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Technical Guidelines for the Establishment of a Coastal Greenbelt

March 2007

Sri Lanka Country Office

Green Coast
For **nature** and **people**
after the tsunami

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கரையோரம் பேணல் திணைக்களம்
COAST CONSERVATION DEPARTMENT

Technical Guidelines for the Establishment of a Coastal Greenbelt

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FOREWORD

The need to establish a coastal green belt following the post-tsunami scenario has led to unregulated and disoriented rehabilitation work that are likely to have serious negative consequences. There is, therefore, an urgent need to set out specially designed guidelines to ensure that well integrated greenbelts will emerge in conformity with basic standards and policies set out for coast conservation. In the light of this, the Coast Conservation Department (CCD) has initiated the development of Guidelines for the establishment of a green belt along the tsunami affected coastal belt.

It is true that hard engineering solutions for impact mitigation and reducing social and economic vulnerability of coastal areas are possible options for disaster mitigation, yet it is known that the heavy investments required for such solutions do not usually receive priority consideration, while their major visual impacts significantly degrade the coastal scenery in many situations. At the same time, such constructions can also disrupt traditional ways of life of many beach dwelling people. On the other hand, the establishment of vegetation as a soft solution for some coastal problems including sea and wind erosion has been scientifically tested with substantial success all over the world in the recent past. In fact, after the Tsunami, it has been found that wherever there were wide, thick belts of mangroves and/or seashore forests had reduced the impact of the tsunami on coastal settlements. Other benefits of coastal vegetation includes the conservation of biodiversity, providing livelihood support for coastal communities through agricultural and forestry crops, affording shade for various human activities, and in contributing to recreation and scenic beauty, and enhancing tourism.

The overall objective of the guidelines is to evolve a systematically designed common approach to rehabilitate a vegetation buffer, which is called the Greenbelt, stable enough to absorb some of the devastating energy of natural disasters, such as tsunamis, and reduce their detrimental effects. The guidelines are meant to facilitate those who intend to undertake projects on regeneration of the green belt. It is prudent to clear the misconception that the motive behind the greenbelt initiative is to acquire private lands by the State. It has to be understood that the Government has no such intention. The philosophy behind the Greenbelt is to achieve the best possible balance between human use and nature conservation needs.

A draft Guidelines was prepared initially by the CCD supported by a technical committee comprising of key stakeholders. This was further improved by the technical assistance provided by IUCN Sri Lanka.

The guidelines are presented in two formats; one is a concise report on best practices, and the other is a detailed report on technical know how. The technical report provides the methodology and in depth view of methods that are essential to know when undertaking greening projects for establishment of the Greenbelt. In general, it provides prospective implementers a sequentially set-out process of rehabilitation of the greenbelt, that includes a clear picture of the current ground situation, the conceptual basis and benefits of greenbelts, a guide to identification of land-use based landscape entities, the procedure to initiate and plan the activities, choice of plant species, factors to be considered in costing, the legal issues to be considered, sources of obtaining information and planting ‘material, and finally a long term strategy for managing and monitoring of progress. On the one hand, the Best Practice Guidelines provides implementers a quick reference to the procedures.

Presented here is the technical guide. After the introduction in Chapter I, Chapter II provides guidelines on project planning and design. It contains information on selecting a site, project appraisal, designing principles, selection of plant species and planting designs, and the legal framework. Chapter III provides guidelines for implementation. It contains information on the sources of planting material, establishment of plant nurseries and methods of planting, protection and maintenance, and the management aspects. Management aspects contain strategies on organizing local communities and assigning responsibilities, coordination with relevant agencies, and providing technical assistance. It further elaborates as to how the sustainability is ensured by means of incentives given to private land owners, providing credit facilities, through competitions and awards schemes, and community mobilization and awareness creation. Chapter IV provides methods suggested for monitoring and evaluation, including time schedules, framework for evaluation, record keeping, and working through participatory appraisals.

Annex I is the Annotated Guiding Principals for Post-tsunami rehabilitation and reconstruction. The maps and tables extracted from the Rapid Environmental Assessment report done by MENR/UNEP (2005) called “Green Assessment” are given in Annex II & III respectively. Annex IV provides the maps of “Natural” Landscapes in the coastal zone of Sri Lanka. Annex V provides design outlays of identified landscapes for greenbelt planting. Annex VI provides the methods of establishment of nurseries and planting. Annex VII: gives limits of the Coastal Set Back by the area.

The limits set out to establish a Greenbelt, however, vary depending on the given site, and are now based, not only on the coastal vulnerability factors, but also on the post-tsunami situation of the beach front. The CCD and the relevant Divisional Secretariats will provide assistance to identify the zones provisionally eligible for the establishment of vegetation covers.

The Green Belt Guidelines can be used wisely by both the project implementers and the Government Authorities, leading to realizing a GREEN COAST for the people of Sri Lanka. The GREEN COAST would, in return, help regaining the minds and lives of tsunami affected people in the long run, regaining their lost world.

Financial assistance for the preparation of the guide was provided by Oxfam through Green Coast project.

Mr. Nissanka Perera
Director
Coast Conservation Department
Sri Lanka

Ms. Shiranee Yasaratne
Country Representative
The World Conservation Union (IUCN)
Sri Lanka

TECHNICAL CONTRIBUTIONS

Dr. R. A. D. B. Samaranayake

Ms. Hester Basnayake

Prof. Hemanthi Ranasinghe

Mr. Jagath Gunawardane

Dr. Ajantha de Alwis

Mr. B. J. H. Premathilake

Mr. L. P. D. Dayananda

Mr. Shamen Vidanage

Mr. Sarath Ekanayake

Mr. Harshana Rajakaruna

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EXECUTIVE SUMMARY

The diverse habitats that comprise the sea and coastal environment have historically provided invaluable tangible benefits to Sri Lanka and its people. The coastline of Sri Lanka is 1620 km, in length, while the coastal region which makes up 24 percent of the country's entire land area of 65,510 sq km, also accounts for 25 percent of the population, 70 percent of the tourist hotels, 67 percent of industrial units, 17 percent of agricultural lands and 20 percent of home gardens. The Coastal Zone of Sri Lanka is clearly defined in the Coast Conservation Act No:57 of 1981, while the set-back limits have now been identified in the Coastal Zone Management Plan based not only on vulnerability factors, but also on the post-tsunami situation of the beach front.

The sandy beaches, estuaries, lagoons, sea grass beds, coral reefs mudflats, mangroves and, sand dunes have for centuries protected and buffered the coastal communities against the hazardous effects of storms, cyclones and hurricanes, and also filtered pollutants from discharges. Although storm surges that accompany cyclones have not been considered frequent phenomena in Sri Lanka, climate change resulting from global warming has in recent times changed this scenario. The harbour waves generated by the Tsunami of December 2004, that struck the Eastern, Southern and South Western coasts, was the worst calamity that Sri Lanka has ever faced in recent times. The magnitude of the destruction awakened the Nation to the reality of seeing the extent of unpreparedness, either to face and mitigate such calamities, or manage an expedient recovery plan. However, it has been recognized that the major causes that affected mitigation, are the nature and extent of coastal erosion and habitat degradation that have taken place over the last several decades.

In early 2005, the Ministry of Environment and Natural Resources carried out a field analysis of tsunami impacts on what may be referred to as the 'Green' environment (ecosystems, biodiversity, protected areas and farmlands) and the 'Brown' environment (pollution, debris and impacts on human settlements and infrastructure). This Report revealed that there was severe beach erosion in patches, both in the east and south-west, with some locations showing extensive erosion and sand migration due largely to the effects of the tsunami back-wash. Much of the beach vegetation also was severely damaged, especially *Ipomoea pescaprae* (Mudu-bim-thamburu), although Pandanus (Mudukeylya) and *Spinifex IIttoreus* (Maha-ravana ravula) are reported to have survived, especially when in clumps. It had also been apparent that where large stands of mangroves existed, buffering tsunami waves were effective, while other coastal forests were for the most part, too open to play such a role.

Although hard engineering solutions for impact mitigation and reducing social and economic vulnerability of coastal areas are possible options for disaster mitigation, yet it is known that the heavy investments required for such solutions do not usually receive priority consideration. On the other hand the establishment of vegetation (Greenbelt) as a soft solution for some coastal problems including sea and wind erosion, has been tested with substantial success.

A Greenbelt is defined as a strip of natural or artificially created coastal vegetation designed to prevent coastal erosion, and mitigate the adverse impacts of natural coastal hazards on human lives and property. It is a country specific and site specific entity defined in relation to risk factors and vulnerability to coastal hazards. In terms of coastal degradation the situation has evidently reached alarming proportions, and hence needed urgent measures to recreate natural systems and restore historical ecosystems that could revitalize the health of the country's coastal zone.

The overall objective in the preparation of these Guidelines is to evolve a systematically designed common approach to restore, rehabilitate and/or recreate a vegetational barrier/buffer (Greenbelt) that may be resilient and stable enough to prevent or mitigate the devastating effects of natural disasters such as cyclones, storm surges and tsunamis.

These guidelines, which are limited to restoration, rehabilitation and/or creation afresh of a greenbelt in degraded stretches of the coastal zone of Sri Lanka, are meant to assist and demonstrate best practices for those who intend to undertake landscape regeneration projects in, and even just behind the coastal reservation. The Guide provides prospective implementers a sequentially set-out process of greenbelt reconstruction/ restoration, that includes a clear picture of the current ground situation, the conceptual basis and benefits of greenbelts, a guide to identification of land-use based landscape entities, the procedure to initiate and plan the activities, choice of plant species, cost estimates, the legal issues to be considered, sources of obtaining information and planting material, and finally the strategy for managing and monitoring of progress.

The Guidelines have been formulated in terms of three characteristic landscape types identified on the basis of a visible division of landscapes from a land use perspective. These are described as natural, rural and urban landscapes. These types are found in varying extents, in the climatic regions of the wet, dry, and the arid zones. Although transitional landforms could be found, for the purpose of these guidelines, the transitional landforms as well as the arid climatic zone would not be *considered as separate entities.*

Areas considered as natural landscapes encompass all areas which are relatively unaffected by human activity, especially those which are already designated as protected areas (national parks and other categories of reserves), e.g. the coastal edges of Yala, Wilpattu and Bundala National Parks, and also areas which, though not yet designated, are potentially suitable for designation as nature conservation/preservation areas. The immediate hinterland of the coastline could be deemed rural in areas where, despite a similar variation in landform to that in natural areas, the natural vegetation has been largely replaced by non-indigenous agricultural species such as *Cocos nucifera* (coconut palms) and *Borassus flabellifer* (palmyrah palms). Urban landscapes are those coastal strips within or bordering urban settlements, usually including seaside parks, playgrounds, esplanades and marine drives, sometimes with seaside retaining walls and often bordered by artificial coastal protection structures such as rock revetments.

As a first step, prospective project proponents are advised to study the area and identify whether the chosen landscape should be considered as urban, rural, or natural. Wherever natural maritime vegetation communities exist, even as small remnants, the basic principle should be to conserve them and integrate them into the design. The advice of coastal engineers should also be sought at the very outset to find out whether it is necessary to construct a bund for protection against tsunamis, and if so, what should be its width, height, profile and structure. The decisions will depend on the particular characteristics and importance of each location and will therefore be site-specific. Once such preliminary activities are completed, an appraisal and design should be done with the aid of relevant experts, always getting at least basic advice from a Coastal Planner. The basic principles and concepts that should be applied when designing should be in the first instance be in accordance with the conditions laid down by the Coast Conservation Department.

In natural landscapes, apart from preserving and restoring natural ecosystems, exotic and introduced plant species should be excluded. There should be as few as possible of structures such as shelters, camping sites and vehicle parks. Footpaths if any should preferably be raised board walks. Bicycle and pedestrian circulation should be minimal. Materials, finishes, shapes, facades, etc. should be in harmony with the natural habitat. In rural landscapes, it is advised that at least a 15 – 20m wide strip of natural littoral woodland and strand plants be planted seaward of agricultural crops. Vegetation belts could take either a naturalistic form or a geometric form. In urban landscapes any plant species could be planted as long as they are adapted to the coastal environment. There could also be open grass, sandy, paved parks, or playgrounds of various sizes, provided there is a substantial belt of trees on the seaward side. There should be a sufficiently wide beach stabilizing vegetation strips between seaside retaining walls and the open beach.

After site selection the next important step therefore has to be a consultation with knowledgeable persons in fields of agronomy, ecology and landscape architecture, as well as a cross section of the local community and representatives of relevant Community Based Organizations. The Guidelines highlight the significance of community participation in planning and successful implementation of greenbelt restoration activities.

The Guidelines recommend that the choice of plant species in greenbelt rehabilitation be primarily based on the growth potential and adaptability of plants to a given situation. The essential considerations in establishing Greenbelts include choice of species, selection of site, collection and germination of seeds, planting in the field, spacing, protection, and maintenance. These issues are discussed, and detailed operational procedures are appended in annexes. A concise review of the legal issues involved and the institutional arrangements available are also presented in order to enlighten prospective project proponents of the existing statutory requirements.

In order to provide a basic guidance on the likely levels of investment required, a basis for estimating costs is also provided. Finally the Guidelines provide information on possible sources of planting material, and also an operational framework for monitoring and evaluation of the progress of work.

1. INTRODUCTION

1.1 Backdrop

The coastal environment is unique because it constitutes the interface where the marine and terrestrial environments merge, making resource management a challenge. The diverse habitats that comprise the sea and coastal environment have historically provided invaluable tangible benefits to the nation and its people. Sri Lanka with its unique geographical location, and its vast territorial sea amounting to 7.8 times the total area of the country, can enjoy and benefit substantially more from its coastal resources than from its limited share of terrestrial natural resources. However, the continuously changing bio-geo-physical conditions and processes, and the underlying interface of two different mega-ecosystems themselves, place the coastal areas at high risk of natural disasters.

The coastline of Sri Lanka is 1620 km, in length inclusive of bays and inlets, but excluding lagoons, while the coastal region comprises 74 Divisional Secretaries' Divisions with a coastal boundary. The coastal region which makes up 24 percent of the country's entire land area of 65,510 sq km, also accounts for 25 percent of the population, 70 percent of the tourist hotels, 67 percent of industrial units, 17 percent of agricultural lands and 20 percent of home gardens. It is also home for a large number of high priority archaeological, historical, religious, cultural, scenic and recreational sites. Apart from the highly economically valuable sites for coastal and marine fishery, the coastal region also supports habitats that are vital for ecological functions and maintaining biodiversity.

Sandy beaches, estuaries, lagoons, sea grass beds, coral reefs mudflats, mangroves and, sand dunes are some of the diverse habitats that make up the coastal environment. These habitats have for centuries protected and buffered the coastal communities against the hazardous effects of storms, cyclones and hurricanes, and also filtered pollutants from discharges, while at the same time providing opportunities for recreation, and significantly contributing to the aesthetic value of the area. These habitats also provide spawning grounds, nurseries, shelter and food for marine life that includes a significant number of rare and endangered species.

However, owing to the population pressure with more people finding livelihoods and employment in coastal areas, and a booming tourist industry that has exceeded the carrying capacity in several locations with critical ecosystems, the coastal habitats have faced increasing degradation, resulting in a substantial lowering of its protective and buffering capacity.

Although storm surges that accompany cyclones have not been considered frequent phenomena in Sri Lanka (with a projected occurrence of one every 5 years), climate change resulting from global warming has in recent times changed this scenario. Tropical storms, floods and erosion are the more frequent natural hazards, and were also the top 10 disasters that had caused one fourth of the total economic damage during the last 50 years.

The tidal waves that accompanied the cyclone of 1978 devastated most of the hotels bordering the shoreline on the East Coast. The harbour waves generated by the Tsunami of December 2004, that struck the Eastern, Southern and South Western coasts indeed constituted the worst calamity that Sri Lanka has ever faced in recent times.

