

Status of forest genetic resources conservation and management in Sri Lanka

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Introduction

Sri Lanka is a tropical island of continental origin and shares tectonic plates with Peninsular India. The island lies between 5°54' and 9° 52' North and 79° 41' and 81°54' East. The island has two main climatic zones, namely the Dry Zone and the Wet Zone with an Intermediate Zone in between. Nearly two thirds of the island is constituted of the Dry Zone, which consists mainly of flat and undulating land receiving less than 2000 mm annual rainfall. The Wet Zone is located in the south and southwest of the island and consists of coastal plains and very rugged mountainous terrain (Montane Zone) rising up to an elevation of 2750 m asl. The Wet Zone receives 2500 mm to 5000 mm of rainfall annually. Sri Lanka receives rainfall from two monsoons; the northeast monsoon between October and January and the southwest monsoon from May to July and these monsoons affect the three climatic zones differently.

Soils in the Dry Zone are reddish-brown and yellowish-brown, varying from medium/heavy to light and are generally well drained. In the Wet and Intermediate Zones, soils are prevalently red-yellow podzolic and are shallow and well drained in the highlands, but deep and poorly drained in the lowlands. The diverse climate, soil types and altitude have contributed to the high variation in natural vegetation in Sri Lanka. The flora includes 192 families of flowering plants with 1290 genera and 3268 species of which 25% are endemic to the country (Sumithraarachchi 1990).

Conservation and use of forest genetic resources

There has been a significant reduction in the natural forest cover in Sri Lanka during the recent past. The main causes of this have been clearing of forests for agricultural development, shifting cultivation and settlements. At present, a moratorium has been imposed on all harvesting activities in natural forests in the country until management plans are prepared for them. Preparation of these management plans has been started recently under the ongoing Forest Resources Management Project.

Status of forest resources and utilization of trees

Forest plantation activities started in Sri Lanka as far back as 1680 with the introduction of teak to the country. During the period of 1680–1890 several other exotic species were included 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 were initiated. Early tree improvement work was carried out on four species used widely in plantation establishment, namely teak, *Pinus caribaea*, *Eucalyptus grandis* and *E. microcorys*. The activities included provenance trials, establishment of seed production areas, selection of plus trees and establishment of clonal seed orchards. However, due to the small-scale nature of these experiments, it was not possible to produce sufficient amount of improved planting materials for commercial planting.

Extent of natural forests and plantations

According to the latest satellite imagery and aerial photographs the total area of natural forests is 1 942 219 ha of which 1 470 636 ha are identified as dense canopy forest, while the remaining area is sparse forest. The total extent of forest plantations is estimated to

be 93 000 ha. The natural forests of Sri Lanka contain more than 100 indigenous timber species. Majority of them are found in the Wet Zone while the Dry Zone and the drier parts of the Montane Zone contain fewer valuable species and the stocking is very poor (Vivekanandan 1975). With regard to the conservation of forest genetic resources (FGR) in natural forests, the Forest Department (FD) is implementing a World Bank-funded Medicinal Plant Project, in which conservation measures are taken with respect to plants with medicinal value occurring in natural forests.

The FD has been experimenting with a number of indigenous species as well as some exotic species since the inception of plantation establishment. The following species have been given priority in plantation establishment during the recent past based on the field experience gained so far:

Teak – Teak, an exotic species, has been considered the highest priority species, considering its importance as a high value furniture timber with relatively fast growth. It is therefore the most popular species planted by private tree growers. In the 1960s and 1970s planting of teak increased in the Dry Zone when degraded natural forests were planted using a modified form of the Taungya system. Many of the mature teak plantations seen today in Sri Lanka are a result of the efforts made under this programme. Presently, 28 115 ha of teak plantations have been inventoried and are managed by the FD. Majority of these plantations are located in the Dry Zone.

Eucalypts – Eucalypts, another group of exotics, have been the dominating species in the uplands since the time of the British colonization. Among the successful introductions have been *Eucalyptus grandis*, *E. microcorys*, *E. robusta*, *E. pilularis*, *E. camaldulensis*, *E. torelliana* and a few others. In the Dry Zone introductions have been relatively recent and among the several species tested *E. camaldulensis* and *E. tereticornis* have been the most promising ones.

Pines – The bulk of the early planting activities in the highlands consisted of *Pinus patula*. In the 1970s, with a growing interest in planting tropical pines such as *P. caribaea* and *P. oocarpa*, the FD, after a number of field evaluations, initiated large-scale planting of *P. caribaea* var. *hondurensis* in the montane and lowland Wet Zone especially in fern lands and degraded tea cultivation areas. In fact, it was the principal species used in reforesting the upland watersheds. The original objective of pine planting was to create a resource for the production of long-fibre pulp; however, local pulp industry never used this raw material for making pulp. Pines were also planted in the upcountry watershed areas with the primary objective being prevention of soil erosion, reduction in sedimentation of reservoirs and regulation of flow of water to Dry Zone reservoirs. Tapping pines for oleoresins is a fast-growing industry and currently 5300 ha of pine plantations have been leased out to the private sector for resin tapping.

Acacias – Acacias were first introduced in the highlands mainly to meet the fuelwood requirements of tea estates and the main species planted were *Acacia melanoxylon*, *A. decurrens* and a few others. The introductions of acacias in the Dry and lowland Wet Zones have been relatively recent. Several field trials have been conducted by the FD with assistance mainly from the Australian Tree Seed Centre, which generously provided the seeds for the trials. Based on the results of the trials, *Acacia auriculiformis* has proved to be an ideal species for the degraded sites in the Dry Zone and is now extensively planted. *A. mangium* has performed well in the intermediate and lowland Wet Zone and it is planted on a limited scale. In addition to these, *A. aulacocarpa*, *A. crassicaarpa*, and *A. leptocarpa* have shown promising performance in field trials.

