trichadenia Thw. (Endemic genus)

T. zeylanica Thw.

GENTIANACEAE

Crawfurdia Wall.

C. championii (Gardner) Trimen

Exacum L.

E. axillare Thw.

var. *pentamera* Clarke in Hook. F.

E. trinervium (L.) Druce

subsp. *trinervium*

subsp. *ritigalensis* (Willis) Cramer

subsp. *pallidum* (Trimen) Cramer

subsp. *macranthum* (Arn.) Cramer

E. walkeri Am.

Swertia L.

S. zeylanica (Griseb.) Walker ex Clarke in Hook. f.

GESNERIACEAE

Aeschynanthus Jack.

A. ceylanica Gardn.

Championia Gardn.

C. reticulata Gardn

Chirita Buch.-Ham. ex D. Don

C. angusta (Clarke) Theobald & Grupe

C. moonii Gardn.

C. walkeri Gardn.

subsp. *walkeri*

subsp. *parviflora* (Clarke) Theobald & Grupe

C.zeylanica Hook.

Didymocarpus Wall.

D. floccosus Thw.

D. zeylanicus R. Br. in Bennett

Rhynchoglossum Blume)

R. gardneri Theobald & Grupe

GRAMINEAE

Arundinella Raddi

A. blephariphylla (Trimen) Trimen ex Hook. f.

A. laxiflora Hook. f.

A. thwaitesii Hook. f.

Cymbopogon Sprengl.

C. thwaitesii (Hook, f.) Willis

Dimeria R. Br.

D. elatior (Hook, f.) Senaratna

D. lehmannii (Nees) Hack.

D. trimenii Hook. f.

Eragrostiella N.L Bor

E. secunda (Nees) N.L. Bor

Eulalia Kunth

E. thwaitesii (Hack.) Kuntze

Garnotia Brongn.

G. fergusonii Trimen

var. *fastigiata* Hook. f. in Trimen

G. fuscata Thw.

G. micrantha Thw.

G. panicoides Trimen

G. scopraria Thw.

Isachne R. Br.

I. multiflora (Thw.) Ferg.

Ischaemum L.

I. rivale Hack.

Lophatherum Brongn.

L. zeylanicum Hook. f.

Oplismenus Beauv.

O. thwaitesii Hook. **f.** in Trimen

Rottboellia L. f.

R. nigrescens Thw.

Sporobolus R. Br.

S. trimenii Senaratna

Zenkeria Trin.

Z. obtusiflora (Thw.) Benth.

HALORAGIDACEAE

Laurembergia Berg.

L. glaberrima Schindl.

var. *minor* (Thw.) Schindl.

L. indica (Thw.) Schindl.

L. zeylanica (Arn. ex C.B. Clarke) Schindl.

HYDROCHARITACEAE

Blyxa Nor. ex Thou.

B. aubertii Rich.

ICACINACEAE

Apodytes E. Meyer

A. gardnerana Miers

Urandra Thw.

U. apicalis Thw.

LAMIACEAE (LABIATAE)

Anisochilus Wall.

A. velutinus Trimen

Coleus Lour.

C. elongatus Trimen

C. inflatus Benth.

C. kanneliyensis Cramer & Balasubramaniam

C. malabaricus Benth.

var. *leptostachys* (Benth.)

Hookf.
C. mollis Benth. in DC.
C. zeylanicus (Benth.) Cramer
Plectranthus L'Herit.
P. capillipes Benth. in DC.
P. gardneri Thw.
P. nigrescens Benth.
var. *pilosus* Cramer
Scutellaria L.
S. oblonga Benth.
S. robusta Benth.
S. violacea Heyne ex Benth. in Wall,
var. *glabra* Trimen
var. *rotunda* Cramer
Leucas R. Br.
L. zeylanica (L.) R. Br.
var. *walkeri* (Benth.) Hook. f.
var. *linearis* Cramer
Pogostemon Desf.
P. hirsutus Benth.
P. reflexus Benth. in DC.
P. rupestris Benth.

LAURACEAE
Actinodaphne Nees
A. ambigua (Meissn.) Hook. f.
A. elegans Thw.
A. glauca Nees
A. molochina Nees
A. pisifera Hook. f.
A. speciosa Nees
A. stenophylla Thw.
Beilschmiedia Nees
B. zeylanica (Thw.) Trimen
Cinnamomum Blume
C. citriodorum Thw.
C. litseifolium Thw.
C. multiflorum Wight
C.ovalifolium Wight
Cryptocarya R. Br.
C. membranacea Thw.
Lindera Thunb.
L. lancifolia (Thw.) Trimen
Lusea Lam.
L. gardneri (Thw.) Hook. f.
L. glaberrima (Thw.) Hook. f.
L. hookeriana (Meissn.) Hook. f.
L. iteodaphne (Nees) Hook. f.
L. longifolia (Nees) Alston
L. nemoralis (Thw.) Hook. f.
L. ovalifolia (Wight) Hook. f.
L undulata Hook. f.
Neolitsea (Benth.) Merr.
N. fuscata (Thw.) Alston

LECYTHIDACEAE
Barringtonia J.R. & G. Forst.
B. ceylanica (Miers) Gardn. ex C.B. Clarke

LEGUMINOSAE
Crotalaria L.
C. multiflora (Arn.) Benth.
C. walkeri Arn.
Crudia Schreb.
C. zeylanica (Thw.) Benth.
Derris Lour.
D. parviflora Benth.
Desmodium Desv.
D. adscendens var. *trifoliastrum* Schindl.
D. jucundum Thw.
Zornia J.F. Gmel.
Z. walkeri Arn.

LILIACEAE
Asparagus L.
A. zeylanicus (Baker) Hook. f.
Urginea Steinh.
U. rupicola (Trimen) Trimen ex Hook. f.

LINACEAE
Hugonia L.
H. ferruginea Wight & Arn.

LOGANIACEAE
Gaertnera Lam.
G. gardneri Thw.
G. rosea Thw. ex Benth.
G. ternifolia Thw.
G. vaginans (DC.) Merr.
G. walkeri (Arn.) Wight
Strvchnos L.
S. benthamii C.B. Clarke
S. cinnamomifolia Thw.
S. coriacea Thw.
S. micrantha Thw.
S. tetragona A.W. Hill

LORANTHACEAE
Barathranthus (Korth.) Miq.
B. mabaeoides (Trimen) Danser
B. nodiflorus (Thw.) Tieghem
Dendrophthoe Mart.
D. ligulata (Thw.) Tieghem
D. lonchiphyllus (Thw.) Danser
D. suborbicularis (Thw.) Danser
Helixanthera Lour.
H. ensifolia (Thw.) Danser
Macrosolen (Blume) Reichb.
M. albicaulis Wiens
M. barlowii Wiens
Scurrula L.
S. cordifolia (Wall.) G. Don
Taxillus Tieghem
T. courtallensis (Gamble) Danser
T. incanus (Trimen) Wiens
T. sclerophyllus (Thw.) Danser
Tolypanthus (Blume) Reichb.

T. gardneri (Thw.) Tieghem

MAGNOLIACEAE

Michelia L.

M. nilagirica Zenker var. *walkeri* Hook. f. & Thorns.

MALVACEAE

Dicellostyles Benth.

D. axillaris (Thw.) Thw.

Julostylis Thw. (Endemic genus)

J. angustifolia (Arn.) Thw.

MARANTACEAE

Stachyphrynium K. Schum.

S. zeylanicum (Benth.) K. Schum.

MELASTOMATACEAE

Axinandra Thw.

A. zeylanica Thw.

Lijndenia Mor.

L. capitellata (Arn.) Bremer

L. gardneri (Thw.) Bremer

Medinilia Gaud, in Freyc.

M. cuneata (Thw.) Bremer & Lundin

M. fuchsioides Gardn.

M. maculata Gardn.

Memecylon L.

M. capitellatum L.

M. clarkeanum Cogn. in DC.

M. cuneatum Thw.

M. discolor Cogn. in DC.

M. ellipticum Thw.

M. fuscescens Thw.

M. giganteum Alston in Trimen

M. gracillimum Alston in Trimen

M. grande Retz.

M. hookeri Thw.

M. leucanthemum Thw.

M. macrocarpum Thw.

M. macrophyllum Thw.

M. orbiculare Thw.

M. ovoideum Thw.

M. parvifolium Thw.

M. petiolatum Trimen ex Alston

M. phyllanthifolium Thw.

M. procerum Thw.

M. revolutum Thw.

M. rhinophyllum Thw.

M. rivulare Bremer

M. rostratum Thw.

M. rotundatum (Thw.) Cogn.

M. royenii Blume

M. sylvaticum Thw.

M. urceolatum Cogn. in DC.

M. varians Thw.

Osbeckia L

O. buxifolia Arn.

O. lanata Alston in Trimen

O. moonii Thw.

O. octandra (L.) DC.

O. rheedii Gardn. ex Thw.

O. walkeri Arn.

Sonerila Roxb.