Recognizing the magnitude of the reconstruction efforts necessary following the Tsunami of December 2004, the United Nations Environment Programme's (UNEP) Tsunami Disaster Task Force, convened a meeting in Cairo in February 2005 to discuss coastal zone rehabilitation and management in the Tsunami affected region. The main outcome of this meeting was the formulation of a set of Guiding Principles for Post-Tsunami Rehabilitation and Reconstruction, which have set forth an integrated pathway towards reconstruction (See Annex I).

Restoration of Coastal Wetlands after the Tsunami is the focus of an Information Paper prepared jointly by the International Water Management Institute (IWMI) and the World Conservation Union (IUCN). A set of guiding principles adopted from the Ramsar Conventions's Principles and Guidelines for Wetland Restoration, highlights critical issues, impacts and the systematic basis for restoration of significant wetlands.

1.2 The Context

The magnitude and devastation of the scale of the tsunami that struck Sri Lanka and several other Indian Ocean countries in December 2004 jettisoned

authorities, civil society, and all other organized groups to the reality of seeing the extent of unpreparedness, either to face and mitigate such calamities, or manage an expedient recovery plan.

However, the major causes that affected mitigation, are the nature and extent of coastal erosion and -habitat degradation that have taken place over the last several decades. Such adverse situations together with sheer disregard for the scientifically determined set- back standards, by those concerned with development programmes, have compromised the ability of the coastal zone to adopt to environmental change.

The government realizing the need for prompt and organized action, immediately established an Interim Committee for Disaster Management. This was followed by the institution of a Disaster Management Center, and the appointment of a Parliamentary Select Committee on Disaster Management. Subsequently a separate Ministry for Disaster Management was established. Presently several Ministries and agencies associated with these ministries are involved in awareness raising on how to respond to such unforeseen natural disasters. These include the Ministry for Disaster Management, the Ministry involved in Disaster Rehabilitation, Ministry of Science and Technology, Ministry of Health, Ministry of Education, Ministry of Environment, Ministry of Fisheries and Aquatic Resources, Ministry of Urban Development/Water Management and the Defense Ministry. In addition, a number of NGOs, as well as intergovernmental agencies such UNDP, IUCN, UNEP, FAO, IWMI, and several others have not only been involved in awareness raising on natural disaster amongst various audiences, but also in mobilizing resources for quick restoration and rehabilitation work.

In early 2005, the Ministry of Environment and Natural Resources carried out a field analysis of tsunami impacts on the 'Green' environment (ecosystems, biodiversity, protected areas and farmlands) and the 'Brown' environment (pollution, debris and impacts on human settlements and infrastructure). This Report highlighted the key issues in the country in the aftermath of the disaster, including pollution of the coastal strip by solid waste and debris, and its contamination by sea water, which are relevant to the task of restoration or establishment of a vegetational buffer.

It was also revealed that there was severe beach erosion in patches, both in the east and south-west, with some locations showing extensive erosion and sand migration due largely to the effects of the tsunami back-wash. Much of the beach vegetation also was severely damaged, especially *Ipomoea pescaprae* (Mudu-bim-thamburu) although Pandanus (Mudukeylya) and *Spinifex Ilttoreus* (Maha-ravana ravula) are reported to have survived, especially when in clumps. It had also been apparent that where large stands of mangroves existed, buffering tsunami waves were effective, while other coastal forests were for the most part, too open to play such a role. The practice of planting monoculture coastal shelterbelts of *Casuarina,* especially in cyclone prone areas however, did not appear to be effective wave barriers, and the current evidence indicate that a good wind shelterbelt mix should include shorter trees and shrubs, which when planted on sand dunes helped indirectly by stabilizing the dunes. Coconut palms can withstand the physical impact and salinity effects and reduce beach erosion, but they do not contribute to protecting areas behind them. Palmyrah palms are less tolerant of salinity. Even trees such as Kohomba, Suriya and Kottamba appear to have been subjected to some breakage and uprooting, besides defoliation owing to increased soil salinity.

Monitoring irrigation water sources for contamination by substances such as arsenic, in order to ensure that agricultural crops (especially those for consumption by humans or animals), planted in the proposed green belts will not be harmful in any way, is also of prime importance.

It is clear that in terms of coastal degradation the situation had reached alarming proportions, and hence needed urgent measures to recreate natural systems and restore historical ecosystems that will revitalize the health of the country's coastal zone.

Restoration and reconstruction however, are major challenges, since many of the affected shorelines are densely populated, often with communities considered to be amongst the poorest. Hence any reconstruction effort must ensure efficiency, sustainability and equality, and be guided by principles that are scientific, participatory, and in harmony with natural systems.

1.3 What is a Green Belt?

It is true that hard engineering solutions for impact mitigation and reducing social and economic vulnerability of coastal areas are possible options for disaster mitigation, yet it is known that the heavy investments required for such solutions do not usually receive priority consideration, while their major visual

impacts significantly degrade the coastal scenery in many situations. On the other hand the establishment of vegetation as a soft solution for some coastal problems including sea and wind erosion, has been tested with substantial success all over the world in the recent past. In fact after the Tsunami, it has been found that wherever there were wide, thick belts of mangroves and/or seashore forest, it had reduced the impact of tsunami on coastal settlements and property. Other benefits of coastal vegetation includes the conservation of biodiversity, providing livelihood support for coastal communities through agricultural and forestry crops, affording shade for various human activities, and in contributing to recreation and scenic beauty.

A Greenbelt could be defined as a strip of natural or artificially created coastal vegetation designed to prevent coastal erosion, and mitigate the adverse impacts of natural coastal hazards on human lives and property. The greenbelt area however is a country specific and site specific stretch of vegetation in the coastal zone, defined in relation to risk factors and vulnerability to coastal hazards. The Coastal Zone of Sri Lanka is clearly defined in the Coast Conservation Act No:57 of 1981, although, issues addressed in the Coastal Zone Management Plan of 2004 are not restricted to the coastal zone, but extends to the District Secretaries Divisions with a coastal boundary. However, the distortions in the shoreline consequent to the tsunami, and the resulting conflicts in relation to tenurial and access rights of coastal dwellers, as well as deprivation of their livelihoods, induced the government to revise the boundary limit of set backs to be in accordance with those determined in the Coastal Zone Management Plan of 1997 (See Annex VIII).

The limits set out however, vary with the particular site, and are now based not only of coastal vulnerability factors but also on the post-tsunami situation of the beach front (See Annexes II and III). The Coast Conservation Department or the relevant Divisional Secretariat can provide assistance to identify the zones provisionally eligible for the establishment of vegetation covers.

1.4 Objectives

The overall objective in the preparation of these Guidelines is to evolve a systematically designed common approach to restore, rehabilitate and/or recreate a vegetational barrier/buffer (Greenbelt) that may be resilient and stable enough to prevent or mitigate the devastating effects of natural disasters such as cyclones, storm surges and tsunamis. A greenbelt will ideally represent a multipurpose investment, in terms of stabilizing a fragile and unconsolidated beach front in the coastal belt, while at the same time functioning as a wind barrier where necessary, providing shade and protection, enhancing the landscape for recreation, tourism, and providing opportunities for economic returns to traditional coastal communities.

Nevertheless the enthusiasm and wide acceptance of the need to rehabilitate or establish afresh, a coastal belt of vegetational cover following the post-tsunami scenario, has in recent times led to unregulated and disoriented rehabilitation work that are likely to have serious negative consequences. There is therefore an urgent need to set out specially designed guidelines to ensure that well integrated greenbelts will emerge in conformity with basic standards and policies on coast conservation.

Specific objectives

The specific objectives of these guidelines are as follows:

- Devise planning guidelines for setting up environmentally sound vegetational barriers that are most likely to give protection from or mitigate the hazardous impacts of natural disasters.
- Determine the basis, composition and layout of greenbelt, where such greening is considered necessary from a conservation, coastal protection, aesthetic, livelihoods, recreational and architectural stand point.
- Provide guidance on restoration of natural habitats with both existing as well as ecologically and bio-physically acceptable plant species.
- Provide guidance on creating bio-physical and livelihood supportive conditions that are better than those that existed before the disaster struck the nation.
- Identify institutional arrangements, for implementation, monitoring and evaluation of greenbelt creation activities approved for implementation at the ground level

1.5 About the Guidelines

These guidelines are meant to facilitate those who intend to undertake landscape regeneration projects in and even just behind the coastal reservation. The guidelines are however, limited to restoration, rehabilitation and/or creation afresh of a greenbelt in eroded and degraded stretches of the coastal zone of Sri Lanka, although the greening process may sometimes need extensive preliminary pre-planting preparatory work such as clearing debris, solid waste disposal de-salinization and water purification. At this point it is necessary to clear the misconception that the motive behind the greenbelt initiative was to acquire private lands by the State. It has to be clearly understood that the Government has no such intention. The aim of the Greenbelt strategy is to achieve the best possible balance between human use and nature conservation needs, while ensuring the following: -

- Creation of conditions that are better than those that existed before Tsunami, in terms of ameliorating/ reducing hazards to life and property, and make communities particularly the poor and marginalized, less vulnerable to such hazards.
- Setting out landscapes that are aesthetically pleasing and varied in character from place to place, of increasing scenic value, while providing shade where necessary, and enhancing coastal tourism, recreation and other activities.
- There is better protection of the shoreline against erosion; (vegetation cover stabilizes the soil increasing resistance to wave action and it disburses wave energy, decreasing possible damage).
- Establishment of dense vegetation cover where necessary, to disburse wave and wind energy to the extent of reducing potential damage to human lives and properties from natural hazards such as Tsunamis and Cyclones.
- Improving the socio-economic conditions of local coastal communities through green belt vegetation contributing to their livelihoods directly (e.g. through sale of agricultural produce) or indirectly (e.g. by providing shade, coolness, shelter, visual enhancement, etc. for other revenue generating activities).

The Guide provides prospective implementers a sequentially set-out process of greenbelt reconstruction/ restoration, that includes a clear picture of the current ground situation, the conceptual basis and benefits of greenbelts, a guide to identification of land-use based landscape entities, the procedure to initiate and plan the activities, choice of plant species, factors to be considered in costing, the legal issues to be considered, sources of obtaining information and planting material, and finally the strategy for managing and monitoring of progress.

2. GUIDELINES ON PLANNING AND DESIGN

2.1 Landscapes of the Coastal Belt

For the purposes of creating or restoring coastal vegetation belts, it is useful to select plant species on the visible division of the landscape from a land use perspective, into three major landscape types – natural, rural and urban. It must nevertheless be noted that there are areas of transition and overlap among them, e.g. urban fringe, suburban, rural-natural. These types are found in varying extents, in the three climatic regions of the wet zone, the dry zone and the arid zone. However, for the purpose of these guidelines, the transitional landforms and the arid climatic zone would not be considered as separate entities.

Areas considered as NATURAL encompass all areas which are relatively unaffected by human activity, especially those which are already designated as protected areas (national parks and other categories of reserves), e.g. the coastal edges of Yala, Wilpattu and Bundala National Parks, and also areas which, though not yet designated, are potentially Decisions may have to be taken as to what should be done with any remaining debris. Should it be taken away or used for creating new landform/features or buried deep at the site itself? Should there be a combination of such remedies? In some cases it might indeed be useful as a landscape construction material, for example, in parapet walls and retaining walls or even protective bunds in an aesthetic manner, keeping in mind that it cannot be used to make artificial sand dunes as the latter must be made up completely of sand.

The advice of coastal engineers should be sought at the very outset to find out whether it is necessary to construct a bund for protection against tsunamis, and if so, what should be its width, height, profile and structure. In any case it would be best to align it along the landward side within the coastal reservation in the case of sufficiently wide reservations, or further inland so as not to disfigure

the scenery. Landscape architects should work closely with coastal engineers to adapt its basic shape, so that it looks as if it is an intrinsic part of the scenery. In strict natural landscapes, such structures should not be introduced at all.

The decisions will depend on the particular characteristics and importance of each location and will therefore be site-specific while requiring expert advice.

2.2 Site Selection and Appraisal

When ever possible the appraisal and design should be done with the aid of relevant experts, always getting at least basic advice from a Coastal Planner even for urban locations, andscape architects should obtain advice from other specialists. For rural locations, landscape architects and sometimes other specialists also are needed besides agriculturists. For natural locations, landscape architects, ecologists and often other specialists such as geologists are needed. Whatever the location, detailed survey sketches and evaluation information of the existing vegetation are essential. In general, apart from ecological and aesthetic factors, social and socio-economic issues must also be addressed.

Based on the appraisal and its recommendations, a "*landscape proposal*" should be drawn up for each site, commencing with conceptualization. After consensus is reached on the concept, the overall "outline landscape design" and the "detailed landscape design" including construction and planting details should be prepared. There should be layout plans giving measurements and planting plans showing how the planting should be set out. There should be section drawings and sometimes elevation drawings and preferably also three-dimensional sketches to clearly illustrate how the work should be done and what its outcome would be. It is vitally important to design appropriate temporary protective fencing for areas to be planted and to have realistic work programs. Cost estimates should be prepared for all items of work including maintenance.

2.3 Design Principles and Concepts

The following basic principles and concepts should be applied when designing, adhering also to conditions laid down by the Coast Conservation Department.

In Natural locations

- Existing natural ecosystems should be preserved. In other locations, the natural terrain should be restored as far as possible and the natural vegetation should be restored or enhanced, keeping visual effect also in mind. In certain places, the growth/regeneration of natural vegetation may be merely facilitated, e.g. by temporary protective fencing of a sympathetic design. In others, some careful planting of natural species could facilitate quicker restoration, and in yet others, planting for simulation of the natural plant community may be permissible. The natural littoral woodland species will be the most used species, because sandy shores border most of the island. Wherever mangroves have been damaged or depleted, they should be rehabilitated and enhanced and wherever they have been destroyed, they should be restored.
- Obviously, the shape and form of vegetation belts or patches should be irregular and naturalistic – not geometric or regular.
- Introduced/exotic species should be excluded. There should be very careful identification/selection of different character/use areas, and the necessary links or barriers between them.
- Structures should be as few as possible: there will probably be a need for small information centers, picnic/rest shelters, toilets and other minor service buildings, e.g. at camp sites.
- Footpaths through mangrove forests and over sand dunes should preferably be raised board walks, to ensure minimum disturbance to the mangroves or the dune stabilizing vegetation.
- Vehicle access should be very limited or even prohibited and parking areas should be at the edges of such sites and as inconspicuous as possible.
- Bicycle and pedestrian circulation should be minimized.
- Materials, finishes, shapes, facades, styles and locations of structures should be chosen very carefully to ensure that they are in harmony with the natural habitat.
- A preservation /conservation management plan should also be prepared.
- Unless debris can be recycled or re-used in keeping with the principles above, it should be taken out of the site completely.

In Rural locations

- At least a 15 to 20m wide strip of natural littoral woodland and strand plants should be planted seaward of agricultural crops. Imitation of the typical mix and distribution of species in the natural community of each site would be best, although some exotic/introduced species may be used. As already pointed out, any patches of natural vegetation should not be removed but integrated. Vegetation belts and patches could take either a naturalistic form or a geometric form, but closer to the sea, should preferably be irregular and naturalistic.
- Agricultural crops, not confined to native and endemic species, should be selected to suit the specific location.
- Structures, vehicle access, footpaths and cycle paths should be minimal and harmoniously integrated.
- In general, materials and finishes should reflect the rusticity of the location.
- A management plan should be prepared.
- Debris may be buried, recycled or used for ground shaping: the terrain should be made suitable for the natural vegetation belt and agricultural crops chosen.

In Urban locations:

- Paches of natural vegetation should be integrated as far as possible with whatever is the most suitable concept for a particular area.