Mahogany – *Swietenia macrophylla* has been planted rather extensively in the Wet and Intermediate Zones. One of the African mahoganies, *Khaya senegalensis* has shown promising performance in the Dry and Intermediate Zones and is planted on a limited scale.

Other species – The FD has been experimenting with a number of indigenous as well as some exotic species since the inception of the silvicultural research branch in 1937. Many of the species trials have been replicated both in time and species and some species have proven to be suitable for specific sites. Of particular interest are *Azadirachta indica* (neem) and *Casuarina equisetifolia* for drier sites and coastal areas, *Melia dubia* for Dry and Intermediate Zones, *Terminalia arjuna* (kumbuk) for waterlogged lowland areas, *Berrya cordifolia* (halmilla) and *Madhuca longifolia* (mee) for relatively fertile lowland dry sites.

The Medicinal Plant Project has selected natural forests from different ecological zones in the country, with one of these forests located in the Dry Zone, two forests in the Wet Zone and two forests in the Intermediate Zone. *In situ* conservation in natural forests as well as *ex situ* conservation measures such as establishment of nurseries, home gardens and demonstration plots have been initiated under this project. The most important tree species in the Medicinal Plant Project include *Diospyros melanoxylon*, *Litsea glutinosa*, *Phyllanthus emblica*, *Pterocarpus marsupium*, *Salacia reticulata*, *Terminalia belerica* and *Terminalia chebula*.

Identification of threats

Most of the natural forests and some of the forest plantations in the country have faced threats from the growing human population. These forests are gradually losing their quality in terms of species diversity 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 wherever necessary in order to provide benefits to the present and future generations. The attempts made towards conservation of forest resources by the FD 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.

Identification of exotic invasive forest trees

Invasive plants are a major threat to conservation of biodiversity. These plants are capable of replacing diverse ecosystems with few species, which is a direct threat to native flora and fauna.

Udawattakele is a wet semi-evergreen forest in the central hilly region of Sri Lanka, located in Kandy, the hill capital of the country. This forest is reserved as a sanctuary in Sri Lanka and the extent of the forest is about 100 ha, with high species richness. The ecological and social value of the Udawattakele is also significant to Kandy since it acts as a watershed, and creates a pleasant microenvironment. However, the introduced tree species *Myroxylon balsamum* has become invasive and is threatening the biodiversity in this forest (Pushpakumara and Hitinayake 2001).

Prosopis juliflora, a leguminous species native to Central and Northern South America has been introduced to the arid areas of the country in the 1950s to improve the salt-affected soils as well as for firewood and to provide vegetative cover. A variety of this species is found to be naturalized and it has now become invasive. The Wetland Site Report published by Central Environmental Authority in 1993 indicates that this species is a serious threat to the Bundala National Park in Hambantota district (Seneviratne and Algama 2001).

Socioeconomic conditions and issues related to the conservation, utilization and management of forest genetic resources

Links between the forestry sector and forest genetic resources

In Sri Lanka, more than 28% of the land area is reserved and administered by either the FD or the Wildlife Department. A distinct feature of these protected areas is that they are fragmented. Thirty percent of protected areas are less than 100 ha in area and 54% are less than 1000 ha in size. Most of the areas that are under the purview of the FD are smaller than 1000 ha. The largest and most important protected areas in the country are the Peak Wilderness Sanctuary and the adjacent Hortan Plains National Park (with a combined area of 25 539 ha), Knuckles Conservation Forest (16 000 ha), and Sinharaja National Heritage Wilderness area (11 187 ha). Out of these, the most important site for biodiversity conservation is Sinharaja, the country's largest remnant of rain forest, which has been declared a biosphere reserve under the UNESCO MAB programme and has been included into the World Heritage List of natural sites.

Agriculture and agroforestry

Multipurpose Tree Species (MPTS) Research Network is a local network working on research to meet the needs of small-scale farms for fuelwood and other tree products. The activities of the network are coordinated by a National MPTS Research Committee where experts from national institutions in forestry, agriculture and social sciences, universities, tree growers as well as NGOs are represented. The focal point of this network is the Faculty of Agriculture of Peradeniya University. One of the main activities is a multi-locational species trial. Other activities include studies on farmers' objectives as regard to tree breeding, regional survey of farm and village forestry practices, regional comparative studies and also establishment of a marketing network for MPTS products.

Recently, a network on *Artocarpus heterophyllus* (jackfruit), a neglected MPTS in Asia, was established. Documentation of available seed sources, collection, storage and *ex situ* conservation of jackfruit are being done under this network. In addition, exchange of seed materials and establishment of provenance trials are also being done. A tree improvement programme of jackfruit has also been initiated.

Animal husbandry

Silvopastoral systems are found in the mid to high elevations in central Sri Lanka, and also in the coconut triangle in the southwest quarter of the country. The practice is widespread in the hilly or wet grasslands. Tree components are mainly *Eucalyptus*, *Pinus* and *Cupressus* species. In the coconut areas cattle is raised in coconut fields, which are not intercropped to any large extent. In some silvopastoral areas, especially in the mid-Montane Zone, there is a danger of fires created by herders who burn the dry grass just before the rains in order to get a new flush of grass for their cattle.

Industry

The indigenous sources of energy for Sri Lanka are biomass (including fuelwood) and hydropower. The country has no fossil fuel deposits. Fuelwood is used mainly in the domestic sector for cooking, to a small extent for keeping houses warm in the montane region and in some industries for drying and heating purposes. Ninety four per cent of Sri Lankan households use fuelwood for cooking. Electricity is used mainly for lighting and in industries.

Numerous fuelwood planting programmes have been started in the country in the recent years. Fuelwood is also produced from thinnings and branches from forest plantations. The agro-based plantation fuelwood and extensive non-forest fuelwood planting programmes are mainly meant to supply fuelwood for industries. In addition to the Forest Department, agencies that have undertaken fuelwood planting programmes of their own include tea industry, Sri Lanka's State Plantation Corporation, Janatha Estate Development

Board, Ceylon Tobacco Company, Ceramic Corporation, Brick and Tile Industries and Mahaweli Development Authority. The FD, with the forestry extension division has provided technical assistance to most of these institutions in raising fuelwood plantations.