S. affinis Arn.

S. arnottiana Thw.

S. cordifolia Cogn. in DC.

S. crassicaulis Lundin

S. firma (Thw. ex Clarke in Hook, f.) Lundin

S. gardneri Thw.

S. glaberrima Arn.

S. glabricaulis (Thw. ex Clarke in Hook, f.) Lundin

S. guneratnei Trimen

S. harveyi Thw.

S. hirsutula Arn.

S. hookeriana Arn.

S. lanceolata Thw.

S. pedunculosa Thw.

S. pilosula Thw.

S. pumila Thw.

S. rhombifolia Thw.

S. robusta Arn.

S. silvatica Lundin

S. tomentella Thw.

S. wightiana Arn.

S. zeylanica Wight & Arn.

MELIACEAE

Aglaia Lour.

A. apiocarpa (Thw.) Hiern

Munronia Wight

M. pumila Wight

Pseudocarapa Hemsl. (Endemic genus)

P. championii (Thw.) Hemsl.

Walsura Roxb.

W. gardneri Thw.

MIMOSACEAE

Abarema Pittier

A. abeywickramae Kosterm.

A. bigemina (L.) Kosterm.

Acacia Willd.

A. lankaensis Kosterm.

Adenanthera L.

A. bicolor Mooni

Albizia Durazz.

A. lankaensis Kosterm.

Painteria Britton & Rose

P. nitida (Vahl) Kosterm.

MONIMIACEAE

Hortonia Wight ex Arn. (Endemic genus)

H. angustifolia (Thw.) Trimen

H. floribunda Wight ex Arn.

MORACEAE

Artocarpus J.R. & G. Forst.

A. nobilis Thw

Broussonetia L'Herit. ex Vent.

B. zeylanica (Thw.) Corner

Ficus L.

F. diversiformis Miq.
F. costata Ait.
F. fergusoni (King) Worthington

MYRISTICACEAE

Horsfieldia Willd.

H. iryaghedhi (Gaertn.) Warb.

Myristica Boehm.

M. ceylanica A. DC

MYRSINACEAE

Ardisia Swartz

A. gardneri C.B. Clarke
A. moonii C.B. Clarke
A. willisii Mez.

MYRTACEAE

Eugenia L.

E. amoena Thw.
E. cotinifolia Jacq.
subsp. *phyllyraeoides* Trimen
E. fulva Thw.
E. glabra Alston in Trimen
E. mabaeoides Wight
subsp. *mabaeoides*
subsp. *pedunculata* Trimen
E. rivulorum Thw.
E. rotundata Trimen
E. rufo-fulva Thw.
E. terpnophylla Thw.

Syzygium R. Browne ex Gaertn.

S. assimile Thw.
subsp. *acuminata* Ashton
S. cordifolium Walp.
subsp. *cordifolium*
subsp. *spissum* (Alston) Ashton
S. cylindricum (Wight) Alston in Trimen
S. firmum Thw.
S. lewisii Alston in Trimen
S. makul Gaertn.
S. micranthum Thw.
S. neesianum Arn.
S. oliganthum Thw
S. rotundifolium Arn.
S. sclerophyllum Thw.
S. spathulatum Thw.
S. turbinatum Alston in Trimen
S. umbrosum Thw.

NEPENTHACEAE

Nepenthes L.

N. distillatoria L.

OCHNACEAE

Ochna L.

O. jabotapita L.
O. obtusata DC. var. *obtusata* Kanis

OLEACEAE

Jasminum L**.**

J. angustifolium (L.) Willd.
var. hirsutum P.S. Green
J. bignoniaceum Wall, ex G. Don
subsp. zeylanicum P.S. Green

Chionanthus L.

C . albidiflora Thw.

ORCHIDACEAE

Adrorhizon Hook. f.

A. purpurascens Hook. f.
in Trimen

Aerangis Reichb. f.

A. hologlottis (Schltr.) Schltr.

Agrostophyllum BIume

A. zeylanicum Hook. F.

Angraecum Bory

A. zeylanicum Lindl.

Arundina Blume

A.minor Lindl.

Bulbophyllum Thou.

B.crassifolium Thw. ex Trimen
B. elegans Gardner ex. Thw.
B. elliae Reichb. f. in Walp.
B. macraei (Lindl.) Reich b.f. in Walp.
B. maskeliyense Livera
B. petiolare Thw.
B. purpureum Thw.
B. thwaitesii Reichb. f.
B. tricarinatum Petch
B. trimeni (Hook, f.) J.J. Sm.
B. wightii Reichb. f. in Walp.

Calanthe R.Br.

A. purpurea Lindl.

Coelogyne Lindl.

C. breviscapa Lindl.
C. zeylanica Hook. f. in Trimen

Dendrobium Swartz

D. diodon Reichb. f.
D. maccarthiae Thw.
D. panduratum Lindl.

Eria Lindl.

E. articulata Lindl.
E.lindleyi Thw.
E.tricolor Thw.
E.thwaitesii Trimen

Gastrochilus D. DON

G. acaulis (Lindl.) Kuntze

Gastrodia R. BR.

G. zeylanica Schlechter

Habenaria Willd.

H. acuminata (Thw.) Trimen
H. dichopetala Thw.
H. dolichostachya Thw.
H. pterocarpa Thw.
H. rhynchocarpa (Thw.) Trimen

Hetaeria Blume

H. gardneri (Thw.) Trimen

Ipsea Lindl.

I.speciosa Lindl.

Liparis Rich.

L. barbata Lindl.

L. brachyglottis Reichb. f. ex Trimen

L. caespitosa (Thouars) Lindl.

Malaxis Solander ex Swartz

M. discolor (Lindl.) Kuntze

M. lancifolia (Thw.) Kuntze

Oberonia Lindl.

O. claviloba Jayaweera

O. dolabrata Jayaweera

O. forcipata Lindl.

O. fornicata Jayaweera

O. longibracteara Lindl.

O. quadrilatera Jayaweera

O. scyllae Lindl.

O. tenuis Lindl.

O. thwaitesii Hook f.

O. truncata Lindl.

O. wallie-silvae Jayaweera

O. weragamaensis Jayaweera

Peristylus Blume

P. brevilobus Thw.

P. gardneri (Hook, f.) Kraenzl.

P. trimenii (Hook, f.) Abeywick.

Phaius Lour.

P. luridus Thw.

Podochilus Blume

P. falcatus Lindl.

P. saxatilis Lindl.

Pomatocalpa Breda

P. decipiens (Lindl.) J.J. Smith

P. maculosum (Lindl.) J.J. Smith

Robiquetia Gaud.

R. brevifolia (Lindl.) Garay

R. rosea (Lindl.) Garay

R. virescens (Gard. ex Lindl.) Jayaweera

Schoenorchis Blume

S. nivea (Lindl.) Schltr.

S. tortifolia (Jayaweera) Garay

Taeniophyllum Blume

T. alwisii Lindl.

T. gilimalense Jayaweera

Thrixspermum Lour.

T. pugionifolium (Hook, f.) Schlechter

T. pulchellum (Thw.) Schlechter

Tropidia Lindl. in Wall.

T. bambusifolia (Thw.) Trimen

T. thwaitesii Hook. f.

Vanda R. Br.

V. thwaitesii Hook. f. in Trimen

Vanilla Mill.

V. moonii Thw.

Zeuxine Lindl.

Z. regia (Lindl.) Trimen

OROBANCHACEAE

Campbellia Wight

C. aurantiaca Wight

Christisonia Gardn.

C. thwaitesii Trimen

C. tricolor Gardn.

OXALIDACEAE

Biophytum DC.

B. nervifolium Thw.

B. nudum (Arn.) Wight

B. proliferum (Arn.) Wight

PALMAE (ARECACEAE)

Areca L.

A. concinna Thw.

Calamus L.

C. delicatulus Thw.

C. digitatus Becc.

C. ovoideus Thw. ex Trimen

C. pachystemonus Thw.

C. radiatus Thw.

C. rivalis Thw. ex Trimen

C. thwaitesii Becc.

C. zeylanicus Becc.

Loxococcus Wendl. & Drude (Endemic genus)

L. rupicola (Thw.) Wendl. & Drude ex Hook. f.

Oncosperma Blume

O. fasciculatum Thw.

Phoenix L

P. zeylanica Trimen

PANDANACEAE

Freycinetia Gaud.

F. pycnophylla Solms

Pandanus L. ex Stickman

P. thwaitesii Martelli

P. ceylanicus Solms

PIPERACEAE

Piper L

P. trineuron Miq.

P. walkeri Miq.

P. zeylanicum Miq.

PITTOSPORACEAE

Pittosporum Banks & Soland. Ex Gaertn.

P. ceylanicum Wight

POLYGALACEAE

Polygala L.

P. glaucoides L.

P.hrsutala Arn.

P. macrolophos Hassk. in Miq.

P. rosmarinifolia Wight & Arn.

P. triflora L.

PODOSTEMACEAE

Dicraea Thou.
D. elongata Tul.
Farmeria Willis
F. metzgerioides (Trimen) Willis
Mnianthus Walp.
M. ceylanicus (Gardn.) Walp.

PROTEACEAE
Helicia Lour**.**
H. ceylanica Gardn.

RANUNCULACEAE
Ranunculus L.
R. sagittifolius Hook.

RHAMNACEAE
Rhamnus L
R. arnottianus Gardn. ex Thw.
Zizyphus Mill.
Z. napeca (L.) Willd.

RHIZOPHORACEAE
Anisophyllea R. Br. ex Sabine
A. cinnamomoides (Gardn. & Champ.) Alston
Carallia Roxb.
C. calycina Benth.