  There could be open grass/sandy/paved parks or playgrounds or sports grounds of various sizes, provided there is a substantial belt of trees on the seaward side, and in cyclone prone areas, wind shelter belts on all sides.
- Any plant species could be planted as long as they are adapted to the coastal location. Where roads happen to run through the site or where they are planned within it, care should be taken to avoid roadside planting of soft wood trees or trees with brittle branches,
- There could be many alternative styles, materials, finishes and colours for structures and surfaces and they should be strong enough to tolerate intensive use.
- Vegetation could be either irregular and naturalistic or regular and geometric in form, but formal geometrical layouts and regular planting will often be desirable.
- There should be sufficiently wide beach stabilizing vegetation strips between seaside retaining walls and the open beach.
- Vehicle access and parking should be minimized.
- Sea walls, piers, quays, street furniture, kiosks, picnic/ rest shelters, infrastructure facilities and other minimal permitted structures should be located and detailed with care, to ensure an attractive townscape.
- A management plan should be prepared.
- Debris could be recycled or re-used as landscape material if suitable.

2.4 Selection of Plant Species and Planting Designs

The choice of plant species in greenbelt rehabilitation has to be primarily based on the growth potential and adaptability of plants to a given situation. Hence the initial consideration has to be a careful assessment of the geo-physical and agro-ecological conditions, the land use values and community needs, and more importantly the existing ground situation of the selected rehabilitation site in relation to the level of disturbance and the existing residual vegetation. It is thus clear that a number of technical as well as non-technical considerations are pre-requisites for the choice of plant species and planting designs.

After site selection the next step therefore has to be a consultation with knowledgeable persons in fields of agronomy, ecology and landscape architecture, as well as a cross section of the local community and representatives of relevant Community Based Organizations. In brief, to ensure establishment of a successful greenbelt, the prospective project proponent must have a perfect understanding of the ground situation before embarking on developing the landscape proposal.

A fairly broad selection of plants for the Wet Zone and the Dry/Arid Zones are summarized in the table below.

Table I. List of Plant Species

Woody plants for site rehabilitation in Tsunami affected areas.

				Climatic preference		Site preference		Remarks
				Dry/Arid zone	Wet zone	Behind beach	More interior	
No.	Botanical name	Family	Local name					on site suitability
1	*Acacia auriculiformis*	Fabaceae		x	x		x	
2	*Adina cordifolia*	Rubiaceae	Kolon	x			x	
3	*Aegle marmelos*	Rutaceae	Beli	x			x	Homegardens
4	*Albizia lebbeck*	Fabaceae	Kabalmara	x			x	
5	*Alstonia scholaris*	Apocynaceae	Rukattana	x	x		x	
6	*Anacardium ocidentale*	Anacardiaceae	Kaju	x			x	Homegardens
7	*Artocarpus heterophyllus*	Moraceae	Kos		x		x	Homegardens
8	*Azadirachta indica*	Meliaceae	Kohomba	x		x	x	
9	*Azima tetracanthe*	Salvadoraceae		x		x	x	
10	*Bambusa vulgaris*	Bambusaceae	Una		x		x	Homegardens
11	*Berringtonia asiatica*	Lecythidaceae	Mudilla		x	x		
12	*Berrya cordifolia*	Tiliaceae	Halmilla	x			x	
13	*Borassus flabblifer*	Palmae	Thal	x		x	x	
14	*Bridelia retusa*	Euphorbiaceae	Ketakela	x			x	
15	*Calophyllum inophyllum*	Clusiaceae	Domba		x	x	x	
16	*Cassia auriculata*	Fabaceae	Ranawara	x		x	x	
17	*Cassia fistula*	Fabaceae	Ehala	x		x	x	
18	*Cassia roxburghii*	Fabaceae	Ratu-wa	x		x	x	
19	*Casuarina equisiafolia*	Casuarinaceae	Kasa	x	x	x		
20	*Ceiba pentandra*	Bombacaceae	Pulungas		x		x	Homegardens

Woody plants for site rehabilitation in Tsunami affected areas.

				Climatic preference		Site preference		Remarks
				Dry/Arid zone	Wet zone	Behind beach	More interior	
No.	**Botanical name**	**Family**	**Local name**					**on site suitability**
21	*Chloroxylon swietenia*	Rutaceae	Burutha	x			x	
22	*Clerodendrum inerme*	Verbenaceae	Burenda		x	x		
23	*Cocos nucifera*	Palmae	Pol	x	x	x	x	
24	*Cordia dichotoma*	Boraginaceae	Lolu	x			x	
25	*Dilonix regia*	Fabaceae	Mal mara	x	x		x	Avenue plant
26	*Diospyros malabarica*	Ebenaceae	Thimbiri	x			x	Riverine
27	*Erythrina spp.*	Fabaceae	Erabadu	x	x	x	x	
28	*Eugenia jambolana*	Myrtaceae	Jambu		x		x	Homegardens
29	*Filicium decipiens*	Sapindaceae	Pihimbiya		x		x	
30	*Gliricidia sepium*	Fabaceae	Wetahira	x	x		x	Homegardens
31	*Hibiscus tiliaceus*	Malvaceae	Belipatta		x	x		
32	*Holoptelea integrifolia*	Ulmaceae	Godakirilla	x			x	
33	*Hydnocarpus venenata*	Flacourtiaceae	Makulu	x	x		x	Riverine
34	*Limonia acidissima*	Rutaceae	Divul	x		x	x	
35	*Madhuca longifolia*	Sapotaceae	Mee	x	x		x	Riverine
36	*Mangifera indica*	Anacardiaceae	Amba	x	x		x	Homegardens
37	*Manilkara hexandra*	Sapotaceae	Palu	x		x		
38	*Melia dubia*	Meliaceae	Lunumidella		x			Homegardens
39	*Mesua ferrea*	Clusiaceae	Na		x		x	Avenue plant
40	*Moringa oleifera*	Moringaceae	Murrunga	x	x		x	Homegardens

Woody plants for site rehabilitation in Tsunami affected areas.

				Climatic preference		Site preference		Remarks
				Dry/Arid zone	Wet zone	Behind beach	More interior	
No.	**Botanical name**	**Family**	**Local name**					**on site suitability**
41	*Nauclea orientalis*	Rubiaceae	Bakmee	x			x	Riverine
42	*Pandanus odoratissimus*	Pandanaceae	Wetake		x		x	
43	*Pisonia grandis*	Nyctaginaceae	Wathabanga	x	x	x	x	
44	*Plumeria rubra*	Apocynaceae	Araliya		x	x	x	Homegardens
45	*Pongamia pinnata*	Fabaceae	Karanda	x	x	x	x	
46	*Psidium guajava*	Myrtaceae	Peera		x		x	Homegardens
47	*Punica granatum*	Punicaceae	Delum	x			x	Homegardens
48	*Salvadora persica*	Salvadoraceae	Malittan	x		x	x	
49	*Samanea saman*	Fabaceae	Mara	x	x		x	Avenue plant
50	*Schleichera oleosa*	Sapindaceae	Koon	x			x	
51	*Sesbania grandifloera*	Fabaceae	Kathurumurunga	x	x		x	Homegardens
52	*Strychnos nux-vomica*	Loganiaceae	Ingini	x			x	
53	*Sweitwnia mahogoni*	Meliaceae	Mahogani		x		x	Homegardens
54	*Syzygium cumini*	Myrtaceae	Madan	x		x	x	
55	*Tamarindus indica*	Fabaceae	Siyambala	x	x		x	
56	*Tectona grandis*	Verbenaceae	Teak	x	x		x	
57	*Terminalia arjuna*	Combretaceae	Kumbuk	x	x		x	Riverine
58	*Terminalia catappa*	Combretaceae	Kottamba	x	x	x	x	
59	*Thespesia populnea*	Malvaceae	Gansooriya	x	x	x	x	
60	*Vitex altissima*	Verbenaceae	Milla	x			x	

Method of Planting

Essential considerations in establishing Greenbelts

- Selection of site
- Choice of species
- Collection and germination of seeds
- Planting in the field
- Spacing
- Protection
- Maintenance

The species selected should ideally grow and establish well in the locations selected for planting. These could be selected either from the area itself or brought from outside. It also should serve the objective of establishing such plants, and be easy to establish with less cost. Another important point to be considered is that the selected species should not have a negative influence on the site. In the tsunami affected areas, it would be ideal to select ground, shrub and tree species which were originally occurring in the natural state in the area.

Further the following aspects should also be considered in selecting plant species:

- Use of multipurpose trees and shrubs
- High adaptability to saline conditions
- Resilience and resistance to wind and wave damage
- Suited to the livelihood, recreational, economic and other needs of the coastal community.

In storm prone areas shelterbelts should be erected preferably on all sides of the landscape features of the coast. The trees used for this purpose are tall and possess a medium crown. They should be fast growing and resilient. The following characteristics should be present in such shelterbelts;

- Adequate porosity from top to bottom.
- Height for shelter purposes should be appropriate.
- Width of the belt to serve its shelter purpose must be adequate.
- Ensure a combination of slow-growing and fast-growing (temporary/nurse planting) species.
- Ensure an appropriate combination of tree and shrub species, and the use of coppicing for some trees.
- Ensure orientation of the shelterbelt at right angles to the predominant wind direction.

The following are the major design outlays for planting the identified landscapes:

Natural locations:

- The natural terrain should be restored as far as possible and the natural vegetation should be restored or enhanced. In certain places growth/ regeneration may occur unaided, e.g. by temporary fencing to a sympathetic design.
- Footpaths through mangrove forests and over sand dunes should preferably be raised board walks to ensure minimum disturbance to the mangroves or the dune stabilizing vegetation.
- Materials, finishes, shapes, facades, styles and locations of structures should be chosen very carefully to ensure that they are in harmony with the natural habitat.
- A preservation /conservation management plan should also be prepared.
- Unless debris can be recycled or re-used in keeping with the principles above, it should be taken out of the site completely.

Diagrams with explanatory notes are given in Annex VI: Design Outlays for Planting Identified Landscapes

Rural locations:

- At least a 15 to 20m wide strip of natural littoral woodland and strand plants should be planted seaward of agricultural crops.
- As already pointed out, any patches of natural vegetation should not be removed but integrated.
- Agricultural crops, not confined to native and endemic species, should be selected to suit the specific location.
- Structures, vehicle access, footpaths and cycle paths should be minimal and harmoniously integrated.
- Debris may be buried, recycled or used for ground shaping: the terrain should be made suitable for the natural vegetation belt and agricultural crops chosen.

Diagrams with explanatory notes are given in Annex VI: Design Outlays for Planting Identified Landscapes

Urban locations:

- Patches of natural vegetation should be integrated as far as possible with whatever is the most suitable concept for a particular area.
- There could be open grassed/sandy/paved parks or playgrounds or sports grounds of various sizes,

provided there is a substantial belt of trees on the seaward side, and in cyclone prone areas, wind shelter belts on all sides.

- Plant species could be endemic/native/introduced, as long as they are adapted to the coastal location.
- There could be many alternative styles, materials, finishes and colours for structures and surfaces and they should be strong enough to tolerate intensive use.
- Formal geometrical layouts and regular planting will often be suitable
- There should be sufficiently wide beach stabilizing vegetation strips between seaside retaining walls and the open beach.
- Vehicle access and parking should be minimal and done so as not to stand out with the general aesthetics of the area.
- Sea walls, piers, quays, street furniture, kiosks, picnic/ rest shelters, infrastructure facilities and other minimal permitted structures should be located and detailed with care, to ensure an attractive townscape.
- A management plan should be prepared.
- Debris could be recycled or re-used as landscape material if suitable.

Diagrams with explanatory notes are given in Annex VI: Design Outlays for Planting Identified Landscapes In cyclone prone areas, whether rural or urban

- Along the north and east coasts in particular, wind shelter belts should be planted around crops and settlements.
- The trees and shrubs used could be introduced species as well as indigenous/native (found naturally in Sri Lanka) and endemic (found naturally only in Sri Lanka) species.
- Medium canopy, long-rooted trees and thick-foliaged shrubs should be combined to provide reasonably dense windbreaks while still allowing the wind to filter through.

Diagrams with explanatory notes are given in Annex VI: Design Outlays for Planting Identified Landscapes

2.5 Estimating Costs

Tree planting material varies in cost depending on the size of the plant (according to prevalent standards for nursery stock) and the species (according to method of growing plants of the particular species, time taken to grow them, distance to be transported and the rarity of the species). It is accepted practice to use rates for supply and planting of healthy, well-formed, container-grown trees which meet specifications for standard nursery stock, including excavation of planting pits, soil improvement, stakes and ties (or other adequate supports if necessary) and maintenance operations for one year, when working out cost estimates.

2.6 Legal Framework and Institutional Arrangements

The legal framework and institutional arrangements that are committed, and have a role in reconstruction efforts of the coastal zone are briefly described below.

The term coast is loosely applied to describe the area of land adjoining the sea and not covered by seawater and is usually denoted by some physically identifiable features. There are no laws that define the extent of land that falls into the areas known as the coast. The term “coastal Zone’ is part of the coast that falls within the jurisdiction of the Coast Conservation Department and has been defined under Section 42 of the Coast Conservation Act No.57 of 1981 as amended by Act No.64 of 1988. According to this definition, the Coastal Zone is the area lying within a limit of three hundred meters landwards of the Mean High Water Line and a limit of two kilometers seawards of the Mean Low Water Line, and in the case of rivers, streams, lagoons or any other body of water connected to the sea either permanently or periodically, the landward boundary extending to a limit of two kilometers measured perpendicular to the straight base line drawn between the natural entrance points thereof, and shall include the waters of such rivers, streams, lagoons or any other water body so connected to the sea.

Several other terms related to the coast are defined under Section 42 of the Coast Conservation Act. One is the Foreshore, which is the area of the shore of the sea between the Mean High Water and the Mean Low Water. The term Coastline means the line of intersection of the plane of water at Mean Sea Level with the coast. An important definition is the Beach which means a gently sloping area of unconsolidated material, typically sand, that extends landwards from the mean high water mark to the area where there is a marked change in material or natural physiographic form. In cases where there is no marked change in the material or natural physiographic form, the beach will be deemed to extend to a distance of 20 meters landward from the mean high water level or to a level of 2.5 meters above mean high water level, whichever is less.

One of the main functions of the Coast Conservation Act is to regulate and control development activities in the coastal zone. The term development is defined under Section 42 to mean any activity that is likely to alter the physical nature of the coastal zone in any way and includes the construction of buildings and works, the deposit of waste or other material from outfalls, vessels and by other means, the removal of sand, seashells, natural vegetation, sea grass and other substances, dredging and filling, land reclamation and mining. The only activity that has been excluded from the category of development activities is fishing. This definition is very wide and covers all those things that can be done in the coastal zone

The regulation of and the controlling of development activities in the coastal zone is achieved by the issuing of permits for development activities that are declared by the minister in charge of the subject of coast conservation (at present it is under the Minister of Fisheries) as prescribed activities under Section 13.The regulations in force at present are the Coast Conservation Regulations, No.1 of 1982. These deal with the types of prescribed projects that do and do not need a licence and the criteria that have to be observed in permitting development activities in the coastal zone. According to regulation 3, the two types of development activities in the coastal zone that do not need a permit are.

- Cultivation of crops,
- Planting of trees and other vegetation.

Therefore, it is clear that the creation of green belts in the coastal zone do not need permits from the Coast Conservation Department. However, there may be efforts and instances to incorporate other activities along with tree plantation, such as erection of buildings (either as watch huts or visitor centers) and the excavation of sand and soil to create dykes and gullies. If there is any such other activities, they need to be done only with the approval of the Coast Conservation Department as they are prescribed projects that need a permit to commence.

The regulation 4 states that if any development activity is planned in an area declared as an Urban Development Area under the provisions of the Urban Development Authority Law, No.41 of 1978, the requirements must be in conformity with the development plans of the Urban Development Authority. It has to be noted that the coastal zone of the Republic of Sri Lanka has been declared an Urban Development Area by order published in gazette extraordinary No.223/16 of 17th December 1982. The coastal zone for the purposes of this declaration is much wider, being the area lying within the limits of one kilometer (1k.m.) landwards from the Mean High Water Line of the sea.