Past and present activities in conservation, utilization and management of forest genetic resources

Agroforestry, plantations and afforestation programmes

The history of cultivating trees in home gardens, social tree planting, protection and management of forests and appreciation of wildlife and the beauties of nature in Sri Lanka goes back to over 25 centuries. In chronicles there are references to social tree planting practices, well-organized village communities, and home gardens planted with flowering and fruit bearing trees. Because of the age-old agroforestry tradition, numerous examples of agroforestry practices are found in all climatic zones of the country.

Today, the traditional knowledge of agroforestry is being developed and expanded with the objective of improving living standards of rural poor. A wide range of agroforestry systems is found in Sri Lanka and their characteristic features (Nanayakkara 1991) could be summarized as below:

Shifting cultivation

Shifting cultivation is an age-old agroforestry system where forest and food crops are grown alternately in temporal sequence. The system is sustainable as long as there is a reasonably long fallow period (at least 15 years). However, with population growth and shrinking forest cover, the fallow period has shortened resulting in severe land degradation. In the Dry Zone, large tracts of forest were lost in the past due to uncontrolled shifting cultivation. Formerly, issuing of cultivation permits by the government regularized the shifting cultivation and in 1981 issuing of these permits was officially terminated. Today only few sporadic, illegal shifting cultivation activities are taking place in remote Dry Zone areas.

Cooperative reforestation

This agroforestry system was a modified form of the Burmese Taungya system. This system was practised especially to convert the degraded Dry Zone natural forests into teak plantations with participation of shifting cultivators in this scheme. Cultivators were provided an opportunity to grow agricultural crops over a three-year year period, while the farmers were also paid a monetary reward. Farmers formed cooperative societies and participated in the programme. This system has produced good results; almost all the best teak plantations established in the Dry Zone and Intermediate Zone have been raised under this scheme. Though this system was originally applied for teak, in later stages some *Eucalyptus camaldulensis* and *E. tereticornis* plantations were also raised. The shortcoming in this system has been the insecure land tenure for the cultivators; the system encouraged nomadism, which did not improve the life standard of cultivators.

Intercropping with other cash crops

Coconut is the most widely planted industrial tree crop in Sri Lanka. It covers about 25% of the total cultivated area on the island. A large number of tree crops such as teak and mahogany are grown in association with coconuts. Tea is the second largest industrial crop in the country and it is grown mainly in the central hill country and in wet southwest lowlands. A large number of leguminous and other shade trees are grown in this agroforestry system. The fuelwood needs of tea estates, including the energy for tea processing and for the domestic needs of tea estate workers, are met with firewood species grown within this system. Rubber is the third largest industrial crop in the country and fruit trees are often intercropped with rubber. As the shade cast by rubber in the later stages of its rotation is dense, intercropping is fairly restricted. Pineapple and cocoa are grown in areas where rubber canopy is not too dense. Palmyrah palm (*Borassus flabellifer*), which is a multipurpose

tree yielding many products inter-cultivated with cashew nut is another agroforestry system found in coastal areas of the Dry Zone and in semi-arid areas of northern and eastern districts.

Sloping agricultural land technology

Sloping agricultural land technology is also widely adopted in central hilly areas of the country. In this system hedgerows are grown along contour lines in sloping lands of abandoned tea areas, alternating with agriculture crops. Fuelwood species, such as *Gliricidia sepium* are commonly grown in hedgerows. Continuous mulching with pruned biomass from hedgerows improves soil conditions and reduces erosion.

Kandyan home garden system

Kandyan home garden system is an age-old traditional agroforestry system practised in the central hilly areas and in some other districts in the Wet Zone. This system is an ideal form of land use combining agriculture, forestry and livestock. Trees are grown in a multi-layer arrangement and mixed cropping of trees yielding timber, small wood, fuelwood, fodder, food, fruits, medicines together with crops yielding food and medicine is practised. Maximum utilization of space, both vertical and horizontal, is ensured in this system.

Farmers' woodlots

Since the 1980s the FD has started establishing partnerships with farmers in the rural areas in raising farmers' woodlots. This system is practiced mainly in the Dry Zone and in drier sites in the central hilly areas. Relatively small blocks of degraded state lands (less than 0.1 ha) have been leased out to local farmers on a long-term lease basis. Seedlings of forest and horticulture species and technical advice are provided to the farmers free of charge by the FD. In this system, the farmer is entitled to harvest the final tree crop, leaving few mother trees in the plot. Farmers are also rewarded in the form of a food ration for successful establishment and maintenance of plantations.

Plantations and afforestation programmes

Plantation forestry is considered to be of great value in relieving pressure from natural forests and, at the same time providing more uniform products as compared to natural forests.

The forest policy of 1929 emphasized increased wood production to ensure self-sufficiency and to allow also for some exports. In 1938, a policy of planting natural grasslands (*patanas*) was commenced and planting of exotic tree species such as pines and eucalypts in up-country, reflected the prevailing emphasis of the policy. The forest policy of 1953 emphasized timber and fuelwood production to meet the increasing demand and with this development some mechanized planting of wet and dry grasslands were carried out using *Pinus caribaea*. Plantations of *Eucalyptus grandis* and *E. microcorys* as well as acacias were established at that time. Most of the *Pinus caribaea* plantations in the country were planted between 1965 and 1984. In latter part of the 1980s, with environmental concerns about monocultures, especially exotics, the planting of *Pinus* species virtually ceased.

In the Dry Zone, large scale planting of teak was carried out until the 1980s and since then the scale of planting has reduced because the successful establishment of teak depends on clearing and burning of natural forests, which is now regarded as undesirable.