ROSACEAE
Agrimonia L.
A. zeylanica Moon ex Hook. f.
Prunus L.
P. walkeri (Wight) Kalkman
P. ceylanica (Wight) Miq.
var. *parvifolium* (Thw.) Tirvengadum
Rubus L.
R. leucocarpus Arn. var. *leucocarpus*
Sanguisorba L.
S. indicum (Gardn.) Tirvengadum

RUBIACEA
Acranthera Arn. ex Meisn.
A. ceylanica Arn. ex Meisn.
Allaeophania Thw.
A. decipiens Thw.
Anotis DC.
A. nummularia (Arn.) Hook. f.
A. nummulariformis (Arn.) Trimen
A. richardiana (Arn.) Hook. f.
Byrsophyllum Hook. f.
B. ellipticum (Thw.) Bedd.
Canthium Lam.
C. campanulatum Thw.
C. dicoccum (Gaertn.) Merr.
C. macrocarpum Thw.
C. montanum Thw.
C. puberulum Thw. ex Hook. f.
Dichilanthe Thw.
D. zeylanica Thw.
Hedyotis L.
H. asperifolia Alston
H. cinereo-viridis Thw.
H. confertiflora (Thw.) Alston
H. coprosmoides Trimen
H. cyanescens Thw.
H. cymosa Thw.
H. dendroides Alston
H. evenia Thw.
H. flavescens Thw.
H. fumata (Thw.) Alston ex Trimen
H. gardneri Thw.
H. inamoena Thw.
H. lawsoniae (DC.) Wight & Arn.
H. lessertiana Arn.
H. marginata Thw. ex Alston
H. membranacea Thw.
H. nodulosa Arn.
H. obscura Thw.
H. quinquenervia Thw.
H. rhinophylla Thw. ex Trimen
H. subverticillata (Trimen) Alston
H. trichoneura Alston
Ixora L
I. calycina Thw.
I. jucunda Thw.
Knoxia L.
K. platycarpa Arn.
Lasianthus Jack.
L. gardneri (Thw.) Hook. f.
L moonii Wight
L. obliquus (Thw.) Thw.
L. oliganthus (Thw.) Thw.
L. rhinophyllus (Thw.) Thw.
L. strignosus Wight
L. thwaitesii Hook. f.
L.varians (Thw.) Thw.
Leucocodon Gardn. (Endemic genus)
L. reticulatum Gardn.
Nargedia Bedd. (Endemic genus)
N. macrocarpa (Thw.) Bedd.
Neonauclea Merr.
N. zeylanica (Hook, f.) Merr.
Neurocalyx Hook.
N. championii Benth. ex Thw.
N. gardnri Thw.
N. zeylanicus Hook.
Ophiorrhiza L.
O. glechomifolia Thw.
O. nemorosa Thw.
O. pallida Thw.
O. radicans Gardn. ex Thw.
Pavetta L.
P. agrostiphylla Bremer
P. gleniei Thw. ex Hook. f.
P. involucrata Thw.
Psychotria L.
P. dubia (Wight) Alston var. *dubia*
var. *affinis* (Thw.) Hook. f.
P. gardneri (Thw.) Hook. f.

var. *gardneri*
var. *jayasuriyae* Sohmer
P. glandulifera Thw.
var. *glandulifera*
var.*trimenii* Sochmer
P. longipetiolata Thw.
P. moonii (Thw.) Hook. f.
P. plurivenia Thw.
P. sordida Thw.
P. stenophylla (Thw.) Hook. f.
P. waasii Sohmer
Saprosma Blume
S. scabridum (Thw.) Bedd.
Schizostigma Arn.
S. hirsutum Arn.
Scyphostachys Thw. (Endemic genus)
S. coffaeoides Thw.
S. pedunculatus Thw.
Timonius DC.
T. jambosella (Gaertn.) Thw.
Tricalysia A. Rich, ex DC.
T. dalzellii (Thw.) Alston
T. erythrospora (Thw.) Alston
Uncaria Schreb.
U. thwaitesii (Hook, f.) Alston
Urophyllum Wall.
U. ellipticum (Wight) Thw.

RUTACEAE
Atalantia Correa
A. rotundifolia (Thw.) Tanaka
Luvunga Buch.-Ham. in Wall, ex Wight & Am.
L. angustifolia (Oliv.) Tanaka
Paramignya Wight
P. armata (Thw.) Beddome ex Oliver
Micromelum Blume
M. minutum (Frost f.) Wight & Am.
var. *ceylanicum* B.C. Stone
Murraya Koenig ex L.
M. gleniei Thw. ex Oliv.
Zanthoxylum L.
Z. caudatum Alston in Trimen

SAPINDACEAE
Allophylus L.
A. acuminatus (Thw.) Radlk.
A. hispidus (Thw.) Trimen
A. varians (Thw.) Radlk.
Dimocarpus Comm.
D. gardneri (Thw.) Thw.
Gleniea Hook. f. (Endemic genus)
G. unijuga (Thw.) Radlk.
Lepisanthes Blume
L. tetraphylla (Vahl) Radlk.
L. trichocarpa (Thw.) Radlk.
Thraulococcus Radlk.
T. simplicifolius (Thw.) Radlk.

SAPOTACEAE
Madhuca Gmel.
M. fulva (Thw.) J.F. Macbr.
M. microphylla (Hook.) Alston
M. moonii (Thw.) H.J. Lam.
Palaquium Blanco
P. canaliculatum (Thw.) Engl.
P. grande (Thw.) Engl.
P. laevifolium (Thw.) Engl.
P. pauciflorum (Thw.) Engl.
P. petiolare (Thw.) Engl.
P. thwaitesii Trimen

SCROPHULARIACEAE
Adenosma R. Br.
A. camphoratum (Vahl) Hook. f.
A. subrepens (Thw.) Benth. ex Hook.
Lindernia All.
L. srilankana Cramer & Philcox
Torenia L.
T. aerinea Alston in Trimen
T. cyanea Alston in Trimen

SMILACACEAE
Smilax L.
S. rettiana Willis ex Livera

STERCULIACEAE
Pterygota Schott & Endl.
P. thwaitesii (Mast.) Alston

SYMPLOCACEAE
Symplocos Jacq.
S. bractealis Thw.
S. cordifolia Thw.
S. coronata Thw.
var. *coronata*
var. *glabrifolia* (Thw.) Noot
S. cuneata Thw.
var. *cuneata* var. *acuta* (Thw.) Noot.
S. diversifolia Brand
var. *diversifolia*
var. *appressa* Noot.
S. elegans Thw.
var. *elegans*
var,. *angustata* Thw.
var. *hirsuta* (Wight & Gardner ex Thw.) Noot.
var. *minor* (Thw.) Noot.
S. obtusa Wall,
var. *cucullata* Thw.
var. *pedicellata* (Clarke) Noot.

THEACEAE
Adinandra Jack.
A. lasiopetala (Wight) Choisy
Gordonia Ellis
G. ceylanica Wight
Ternstroemia Mutis ex L. f.
T. emarginata (Gardn.) Choisy

THYMELAEACEAE
Gnidia L.

G. glauca (Fresen.) Gilg var. *Insularis* (Gardn.) C.C. Townsend

TILIACEAE

Grewia L.
G. diplocarpa Thw.
Pityranthe Thw. (Endemic genus)
P. verrucosa Thw.
Triumfetta L
T. glabra Rottl. in Spreng

TRIURIDACEAE

Sciaphila Blume
S. erubescens (Champ.) Miers
S. inornata Petch ex Alston
S. secundiflora Thw. ex Benth

UMBELLIFERAE

Heracleum L.
H. ceylanicum Gardner ex Clarke in Hook. f.
Peucedanum L.
P. ceylanicum Gardn.

URTICACEAE

Debregeasia Gaudich
D. ceylanica Hook. f.
Elatostema J.R. & G. Forst.
E. walkerae Hook. f.
Pouzolzia Gaudich.
P. walkeriana Wight

VALERIANACEAE

Valeriana L
V. moonii Arn. ex C.B. Clarke

VERBENACEAE

Glossocarya Wall.
G. scandens (L. f.) Trimen
f. *pubescens* (Moldenke) Moldenke
f. *scandens* Moon
Premna L.
P. alstoni Moldenke
var. *alstoni*
var. *mollis* Moldenke
var. *subcrenata* Moldenke
P. purpurascens Thw.
P. thwaitesii Clarke in Hook. f.
P. glabrescens Moldenke

VIOLACEAE

Hybanthus Jacq.
H. ramosissimus (Thw.) Melch.
Rinorea Aubl.
R. decora (Trimen) Melch.
R. virgata (Hook. f. & Thorns.) Kuntze

VISCACEAE

Ginalloa Korth.
G. spathulifolia (Thw.) Oliv.
Notothixos Oliver
N. floccosus (Thw.) Oliv

VITACEAE

Ampelocissus Planch.
A. phoenicantha Alston
Cayratia A. Juss.
C. retivenia (Planch.) Suesseng
Cissus L
C. acuminata Thw.
C. gardneri Thw.
C. glyptocarpa Thw.
C. lonchiphylla Thw.