The Section 29 of the Urban Development Authority Law interprets and defines the term development activity for the purposes of this law. This definition has several exclusions, which include the use of any land for the purpose of agriculture and horticulture. Thus, any green belt planting that does not include any erection of buildings or the creation of embankments or gullies or the making of structures do not need to be bound by the provisions of this law.

The Coast Conservation Regulations also impose the following conditions on development activities that may or may not need a permit:

- The activity should not infringe upon the right of access to the beach by the public,
- The activity should not adversely affect the quality of beaches or affect their preservation,
- It should not dislocate any existing fishing activities,
- It should not affect any Marine Sanctuary,
- It has to be sited so as to allow an adequate buffer zone to accommodate the dynamics of coastal processes.
- It should not be located within any place of religious worship or of performance of any religious rite,
- It should not be sited within any area reserved as a wildlife habitat,
- It should not be sited within an area reserved for the purpose of recreation by the public.

There are some areas of the coastal zone that fall within extents of land declared either as Sanctuaries (e.g.- Kalametiya – Lunama and Rumassala) or as National Reserves (e.g.- Ruhuna National Park, Hikkaduwa National Park) under the Fauna and Flora Protection Ordinance. Issues related to these areas therefore fall within the jurisdiction of the Forest Department (FD) and the Department of Wildlife Conservation (DWLC). The foregoing provisions therefore restrain tree planting activities or cultivation of plants for the purposes of creating green belts in such areas by any third party. This extends to those areas that can be declared even under the provisions of the Forest Ordinance such as Conservation Forests and Reserved Forests, and to any National Heritage Wilderness area declared under the National Heritage Wilderness Areas Act.

The Marine Pollution Protection Act of 1981 which provides for prevention, reduction and control of pollution in Sri Lankan waters, with provision for penal action, together with the National Environmental Act of 1980 with its amendments of 1993, empowers the Central Environment Authority to have regulatory control over pollution, and also calls on project approving agencies to submit and obtain approval for EIA's for prescribed development projects.

3. GUIDELINES FOR IMPLEMENTATION

3.1 Sources of Planting Material

There is a general lack of plant nurseries in suitable locations, which stock adequate quantities of plant material of suitable species. The following is a list of some of the major State institutions that maintain nurseries in different parts of the country:

The Forest Department, 82, Rajamalwatta Road, Battaramulla (Tel. 011 – 2866616, Fax 011 - 2866633), has District Forest Officers (DFOs), Regional Forest Officers (RFOs) and nurseries in the following relevant locations:

- Puttalam District: DFO (tel. 032 – 65360), nurseries in Puttalam and Chilaw,
- Kalutara District: DFO (tel. 034 – 22138),
- Galle District: DFO (tel. 091 – 34036), Kottawa central plant nursery,
- Matara District: DFO (tel. 041 – 21164),
- Hambantota District: DFO (tel. 047 – 20371),
- Ampara: DFO (tel. 063 – 22054), nursery at Paragahakalle, Kalmunai.
- Batticaloa: DFO (tel. 065 – 22355), nursery in Kalawanchikudy.
- Trincomalee: DFO (Tel. 026 – 22306).

The Forest Department may undertake provision of plants on order, given sufficient time for preparation.

- The Botanic Gardens at Peradeniya (Tel. 081 – 2388307, 2388238) and Gampaha (Tel. 033 – 2222316) will accept orders for plants if they are allowed enough time for preparation.
- Certain agricultural crop species are available in the Department of Agriculture Sales Rooms in Colombo (Tel. 011 - 269 6547) and Matara (Tel. 041 - 2221872): They can also provide information on the department's farm nurseries and out-growers in various parts of the island.
- Cashew plants can be ordered from the Sri Lanka Cashew Corporation, 396, Galle Road, Colombo 3 (Tel. 011 – 2575118, 2576054), and from their Hambantota nursery (Tel. 047 – 2221572). Smaller orders for up to about 1000 plants should be placed 2 –3 months in advance, while large orders should be placed about 6 months in advance. Seedlings 0.3 to 0.6 m tall are usually available.
- Coconut (and King Coconut) plants can be obtained by contacting the Coconut Cultivation Board at 9/428, Denzil Kobbekaduwa Mawatha, Battaramulla, (Tel. 011 – 2861331/2, Fax 011 - 5549507).
- For Palmyrah plants, one should contact the Palmyrah Development Board, 244, City Office, Galle Road, Colombo 4 (Tel. 011 – 2586820, Fax 011 - 2553697).

A more comprehensive list of nurseries maintained by the State and private sector organizations is given in Annex VII

It is however, strongly recommended that local communities be encouraged to set up nurseries, with the guidance of technical experts, to provide plant material for both coastal green belt projects and other projects in their particular regions.

In any case, a temporary nursery should be established for each green belt project, at least for plant storage on a temporary basis, and may be also for growing the plants till they reach suitable sizes for planting out at the site.

3.2 Establishment of Plant Nurseries and Methods of Planting

Plant nurseries for provision of planting material for beach reservation/coastal green belt planting should be as close as possible to the restoration site, preferably within the official coastal reservation or comparable areas. Propagation should be done in these nurseries themselves, in order to ensure that newly planted material will become acclimatized to the maximum. The following is the sequence of steps in the establishment of plant nurseries.

- Collection and Storage of Seed
- Nursery Arrangement
- Seed Germination and pre-treatment

- Site Selection, Preparation and Design
- Boundary and Other Buildings
- Nursery stock
- Sowing Seeds, Watering and Shading
- Alternative use of Poly-pots and Potting Medium

The detailed explanation of the manner in which a nursery should be established and the method of planting in the field are given in Annex VII. The information was extracted from the Tree Planting Manual (Nisi Lesa Pelayak Sitawamu) and the Forest Nursery Manual for Sri Lanka published by the Forest Department (1994). The given information on planting techniques are more suitable for normal sites, but directly applicable for coastal belts. Therefore, for the site specific methods and techniques, it is recommended that one should consult the District Forest Officers.

3.3 Protection and Maintenance

In the case of individual tree planting using whips or standard trees, tree guards should be provided immediately after planting.

Belts/groups/patches/strips of closely planted trees or shrubs or creepers or mixed vegetation should be surrounded by sufficiently strong temporary fencing, to last three to five years, depending on the period required for the selected mix of species to grow to substantial sizes. Fencing should be installed before actual planting commences. Jungle timber posts preferably with plastic coated (maybe barbed) wire strands is usually economical. Cattle/goat/deer proof gates or stiles should be made for access for maintenance. There should be a reasonably permeable screen along the windward edge of the fence, made of brush wood or wattle hurdles or thatched palm leaves or palm leaves/fronds fixed on a post and wire fence.

In some locations, rabbit/hare or rodent proof mesh or wire netting may also be needed. It is recommended to use woven netting (fixed to posts) with the bottom turned down at right angles and held down on the ground by sods or buried vertically in the ground, strengthened by two line wires – one along the top of the netting, which is fixed to it, and the other 15cm above it. The height of such a barrier should be 105cm, with the height of the netting being 90cm, and the width of netting buried or turned flat being 15cm.

Fences for protection from larger animals should be higher – at least 1.5 m (5 feet) and they should be sufficiently far away from the outside lines of planting, to ensure protection of the branches and foliage as the plants grow larger.

While the character of the tree guards/fences should be matched to the natural/rural/urban character of the location, they should preferably be strong enough to withstand the seaside climate without needing replacement, or much maintenance and repair.

In very bare, exposed situations, temporary shade should also be provided as far as possible using materials such as palm leaves/branches or jute. Since post maintenance operations of planting trees are very much critical for the survival of the greenbelts, for more technical details, it is recommended that one should consult the District Forest Officers.

3.4 Management

Organizing local community and assigning responsibilities

Whoever undertakes coastal greening activities, the involvement of local community is vital for the sustainability of the programme. Therefore enough community participation should be ensured throughout the project from project design to monitoring. It must be understood that at all important stages from project design to monitoring the involvement of local community is vital for maintenance and sustainability of the greenbelt programme. Following are important tools for ensuring community participation

- Select the target community with whom the programme is to be implemented and make them aware of the project, especially about the potential short-term and long-term benefits that would ensue. A proper education and awareness programme targeting both adults and children of the community should be is conducted before initiating planting activities. For this purpose the required expertise and resource persons for education and awareness activities can be obtained from Government agencies such as the Forest Department, Coast Conservation Department, Universities, and technically capable Non Government agencies like IUCN.
- Tangible short-term benefits are important to attract people at the initial stage. They can be incorporated into the program in different ways as follows;
- Providing a Daily working allowance for people who are involve with project activities. These include

mainly plant material collections, ground preparations, nursery maintenance, watering and weeding, plant protection and other relevant work.

- Local people can be asked to produce plant materials and the project can buy them by paying reasonable amount. The selected families for nursery establishment are to be trained well.
- Some monthly/daily allowance for maintenance of nurseries and new plantations
- Allocating a block grant for a community Trust, or for an existing community welfare programme handled by the community for their common benefits. This kind of arrangements should be discussed with the community, and get their agreement before initiating.

Local community members should be properly educated about all direct and indirect benefits of the project and necessary arrangements to be made to ensure that local people can derive some economic benefits. As an example, the benefits of harvesting of economic crops like coconut can be obtained by the local people who participate in the programme. Regarding private land, the gains of the beneficiary party are very clear. However where state lands are concerned the situation may not be so. Therefore following management alternatives can be suggested for planting in state lands.

Alternative 1

The people who are engaged in the initial phase of the project can be further organized to form community organization or if the work is to be carried out with an existing organization, their capability can be strengthened. Such a CBO can come to an agreement with the Divisional Secretariat of the particular area, which owns the state land, regarding the harvest. The organization may be required to distribute the returns among members after paying a predetermined share to the state.

Alternative 2

Private individuals/organizations interested in greenbelt restoration are encouraged to lease state owned coastal lands for undertaking tree planting programmes. The Coast Conservation Department can recommend release of available state lands for tree planting only. The interested party should plant the recommended species within the coastal reservation (as set out in the CZMP 1997), and the rest of the lease land can be cultivated with a commercially important species such as coconut. The direct benefits to the interested party are through the harvest of their commercial plantation. There are number of opportunities from which interested parties could drive a range of indirect benefits.

These alternatives can also be used for transferring the ownership of a particular programme to the involved communities.

Assignment of responsibilities

Other important aspect for a successful greenbelt initiative is that the division and assignment of works among the involved people, especially during planting and maintenance stages. Each task should have a responsible person / party who should ensure that the assigned work is done in a correct and efficient manner.

Coordination with relevant agencies

Establishment a proper coordination with relevant government and other research agencies are important in terms of contributing to the national level objectives of the coastal green belt. The outcomes of individual projects are finally to be contributed these objectives. The coast conservation department basically coordinates the coastal green belt establishment activities with the assistance of forest department. It is recommended to coordinate at the very initial stage of your project to ensure maximum contribution to the national objectives and to avoid wasting resources. If your site/s comes within the category of Urban according to the above classification, Urban Development Authority should be consulted for especial landscape designing of the project.

Providing technical assistance

Initial field level technical assistances to undertake green belt activities are provided by the field officers of Coast Conservation Department and Forest Department. They regularly visit the planting sites and coordinate with relevant persons and agencies for any specific technical inputs if required. Technical assistance to prepare especial landscapes designs for your site/s can be obtained from the landscape and environment division of Urban Development Authority The Forest Department, Coast Conservation Department, Botanical Gardens Department, universities, Urban Development Authority, and organizations like IUCN potential agencies to provide technical inputs to this project. Two joint committees, one at National level and other at district level will be established for better coordination. At national level committee, Director/CCD and the

conservator General of Forests are co-chaired and discussed policy level issues pertaining to Green Belt implementation. The proposed district level committee will be co-chaired by area Engineer, CCD and District forest officer and discuss issues related to the field level implementation.

Financial Resources

Availability of adequate financial resources is a crucial factor for sustainability of coastal planting programmes. Once the trees are planted in the field it is necessary to carefully maintain these plants for at least 2 to 3 years for which sufficient funds must be available. Furthermore monitoring, evaluation and recording the growth progress are aspects to be considered in the allocation of funds.

3.5 Ensuring Sustainability

Incentives for private land owners

It is important to have some incentive schemes to encourage communities and private land owners to contribute resources and efforts for greenbelt reconstruction activities, since most lands along the coastline of the country belong to private parties. There are no laws and regulations to compel people to undertake activities in their land without their willing cooperation.

Among measures to induce individuals and communities to undertake greenbelt activities is the provision of training and awareness creation programmes to demonstrate the potential direct and indirect benefits of a greenbelt, especially its function as a protection against coastal erosion, which will save a considerable amount of money for restoration.

If private land owners are willing to plant recommended plant species at the seafront of their land, government or other greenbelt supportive agencies can provide seedling of commercial crop species, home garden tree species and fertilizers for a certain period as an incentive for their participation. Also technical inputs for planting can be arranged freely. The number of seedlings and the amount of fertilizers depend on the extent of their coastal greenbelt.

Credit Facilities

Credit facilities at concessionary interest rates for coastal planting in private lands can be promoted through banks and other financial services institutions, to persuade private land owners to contribute their efforts in establishing greenbelts. People who own sufficient extents of beachfront lands can have greenbelts at their seafronts, while planting economically useful crops towards the interior parts. This will not only enable such persons to benefit economically, but will also ensure the sustainability of the greenbelt.

Competitions and awards

It is also important to have programmes to appreciate the efforts of people and organizations who have contributed to a greenbelt as a national endeavour for disaster mitigation. A government agency like CCD, with the involvement of the private sector, can initiate an awards scheme or some competitions among the contributors to enhance their motivation.

Community mobilization and awareness creation

Positive attitudes of the local community towards greenbelts are extremely important to ensure their optimum participation in the programme. According to a survey conducted by CCD, it has been revealed that a majority of coastal people believe that a coastal greenbelt with a natural vegetation would improve the protection of coastal environment against natural hazards. Also they believe that natural vegetation in the coastal green belt would improve the scenic value of the coastal environment which supports to attract more tourists. Therefore increased awareness and education on the potential benefits of greenbelt, will help to build up positive attitudes among coastal people. Awareness creation among school children is an investment to ensure sustainability of a project, because they can be a useful conduit to transfer the relevant message to the adults

Other coastal uses

A green belt project should be designed after a clear site assessment, and all other coastal uses have been taken into consideration. Traditional uses and beach accesses should not be disturbed by the proposed green belt activities. It is important to have a dialogue with identified coastal resource users in the selected location to get their views for designing the green belt activities. It is also important to ensure consultation with relevant government agencies like the Fisheries Department and the Ceylon Tourist Board.

4. MONITORING AND EVALUATION

4.1 Basic Groundwork

Monitoring and Evaluation (M&E) are key operations that ensure good management and implementation of the Greenbelt Restoration Programme. The primary objective of M & E is to systematically assess and guide the implementation strategy of project activities to a successful completion, within a specified timeframe.

This activity obviously has to be operated through Committees functioning on a hierarchical basis. In the previous section the creation of two coordinating committees was mentioned. These Committees too will be responsible for assessment of progress.

Initially it has to be mentioned that at the designing stage of the project proposal, the proponents of a Greenbelt restoration project, should as a part of the implementation process, develop a mechanism for monitoring and evaluation of the progress of their project activities. This must be done in consultation with CCD, UDA, and Forest Department, because the M & E process must be in accordance with the relevant Guidelines for Establishment of Coastal Zone Greenbelt.