During the 1970s and 1980s, *Eucalyptus camaldulensis* and *E. tereticornis* were established extensively in the Dry Zone, together with *Acacia auriculiformis*. These species were planted in a response to the concerns about a potential deficit in fuelwood supply. Some of these plantations were not successful due to damages by animals and fires.

One of the main forestry projects in the 1980s was the ADB-funded Community Forestry Project, under which the development of fuelwood plantations and agroforestry in five districts took place. During the same period, the International Development Agency (IDA) and the Finnish International Development Agency (FINNIDA) funded a Forest Resources Development Project and the FD established extensive commercial plantations under various rural development projects.

During the 1990s, under the Forestry Sector Development Project funded by the British Overseas Development Agency (ODA), UNDP/FAO and IDA, the FD established plantations of species such as acacias, mahogany as well as indigenous species. In 1993, the FD implemented an ADB-funded Participatory Forestry Project where emphasis was given to increasing wood production in home gardens, farmers' woodlots, protective woodlots and public reserve lands. This work was carried out through participation of farmers.

Presently, the FD is implementing reforestation activities under the ADB-funded Forest Resources Management Project. The main species that is being planted in the Dry Zone is 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.

Demand and supply of seed

The seeds of indigenous tree species, such as *Terminalia arjuna*, *Holoptelea integrifolia*, *Terminalia belerica*, *Madhuca longifolia*, *Diospyros ebenum*, *Chloroxylon swietenia*, *Lagerstroemia speciosa* and *Pericopsis mooniana* are collected locally by farmers as well as by the FD. The FD also imports seeds of exotic species required for agroforestry and reforestation programmes. 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. A Tree Seed Centre has been established in the FD, attached to the Forest Research Centre. The Seed Centre building and cold storage facilities have been constructed with assistance from the ADB.

National seed demand is calculated and seed procurement from local and foreign sources is planned accordingly. Priority is given to seed collection from seed orchards and seed production areas. Collected seeds are cleaned and dried in the sun until the seed weight remains constant. Small-scale seed collecting for special purposes is done when requested. Collected seeds are labelled and stored for future use. Seed testing is done for seed moisture, viability and germination. Certified and high-quality seed is dispatched to divisional staff as and when required. Seeds and planting materials of fruit trees and horticultural plants are supplied by the Agriculture Department through departmental and farmer nurseries.

***In situ* conservation**

Conservation of FGR necessarily involves management of the resources in the context of human use. Long-term conservation of genetic resources requires regeneration of representative populations. Indigenous tree species and populations are most efficiently maintained *in situ* through natural regeneration or by planting trees of local origin and of wide parentage.

Many important indigenous tree species such as *Lumnitzera litoria* and *Carapa moluccensis* are facing genetic degradation due to continuous removal of phenotypically better trees under the selective management system. Thus, some of the indigenous tree species are found at present only in natural habitats. Their natural regeneration is threatened due to various factors. The activities conducted by the Forest Department in relation to *in situ* conservation could be listed as:

- Strict protection of highly valued natural forests without permitting any kind of disturbance including harvesting (Knuckles Forest and Sinharaja area have been declared as strict conservation forests under the new categorization of forests).
- Development of separate management plans for important forests to ensure their conservation while obtaining essential services.
- Maintenance of a computerized environmental database – Environmental Information Management Systems (EIMS) that contains data e.g. on plant and animal species in the country.

- Implementation of Sinharaja, Knuckles and Mangrove Conservation projects.
- Maintenance of the Man and Biosphere (MAB) reserves.
- Buffer zone management in natural forests.
- National conservation review to assess the biodiversity of natural forests, which are 200 ha or more in extent. (The work in 33 natural forests in the Wet Zone has already been completed while the work in the Dry Zone will be done in the future).
- Development of forest plantations, homegardens and other agroforestry systems to meet the social needs, which can reduce the threats to natural forests.
- Identification of medicinal plant conservation areas in selected natural forests.
- Acquiring mangrove areas from local authorities to the FD, declaring them as conservation areas and preparing management plans for them.
- Conducting research on enrichment planting and related areas in degraded natural forests. Studying natural forests in terms of biodiversity, rarity and endemism.
- Research on natural regeneration and floral biology in the natural forests.

Ex situ conservation (seed, conservation stands, in-vitro cultivation)

With respect to *ex situ* gene conservation, the following activities are being conducted by the Forest Department:

- Collection of germplasm of endangered species from their natural range and planting in blocks as genebanks.
- Collection of seeds of native species and establishment of plantations.
- Establishment of seed orchards to conserve superior germplasms.
- Vegetative propagation of valuable local species for genetic improvement.
- Importation of genetic materials of plantation species from other countries and planting them in the field either to broaden the genetic base of existing species or to introduce new species.
- Planting of medicinal plants in buffer zones of natural forests, home gardens, etc.

In addition to *in situ* and *ex situ* conservation measures taken by the FD under the Medicinal Plant Project, the Biodiversity Division of Ministry of Environment and Natural Resources is establishing Plant Sanctuaries, which is a form of *ex situ* conservation blocks for the conservation of indigenous tree species such as *Pterocarpus santalinus*, *Lumnitzera litoria*, *Carapa moluccensis*. This work is carried out in collaboration with the Faculty of Agriculture of the University of Ruhuna.

Tree improvement (provenance trials, progeny tests, seed orchards, etc.)

The choice of seed sources is one of the main factors affecting the establishment and productivity of tree plantations. During the pioneering years, there were hardly any scientific studies on provenance variation within species and species introductions were done in an *ad hoc* manner. The present practice of silvicultural provenance research provides a sound basis for selection of seed sources.

Tree improvement research in the Dry Zone

In the Dry Zone, the most important species for tree improvement research have been teak, eucalypts and acacias. Starting in 1941, the first teak trials examined the performance of five provenances originating from Burma as well as 'local' landraces that presumably originate from the old introductions from India (Vivekanandan 1977).