ZINGIBERACEAE

Alpinia Roxb.
A. fax Burtt & Smith
A. rufescens (Thw.) Schum.
Amomum L.
A. acuminatum Thw.
A. benthamianum Trimen
A. echinocarpum Alston
A. masticatorium Thw.
A. nemorale (Thw.) Trimen
A. trichostachyum Alston
Curcuma L.
C. albiflora Thw.
C. oligantha Trimen
Cyphostigma Benth. (Endemic genus)
C. pulchellum (Thw.) Benth
Zingiber Boehmer apud Ludwig
Z. cylindricum Thw.

Sources: Ashton *et al*. (1997); Bandaranaike and Sultanbawa (1991); Senaratne (2002).

Annex 6: List of threatened plant species of Sri Lanka.

CRITICALLY ENDANGERED SPECIES

Family-Acanthaceae
Andrographis macrobotrys Nees
Barleria nitida Nees
Barleria strigosa Willd.
Brillantaisia thwaitesii (T. Anders.) Cramer*
Gymnostachyum ceylanicum Am. & Nees
Lepidagathis hyalina Nees*
Pseuderanthemum angustifolium Ridley
Strobilanthes arnottiana Nees*
Strobilanthes deflexa T. Anders.*
Strobilanthes exserta C. B. Clarke*
Strobilanthes gardneriana (Nees) T. Anders.*
Strobilanthes habracanthoides J. R. I. Wood*
Strobilanthes hypericoides J. R. I. Wood*
Strobilanthes laxa T. Anders.*
Strobilanthes pentandra J. R. I. Wood*
Strobilanthes rhamnifolia (Nees) T. Anders.*
Strobilanthes rhytisperma C. B. Clarke*
Strobilanthes stenodon Clarke*
Strobilanthes zeylanica T. Anders.*
Strobilanthus willisii M. A. Canine*

Family-Amaranthaceae
Cyathula ceylanica Hook, f.*

Family-Anacardiaceae
Mangifera pseudoindica Kosterm.*
Semecarpus obovata Moon*
Semecarpus pseudo-emarginata Kosterm.*

Family-Annonaceae
Polyalthia persicaefolia (Hook.f. & Thorns.) Thw.'

Family- Apiaceae
Peucedanum ceylanicum Gardner*

Family-Apocynaceae
Wrightia flavido-rosea Trim.*
Wrightia puberula (Thw.) Ngan*

Family-Araceae
Alocasia fornicata (Roxb.) Schott
Arisaema constrictum Barnes*
Cryptocoryne alba de Wit*
Cryptocoryne bogneri Rataj*
Cryptocoryne parva de Wit*
Cryptocoryne undulata Wendt*
Cryptocoryne walkeri Schott*
Cryptocoryne x willisii Reitz*
Lagenandra bogneri de Wit*
Lagenandra lancifolia (Schott) Thw.*
Rhaphidophora decursiva (Roxb.) Schott
Typhonium flagelliforme (Lodd.) Blume

Family-Arecaceae
Areca concinna Thw.*
Calamus pachystemonus Thw.*

Family-Asclepiadaceae
Brachystelma lankana Dassanayake & Jayasuriya*
Ceropegia thwaitesii Hook.
Cosmostigma racemosum (Roxb.) Wight
Gymnema rotundatum Thw.*
Tylophora zeylanica Decne.

Family-Asteraceae
Anaphalis thwaitesii C.B. Clarke*
Blumea lanceolaria (Roxb.) Druce
Gynura hispida Thw.*
Notonia walkeri (Wight) C.B. Clarke
Senecio gardneri (Thw.) C.B. Clarke*

Family-Balanophoraceae
Balanophora fungosa J.R. & G. Forst.

Family-Balsaminaceae
Impatiens grandis Heyne ex Wall.
Impatiens janthina Thw.*
Impatiens leucantha Thw.*
Impatiens repens Moon*
Impatiens taprobanica Hiern*
Impatiens thwaitesii Hook.f. ex Grey-Wilson*
Impatiens walkeri Hook.*

Family-Boraginaceae
Cordia subcordata Lam.
Heliotropium supinum L.

Family-Campanulaceae
Asyneuma fulgens (Wall.) Briq.
Campanula benthamii Wall.ex Kitam.

Family-Clusiaceae
Mesua stylosa (Rhw.) Kosterm.*

Family-Convolvulaceae
Argyreia splendens (Roxb.) Sweet
*Bonamia semidigyna (*Roxb.) Hall.f.

Family-Cornaceae
Mastixia congylos Kosterm.*

Family-Cucurbitaceae
Mukia leiosperma (Wight & Am.) Wight

Family-Cyperaceae
Eleocharis confervoides (Poir.) T.Koyama
Eleocharis lankana T.Koyama*
Mapania immersa (Thw.) Benth.ex Ckarke*
Pycreus stramineus (Nees) Clarke
Scirpodendron ghaeri (Gaertn.) Merr.
Trichophorunn subcapitatum (Thw. & Hook.) D.A.Simpson
Tricostularia undulata (Thw.) Kern

Family-Dilleniaceae
Acrotrema thwaitesii Hook.f. & Thorns.ex Hook.f.*

Family-Dipterocarpaceae
Balanocarpus kitulgallensis Kosterm.*
Stemonoporus affinis Thw.*
Stemonoporus bullatus Kosterm.*
Stemonoporus gilimalensis Kosterm.*
Stemonoporus gracilis Kosterm.*
Stemonoporus kanneliyensis Kosterm.*
Stemonoporus laevifolius Kosterm.*
Stemonoporus latisepalum Kosterm.*
Stemonoporus marginalis Kosterm.*
Stemonoporus moonii Thw.*
Stemonoporus nitidus Thw.*
Stemonoporus petiolaris Thw.*
Stemonoporus revolutus Trimen ex Hook, f.*
Stemonoporus rigidus Thw.*
Stemonoporus scalarinervis Kosterm.*
Stemonoporus scaphifolius Kosterm.*
Vatica lewisiana (Trimen ex Hook, f.) Livera*
Vatica paludosa Kosterm.*

Family-Ebenaceae
Diospyros atrata Alston*
Diospyros crumenata Thw.
Diospyros koenigii Kosterm.*
Diospyros oppositifolia Thw.*
Diospyros pemadasai Jayasuriya
Diospyros rtheophytica Kosterm*

Family-Eriocaulaceae
Eriocaulon subglaucum Ruhland*

Family-Euphorbiaceae
Cleidion nitidum (Muell. Arg.) Thw. ex Kurz
Croton caudatus Geisel
Croton moonii Thw.*
Croton nigroviridis Thw.*
Dalechampia indica Wight
Euphorbia granulata Forssk.
Tragia muelleriana Pax & Hoffm.

Family-Fabaceae
Albizia lankaensis Kosterm.*
Crotalaria linifolia L.f.
Crotalaria triquetra Dalz.
Crotalaria wightiana Graham ex Wight & Arn.
Cynometra iripa Kostel.
Desmodium jucundum Thw.*
Desmodium zonatum Miq.
Galactia striata (Jacq.) Urban
Indigofera constricta (Thw.) Trim.
Indigofera wightii Grah.ex Wight & Arn.
Mucuna gigantea (Willd.) DC.
Rhynchosia acutissima Thw.
Rhynchosia suaveolens (L.f.) DC.
Sesbania sericea (Willd.) Link
Sophora violacea Thw.*
Tephrosia spinosa (L.f.) Pers.

Family-Gentianaceae
Exacum sessile L.

Family-Gesneriaceae
Didymocarpus floccosus Thw.*

Family-Lamiaceae
Isodon capillipes (Benth.) H.Hara*
Leucas longifolia Benth.
Plectranthus glabratus (Benth.) Alston

Family-Lauraceae
Cassytha capillaris Meissn.

Family-Loranthaceae
Barathranthus mabaeoides (Trimen) Danser*
Barathranthus nodiflorus (Thw.) Tieghem*
Dendrophthoe lonchiphyllus (Thw.) Danser.*
Macrosolen albicaulis Wiens*
Macrosolen barlowii Wiens*

Family-Melastomataceae
Medinilla maculata Gardner*
Osbeckia rheedii Gardner ex Thw.*
Sonerila glaberrima Am.*
Sonerila glabhcaulis (Thw. ex Clarke in Hook, f.) Lundin*
Sonerila guneratnei Trimen*
Sonerila hirsutula Am.*
Sonerila hookeriana Am.*
Sonerila lanceolata Thw.*
Sonerila pedunculosa Thw.*
Sonerila pilosula Thw.*
Sonerila robusta Am.*
Sonerila wightiana Arn.*

Family-Memecylaceae
Memecylon gracillimum Alston*
Memecylon leucanthemum Thw.*
Memecylon macrocarpum Thw.*
Memecylon macrophyllum Thw.*
Memecylon orbiculare Thw.*
Memecylon phyllanthifolium Thw. ex Trimen*
Memecylon sessile Benth.
Memecylon wightii Thw.