4.2 Committees for Monitoring and Evaluation

Although as explained in Section 3.5, two Committees; one at the National level and the other at the District level would be installed for coordination of Greenbelt project activities throughout the entire coastal belt, there will necessarily exist a ground level M & E Committee at the Divisional Secretariat level. This Committee will be chaired by the Divisional Secretary, and will include technically qualified representatives of the relevant stakeholders state agencies based in the area. The Committee would be expected to appoint a team to undertake monitoring and evaluation in accordance with the Guidelines. The M & E team should not exceed 3 members, of whom at least one member should preferably be with experience in project management and evaluation. The other two members should be representatives of two of the key stakeholder state institutions linked to project activities (viz., CCD, UDA, FD and the Department of Agriculture), identified on the basis of the type of project activities involved.

Table II . List of Plant Species
Woody plants for site rehabilitation in Tsunami affected areas.

Activity/ Subactivity	Indicator	Commencement Dates		Completion Dates		Current Status
		Actual	Scheduled	Actual	Scheduled	
Nursery Site identification Site Preparation Seed Collection & Treatment Seed Storage Construction of huts Seedbed Preparation Sowing/Planting	--- % Extent cleared % of target % of target --- % Extent completed % done					
Project Site Debris Removal Site Preparation Landscape Demarcating planting areas footpaths etc. Fencing	--- % completed % Extent completed % Extent completed % completed					
Greenbelt Implementation Sowing/Transplanting Growth Progress Basal Fertilizer Pest & Diseases	Area done/ No. of species established Survival % Average ht. Of tree space .% completed Affected %					

4.3 The Time Schedule

Although the design, plan and implementation strategy of the project proposal would have received prior approval at the National Coordinating Committee, the initial step that the M & E Team should take is to ensure that the timelines set in the project document are realistic in the context of the site-specific ground situation, especially in relation to community attitudes, availability of resources locally, the existing state of the site, and the possible conflicts with other planned or on-going projects within the identified greenbelt project area. If such local site-specific issues do not make the original timelines realistic, the M & E team must immediately call a meeting with the project proponents, and re-set the timelines for project implementation.

4.4 Framework for Evaluation

Monitoring and evaluation has to be undertaken according to an analytical framework devised on the basis of the schedule of activities to be carried out. This conceptual framework therefore begins with the project design as described above, in terms of time tables for undertaking and completing the project activities. In its simplest form the analytical framework for evaluation would be as shown below for the first quarterly Report:

4.5 Record Keeping

Maintaining of progress records is an important aspect in project implementation. The project proponent should preferably identify a competent and committed senior or honorable member of the local community to supervise and maintain schedules and records of all activities undertaken in the Project. The selected community member should be paid an incentive allowance for the services provided.

4.6 Participatory Appraisal

The M & E team must ensure that the monitoring and evaluation process takes place with the participation of the local community organization that has taken the initiative to assist in the implementation of the project. On arrival at the site, the team can be accompanied by a few members of the committee for on the spot, first hand observations and evaluations of the state of the ground operations. While taking down personal notes of the current status, the team should seek the advice of the community on different aspects of the work programme, especially in relation to any constrains and problem in carrying out the schedule of work. All such observation must be taken note of in assessing the implementation status. In addition, based on the records maintained by the supervising community member, the analytical framework should be completed, and a concise quarterly report prepared for the Divisional Secretary. The M&E Team should present an analytical view of the current situation, that incorporates the views of both the project implementers and the local community.

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ANNEXES

Annex I

Annotated Guiding Principles For Post-Tsunami Rehabilitation And Reconstruction

(Cairo Principles)

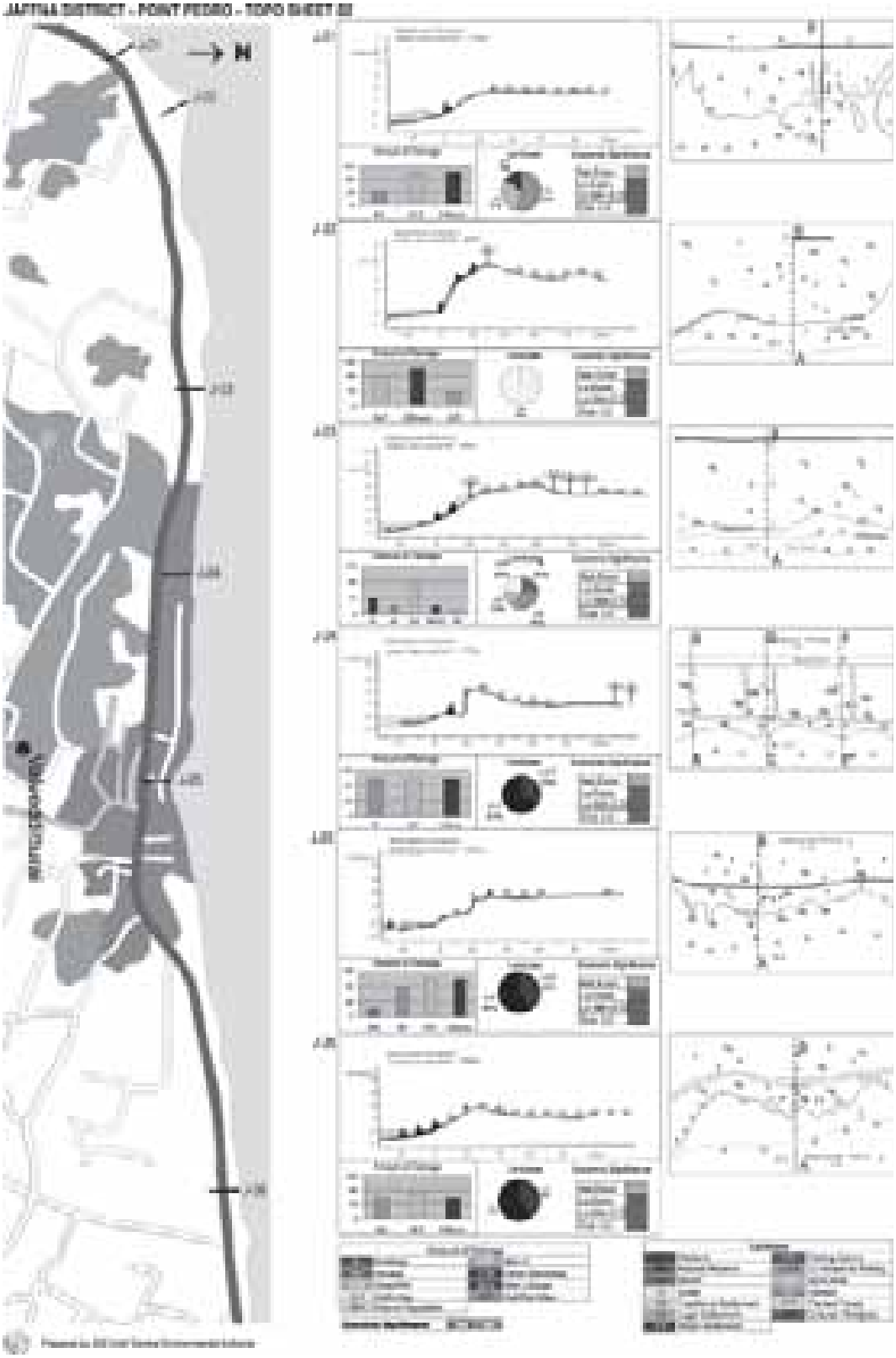
To guide the massive coastal reconstruction effort, the United Nations Environment Programme (UNEP) Tsunami Disaster Task Force in cooperation with the UNEP Coordination Office of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (UNEP/GPA) convened a meeting on February 17,2005 in Cairo to discuss coastal zone rehabilitation and management in the tsunami – affected region. Attendees from the affected nations and supporting international institutions[1] endorsed twelve key principles (hereafter referred to as the Guiding Principles) consistent with an advance to more sustainable forms of coastal development and the United Nations Millennium Development Goals.

The Guiding Principles

1. (Overarching principle) Reduce the vulnerability of coastal communities to natural hazards by establishing a regional early warning system; and applying construction setbacks, greenbelts and other no-build areas in each nation, founded on a science –based mapped "reference line".
   Using concepts of integrated coastal management, including public engagement in local decision-making, employ a rapid assessment zoning and planning process to:
2. Promote early resettlement with provision for safe housing; debris clearance; potable water, sanitation and drainage services; and access to sustainable livelihood options.
3. Enhance the ability of the natural system to act as a bio-shield to protect people and their livelihood by conserving, managing and restoring wetlands, mangroves, spawning areas, sea grass beds and coral reefs; and by seeking alternative sustainable sources of building materials, with the aim of keeping coastal sand, coral mangroves and rock in place.
4. Promote design that is cost- effective, appropriate and consistent with best practice and placement of infrastructure away from hazard and resource areas, favouring innovative and soft engineering solutions to coastal erosion control.
5. Respect traditional public access and uses of the shoreline, and protect religious and cultural sites.
6. Adopt ecosystem based management measures; promote sustainable fisheries management in over-fished areas, and encourage low impact aquaculture.
7. Promote sustainable tourism that respects setback lines and carrying capacity, benefits local communities and applied adequate management practices.
   How things are done is as important, sometimes more important, than what is done, Local knowledge and insights are critically important to successful planning and decision-making, and local citizens must be engaged in the rehabilitation and reconstruction process at every stage. It is essential that the application of the construction setback line and the boundaries of bio shields are defined in consultation with the local communities coastal reach by coastal reach.
8. Secure commitments from governments and international organizations to abide by these Principles and build on and strengthen existing institutional arrangements where possible.
9. Ensure public participation through capacity building and the effective utilization of all means of communication to achieve outcomes that meet the needs and realities of each situation.
10. Make full use of tools such as strategic environment assessment, spatial planning and environmental impact assessment, to identify trade-offs and options for a sustainable future.
11. Develop mechanisms and tools to monitor and periodically communicate the outcomes of the reconstruction through indicators that reflect socio-economic change and ecosystem health.
12. Widely disseminate good practices and lessons learned as they emerge.

Annex II

Maps from the MENR/UNEP REA Report (2005)



Annex III

Tables from the MENR/UNEP REA Report (2005)

Table III.1 Landward tsunami penetration in Trincomalee and Ampara district

TRINCOMALEE DISTRICT

Grama Niladhari Division & No	Place name	Penetration (m)
Pulmottai - 04	Kokkilai Lagoon	200
Pullmoatai - 04	3rd Mile post	200
Pulmoattai - 04	Kuttikaldai	300
Pulmotai - 11	Behind Ilmenite Factory	200
Pullmottai - 11	Pulmodai Town	300
Pulmoddai - 11	Arisimaalai	100
Thiriyaai	Panmalaikudah	200
Thiriyaai	Kalrawa	300
Thiriyaai	Thiriyai-kalrawa	200
Thiriyaai - 237	Thiriyai Junction	300
Senthoor - 237B	Senthoor	300
Senthoor - 237	Puddavaikattu	350
Jaya Nagar - 239C	Valapattukudah	200
Jaya Nagar - 239C	Karadimaalai	200
Veerancholai - 239B	Veerancholai	650
Kumburupiddy East - 240B	Kumburupiddy	300
Kumburupiddy East - 240B	Sallaipaiaru	150
Kumburupiddy East - 240B	Sallaipaiaru	400
Kumburupiddy North - 240A	Sallaipaiaru	300
Kumburupiddy North - 240A	Thavicalmaalai	200
Kumburupiddy South - 240	Devimaalai	100
Irrakakandy - 241A	Irrakakandy	150
Vaalaiyoothu	Vaalaiyoothu	200
Nilaveli Gopalapuram	Gopalapuram	500
Nilaveli - 241	Nilaveli	500
Veloor - 241C	Veloor	400
Iqbal Nagar - 241D	Ragulthottam	700
Iqbal Nagar - 241D	Adukkuparai	400
Sampalthivu - 242	Manganai	50
Sampaltivu - 242	Sampalthivu Ward	350
Salla - 242A	Salli	150
Uppuveli - 243	Alles Garden	300
Uppuveli - 243	Uppuveli	200
Pattanatheru	NC Road	350
NC Road - 244	Pattanatheru	75
Pattanatheru	Fort Frederick Road	300
Villundy	Town Beach	60
Arunagrinagar - 244G	Inner Harbour Road	100
Orr's Hill Lower Road - 244P	Lower Road	20

AMPARA DISTRICT

Grama Niladhari Division & No	Place name	Penetration (m)
Sinna Muhaththuvaram - 9	Sinna Muhaththuwaram	400
Thampaddai - 2	Thampbaddai	300
Thampaddai - 2	Thampaddai	300
Thambaddai	Thambaddai	300
Thambaddai - 3	Periya Muhaththuwaram	400
Thambiluvil - 01	Thambiluvil	300
Thambiluvil - 01	Kanagaratnam	450
Thambiluvil - 02	Thambiluvil	450
Thiruk	Thirukkovil 1	300
Thhambiluvil	Thambiluvil - 02	600
Vinayahapuram - 4	Vinayahapuram	800
Thirukkovil	Vinayahapuram	400
Korawatha	Korawatha	600
Korawatha	Korawatha	200
Omiree	Korawatha	350
Omiree	Thirupathi	400
Omiree	Omiree	1000
Omary	Omary	600
Manelaichenai	Manelaichenai	600
Komari	Komari	80
Komari	Komari	80
Sinna Muhathhtuwaram - 9	Sinna Muhaththuwaram	400

Table III.2 Tsunami impacts on lagoons and estuaries

District	Beach	Observations
Gampaha	Negombo lagoon estuary	Slight damage, rubble in mouth area, a few uprooted mangroves Absorbed energy; changed wave to flood
Colombo	Lunawa lagoon	Opened barrier at mouth. Absorbed energy; the revetment was more significant in settlement protection
Kalutara	Kalu Ganga estuary	Slight erosion at mouth. Absorbed energy; many contributory factors connected with settlement protection
Galle	Madu Ganga estuary	Slight mangrove uprooting, sand barrier at mouth breached. Absorbed energy; many contributory factors connected with settlement protection
	Kosgoda lagoon	Sand barrier at mouth breached. Probably contributed to funnelling energy in to settlement area and contributed to settlement damage, likely to improve fishery productivity
	Koggala lagoon	Sand barrier at mouth breached. Minor if any role in settlement protection
Hambantota	Rekawa lagoon	Sand barrier at mouth temporarily breached. Minor if any role in settlement protection
	Kalametiya lagoon	Sand barrier at mouth temporarily breached. Settlement on beach front, not protected by lagoon
Ampara	Arugam kalapu	Sand barrier temporarily breached. some mangrove uprooting, much sand and debris deposited. partial energy absorption, partial funnelling of wave energy; sink for debris facilitated, salt intrusion into paddy fields
	Komari lagoon	Sand barrier temporarily breached, some mangrove uprooting, much sand and debris deposited. partial energy absorption, partial funnelling of wave energy; sink for debris, facilitated salt intrusion into paddy fields.
Batticaloa	Batticaloa lagoon	Several openings to the sea seasonally blocked by sand barrier, most re-opened sink for debris. partially absorbed energy while partially funnelling energy and flood water mainly through the opening at Batticaloa (Barr Road) may have caused extensive salt intrusion with serious consequences for paddy cultivation
	Uppar Panichankerny estuary	Opening of sand barrier at mouth. partial absorption and partial funnelling of energy
Trincomalee	Sinnakarachchiya	Opening of estuary mouth. partial absorption and funnelling of energy
	Periyakarachchiya	Opening of estuary mouth. partial absorption and funnelling of energy
	Kokkilai lagoon (shared)	Opening of estuary mouth. Failed to absorb energy, extensive settlement destruction
Mullaitivu	Kokkilai lagoon (shared)	Opening of estuary mouth. Failed to absorb energy, extensive settlement destruction
	Nayaru	Opening of estuary mouth. Failed to absorb energy, extensive settlement destruction
	Nanthi Kadal	Opening of estuary mouth. Failed to absorb energy, extensive settlement destruction
Jaffna	Thondamanaru lagoon	Opening of estuary mouth. Failed to absorb energy, extensive settlement destruction