Eucalypts have been introduced into Sri Lanka since 1960s. Systematic evaluations and provenance trials have been conducted by the Research Division of the FD e.g. for *Eucalyptus tereticornis*, *E. alba* and *E. camaldulensis* (Vivekanandan 1979; Connelly 1990; Nikles 1992; Bandarattillake 1997); for a summary, see Appendix 1. As for acacias, *A. auriculiformis* and *A. crassicaarpa* have shown promising performance in the Dry Zone.

Tree improvement research in the Wet, Intermediate and Montane Zones

Acacias – During the 1980s there was a widespread interest in new species of phyllode acacias that were found in Australia. *Acacia mangium* was introduced into Sri Lanka in the 1980s and was planted on a trial basis on different sites in the Wet and Intermediate Zones. The FD, in close collaboration with the Australian Tree Seed Centre embarked on the evaluation of several new species of acacias from different geographic locations in Australia (Weerawardane and Phillips 1991).

Eucalypts – Eucalypts have been the principal species planted in the hill country, the most important species being *E. grandis*. During the early stages seeds have been imported from overseas, mainly from Australia and very little attention was paid to the seed origin. Over the years the best seed sources, even though their origins are unknown, have become adapted to the local conditions and have been performing well. In the 1980s a number of species cum provenances trials were initiated in a number of locations (Weerawardane and Phillips 1991; Vivekanandan 2002).

Pines – During the 1970s, the Oxford Forestry Institute in cooperation with national forestry institutions initiated several international species cum provenance trials of tropical *Pinus* species in a number of countries in Asia, including Sri Lanka. The provenance trials of *Pinus caribaea* and *Pinus oocarpa* are of particular interest. These trials provide the basis for the large-scale establishment of plantations in degraded sites in the upland and in the low country Wet Zone.

Institutional framework**Institutions, their roles, responsibilities and capabilities**

The office of the Conservator of Forests of Sri Lanka was established in 1887 but a separate Department to undertake forestry activities was not established until 1899. There have been several changes in institutions since then and currently almost all the FGR work is under the jurisdiction of the FD, in collaboration with other departments such as the Department of Agriculture, etc. There are two main research stations and the one at Kumbalpola has been developed as the Central Forest Research Station of the country, while the other centre at Badulla is functioning as a sub-station.

The FD is headed by the Conservator General of Forests with the assistance of three Additional Conservators of Forests. The research division is headed by the Additional Conservator of Forests (Research) and consist of five Research Officers, five Technical assistants and three Lab Attendants. In addition, a forestry information service unit with desktop publishing facilities has been established recently at the Head office.

National legislation, policies and strategies on forest genetic resources

The Forest Ordinance has provisions for Minister-in-charge of the Forest Department to declare areas for forest conservation. In this regard the Minister may publish gazette notifications declaring any forest area, which has unique ecosystems, genetic resources or is a habitat of rare and endemic species of flora and fauna or of threatened species, in order to achieve an ecological balance as a conservation forest. For example, most of the threatened mangrove areas that had been owned by the private sector have been taken over by the FD for conservation under this provision.

The National Forest Policy approved in 1995 gives an overriding priority to conservation of biodiversity and protection of watersheds in the forest ecosystems. One of the main objectives identified in the policy is to conserve forests for posterity, with particular emphasis to biodiversity, soils, water and historical, cultural, religious and aesthetic values. The following statements in the policy clearly stressed the need for conservation of biodiversity:

Statement 2.1: All state forest resources will be brought under sustainable management both in terms of continued existence of important ecosystems and flow of forest products and services.

Statement 2.3: The natural forests will be allocated firstly for conservation, and secondly for regulated multiple-use production forestry.

Statement 2.4: For the management and protection of the natural forests and forest plantations, the state will, where appropriate, form partnerships with local people, rural communities and other stakeholders to introduce appropriate tenurial arrangements.

Statement 4.4: Effective measures to protect the forest and prevent illegal trade in wood, non-wood forest products and endangered species of flora and fauna will be instituted.

Statement 5.3: The state will provide full support to the various resource managers for sustainable forestry development, and its institutions will be reoriented and strengthened to enable them to accomplish their role.

Statement 6.3: Nature-based tourism will be promoted to the extent that it does not damage the ecosystems and insofar as it provides benefits to the local population.

Statement 6.5: The general public and industries will be educated about the importance of forestry and of conserving biodiversity and protecting watersheds.

National forest policy and institutional issues

There are several agencies involved in forestry development activities. The major government Institutions that are directly involved in forestry activities are the Forest Department (FD), Wildlife Conservation Department (DWLC) and State Timber Corporation (STC). The FD deals with conservation, management, regulation of utilization, research and extension of forestry activities, the DWLC deals with conservation while the STC, which is a statutory body, deals with harvesting, processing and marketing of timber. The mission of the FD is to conserve and develop the forest resources in Sri Lanka to ensure the prosperity of the nation. All these three institutions are under the purview of the Ministry of Environment and Natural Resources. The Ministry is headed by the Minister who is a political appointee. The responsibility of the Secretary to the Ministry is to advise the Minister on policy formulation and implementation. In addition to the above three line agencies that are directly involved in forestry, there are several other line agencies that come under the same Ministry, such as the Central Environmental Authority and Geological Survey and Mining Bureau. There is a Planning Division operating within the Ministry to ensure that the plans produced in the Ministry are in line with the national and ministerial policies and to identify source of funds.

In addition to the FD, DWLC and STC, the other state agencies that play minor role in forestry are Mahaweli Authority, which is the body controlling activities of the largest national irrigation scheme in the country, the Plantation Ministry and Agriculture Department.

Adoption of the new National Forest Policy in 1995 required changes in the organizational structure of the forestry sector and prioritizing its various functions. As a result, the FD was subjected to restructuring in 2000, bringing about major changes in its administrative structure. Central organizational structure has been decentralized to a great extent to the regional level. Furthermore, as a measure of re-organization of the forestry sector, the FD and the DWLC were brought under one Ministry.