Family-Moraceae
Madura cochinchinensis (Lour.) Comer

Family-Myrsinaceae
Ardisia wightiana (Wall.ex.A.DC.)Mez*

Family-Myrtaceae
Eugenia cotinifolia Jacq.
Eugenia glabra Alston*
Eugenia sripadaens Kosterm.*
Syzygium lewisii Alston*

Syzygium sclerophyllum Thw.*

Family-Orchidaceae
Arundina minor Lindl.*
Bulbophyllum tricarinatum Petch*
Coelogyne zeylanica Hook.f.*
Corymborkis veratrifolia (Reinw.) Blume
Didymoplexis seidenfadenii Sathish & Ormerod.
Dienia ophrydis (J.Konig) Seidenf.
Eria tricolor Thw.*
Gastrodia zeylanica Schlechter*
Goodyera fumata Thw.
Habenaria dichopetala Thw.*
Habenaria dolichostachya Thw.*
Habenaria pterocarpa Thw.*
Nervilia Juliana (Roxb.) Schlechter
Oberonia dolabrata Jayaweera*
Oberonia fornicata Jayaweera*
Oberonia wallie-silvae Jayaweera*
Oberonia weragamaensis Jayaweera*
Phalaenopsis mysorensis Sadanha
Schoenorchis tortifolia (Jayaweera) Garay*
Sirhookera latifolia (Wight) Kuntze
Tainia bicornis (Lindley) Reichb. f.
Zeuxine longilabris (Lindl.) Trimen

Family-Orobanchaceae
Aeginetia pedunculata Wall.
Campbellia cytinoides (Reuter)Wight
Christisonia albida Thw. Ex Benth.*
Christisonia lawii Wight
Legocia aurantiaca (Wight) Livera

Family-Phyllanthaceae
Cleistanthus acuminatus (Thw.) Muell. Arg.*
Glochidion acutifolium Alston*
Phyllanthus heyneanus Muell. Arg.
Phyllanthus oreophilus Muell. Arg. *
Phyllanthus zeylanicus Muell. Arg.*
Sauropus assimilis Thw.*
Sauropus quadrangularis (Willd.) Muell. Arg.
Sauropus retroversus Wight*

Family-Piperaceae
Peperomia wightiana Miq (P. species 6)

Family-Poaceae
Arundinaria scandens Soderstrom & Ellis.*
Arundinella thwaitesii Hook.f.*
Garnotia fuscata Thw.*
Garnotia panicoides Trimen*
Ischaemum polystachyum J.& C.Pres.
Oplismenus thwaitesii Hook.f.*
Zenkeha obtusiflora (Thw.)Benth.*

Family-Putranjiavaceae
Drypetes lanceolata (Thw.) Pax & Hoffm.*
Drypetes longifolia (Blume) Pax & Hoffm.

Family-Rhamnaceae
Ziziphus lucida Moon ex Thw.*

Family-Rubiaceae
Hedyotis evenia Thw.*
Hedyotis gardneri Thw.*
Hedyotis gartmorensis Ridsd.*
Hedyotis inamoena Thw.*
Hedyotis marginata (Thw.ex Trimen) Alston*
Hedyotis membranacea Thw.
Hedyotis neolessertiana Ridsd.*
Hedyotis obscura Thw.*
Hedyotis rhinophylla Thw.ex Trimen*
Hedyotis subverticillata Alston*
Hedyotis trichoneura Alston*
Hedyotis tridentata Ridsd.*
Lasianthus varians (Thw.) Thw.*
Mitragyna tubulosa (Arn.)Havil.
Neanotis richardiana (Am)W.H.Lewis
Neurocalyx gardneri Thw.*
Ophiorrhiza glechomifolia Thw.*
Ophiorrhiza nemorosa Thw.*
Oxyceros rugulosus (Thw.) Tirv.
Pavetta macraei Bremek.*
Psilanthus wightianus (Wight & Arn.) Leroy
Psychotria longipetiolata Thw.*
Psydrax pergracilis (Bourd.) Ridsd.
Saprosma scabridum (Thw.) Beddome*
Scyphiphora hydrophyllacea Gaertn. f.

Family-Santalaceae
Notothixos floccosus (Thw.) Oliver*
Ginalloa spathulifolia (Thw.) Oliver*
Viscum ramosissimum Roxb.

Family-Scrophulariaceae
Adenosma subrepens (Thw.) Benth.*
Verbascum chinense (L.) Santapau

Family-Stylidiaceae
Stylidium uliginosum Sw. ex Willd.

Family-Symphoremaceae
Symphorema involucratum Roxb.

Family-Thymelaeaceae
Phaleria capitata Jack

Family-Triuridaceae
Sciaphila secundiflora Thw.ex Benth.
Sciaphila tenella Blume

Family-Zingiberaceae
Alpinia rufescens (Thw.) Schum.*
Amomum acuminatum Thw.*
Amomum benthamianum Trim.*
Amomum hypoleucum Thw.
Amomum nemorale (Thw.)Trimen*

ENDANGERED SPECIES

Family-Acanthaceae
Barleria amottiana Nees
Barleria involucrate Nees
Barleria tomentosa Roth
Barleria vestita T. Anders.
Dicliptera zeylanica Nees
Gymnostachyum hirsutum T. Anders.*
Gymnostachyum paniculatum T. Anders.*
Hemiadelphis polysperma (Roxb.) Nees
Justicia prostrata (Clarke) Gamble
Lepidagathis walkeriana Nees*
Monothecium aristatum (Wall, ex Nees) T. Anders.
Rhinacanthus polonnaruwensis Cramer*
Strobilanthes nockii Trimen*
Strobilanthes punctata Nees*
Strobilanthes vestita Nees*
Strobilanthes walkeri Am. ex Nees
Thunbergia laevis Wall.ex Nees

Family-Anacardiaceae
Buchanania axillaris (Desr.) Ramamoorthy
Semecarpus moonii Thw. *

Family-Annonaceae
Goniothalamus salicina Hook. f. & Thorns*
Miliusa tomentosa (Roxb.) Sinclair
Miliusa zeylanica Gardner ex Hook. f. & Thorns*
Phoenicanthus cohacea (Thw.) H. Huber*

Family-Aquifoliaceae
Ilex knucklesensis Philcox*

Family-Araceae
Ahsaema tortuosum (Wall.) Schott
Cryptocoryne beckettii Trimen*
Cryptocoryne nevillii Trimen ex Hook, f.*
Cryptocoryne thwaitesii Schott*
Lagenandra koenigii (Schott) Thw.*
Lagenandra ovata (L.) Thw.
Lagenandra thwaitesii Engl.*
Pothos parvispadix Nicolson*
Remusatia vivipara (Roxb.) Schott
Rhaphidophora pertusa (Roxb.) Schott

Family-Arecaceae
Calamus delicatulus Thw.*
Calamus ovoideus Thw. ex Trimen*
Calamus radiatus Thw.*

Source: IUCN & MENR (2007).

Annex 7: List species with data deficient in assessment of threatened status of plants.

CRITICALLY ENDANGERED SPECIES

Family	***Species Name***
Apocynaceae	*Anodendron rhinosporum* Thw.
Celastraceae	*Bhesa nitidissima* Kosterm.
Dilleniaceae	*Dillenia triquetra* (Rottb.) Gilg
Dilleniaceae	*Schumacheha alnifolia* Hook.f. & Thorns.
Icacinaceae	*Stemonurus apicalis* (Thw.) Miers
Lauraceae	*Cinnamomum rivulorum* Kosterm.
Loganiaceae	*Strychnos tetragona* A. W. Hill
Meliaceae	*Dysoxylum peerisi*
Meliaceae	*Walsura gardneri* Thw.
Monimiaceae	*Hortonia angustifolia* (Thw.)Trimen
Myristicaceae	*Horsfieldia iryaghedhi* (Gaertn.) Warb.
Myrsinaceae	*Rapanea ceylanica*
Ochnaceae	*Ochna jabotapita L*.
Oleaceae	*Chionanthus albidiflora* Thw.
Sapindaceae	*Allophylus zeylanicus* L.
Sapotaceae	*Palaquium laevifolium* (Thw.) Engl.
Urticaceae	*Debregeasia wallichiana* (Wedd.)Wedd

ENDANGERED SPECIES

Family	***Species Name***
Celastraceae	*Euonymus thwaitesii* Lawson
Clusiaceae	*Garcinia thwaitesii* Pierre
Clusiaceae	*Garcinia zeylanica* Roxb.
Eleocarpaceae	*Elaeocarpus coriaceus* Hook.
Eleocarpaceae	*Elaeocarpus zeylanicus* (Arn.)Masters
Lauraceae	*Beilschmiedia zeylanica* (Thw.)Trimen
Lauraceae	*Cinnamomum citriodorum* Thw.
Lauraceae	*Cryptocarya membranacea* Thw.
Lauraceae	*Litsea glaberrima* (Thw.)Trimen
Lauraceae	*Litsea nemoralis* (Thw.)Trimen
Rosaceae	*Prunus ceylanica* (Wight) Miq.
Sapotaceae	*Madhuca microphylla* (Hook.) Alston
Sapotaceae	*Madhuca neriifolia* (Thw.) H.J.Lam.
Sapotaceae	*Palaquium canaliculatum* (Thw.) Engl.