Table III.3 Tsunami impacts on beaches

District	Beach	Observations
Gampaha	Lewis Place, Negombo, ca 5km	Beach scouring by diffracted or reflected wave. Beach stabilized by off shore breakwaters, absorbed energy, protected hotels
Colombo	Wellawatte-Mt lavinia, ca 2km	Beach scouring by diffracted or reflected wave. Beach partially fronted by rock reef, partial absorption of wave energy.
Kalutara	Panadura, 2-3km	Slight erosion by diffracted or reflected wave. Adjoining estuary failed to absorb energy; severe damage to settlement
	Tangerine, 3km	Slight erosion by diffractedor reflected wave. Broad beach absorbed wave energy
	Maggona, 2-3km	Slight erosion over 2-3km by diffracted or reflected wave. Broad beach absorbed wave
	Moragalla, >2km	Pitting, Observable erosion over 2-3 km by diffracted or reflected wave. Partial energy absorption, solid, low-income housing protected
	Kosgoda, 2-3km	Observable erosion over 2-3km by diffracted or reflected wave. Narrow beach failed to absorb energy; Kosgoda Beach Resort destroyed
Galle	Benthota, 2-3km	Slight erosion by diffracted or reflected wave. Partial abosorptior of energy, Soliday built hotels not vulnerable.
	Godagala-Induruwa	Little observable erosion
	Akurala-Seenigama >4km	Narrow beach, backed by high revetment, observable but slight erosion, Extensive settlement and train damage. many contributory factors
Hambantota	Hambantota	Broad beach, raised berm, slight erosion. Failed to absorb energy, extensive settlement damage
Ampara	Arugam Bay, >2km	Broad beach, low berm, slight reshaping and erosion. Failed to absorb energy, extensive damage to settlements and agricultural land
	Kalmunai, >5km	Broad beach, raised berm, visible erosion, scarring and pitting. Failed to absorb energy, extensive damage to settlements and agricultural land
batticaloa	Kalladi, >3km	Broad, Flat beach, reshaping and considerable erosion, adjoining estuary mouth. Failed to absorb energy, flood and energy dissipation on settlement, extensive damage.
Mullaitivu	Nayaru, 2-3km	Broad beach, pitted and scarred by erosion, sand layers removed to expose previously buried culverts. Failed to absorb energy, extensive damage to building, including some solid structures.
	Nanthi kadal 2-3km	Broad beach, pitted and scarred by erosion, sand layers removed to expose previously buried culverts. Failed to absorb energy, extensive damage to buildings, including some solid structures
Jaffna	Uduththurai	Broad beach with raised berm, slight erosion, failed to dampen energy, extensive damage to vulnerable houses, churches survived
	Maruthankerny	Broad beach with raised berm, slight erosion, failed to dampen energy, extensive damage to vulnerable houses, churches survived
	Casuarinas	Beach fronted by dead coral, backed by road on embankment, corals scattered, boat access obstructe, Absorbed energy, assisted by embankment, mainly flood damage.

Table III.4 Tsunami impacts on sand dunes

District	Sand spit	Observations
Kalutara	Kalutara	Slightly reshaped
Galle	Bentota	Breached, serious damage. Absorbed energy, probably protected some structures
	Kosgoda	Breached, self-rapaired. Probably absorbed energy and protected road and bridge
Batticaloa	Vakarai	Slight erosion. Failed to absorb energy, extensive settlement damage
District	**Sand dune area**	**Observations**
Jaffna	Manalkadu	Some shifting of dunes, some shape change, Protected some houses at higher elevation, provided refuge.
	Vadamarachchi East	Little visible damage. May have accelerated wave flow and energy on the landward decline of berm and low dune combination, thereby increasing settlement damage.
Ampara	Kalmunai-Pottuvil	Little damage to dunes. Mixed role of dunes: in some stretches they provided protection, but not in others.
	Pottuvil	Wave energy penetrated at points north and south of Pottuvil Town where dunes had been denuded Stable, vegetated dunes provided protection.
Hambantota	Panama	Breached low points of dunes and created fresh pools with new tidal inlets. No settlements.
	Yala (Protected Area)	Overtopping where dune elevation had been reduced by people. Failed to protect two hotels which had flattened dunes to provide beach access Protected hotel situated behind intact dune.
	Karagan Lewya	Overtopped partially-mined dune. Failed to protect road traffic resulting in many deaths.
Gampaha	Palliwatte-Duwa	Dune not overtopped. Protected settlements.

Table III. 5 Protected Areas in coastal districts affected by the tsunami

Protected Areas under the Department of Wild Life Conservation (DWLO)

District	Name	Status
Ampara	Lanugala	National Park
Ampara	Sangamam	Sanctuary
Ampara	Kudimbigala	Sanctuary
Ampara	Yala East	National Park
Batticaloa/Polonnaruwa	Triconamadu	Nature Reserve
Galle	Hikkaduwa	National Park
Galle	Honduwa Island	Sanctuary
Galle	Rocky Islets Ambalangoda	Sanctuary
Galle	Telwatte	Sanctuary
Galle	Parapaduwa Nun's Island	Sanctuary
Galle	Rumassala	Sanctuary
Galle	Madinduwa	Sanctuary
Galle	Maduganga	Ramsar site
Galle	Elweliyaya	Sanctuary
Gampaha	Muthurajawala	Sanctuary
Hambantota	Yala Stict Natural Reserve	Strict Natural Reserve
Hambantota	Bundala	National Park/ Ramsar wetland
Hambantota	Katagamuwa	Sanctuary
Hambantota	Nimalawa	Sanctuary
Hambantota	Palle mallale	Sanctuary
Hambantota	Kalametiya	Sanctuary
Hambantota	Kirama	Sanctuary
Hambantota	Weerawila	Sanctuary
Hambantota	Madunagala	Sanctuary
Hambantota	Rekawa	Proposed Turtle Refuge
Hambantota	Godawaya	Proposed Turtle Refuge
Hambantota/Monaragala	Ruhuna(Yala)	National Park
Jaffna	Chundikulum	Sanctuary
Matara	Kirilakele	Sanctuary
Monaragala	Kataragama	Sanctuary
Mullaitivu	Kokilai	Sanctuary
Puttalam	Anawilundawa	Sanctuary/ Ramsarwetland
Trincomalee	Pigeon Island	National Park
Trincomalee	Great Sorber Island	Sanctuary
Trincomalee	Little Sorber island	Sanctuary
Trincomalee	Trincomalee Naval Head works	Sanctuary
Trincomalee	Seruwela-Allai	Sanctuary

Mangrove areas proposed for conservation by the Forest Department		
Galle	Hikkaduwa	Proposed Conservation area
Galle	Magala	Proposed Conservation area
Galle	Balapitiya	Proposed Conservation area
Gampaha	Munakarei	Proposed Conservation area
Hambantota	Kalametiya	Proposed Conservation area
Hambantota	Kahandamodara	Proposed Conservation area
Hambantota	Rekawa	Proposed Conservation area
Kalutara	Hirana 1	Proposed Conservation area
Kalutara	Hiarana 11	Proposed Conservation area
Kalutara	Kaluwamodara	Proposed Conservation area
Kalutara	Megama	Proposed Conservation area
Kalutara	Ittapana	Proposed Conservation area
Kalutara	Ollewa	Proposed Conservation area

Table III. 6 Tsunami impacts on Special Area Managements sites

SAM site	Key environmental impacts
Negombo	The lagoon mouth was deepened by the tsunami, but the six canals connected to the lagoon were blocked by debris. The beaches are polluted with debris and rubbish. There was little damage to coastal vegetation such as mangroves. Sand dunes in Morawalla, Sethapaduwa and Thalahena were damaged; in some places these dunes had been up to 15m high but they have now been eroded and have lost areas of vegetation. Much debris has been deposited inside the lagoon.
Lunuwa	The mouth of Lunawa lagoon was swept open and water level in the lagoon decreased. After a few days the lagoon mouth closed again. Beaches in the SAM area are being used as dumps for plastic, wood and solid waste. Some beaches are being cleaned, but others are polluted with debris and rubble. The coastal vegetation has been damaged severely; even some coconut palms have been destroyed indicating the force of the water.
Maduganga	The physical structure of the mouth of Maduganga lagoon has not changed, but the sandbar blocking the lagoon from the sea was swept away and the southern bank was slightly damaged in places. A large amount of debris is still inside the lagoon, including several sunken boats. Due to the opening of the lagoon mouth, salinity inside the lagoon has increased, which could cause salt-water intrusion into paddy fields. In several places the coastal vegetation has been damaged.
Hikkaduwa	Salt water has intruded into ground water and the lagoon. The coastal vegetation has been affected. Debris and rubbish have entered the lagoon. Debris and nets have been deposited on the coral reefs. Sewage lines are still intact. Two canals (Wulaguda, Mahakadewella Ella) have been polluted with debris and rubbish, as have nearby beaches.
Habaraduwa	The lagoon mouth of Kogalla is intact and does not seem to have changed. Salt water intruded into inland, wells, water bodies and paddy fields. The mangroves near kogalla lagoon have been destroyed. Coastal vegetation and crops have been destroyed.
Mawella	Groundwater polluted with salt water, resulting in unusable wells. The Mawella canal and the Moreketiva lagoon are heavily polluted with debris and rubbish; there is a large amount of vegetation and organic material inside the Moreketiya lagoon. The canal is now open but blocked by debris. The beach in the SAM area is polluted with debris and rubbish.
Kalametiya	The lagoon mouth seems to be damaged. The walls of the canal that connect the sea and the lagoon have b een damaged. An opening between the lagoon and the sea was created directly south of this canal. About 17 ha of paddy in Ussangoda has been destroyed by the tsunami. The lagoon has been polluted with debris and rubbish. Sand dunes have been damaged in some areas. Vegetation has been cleared widely for temporary or permanent housing.

Annex IV

Natural Landscapes of Sri Lanka's Coastal Zone (Coastal Habitats)

Coral Reefs

Coral reefs consist of a large rigid structural mass of calcium carbonate formed by the cemented skeletal remains resulting from the successive growth and development of reef building corals and coralline algae. The corals constitute the more important component since they give vivid color and varied three-dimensional form to the reef.Coral reefs in Sri Lanka can be found along 2 to 3 percent of the nation's total shoreline (Figure 1). They are mostly of the fringing type, meaning they occur adjacent to shore and grow from the sea floor, usually on a nucleus of rock.Barrier reefs, which are ridges of corals lying some distance from shore and running parallel with it. are rare in Sri Lanka. Examples of barrier reefs are the formations at Vankalai and Silavathurai. Both fringing and barrier reefs dissipate wave energy and are important for coastal stability and as a source of beach material. Coral reefs occur in shallow coastal waters that are clear and free from excessive freshwater and nutrients. Growth of corals depends on the presence of microscopic symbiotic plants in their body walls. These plants require sunlight that passes through the clear, shallow water.Surveys have recorded 171 species of reef building corals in Sri Lanka waters. The staghorn coral (Acropora spp.) is the dominant genera. Spatial heterogeneity is a key reef characteristic providing diverse living opportunities for a multitude of plants and animals. This spatial heterogeneity is lost when corals are broken or removed. Loss of spatial heterogeneity inevitably results in a general decrease in the diversity of coral reef organisms. The growth rate of corals is slow and varies between 2 cm per year for the massive brain coral and 10cm per year for branching corals. When physical damage occurs, its consequences are rapid and obvious. Coral reefs can become masses or rubble encrusted by algae without the color and productivity that characterizes living reefs. Reef degradation by pollution, however, is insidious and them anifestation of damage occurs over a prolonged period. This process is seen in some of the reefs at Vanderloos Bay where white patches on boulder corals correspond to areas where corals have died. In Polhena, rotting of coconut husks in the intertidal region has led to the destruction of coral reefs.

Estuaries and Lagoons

An estuary is a semi-enclosed coastal body of water which has a free connection with the sea, and within which sea water is measurably diluted by freshwater derived from land drainage. For management, the estuaries in Sri Lanka need to be subdivided as basin estuaries and riverine estuaries, since the main management issues for the two types are fundamentally different. Basin estuaries form where rivers discharge into relatively shallow basins which in turn connect with the sea (Negombo and Puttalam Lagoons). Numerous coastal bodies of water that are named as lagoons (Puttalam, Negombo, Chilaw, Jaffna and Batticaloa Lagoons) are actually basin estuaries. Riverine estuaries are formed by rivers discharging directly into the sea by way of relatively narrow channels (Kelani Ganga estuary, Nilwala Ganga estuary). Lagoons are coastal bodies of water containing brackish water which are either permanently separated from the sea or are connected to this sea only during part of the year. Sri Lanka's estuaries and lagoons are shown in Figure 2. Many of these estuaries are closely linked with the major urban centers along the coast. As populations increase and urban expansion continues, the estuaries, in addition to their natural functions, will be required to support a widening range of human activities. Sri Lanka's estuaries support many commercially important organisms that contribute both to estuarine and nearshore fisheries. Some 90 percent of organisms of commercial importance captured in estuaries and lagoons arrive as migrants from the sea. This productivity depends largely on the estuary's mix of fresh and marine waters in providing and renewing nutrients, organic material, sand, oxygen, and water circulation patterns. Sand transported by rivers into the sea by way of riverine estuaries is important to beach maintenance. The eventual fate of basin estuaries and lagoons is extinction by sedimentation. This process occurs through the stabilization of shoals by vegetation, barrier formation by long shore drift or opening up to an estuary mouth by erosion to form a bay. The pace of extinction depends primarily upon geomorphology and can be increased by human activities.

Mangroves

Mangroves are salt-tolerant, woody, seed-bearing plants ranging in size from small shrubs to tall trees. They occur along sheltered intertidal coastlines, and in association with estuaries and lagoons. Although mangroves occur on saline soils they have the usual plant requirements of freshwater, nutrients and oxygen. Mangrove cover was 8687 hectares in 1993. This area represents a small percent of Sri Lanka's total low energy coastal habitat (salt marshes, tidal flats, estuaries, lagoons). Since tidal amplitude in Sri Lanka rarely exceeds 75 cm. mangroves occur as a narrow intertidal belt and extend less than one kilometer landward from the mean low water tidal level. There are 14 species of true mangroves and 12 species of mangrove associates in Sri Lanka. The most extensive mangrove stands occur in the Puttalam, Batlicaloa, Trincomalee, Jaffna and Gampaha districts. They are absent along exposed shorelines affected by seasonally high wave energy in the southwestern, southern and northeastern coastal sectors. Some dense localized stands occur in association with lagoons at Koggala and Kalametiya which are more or less separated from tidal influence. The mangrove ecosystem can be a major source of food and nutrients to estuarine, lagoon and nearshore coastal waters, and provides a nursery for the early stages of commercially important crustaceans and fish.Mangroves stabilize shorelines against erosion, both in estuaries as well as along some segments of the eastern coast where their presence inhibits wave damage. Mangrove stands also help control runoff thereby reducing siltation in estuaries and seagrass beds. Mangroves support a number of subsistence and commercial uses critical to the welfare of some coastal communities. Permits are being issued for cutting mangroves in certain areas by District and Divisional Secretaries under the provisions of the Forest Ordinance.

Seagrass Beds

Scagrass beds are composed of rooted, seed-bearing, marine plants (halophytes). They occur in shallow, nearshore coastal waters that are sheltered from high wave energy, and in estuaries and lagoons. The seagrasses, epiphytes and the abundant detritus found in seagrass beds together comprise a highly productive habitat that supports many commercially important organisms. Seagrass beds are abundant along Sri Lanka's coast although their locations and extent have not been precisely mapped and estimated. They form dense underwater meadows, the edges of which may be glimpsed during low tide. They often occur in association with coral reef ecosystems. Seagrasses allow epiphytic organisms to obtain sites for attachment and provide nesting habitat and food for a number of species of fish. They also provide habitats and food for the endangered Dugong and Sea turtles. Some herbivorous fish consume the leaves, some juvenile fish feed upon epiphytes and several shrimp species feed upon grass detritus. Lastly, seagrass binds sediment and stabilizes it against erosion.The major portion of marine fisheries production in Sri Lanka is obtained from the nearshore coastal waters along the northwestern and northeastern coasts. These are also the areas where seagrass beds are most extensive. The linkage between seagrass beds, coral reefs, and fisheries production is direct and critical, but not usually quantified nor always recognized.