The long terms goals, envisaged with bringing about institutional reform under the new National Forest Policy could be summarized as follows (Sri Lanka Forestry Sector Master Plan 1995):

- Policy and legislation, as well as both state and other institutions will be made effective instruments for forestry development.

- The organizational structure of forestry and related agencies will be developed to enable them to implement the partnership approach to forestry development.
- Commercial forestry and forest industry operations of the state are separated from other operations and made financially self-sustaining and efficient, with an increasingly important role reserved for the non-state sector.
- Policy evaluation, legal and institutional reform will be institutionalized and become routine government activities.

Links with international initiatives

Sri Lanka has become a party to a number of international agreements related to the conservation of biodiversity; these include the UNESCO Man and the Biosphere Programme, Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention), Convention on Wetlands of International Importance (Ramsar Convention on Wetlands), Convention on Biological Diversity and Convention on Climate Change.

Biosecurity regulations

The Forest Ordinance has provisions to regulate the import and export of timber and seeds of forest tree species and other forest products and to provide for the issue of permit for these items. The regulations have been framed under this provision to restrict export of plants, seeds and plant products of species listed under the publication "The 1999 List of Threatened Fauna and Flora of Sri Lanka" compiled by the IUCN.

Legislation regarding access to genetic resources, property rights and benefit sharing

The new Forest Policy includes provisions for:

- Enhancing the contribution of forestry to the welfare of the rural population and strengthening of the national economy, with emphasis on equity.
- Putting state forest resources under sustainable management, allocating the natural forests for regulated multiple-use forestry after the needs for conservation have been given priority.
- Forming partnerships with rural people, rural communities, and other stakeholders, and introducing appropriate tenurial arrangements.
- Rehabilitating degraded forestlands for conservation and multiple-use production.
- Promoting tree growing by rural people – individually or collectively – and by NGOs.
- Putting the responsibility for production and marketing of commercial forest products into the hands of rural people, organized groups, cooperatives, etc.

The Forest Ordinance is being revised, providing the legal basis for the above-mentioned issues. A prominent feature of the new legislation is that it classifies the forest estate into three categories, namely: Strict Conservation Forests, Conservation Forests and Multiple Use Forests. The definition of the Multiple Use Forests as a category of forest in Forest Ordinance provides much flexibility to develop partnerships and share benefits with local community. The regulations that will be framed under the new Forest Ordinance are going to enhance the accessibility to Multiple Use Forests by the local community.

Identification of national priorities

The Forest Department appointed a committee in 1992 to recommend suitable species for reforestation programmes. Concurrently, a new emphasis was given to tree improvement in the early 1990s. Teak was considered as the highest priority species considering its importance as a high value as furniture timber with relatively fast growth and the fact that it is the most popular species among private tree growers. Other major species identified were *Swietenia macrophylla*, *Acacia auriculiformis*, *Azadirachta indica*, *Eucalyptus grandis*, *E. microcorys* and *E. tereticornis*. Three indigenous species, namely *Albizia odorotissima*, *Melia*

dubia and *Pterocarpus marsupium* were identified for *ex situ* conservation. Appendices 2–4 provide more information on priority species for Sri Lanka.

Exploration and conservation of *Albizia odoratissima*, *Melia dubia* and *Pterocarpus marsupium*

In addition to the species identified for conservation under the Medicinal Plant Project, other important indigenous species that have been identified for gene pool conservation are *Albizia odoratissima*, *Melia dubia* and *Pterocarpus marsupium*. Some of these tree species are at the present found only in home gardens while others are confined to a few remaining natural habitats and their natural regeneration is threatened due to various factors. Therefore, it has been recommended to establish *ex situ* conservation stands for these three species. Activities proposed and initiated under this programme include:

1. Explore and document natural occurrences. Select 10–20 locations throughout the natural range in Sri Lanka, where groups of trees of these species occur and collect seeds from about 200 trees per location (These trees should be sufficiently apart from each other to minimize collecting seeds from close relatives).
2. Mix equal quantities of seeds from each tree to form a bulk seed lot.
3. Plant out 10–15 ha at two to three locations. These plantations will be *ex situ* conservation stands and base populations for breeding work. These also can be used as seed production areas.

Support activities

Training and capability building

Since the early days, forestry training has been given major emphasis, for example, the first training for staff of the Forest Department was conducted in 1949 by the school of agriculture at Peradeniya. From 1958 to 1983, two-year courses were developed for Range Forest Officers and one-year courses for Beat Forest Officers at the Ceylon Forest College at China Bay, Trincomalee. In 1985, this college was closed due to security risks and later the Sri Lanka Forestry Institute was opened at Nuwara Eliya in 1990.

Until 1993, the Sri Lanka Forestry Institute offered training as a one-year course for Range Forest Officers and a 6-month course for Beat Forest Officers. A six-hectare forest plantation, within which the Institute is located, provides practical training ground in forest surveying, forest management, forest mensuration, etc. A nursery with the capacity to produce 50 000 seedlings per year is being developed to provide practical training in nursery activities. In addition to the field staff of the Forest Department, Coupe Officers of the State Timber Corporation also obtained their training from the Institute at that time.

After 1993, with the revision of the curricula of the Forestry Institute, the Range Forest Officers' course was developed into a two-year Diploma Course while Beat Forest Officer's Course was developed into a one-year Certificate course. In addition, the Sri Lanka Forestry Institute conducts in-service training programmes for the departmental officers and short-term training courses for offices of other government organizations.

Another important national institution that conducts forestry education is the University of Sri Jayawardhanapura with an MSc degree programme on Environmental Forestry. The Post Graduate Institute of Agriculture (PGI) in Peradeniya University also offers MSc degree programmes in Environmental Forestry, under which courses on FGR are included.