VULNERABLE SPECIES

Family	***Species Name***
Apocynaceae	*Willughbeia cirrhifera* Abeywick.
Bombacaceae	*Cullenia ceylanica* (Gardner) K.Schum.
Burseraceae	*Canarium zeylanicum* (Retz.) Blume
Celastraceae	*Bhesa ceylanica* (Am.ex Thw.) Ding Hou.
Celastraceae	*Euonymus walked* Wight
Clusiaceae	*Garcinia quaesita* Pierre
Combretaceae	*Terminalia zeylanica* van Heurck & Muell. Arg.
Cornaceae	*Mastixia macrophylla* (Thw.) Kosterm.
Eleocarpaceae	*Elaeocarpus glandulifer* (Hook.) Masters
Eleocarpaceae	*Elaeocarpus subvillosus* Arn.
Erythroxylaceae	*Erythroxylum obtusifolium* (Wight.) Hook.f.
Fabaceae	*Abarema bigemina* (L.) Kosterm.
Fabaceae	*Acacia ferruginea* DC.
Fabaceae	*Adenanthera bicolor* Moon

Fabaceae	*Humboldtia laurifolia* (Vahl) Vahl
Fabaceae	*Pericopsis mooniana* (Thw.) Thw.
Fabaceae	*Pterocarpus indicus* Willd.
Fabaceae	*Pterocarpus marsupium* Roxb.
Fabaceae	*Saraca asoca* (Roxb.) de wild.
Flacourtiaceae	*Hydnocarpus octandra* Thw.
Flacourtiaceae	*Thchadenia zeylanica* Thw.
Lauraceae	*Actinodaphne albifrons* Kosterm.
Lauraceae	*Cinnamomum capparu-coronde* Blume
Lauraceae	*Cinnamomum litseifolium* Thw.
Lauraceae	*Cryptocarya wightiana* Thw.
Lauraceae	*Litsea gardneri* (Thw.) Meissner
Lauraceae	*Litsea iteodaphne* (Nees) Hook.f.
Lauraceae	*Litsea longifolia* (Nees) Trimen
Loganiaceae	*Strychnos benthami* C.B. Clarke
Meliaceae	*Aglaia apiocarpa* (Thw.) Hiern
Meliaceae	*Dysoxylum championii* Hook.f. & Thorns, ex Thw.
Moraceae	*Artocarpus nobilis* Thw.
Myristicaceae	*Myristica ceylanica* A. DC.
Nepanthaceae	*Nepenthes distillatoria* L.
Rhizophoracraceae	*Anisophyllea cinnamomoides* (Gardner & Champion) Alston
Rhizophoracraceae	*Carallia calycina* Benth.
Rosaceae	*Prunus walkeri* (Wight) Kalkman
Rutaceae	*Chloroxylon swietenia* DC.
Sapindaceae	*Allophylus zeylanicus* L.
Sapindaceae	*Glenniea unijuga* (Thw.) Radlk.
Sapotaceae	*Madhuca fulva* (Thw.) Macbride
Sapotaceae	*Madhuca moonii* (Thw.) H.J. Lam.
Sapotaceae	*Palaquium grande* (Thw.) Engl.
Sapotaceae	*Palaquium pauciflorum* (Thw.) Engl.
Sapotaceae	*Palaquium rubiginosum* (Thw.) Engl.
Sapotaceae	*Palaquium thwaitesii* Trimen
Sapotaceae	*Palaquium zeylanicum* Verde.
Symplocaceae	*Symplocos bractealis* Thw.
Symplocaceae	*Symplocos cordifolia* Thw.
Symplocaceae	*Symplocos pulchra* Wight

Source: IUCN & MENR (2007).

Annex 8: An example of species conservation profile.

***Garcinia quaesita* Pierre**

SPECIES	*Garcinia quaesita* Pierre
CLASS/FAMILY	Clusiaceae
COMMON NAME	Goraka, rata goraka, rath goraka (S) korakkaipuli (T), brindleberry, malabar tamarind (E)
GLOBAL REDLIST STATUS	Vulnerable
NATIONAL REDLIST STATUS	Not listed
COMPILERS	DKNG Pushpakumara

BACKGROUND
(Short details of family, genus, endemicity ect)

G. quaesita is a member of the family Clusiaceae (Guttiferae). It is an endemic underutilized fruit tree species. *G. cambogia*, *G. affinis* and *G. zeylanica* have been used as synonyms (Ashton *et al*., 1997; Bandaranaike and Sultanbawa, 1991; Ekaratne *et al*., 2003; IUCN, 2000; Kostermans, 1980), Senaratna, 2001 and Wijesinghe, 1994).

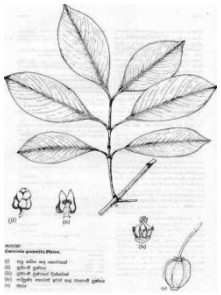
The family Clusiaceae consists of 4 genera; *Clusia*, *Garcinia*, *Mesua* and *Calophyllum*. In Sri Lanka, 25 species have been listed in this family. Members of the family are lactiferous or resiniferous trees with opposite, entire leaves without stipules. Flowers are regular, hermaphrodite or polygamously dioecious. Different genera can be identified by leaf, floral and fruit characters (Kostermans, 1980; Senaratna, 2001; Wijesinghe, 1994).

The genus *Garcinia* consists with 10 species of which 50% are endemic. The genus consists of trees with white or yellow thick sticky latex in bark, branchlets and fruit. Leaves are decussate, petiole with an adaxial foveola with thin, raised margin. Flowers are axillary and psudoterminal, polygamously dioecious.

Its fruits are edible. They are valued for their sun-dried rind, which is widely used in Sri Lanka as a condiment for flavoring curries, curing of fish. In average, each family in Sri Lanka consumes 5-10 kg of dried rind annually. The price is about Rs. 300/kg in the market although farm gate price is about Rs. 120-150/kg. Some private companies are exporting dried powder in large quantities. Demand for fruits cannot be satisfied due to lack of continuos production and poor quality of the products (Jayaweera, 1981; Kostermans, 1980; Pushpakumara, 1999; Pushpakumara *et al.*, 2006).

Photo of Species

Mature plant



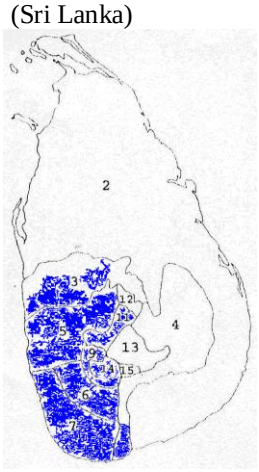
Branch with leaves, flowers and fruit
Source: Ayurvedic Department (2002)

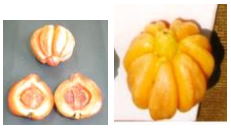
Female flowers and branch

Male flowers and branch

Development of fruit

Distribution Map (Sri Lanka)





Orange and yellow fruits

Variation of fruit characters

DISTRIBUTION
(Short description on localities, altitude ect)

It is naturally found in the lowland tropical rainforests. It grows well on a variety of soils in wet zone particularly KDN complex, Singharaja, Peak wilderness, Bambarbotuwa and some areas of intermediate zones up to 1000 m altitude. It is often cultivated in homegardens and other non forest lands of lowland areas of wet and some areas of intermediate zones. It can be found in 12 districts (Badulla, Colombo, Galle, Gampaha, Kalutara, Kandy, Kegalle, Kurunegala, Matale, Matara, Nuwara Eliya and Rathnapura) and 89 AGA divisions (Kostermans, 1980; Pushpakumara *et al*., 2006). Thus it is distributed in some areas of at least 8 floristic (3, 4, 5, 6, 7, 9, 11, 14) regions.

FIELD IDENTIFICATION
(Characteristics morphological features)

Identification of *G. quaesita* and *G. zeylanica* is still confused. According to Kostermans (1980), *G. quaesita* and *G. zeylanica* can be distinguished using the following characters.

Character	***Garcinia quaesita***	***Garcinia zeylanica***
Flowers		
Anthers	C 10	C 30
Fruit		
Colour of fruit rind	Red to orange red	Pale yellow
Juice content of fruit	Less	More
Grooves of the fruit	Very deep	Not very deep
Position of grooves at the top of the fruit	Grooves Reaching the top of the fruit	Not reaching the flat top
Mamilla (nipple like structure)	Present at top centre	Not present

However, Pushpakumara *et al*. (2006) showed that two sppecies are difficult to distinguish each other using fruit and floral characters because anther numbers are varied in yellow and red fruit types, mamilla is observed in both red and yellow fruit types whilst deep groves were also observed in red, yellow and orange fruit types (see Photos). Further, yellow and red types are easily inter-crossed each other. Molecular works are currently undergoing to clarify this issue.

HABITAT AND BIOLOGY
(details of habitat/micro-habitat .Co-occurring species ect)

Its natural habitat is the sub canopy of lowland tropical rainforests (Kostermans, 1980). Its domesticate habitat is homegardens in the wet zone.

It is an evergreen, shade loving, relatively slow growing, and small to medium-sized (15-20 m high) tree with horizontal or dropping branches. Flowering is seasonal, usually after pronounced dry weather from February to April and fruit ripening during the rains from June to September. The flowers are small, and occur as clusters in branches. The fleshy fruit is ovoid in shape and about 7 cm in diameter, yellow or red when ripe with 6-8 groves. Seeds are 12 mm long and 6-8 in number and surrounded by a succulent aril (Jayaweera, 1981; Kostermans, 1980).