Salt Marshes

Salt marshes consist of herbaceous, salt resistant plants growing in sandy or muddy tidal flats in arid areas which are periodically inundated by sea water.Salt marshes are common characteristics of coastal areas in temperate climatesand they are generally replaced in the tropics by mangroves. Nevertheless,tropical versions of salt marshes occur.In Sri Lanka salt marshes occur mainly in regions where the dry season is prolonged as in the north, northwest, northeast and southeast. Whereas the saltmarshes in the northern regions occur mainly on exposed tidal flats, in the souththey occur largely in the shelter of sand dunes.Salt marsh vegetation in Sri Lanka typically occurs as sparse, short growth interspersed with scrub mangroves. In the Mannar district where tidal flats are more extensive, marsh vegetation contains up to 56 species. In the vicinity of Mundel Lake, there are salt marsh and mangrove associations. This type of salt marsh mangrove association is created by changes that occur in mangrove stands when the canopy is removed causing the soil to become dehydrated and hypersaline, allowing salt marsh vegetation to develop. The major natural functions of salt marshes are to provide nutrients to nearshore coastal waters, provision of bird habitat, supply of seed fish for coastal aquaculture and as a discharge area that can absorb storm water runoff. Salt marshes are not heavily utilized in Sri Lanka at the present.

Barrier Beaches, Spits and Dunes

Barrier beaches and spits. Barrier beaches are accumulations of unconsolidated sediment transported ashore by waves and molded into a form that lies across a body of water and isolates it from the sea (Rekawa beach). Spits are essentially incipient barrier beaches that project from the shore in the direction of dominant drift and are free at one end (e.g. the shoal that builds seasonally at the mouth of Negombo Lagoon).

Dunes are wind blown accumulations of sand which are distinctive from adjacent land forms such as beaches and tidal flats. Although they resemble beaches they differ mainly with respect to absence of tidal effect. Dunes are unstable unless covered by vegetation.

Certain reaches of Sri Lanka's coastline consist of barrier beaches that isolate lagoons and swamps from the sea, and spits that partially enclose estuaries. Some of these formations have extensive dunes associated with them as at Kalpitiya. Other barrier beaches are free at both ends and form islands (Karaitivu). Barrier beaches predominate along the southern and southwestern coasts while spits are more common along the western and eastern coasts.

Sri Lanka's most prominent spits occur along the western and eastern coasts, forming in the direction of longshore drift. Most spits are unstable. regularly shifting position, and changing the location of estuarine inlets. For instance, the inlet of Batticaloa has moved to its present position from a previous location 5 km south. Spits that protrude into estuaries are especially unstable (the spit at the Kalu Ganga estuary).

Coast protection and sand supply are the major natural functions of barrier beaches and spits. In addition, some segments of beaches serve as nesting areas for sea turtles (Kosgoda). The dynamic spits ' that form seasonally at estuarine inlets obstruct natural water flow patterns, often resulting in the flooding of low-lying lands (Kalu Ganga and Maha Oya estuaries), and in decreased fishery productivity. For example, fishery yields at Koggala Lagoon declined sharply after a spit expanded into a barrier beach and sealed off the inlet.

Prominent sand dunes in Sri Lanka are found along portions of the southern northeastern and northwestern coasts. Extensive dune systems stretch between Mullaitivu and Point Pedro, and Ambakandawila, K-alpitiya, Kirinda and Sangamakande Points.

The formation and persistence of dunes depends on the delivery of sand to the dune by wind and retention of sand by moisture and vegetation cover. Removal of vegetation results in dune migration as experienced in Manalkadu, Point Pedro in 1950.

Dunes serve as protective barriers particularly during storm conditions. Lowering of the dune by mining or by creating access to the beach decreases their effectiveness as barriers (Uswetakeiyaw'a).

Annex V

Design Outlay for Planting of Identified Landscapes

Introduction

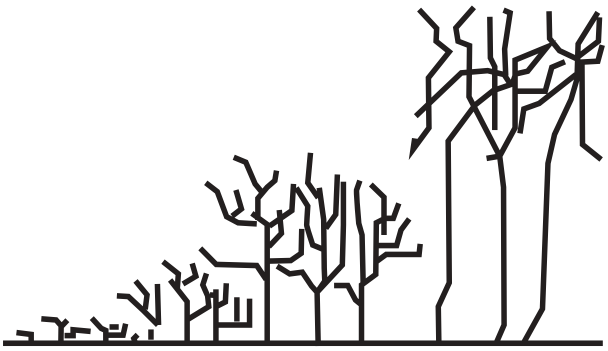
In setting out to design planting outlays the first important step is to study the area and identify whether it is urban, rural, natural or transitional. Wherever natural maritime vegetation communities exist, even as small remnants, the basic principle should be to conserve them and integrate them into the design.

Decisions have to be taken as to what to do with debris. Should it be taken away or used for creating new landform/features or buried deep at the site itself? Should there be a combination of such remedies? In some cases it might indeed be useful as a landscape construction material.e.g. for making a protective bund in an aesthetic manner.

The decisions will depend on the particular characteristics and importance of each location and will therefore be site-specific while requiring expert advice.

The appraisal and design should be done with the aid of relevant experts, always getting at least basic advice from a coastal engineer. For urban locations, landscape architects are a must. For rural locations, landscape architects are needed besides agriculturists and sometimes also foresters, because of the scenic value of the coastal strip. For natural locations, ecologists and landscape architects and sometimes other specialists such as geologists are needed. Socio-economic as well as ecological and aesthetic factors must be considered.

Arrangement of the Tree Belt



In the areas where the natural coastal tree belt had prevailed, care should be taken to mimic its original condition. The arrangement of the belt should be as follows where the design includes both ground vegetation, shrubs and then trees.

With regard to the mangrove areas, care should be taken to reinstate the mangroves from the species which were present prior to tsunami.

In Natural locations:

The natural terrain should be restored as far as possible and the natural vegetation should be restored or enhanced. In certain places its growth/regeneration may be merely facilitated, e.g. by temporary fencing to a sympathetic design.

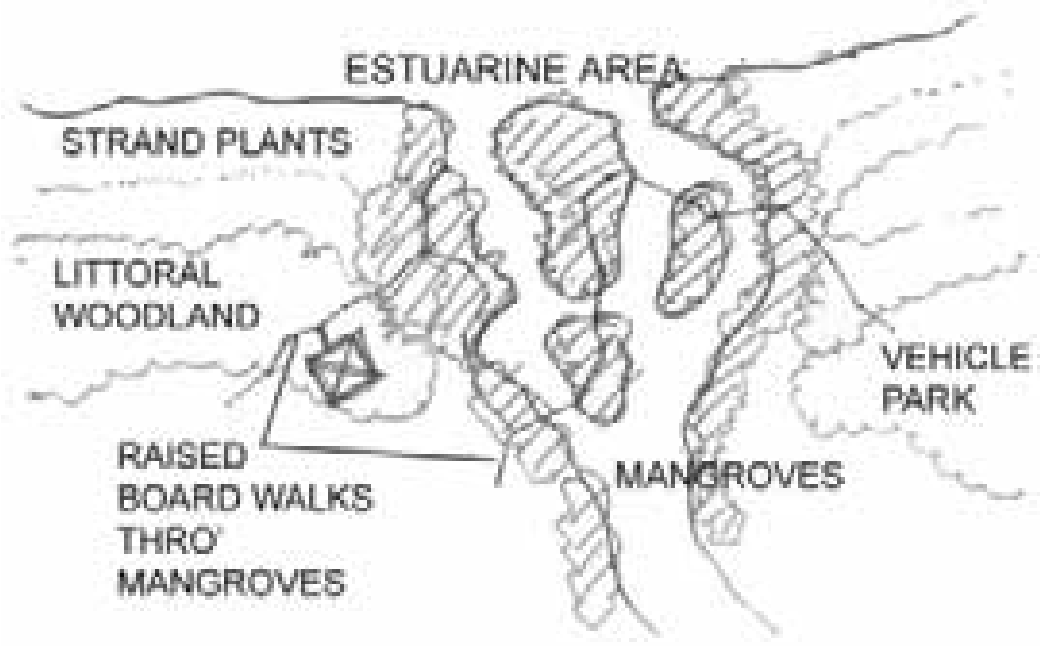
There should be very careful identification of character/ use areas and the necessary links or barriers between them.

Footpaths through mangrove forests and over sand dunes should preferably be raised board walks to ensure minimum disturbance to the mangroves or the dune stabilizing vegetation.

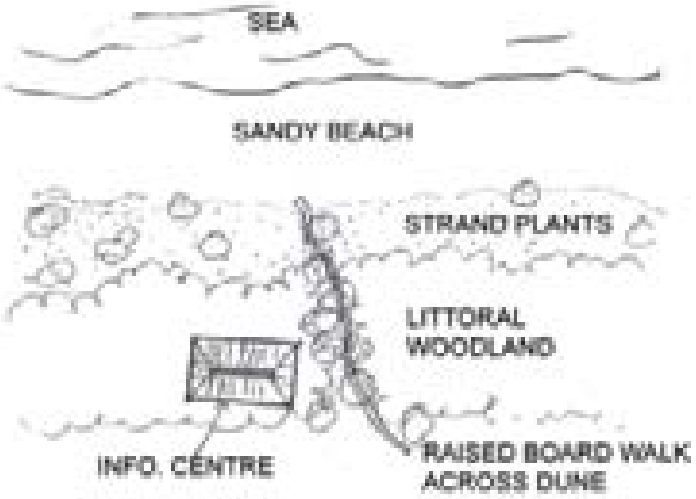
Materials, finishes, shapes, facades, styles and locations of structures should be chosen very carefully to ensure that they are in harmony with the natural habitat.

A preservation /conservation management plan should also be prepared.

Unless debris can be recycled or re-used in keeping with the principles above, it should be taken out of the site completely.



A NATURAL EXAMPLE (MANGROVE)
(Courtesy of UDA)



A NATURAL EXAMPLE (SAND DUNE)
(Courtesy of UDA)

In Rural locations:

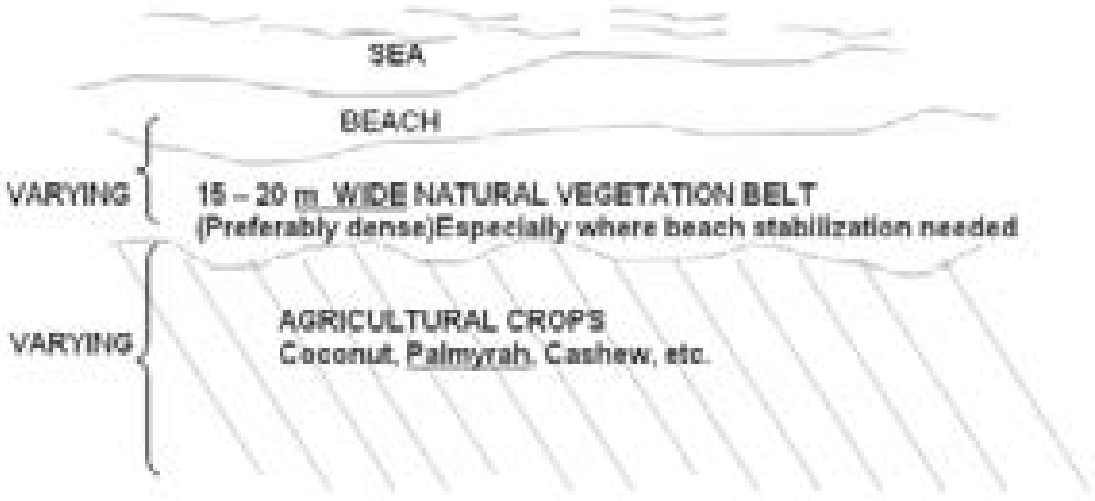
At least a 15 to 20m wide strip of natural littoral woodland and strand plants should be planted seaward of agricultural crops.

As already pointed out, any patches of natural vegetation should not be removed but integrated.

Agricultural crops, not confined to native and endemic species, should be selected to suit the specific location.

Structures, vehicle access, footpaths and cycle paths should be minimal and harmoniously integrated.

Debris may be buried, recycled or used for ground shaping: the terrain should be made suitable for the natural vegetation belt and agricultural crops chosen.



A RURAL EXAMPLE
(Courtesy of UDA)

In Urban locations:

Patches of natural vegetation should be integrated as far as possible with whatever is the most suitable concept for a particular area.

There could be open grassed/sandy/paved parks or playgrounds or sports grounds of various sizes, provided there is a substantial belt of trees on the seaward side, and in cyclone prone areas, wind shelter belts on all sides.

Plant species could be endemic/native/introduced, as long as they are adapted to the coastal location.

There could be many alternative styles, materials, finishes and colours for structures and surfaces and they should be strong enough to tolerate intensive use.

Formal geometrical layouts and regular planting will often be suitable

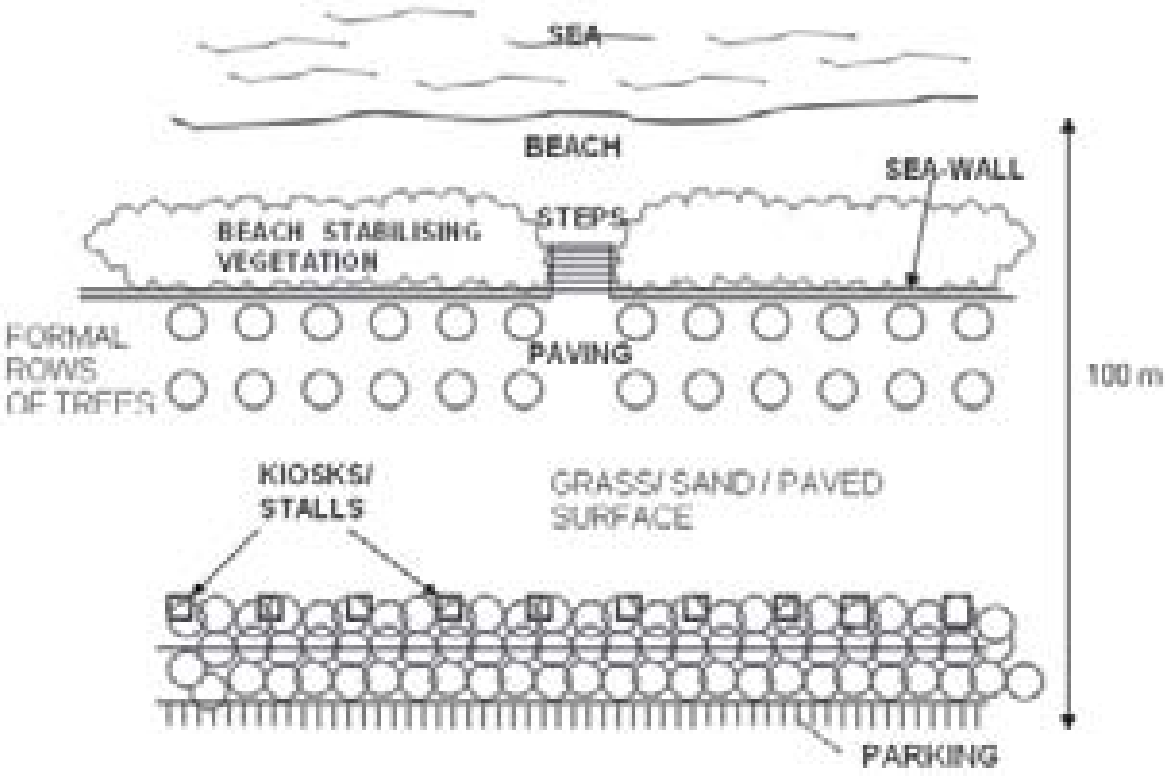
There should be sufficiently wide beach stabilizing vegetation strips between seaside retaining walls and the open beach.