Research

Research and development have an important role to play in solving the problems connected with conservation, utilization and promotion of forest and tree genetic resources. Answers to many of the existing problems can be obtained only by carrying out long-term research. During the recent past, the Forest Department based the Departmental Research Programme on five priority areas: tree improvement, plantation conversion, fire prevention, site/species matching and bamboos and rattans. However, a limited amount of work could be completed

in these fields due to constraints such as continuous changes in the senior staff and the lack of research officers and technical assistants. In addition to the FD, universities, various research institutes and projects are also involved in forestry research. Among Universities, Peradeniya University conducts a considerable amount of research on natural forest ecology and management, hydrology and agroforestry while the University of Sri Jayawardenapura does a lot of research in the form of projects conducted by MSc degree students. The Royal Botanical Gardens at Peradeniya undertakes research on flora, including especially medicinal forest plants, and the conservation of genetic resources. A Research and Education division in the FD implements forestry research and education programme of the Department.

Regional and international collaboration

Currently, Sri Lanka is involved in a number of international collaborative initiatives, such as the International Neem Network, Asia Pacific Agroforestry Network (APAN), Regional Wood Energy Development Programme (RWEDP), 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) and Teaknet.

International Neem Network

The National Focal Institute (NFI) in Sri Lanka for the International Neem Network is the FD. The Faculty of Agriculture of the University of Peradeniya is a major collaborator with the FD in carrying out the activities planned under this network. Activities that are undertaken include identification, documentation, collecting and distribution of seeds of local provenances. Some of the seeds of different provenances collected have been documented and dispatched to other foreign network collaborators.

Asia Pacific Agroforestry Network (APAN)

The National Focal Point for APAN in Sri Lanka is the FD while the Faculty of Agriculture of the Peradeniya University participates in the activities planned under the network. The activities implemented under this network include coordination of mechanisms for agroforestry research and development, information sharing and exchange, agroforestry training and field demonstrations.

National Forestry Research Committee and MPTS research committee

The National Forestry Research Committee and MPTS research committee coordinate agroforestry research activities in Sri Lanka.

Regional Wood Energy Development Programme (RWEDP)

The FD is the national focal point for this programme and is instrumental in the establishment of the National Coordinating Mechanism of Sri Lanka whose chairman is the Conservator General of Forests. Through the networking activities of this project, Sri Lanka has obtained assistance to mobilize national efforts and strengthen inter-institutional linkages for wood energy planning. The project secretariat provided information through technical materials, publications and the Wood Energy Newsletter. The assistance provided by the project includes development of syllabi and training materials for community forestry for training institutions, training materials for rapid rural appraisal (RRA) for community forestry and publicising a report on social forestry in integrated rural development and wood energy status in Sri Lanka.

UNDP/FAO Regional Project on Improved Productivity of Man-made Forests in Tree Breeding and Propagation (FORTIP)

Under this programme seed production areas were established for *Eucalyptus grandis* and *Eucalyptus microcorys*, and clonal seed orchards were established for teak. In addition, identification of *Swietenia macrophylla* stands for seed production under a Species Improvement Network (SPIN) was conducted.

IUFRO, Asia Pacific Association of Forestry Research Institution (APAFRI) and Teaknet

The FD continues to be a member of IUFRO, APAFRI and Teaknet.

Proposals for regional and international collaboration

The following regional and international collaborations are proposed:

1. A sound germplasm exchange programme should be developed.
2. Facilities should be arranged to obtain proven provenances from international provenance trials.
3. Scientists, researchers and managers should be given opportunities to visit trials and other sites in the region and to exchange views and experiences.
4. Suitable training programmes should be developed particularly for researchers.
5. A website should be created to provide information about genetic conservation and improvement in the region.
6. Assisting in getting financial support from donor agencies for the development of appropriate FGR conservation techniques.
7. Development of a network of researchers for information exchange.
8. Organising scientific seminars and workshops to disseminate research results.

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Appendix 1

Summary of *Eucalyptus* provenances tested in Sri Lanka

Species	Provenance	CSIRO No.	Alt. (m)	No of plots
<i>Eucalyptus melanoxyton</i>	Samford, QLD	14766	300	4
<i>E. saligna</i>	Consuelo tableland, QLD	13263	1090	3
<i>E. saligna</i>	Kenilworth, QLD	13341	470	3
<i>E. saligna</i>	40 km W of Coffs Har our, NSW	13320		4
<i>E. saligna</i>	Kroombit Tops, QLD	14432	800	4
<i>E. saligna</i>	Blackdown Tableland, QLD	14429	780	4
<i>E. saligna</i>	Chaelundi State Forest, QLD	14507	640	4
<i>E. saligna</i>	Kenilworth State Forest, QLD	14435	600	4
<i>E. grandis</i>	Baldy State Forest, QLD	14423	1000	4
<i>E. grandis</i>	Belithorpe State Forest, QLD	14431	500	4
<i>E. grandis</i>	Cascade via Dorrigo, NSW	14510	640	4
<i>E. grandis</i>	14.5 km S of Ravens Hoe, QLD	12409	940	4
<i>E. cloeziana</i>	SE of Gympie, QLD	13450	150	4
<i>E. cloeziana</i>	26 km SW of Monto, QLD	13543	480	4
<i>E. resinifera</i>	14.5 km S of Ravens Hoe, QLD	12-411	940	4
<i>E. resinifera</i>	SW of Coffs Harbour, NSW	13977	200	4
<i>E. resinifera</i>	WNW of Beerburum, QLD	13981	40	4
<i>E. pilularis</i>	Local (Kandapola)			4
<i>E. pilularis</i>	W of Coffs Harbour, NSW	13523	100	4
<i>E. pilularis</i>	Gallangowan State Forest, QLD	13451	610	4
<i>E. urophylla</i>	Mt Lewotobi, INDO	14532	398	4
<i>E. urophylla</i>	Mt Egon, INDO	14531	515	4
Seed lots showing poor survival or growth				
<i>E. alba</i>	Mt Lewotobi, INDO	14533	340	0
<i>E. tereticomis</i>	9 km SW of Imbil, QLD-	13541	100	0
<i>E. tereticomis</i>	5-12 km S of Helenvale, QLD	14212	500	2
<i>E. torelliana</i>	SSW of Kuranda, QLD	14130	420	0
<i>E. torelliana</i>	S of Helenvale, QLD	14855	200	0
<i>E. camaldulensis</i>	E of Petford, QLD	14338	500	0
<i>E. staigerana</i>	Maitland Downs, QLD	13631	550	0
<i>E. dunii</i>	NNW of Urbenville, NSW	14113	675	4
<i>E. citriodora</i>	Local			0