Flowers are either androecious or hermaphrodite. Individual plants are either androecious or hermaphrodite. Thus, sexual system at population level is andromonoecious. It is an insect pollinated species (mainly by *Trigona* spp.). It is a self-compatible species with some level of outcrossing and facultative agamospermy. Species shows ample variation for fruit characters, mainly for size, shape, presence/absence of mamilla at the tip of fruit, number of rinds (furrows), total weight and rind weight, number of seeds and color of fruit. Except colour of fruit and size of mamilla those not variable within a given tree, all other characters are variable within and among plants. Fresh seeds take nearly 20 weeks to germinate if they sown just after harvesting and washed with water. Seed germination can be accelerated with acceptable level of germination percentage with removal of seed coat either manually or mechanically (Pushpakumara *et al*., 2006).

POPULATION (UNDER ANY OF FOLLOWING CATEGORIES)

Estimated (Source)
Assumed range (Source)
Unknown

No exact population estimate is available for *G. quaesita*. Germplasm exploration study identified over 300 individuals of red, yellow and orange fruit types distributed in 12 districts. In addition during the field exploration over 3000 individuals were observed from forest and non forest lands of 12 districts.

CONSERVATION HISTORY

Legal protection status, active conservation measures taken ect.)

G. quaesita is not protected under FFPO (Ekaratne *et al*., 2003). Although it is suggested as a vulnerable species in the global red list, nothing stated in the national red list 1999.

Approximately 25-30% of its habitats is under protection of the protected area network within the wet zone. Species is slowly naturally regenerating in tropical lowland rainforests, particularly along stream banks. In homegardens the species is cultivated (mainly naturally regenerated) which is supportive of conservation of the species. Selected germplasm is also conserved at experimental fields of the Department of Agriculture, Department of Export Agriculture and Faculty of Agriculture, University of Peradeniya.

POSSIBLE THREATS

Category	**Yes/No**
Habitat loss	
- Agriculture	Yes
- Development	Yes
- Reclamation	No
- Deforestation	Yes
- Fragmentation	Yes
Direct Loss/ Over-exploitation	
- Hunting	-
- Commercial trade	Yes
- Accidental mortality	No
Invasive Alien Species	No
Land/Water Pollution	No
- Agrochemicals	
- Industrial effluents	
Natural causes	Low seed germination

The major threats to natural populations are destructive collection of fruits by branch or tree felling and removal of all fruits with seeds from forests. Further, harvesting of bark also led to dead trees. Deforestation also caused loss of individuals.

RECOMMENDED ACTIONS

Action	**Yes/No**
In-situ Conservation	
- Declaration PA's/refuges	Yes
- Habitat enrichment	-
Ex-situ Conservation	
- Captive breeding for re-introduction	Yes
- Captive breeding for Commercial trade	Yes
(Collection, characterization and domestication of genetic resources)	
Monitoring of Populations *Specially in selected plots and homegardens*	Yes
Other	Introduction of species into homegardens and other non forest lands through domestication

While conserving existing natural forests in the wet zone and their monitoring, it is important to incorporate the species into wider cultivation through domestication. In addition, existing live germplasm collections can be strengthened.

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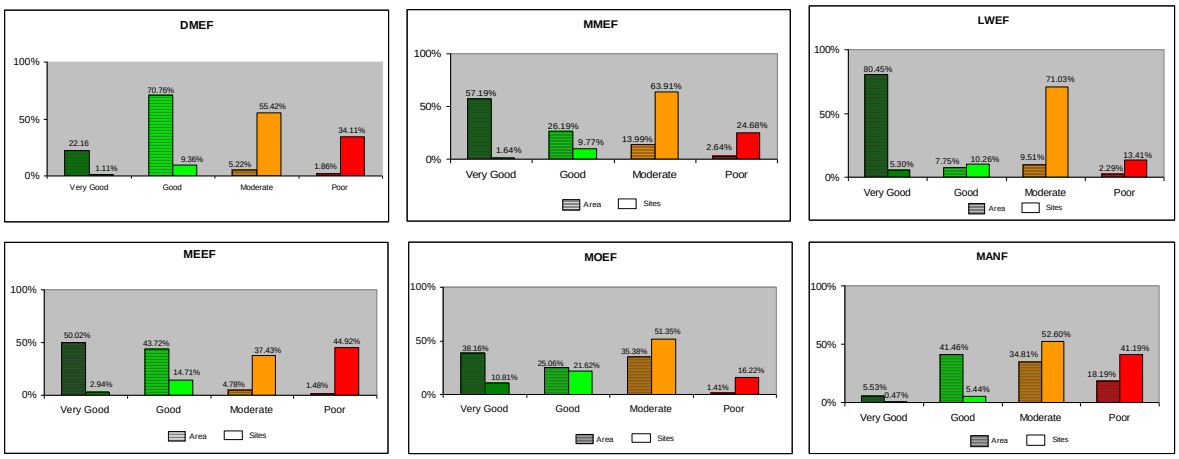
Annex 9: Distribution of viability categories in six different forest types in Sri Lanka.



Source: MENR (2006).

Note 1: DMEF=Dry mixed evergreen forest; MMEF=Moist mixed evergreen forest; LWEF=Lowland wet evergreen forest; MEEF=Mid elevational evergreen forest; MOEF=Montane evergreen forest; MANF=Mangrove forest.

Note 2: Viability of each forest type was assessed based on the long-term viability (100 years) of populations whereas occurrences of conservation targets was assessed with the three main criteria of size, condition, and landscape context. These are organized into five measurable indices, *viz*. condition, area, wilderness, shape and isolation and loaded with suitable loading factors and viability indices were then calculated.

Annex 10: The main legislation relating to biodiversity (plants) and environmental conservation and management in Sri Lanka.

Legislation	Conservation measure
The Forest Ordinance (FO) No. 16 of 1907, and its subsequent amendments, including Act no 23 of 1995; and No. 56 of 2009 Forest Conservation Act.	The Forest Department is responsible for the implementation of this law (FO) which has been subject to many revisions to make provision for the protection of state forests from unlawful felling, clearing, encroachment, removal of produce, etc; the declaration of forests as Reserve Forests: the control of felling and other forms of exploitation in forests; and the transportation of timber. The 1995 amendment has created Conservation Forests. While encroachment and illicit felling of timber from wet zone forests has been largely controlled, some illicit activities continue in state forests.
The Fauna and Flora Protection Ordinance No. 2 of 1937, and subsequent amendments including Act No. 22 of 2009.	The Department of Wildlife Conservation is primarily responsible for the implementation of this law (FFPO) which recognises six categories of wildlife reserves. This Act, besides protecting animal and plant life within the national reserves, has provision to protect certain categories of animals and plants wherever they are found and states the penalties for violation of the law. For post faunal groups there is negative listing so that most species un the vertebrate groups are protected. The Act also lists penalties for violation of the law. However, enforcement of this Act remains weak with respect to protection of all species listed under this Act. In contrast, the Act requires a permit for export of any wild plant or animal or their parts, and this is enforced by the Customs Department at ports of exit from the country. This is an ordinance to provide protection, conservation and preservation of the fauna and flora of Sri Lanka; for the prevention of the commercial exploitation of such fauna and flora.
Felling of Trees Control Act No. 9 of 1951 as ammended.	The Divisional Secretary is the implementing agency for this act, which makes provision for the prohibition, regulation or control of the felling of specified valuable tree species, including cultivated species such as jak found in homegardens. This Act is largely ineffective with respect to cultivated species, particularly in urban areas.
The National Heritage Wilderness Area Act No. 3 of 1988.	The Forest Department is the implementing agency for this act, which was enacted to enable the preservation of unique natural ecosystems under the jurisdiction of the Forest Department and the genetic resources in them. Sinharaja and Hurulu forests have been declared under this Act.
Soil Conservation Act, No. 25 of 1951; amended in 1996.	This Act empowers the Director General of Agriculture to undertake surveys and investigations for the purposes of ascertaining the nature and extent of land degradation

	due to various factors including floods, droughts, salinisation, desertification, siltation and soil erosion measures on a watershed basis. Implementation of this Act is weak.
Coast Conservation Act No. 57 of 1981, and the amendment Act No.64 of 1988.	This Act requires the Coast Conservation Department to survey the Coastal Zone and inventory the resources available therein, including coastal ecosystems and material regularly removed for commercial or industrial purposes from this area, and to draw up Coastal Zone Management Plans periodically. The Act vests the administration, custody and management of the coastal zone in the island, while the responsibility of administering and implementing the Act devolves on the Director of the Coast Conservation Department who has to issue permits for all development activities undertaken within the area designated by law as the coastal zone. This requires calling for an Environmental Impact Assessment (EIA) before permitting any such activities.
Plant Protection Act No. 35 of 1999 (replacing Plant Protection Ordinance No.10 of 1924).	The Director General of Agriculture is the administering authority under this Act which controls the introduction of noxious plants, pests and diseases of plants into Sri Lanka. This Act will be revised to better address alien invasive species, GMOs, and LMOs (note: a new Act to specifically cover IAS is being proposed). An act to make provision against the introduction into Sri Lanka and the spreading therein, of any organism harmful to or injurious to, or destructive of, plants, and for the sanitation of Plants Protection Ordinance (Chapter 417) and for matters connected therewith or incidental thereto.
The Botanic Gardens Ordinance No. 31 of 1928.	This deals with *ex situ* conservation of plants, and concerns the management and administration of the National Botanic Gardens.
The National Environmental Act No. 47 of 1980 and the amendment No. 56 of 1988. (a new National Environmental Protection Act is being drafted).	This Act created the Central Environmental Authority, and the amendment Act of 1988 empowered all project approving agencies to obtain an Environmental Impact Assessment (EIA) from any developer for prescribed developmental projects and for control of environmental pollution through the issuing of Environmental Pollution Licenses (EPLs). This Act also provides for identification of environmentally sensitive areas termed Environment Protection Areas (EPAs) outside PAs, including biodiversity rich areas Protected Areas. As such it complements the FFPO and the FO.
Seed Act No 22 of 2003, a new draft of seed act has been prepared	The Director General of Agriculture is the administering authority under this Act which controls the movement and quality of seeds.
Water hyacinth Ordinance No 9 of 1909	This controls the introduction and proliferation of water hyacinth and other weeds and invasive plants in the country.