QLD = Queensland, Australia; NSW = New South Wales, Australia; INDO = Indonesia

Appendix 2

Value and use of target species

Species name	Value and present or potential future use										
	ti	po	Wo	nw	pu	fo	fd	sh	ag	co	am
<i>Acacia auriculiformis</i>		1	1								
<i>Azadirachta indica</i>	1										1
<i>Eucalyptus grandis</i>	1								1	1	
<i>E. microcorys</i>	1								1	1	
<i>Swietenia macrophylla</i>	1								1		
<i>Tectona grandis</i>	1								1		
<i>Terminalia chebula</i>				1							
<i>Diospyros melanoxylon</i>	1			1							
<i>Litsea glutinosa</i>				1							
<i>Phyllanthus emblica</i>				1							
<i>Pterocarpus marsupium</i>	1			1							
<i>Salacia reticulata</i>				1							
<i>Terminalia belerica</i>				1							
<i>Pterocarpus santalinus</i>				1							
<i>Lumnitzera litoria</i>	1			1							
<i>Carapa moluccensis</i>	1			1							

VALUE: 1 = Species of current socioeconomic importance; 2= Species with clear potential of future value; 3 = Species of unknown value given present knowledge and technology

UTILIZATION: ti = timber production; po = posts, poles, roundwood; wo = fuelwood, charcoal; nw = non-wood products (gums, resins, oils, tannins, medicines, dyes, etc.); pu = pulp and paper; fo = food; Fd = fodder; sh = shade, shelter; ag = agroforestry systems; so = soil and water conservators; am = amenity, antithetic, ethical values

Appendix 3

List of priority species for conservation, improvement and seed procurement plus recommended activities

Species	Use				Operations/activities needed							
	W	NW	FW	O	Exploration & Collection		Evaluation		Conservation		Germplasm use	
	1	2	3	4	5	6	7	8	9	10	11	12
<i>Albizia odoratissima</i>	1				1	1	1			1		1
<i>Melia dubia</i>	1				1	1	1			1		1
<i>Swietenia macrophylla</i>	1				1	1		1		1		1
<i>Tectona grandis</i>	1				1	1		1		1		1
<i>Terminalia chebula</i>				1					1	1		
<i>Diospyros melanoxylon</i>				1					1	1		
<i>Litsea glutinosa</i>				1					1	1		
<i>Phyllanthus emblica</i>				1					1	1		
<i>Pterocarpus marsupium</i>				1					1	1		
<i>Salacia reticulata</i>				1					1	1		
<i>Terminalia belerica</i>				1					1	1		
<i>Pterocarpus santalinus</i>				1			1		1	1		
<i>Lumnitzera litoria</i>				1			1		1	1		
<i>Carapa moluccensis</i>				1			1		1	1		

End uses: **1** = Industrial wood products (logs, sawtimber, construction wood, plywood, chip and particle board, wood pulp etc.); **2** = Industrial non-wood products (gums, resin, oils, tannins); **3** = Fuelwood, posts, poles (firewood, charcoal, roundwood used on-farm, wood for carving); **4** = Other uses, goods and services (food, medicinal use, fodder, land stabilization/amelioration, shade, shelter, environmental values).

Exploration & collection: **5** = Biological information (natural distribution, taxonomy, genecology, phenology etc.); **6** = Collection of germplasm for evaluation

Evaluation: **7** = *In situ* (population studies); **8** = *Ex situ* (provenance and progeny tests)

Conservation: **9** = *In situ*; **10** = *Ex situ*

Reproductive use/germplasm use: **11** = Semi-bulk/bulk seedlots, reproductive materials; **12** = Selection and improvement

Rating for columns 5–12: **1** = Highest priority, action should start, or be continued, with immediate effect; **2** = Prompt action recommended, action should start within next two biennia; **3** = Action required in next five to ten years

Appendix 4

Management and location of genetic resources, by natural site and species

Species in ecogeographic zones	Nature reserves, protected areas	In situ conservation stands	Managed forests	Unmanaged forests	Plantations (ha)	Ex situ conservation stands	Villages, fields, homesteads	Experiment, fields, trials	Degree of Threat Index
Wet Zone									
<i>Acacia auriculiformis</i>					589				3
<i>Swietenia macrophylla</i>					1509				3
<i>Tectona grandis</i>					246				3
Montane Zone									
<i>Eucalyptus grandis</i>					6038				1
<i>E. microcorys</i>					8486				1
Dry Zone									
<i>Acacia auriculiformis</i>					1081				2
<i>Azadirachta indica</i>					673				2
<i>Swietenia macrophylla</i>					206				2
<i>Tectona grandis</i>					23 833				2
<i>Terminalia chebula</i>		1							
<i>Diospyros melanoxylon</i>		1							
<i>Litsea glutinosa</i>		1							
<i>Phyllanthus emblica</i>		1							
<i>Pterocarpus marsupium</i>		1							
<i>Salacia reticulata</i>		1							
<i>Terminalia belerica</i>		1							
Intermediate Zone									
<i>Acacia auriculiformis</i>					236				3
<i>Azadirachta indica</i>					115				3
<i>Swietenia macrophylla</i>					3498				3
<i>Tectona grandis</i>					4037				3
<i>Pterocarpus santalinus</i>						1			
<i>Lumnitzera litoria</i>						1			
<i>Carapa moluccensis</i>						1			