Source: Modified from MENR (2009).

Annex 11: Details of selected international collaborations and their outcomes.

Annex 11.1 Crop Wild Relatives Project

In situ Conservation of Crop Wild Relatives (CWR) through Enhanced Information Management and Field Application was a five-year (2004-2009) UNEP/GEF supported project that aims to effectively conserve and use CWR. It brought together seven international organizations (UNEP, IPGRI, FAO, BGCI, UNEP-WCMC, IUCN and ZADI) and five countries (Armenia, Bolivia, Madagascar, Sri Lanka and Uzbekistan). Each country has a significant number of globally important and threatened CWR (including forest genetic resources) and is also among the world's biodiversity hotspots–places that have the highest concentrations of unique biodiversity on the planet. The project aims to protect natural populations of CWR while setting a precedent for conservation that the rest of the world can follow. The project has three broad goals: (a) to develop national and international information systems on CWR that include data on species biology, ecology, conservation status, distribution, crop production potential, uses, existing conservation actions and existing information sources; (b) to build capacity of national partners to use this information to develop and implement rational, cost-effective approaches to conserving CWR; and (c) to raise awareness of the potential of CWR for improving agricultural production among policy-makers, plant breeders, educators and local users.

The Sri Lankan component of the CWR project was jointly conducted by the Ministry of Environment and Natural Resources and Department of Agriculture. The FD, DWLC, CEA, DEAC, BMARI, IUCN, Universities and relevant NGOs were other project partners. It has conducted an inventory of food CWR species at country and provincial levels. It also has initiated a coordinated effort to increase awareness, document populations, evaluated threats and conserve food CWR in Sri Lanka.

As the five countries were expected to priorities CWR, Sri Lanka has selected rice, cowpea, black pepper, banana and cinnamon to be considered within this project. The Department of Agriculture has recently established Agriculture Information Park at Gannoruwa to increase public awareness on modern agriculture, traditional farming systems and conservation of germplasm in genebanks etc. This facility also includes the potential role of CWR in crop improvement. So far, CWR of pepper, bean, okra, banana and rice have been established in the park. The DOA is also in the process of establishing a second such park in Bata ata in Hambanthota District, which will also feature a section devoted to CWR. The success of the park has prompted plans by the DNBG to establish similar exhibits throughout the country and the idea has reached beyond the crop sector. Using a similar concept, the FD has established a Forest Education Park at Kande Ela in Ambewela. Through the CWR project species recovery plan was prepared for *Cinnamomum capparu-corudo* which is an endemic threatened wild relative of *Cinnamomum verum*.

Annex 11.2: Sri Lanka Conservation and Sustainable Use of Medicinal Plants Project

The Sri Lanka Conservation and Sustainable Use of Medicinal Plants Project (SLCSUMPP) was carried out between 1998 and 2003 with the support of the GEF to conserve medicinal plants and to promote their sustainable use. The project was implemented by the establishment of Medicinal Plant Conservation Area (MPCA) with the collaboration of the FD and the DWLC. The project intended to secure conservation of globally and nationally significant medicinal plant species, and their habitats, through: (a) *in situ* conservation by

establishing five medicinal plant conservation areas (MPCAs) in different ecological zones of Sri Lanka, as a part of, or adjacent to existing natural forests which are the home for some of the threatened species of medicinal plants; (b) *ex situ* cultivation and supporting propagation and agronomic research; and (c) by providing information and institutional support including promotion of appropriate legal and policy environment. An important element of the strategic approach adopted is to define and demarcate medicinal plant reserves in bio-geographically representative areas and use these as centers for a wide range of activities covering conservation, propagation, basic processing, ethno botanical and ecological studies and outreach programs. For this purpose, five MCPA were established in Bibile (Uva Province) and Ritigala (North Central Province) in the dry zone, Rajawaka (Sabaragamuwa Province) and Naula (Central province) in the intermediate zone and Kanneliya (Southern Province) in the wet zone, adjacent to natural forests which harbor medicinal plant species (Mahindapala and Kumarasiri 2002).

Efforts have been taken to promote *in situ* conservation of medicinal plant genetic resources. These are essentially carried out with the collaboration of the main stakeholders of the *in situ* conservation, viz. FD and DWLC.

As an example, Naula MPCA is located in the Matale District and seven Grama Niladari (GN) divisions (Kumbiyangahaella, Maragamuwa, Pubbiliya, Nayakkumbura, Kalundewa, Haduwa, Haduwela), are selected to be included in this MPCA. Traditionally, medicinal plants in the area are well known to many people in an outside Naula MPCA. Two most popular sites were Kumaragala Kanda and Pubbiliya forests. These two locations are constantly invaded by people for many purposes, such as collection of medicinal plants and firewood, felling of trees for timber and many other purposes. Some illegal businessmen in the area ran these activities as organized businesses. Only a few genuine users visited forest areas to collect medicinal plants or their products. It is revealed that most of the above illegal activities are carries out by people from Dambulla, Naula, Matale and even from far places such as Elahera, Bakamuna and Radawewa. Small groups of two or three individuals carry out illegal collection of medicinal plants. Some of the most exploited medicinal plants are *Munronia pinnata*, *Terminalia chebula*, *Phyllanthus emblica*, *Litsea glutinosa*, *Terminalia bellirica*, *Santalum album*, *Pterocapus marsupium*, of which many are forest genetic resources. Although state agencies tried their best to stop such activities, no community organizations or organized collective efforts by people in the area were sufficient to oppose illegal activities. Felling of trees and setting fire during dry periods were other serious processes that destroyed the natural environment. Lack of non-farm income sources and lands and the poverty seem to drive people engaged in cutting of firewood and collection of bee honey from forests while some farmers have cleared virgin forest lands for chena cultivations. However, the most serious destruction was the setting of indiscriminate fire in the interior of thick jungles by intruders (EML 2002). Prior to the SLCSUMPP, there were no collective efforts by communities around these forests. Main reason was that they were unaware about the real value and extent of threat on medicinal plants in the area. Most of them were of the view that medicinal trees as trees grown only in wild. The government officials could not do much as there was no organized institutional framework to act against such malpractices. Hence, they did not want to be involved in protecting forests. There were occasions where community leaders such as priests and traditional practitioners who lodged complain to GNs and other relevant authorities, but without success (EML, 2002).

Evaluation of SLCSUMPP impacts in terms of natural environment, community livelihood and income, local knowledge and social capacity have shown positive development. It is said

that the most visible impact is the improvement in the natural and physical environment due to reduction of deliberate fires, chena cultivation and felling of trees for timber and firewood. Since community is vigilant and aware, degree of such destructive activities has been greatly reduced. It has been observed that certain sections of the Kumaragala Kanda were dry and brownish during most times of the year, but now they are relatively greener and the soil is moist. The economic benefits for local communities by engaging in various commercial ventures such ad cutting of fire belts (Gini pati) packing of medicinal products, medicinal crop farming and bee keeping etc. have improved. More importantly, the project has made significant positive impacts on community's knowledge on medicinal plants, traditional medicinal systems, leadership skills and social status etc. However, the above impacts vary by place and type of activity. An assessment of levels of social and environmental benefits of the seven GN divisions due to SLCSUMPP has shown positive trends in cutting fire belts, bee keeping, provision of agricultural implements, medicinal crop nurseries and processing, fuel wood cultivation, Ayurveda teacher-trainee system (Gurukula padanama), School medicinal plants gardens, commercial cultivation of medicinal crops, training/awareness programs and Watershed and stream bank restoration (EML, 2002).

Annex 11.3: World Agroforestry Centre (ICRAF) Sri Lanka Program

The ICRAF (World Agroforestry Centre) Sri Lanka program under the ICRAF south Asia Office is established aimimg network tree domestication research and development activities on fruit and timber trees and medicinal plants in Sri Lanka. The project involve identification of stakeholders and their research activities, prioritization of tree species for domestication, identify gaps which hinder the acceleration of domestication for both commercial and small scale utilization. This project will be a part of the South Asia Network of Tree Domestication with India, Nepal and Bangladesh. The project will help partners to use, enhance and adapt these systems, and to identify and remove policy constraints. It will also develop models for tree germplasm management, as well as systems to tree conserve genetic resources, allow small farmers to benefit from these resources.