Vehicle access and parking should not appropriately done not to stand out with the general aesthetics of the area.

Sea walls, piers, quays, street furniture, kiosks, picnic/ rest shelters, infrastructure facilities and other minimal permitted structures should be located and detailed with care, to ensure an attractive townscape.

A management plan should be prepared.

Debris could be recycled or re-used as landscape material if suitable.



URBAN EXAMPLE: FORMAL ESPLANADE
(Courtesy of UDA)

Annex VI

Establishment of Nurseries and Methods of Planting

The following information was extracted from the Tree Planting Manual (Nisi Lesa Pelayak Sitawamu) and the Forest Nursery Manual for Sri Lanka published by the Forest Department (1994).

Establishment of Plant Nurseries

Plant nurseries for provision of planting material for beach reservation/coastal green belt planting should be as close as possible to the restoration sites. Propagation should be done in these nurseries themselves, in order to ensure that newly planted material will become acclimatized to the maximum.

a) Collection and Storage of Seed

Use of good quality seeds is the secret to a successful planting programme. In collection of seeds, the following guidelines should be adhered to;

- Source of seed
  - *From superior trees; in size, length, stem shape, height, diameter, disease resistance (visually)*
- Time of collection
  - *When ripe, before dispersal*
  - *Change of color of fruit taken as an indicator*
- Sound, healthy, good quality seeds selected
- Twisted or less vigorous seeds rejected
- Methods of seed collection
  - *From ground – naturally fallen or after shake*
  - *From freshly fallen trees/lopping branches*
  - *From standing trees*
- Seed extraction
  - *Pulpy/fleshy fruits*
    - *By hand after drying in sun*
    - *Macerating by soaking*
  - *Dry fruits like pods, cones, capsules*
    - *By drying*
  - Seed cleaning
    - *By handpicking, Water separation, Sieving*

When storing seed, their viability period should be taken into consideration. Usually seeds within coats lose viability (life) during a short period of time, while thick coated seeds can retain viability longer. Store only seeds that are in good condition –fully mature and undamaged. Dry the seeds in a well ventilated shady area. Place the dried seed in airtight containers. Keep the seeds in a cool, dry location.

b) Seed Germination and pre-treatment

It is always better to make a germination test before sowing. Follow the steps below for a germination test of a seed batch:

- Fill a small wooden box or metal dish with fine sand (preferably sterilized) and moisten it.
- Level the sand and press a counted number of seeds just into the surface, with the width of a seed between each couple. For small seeded species sprinkle a set weight of seed evenly over the tray.
- Cover with dry sand to the depth of the seed thickness
- Place it in a plastic bag or cover with transparent polythene sheeting making sure there is plenty of air space inside and seal with string or with stones round the edge.
- Place the samples in a warm place but not in direct sunlight.
- Condensation should form on the inside of the plastic in less than twenty four hours. If such moisture goes of, carefully moisten the samples with a water sprayer.
- Count how many seeds have germinated out of the original seed lot. This can be calculated to a percentage, and this is called germination percent. This will give you an idea of the germination capacity of the particular tree species.

The seeds of species which do not readily germinate, need some kind of pretreatment. Pretreatment has two objectives; 1) to obtain a high germination percentage, and 2) to reduce the time over which germination takes place. Dormancy may be controlled by the seed coat or by the embryo, or by both. It is easy to overcome dormancy by the seed coat. When the seed coat is hard it prevents germination. Pretreatments are designed to split, soften or rub away the seed coat or remove the inhibiting chemicals. Some of the pretreatments which can be used for hard seed coated species in the replanting process are detailed below;

- Add seeds to 15 times their volume of water, which has just boiled and leave for 3 minutes, then put the seeds in cold water and leave for 24 hrs.
- Soak the seeds in water for two days and dry under shade
- For pods
  - Cut across the ends of the pods to allow water into the seed, then soak for few days. As soon as germination starts extract the seeds for sowing.
  - For very thick seed coats
  - Soak in water for 3 days, air dry for 3 days (in shade) then soak for two days, air dry for 2 days, then soak for one day and air dry for one day.
  - Mechanical treatment
    - Mechanically cutting the impervious seed coat
  - Chemical treatment
    - Soaking in lime water
    - Dilute alkali/acid
    - Salt solutions
  - Fire treatment
    - Spread the seeds on a wire mesh and subject to smoke.
  - Stratification

    Seed layers and sand/peat/charcoal layers arranged alternatively in cardboard boxes dug in soil

c) *Nursery Arrangement:*

Nurseries should be laid out so that the "*nursery stock*" (planting material) is available in healthy condition**,** with the plants spaced as necessary to ensure balanced, even growth. Trimming may be done throughout production if genuinely necessary.

The trees and other plants should preferably be grown in suitable light containers**.** Container grown trees should be regularly transplanted and grown at sufficiently wide spacing to enable full development. For example, if aiming for container grown trees with main stems having a girth (the measurement of the circumference of the stem) of 100-150 mm, meaning that the diameter will be 32-48 mm, the spacing should be at 2 m.

Footpaths and mobile equipment (e.g. cart) routes in the nurseries should be carefully laid out, and wide enough to facilitate handling of the plants by the workers as well as inspection of plants. Numbers of rows of plants should be such that the plants could be comfortably reached from the footpaths. The minimum width of a footpath, allowing one person to walk while pushing a basic handcart, should be more than the width of the cart by at least 300 mm; generally a 1.2 m overall path width is sufficient. This is also the minimum width of a footpath on which two people walking in opposite direction can pass each other comfortably. If two workers with such carts need to pass each other, then the path width should be at least 2.4 m, but this depends on the width of the carts. Special attention should be given to the width of lanes if more complex or sophisticated machinery**,** such as machinery for lifting of "standard trees" and "semi-mature trees" are to be used.

Ensure that each group of plants of the same species are stacked separately and clearly labeled, giving the botanic name and the common names.

There should be sturdy fencing and gateways for pedestrians and vehicles, a nursery office cum store including workers' facilities and also a propagation shed if necessary

d) *Site Selection, Preparation and Design*

1. Water Supply:- Water must be available all the year. Quality of water is important as much as water quantity. Approximately 1000 litres (one cubic meter) is needed each day for 20,000 seedlings.
2. Soil:- There must be supplies of sand and soil nearby. Use only top soil in potting mixtures. The effective volume of a standard polypot (4 x 9 ") is 650 cm^3. The best potting mixture is 2:1:1: (soil:sand:organic matter).
3. Access:- As close to the planting site/s as possible
4. Slope:- A very slightly sloping site is ideal to provide for drainage of surface water. There must never be water standing as this will cause roots to die and will encourage the growth of damping off fungi.
5. Exposure:- Select a site with no strong or drying winds. If necessary, erect temporary barriers of bamboo mats or coir cloth. Where strong winds are common tree or shrub wind breaks or hedges should be grown around the boundary of the nursery.
6. Labour:-Ensure that adequate local labour will be available whenever it is needed.

The following items should be included in a proper design;

- Fenced boundary
- Seedbed and stand out beds
- Internal paths
- Store for tools and materials
- Water storage
- Drains
- Soil storage shelter
- Composting area
- Shade area

Clear away all rocks, shrubs and old tree stumps. Level the site. Avoid all standing water or water-logging, and if needed build internal drains. On gently sloping sites the drains should be broad (1m wide) and shallow (15 cm deep in the centre). Lay out the position of the huts and beds with pegs and string.

It is important to ensure that a continuous water supply is available. The nursery should be set up where a deep well can be dug or piped water is present. In nursery sites which are large in extent, a concrete tank should be constructed for water storage.

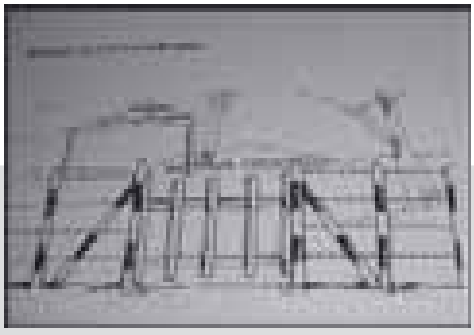
e) *Boundary and Other Buildings*

Make a wall or fence around the whole nursery to keep out animals. Possible materials are;

- Barbed wire
- Wire mesh
- Palm fonds
- Stone

In the entrance put the following;

- A gate
- A cattle grid
- A goat proof style



Every temporary or permanent nursery needs a small store with a door which can be locked to ensure safety of equipment and nursery records. It will also require a shed 4m by 2.5m to protect the soil and workers from the sun and rain. Soil which dries out in the sun become inactive because microorganisms beneficial for plant growth need moisture for survival. Seeds which are sown in trays will usually be kept in a germination shed. The germination shed should be about 2.5m high, made of local materials and lined with clear plastic to maintain humidity.

f) Seed beds

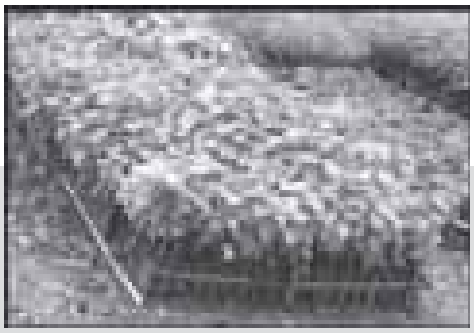
Seedbeds should be one meter wide so that it is easy to reach over the whole bed without standing on it.

- Mark out the bed with string tied to sticks (5 x 1m)
- Make a shallow trench 5 – 10m deep and erect the frame to a total height of about 25cm
- Make the frame from flat stones, wood, bamboo or bricks
- Fill the bottom of the bed with 10 cm of small round stones (3-5cm in diameter)
- Cover the layer of small stones (1-2 cm in diameter) and then coarse gravel. Total depth of these two layers about 6 cm.
- Finally cover with 5 cm of the same sterilized mixture or sand used in seed trays
- The surface should be 4 cm below the rim of the frame.
- Level and firm down.

Once the seedlings are pricked out and planted in poly-pots, these are stacked in stand out beds until taken for planting out in the field. To hold about 15 poly-pots the bed should be about 1m wide and 6m long. The distance between 2 stand out beds are about 60cm which can be used as paths. In order to prepare a stand out bed the following steps should be taken;

- Mark the corners and edges of the beds with string and wooden pegs
- Shape the ground so that the centre of the bed is slightly higher (2-3 cm) than the edges. This will ensure drainage of excess water away from the bed into the drains.
- Lay a sheet of heavy gauge polythene on the surface of the bed before the pots are set out. Make sure the edges are not turned up or they will trap water. Alternatively, use a layer of flat stones.

- Make the frame of the bed 15 cm high. It may be of split bamboo, old boards, brick or any other locally available material.
- Do not use a frame which traps water.
- Never use soil as a frame
- Make sure that water drains away freely between beds and never sands round the pots.
- Ensure that pots stay upright or bent stems will be produced.



Seedbeds and standout beds may be shaded by making a frame, and covering it with locally available materials such as split bamboo supporting palm fronds, coir or gunny bags. The shade must be movable and adjustable. Aim for approximately 70% evenly distributed shade. Polythene sheeting may be used to line the covering if protection from heavy rain is needed. Shade should be constructed in sections so that it can be rolled up.

Make provision for tying down the shade during windy weather. However, it must always be ensured that fresh air can circulate freely.

g) Nursery Stock

Nursery stock is produced in several ways

- Direct sowing in pots
  - Seeds are sown directly in the polypots.
- Sowing in seedbeds or trays and pricking out later
  - Seeds are sown in seedbeds or in small trays, and pricked out into polypots
- Direct sowing in beds and stumping
  - Seedlings are grown in open beds. At planting time, the seedling is lifted from the bed and the shoot and roots are trimmed to produce a 'stump' for planting (eg. teak)
- Taking wildings
  - Transplanting naturally regenerated seedlings from the wild into polypots

In general, the root system of a plant should be well balanced in relation to the plant, and it should be conducive to successful transplantation. Trees and shrubs should be materially undamaged and free from pests, diseases, discoloration and deformity. The root ball or the compost in the container should be free from perennial weeds.

***h)* Sowing Seeds, Watering and Shading**

For species which take three or more weeks to reach a size at which they can be safely picked out, use a mixture of equal parts of sand and top soil. For species that are ready for picking out in less than three weeks, use pure sand. Remove silt from sand by washing with five times its volume of water in a bucket. Shake vigorously and pour off the water. Repeat until the water is clean. This will improve drainage and more importantly it will stop a crust forming on the surface. Do not add animal manure or compost to the mixture. Pass the mixture through a sieve with a 2 mm mesh. Newly germinated seedlings are very susceptible to fungal attack and can be killed within 24 hours. Therefore it is necessary to sterilize the medium used in seedbeds/trays so as to kill not only harmful fungi but also weed seeds, insects and nematodes. This can be done by the following method;

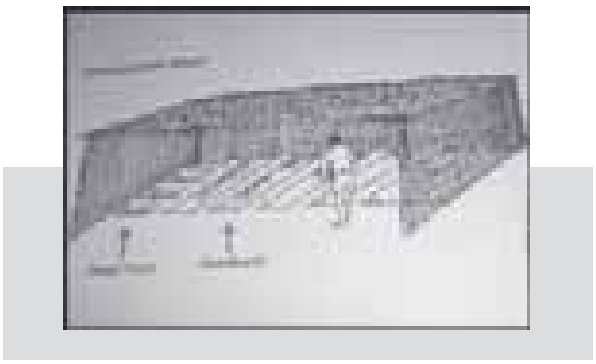
Cut a 200 litre oil drum in half lengthwise. Scrub the drum with warm, soapy water. Put the medium in it and moisten well. Heat over a fire to 60^0 C (just too hot to touch) for half and hour constantly turning the medium over with a spade so that the soil at the bottom is not overheated.

Sowing should be done in the germination shed. Do not grow more seedlings per square meter as the danger of damping off will be increased, and overcrowding will result in weak seedlings. Very small seed can be mixed with twice its volume of sterilized sand to make it easier to spread evenly. Cover the seed with its own thickness of sand or soil mixture.

Keep the seedbeds moist but do not over water as this will lead to damping off. To judge the wetness of the soil press back of the finger on to the surface. If the soil is moist enough it will feel wet and particles will stick to the skin. If the soil is dry and hardly any particles stick to your finger watering is needed. Watering may be needed up to four times a day. Water with a mist sprayer. Better to avoid watering cans as they are much too coarse for the fine seeds. When watering, direct the nozzle of the spray upwards or hold it at least 60 cm from the bed so that the seeds are not disturbed.

Newly germinated seedlings of most tree species require shade. Provide shade about 30 cm above soil level.

Normally seedlings are ready for picking out when they are not more than 2-3 cm high and with 3 to 4 true leaves, as well as the cotyledons. Picking out is a most delicate operation, as small seedlings are very tender. The precise stage for best results varies with species. Water the pots the day before picking out. Water the seedbeds both on the day before and again just before lifting the seedlings. Work under shade in the late afternoon or early morning. Lift a few seedlings at a time with a flat stick and drop them at once into a shallow bowl of water. When lifting seedlings, hold them by their oldest leaves or the cotyledons. Never hold them by their stems. Make a hole in the potting medium with a round stick about thickness of a pencil. The hole must be deep enough for the roots to drop in without being bent into a J or U shape. If necessary lay the wet roots on dry sand to add weight to assist in lowering the roots into the hole. Fill the hole with a finely sieved mixture of dry sterilized sand poured from a bottle. This dry sand will quickly absorb moisture from the soil. Water with a knapsack sprayer. Keep the pots very moist for the next two to three days. Keep the seedlings shaded for a few days. When the seedlings start to grow new leaves, gradually remove the shade by taking it off for one hour in the morning and one hour in the late afternoon. Gradually increase this period until after one week after which no shade is provided.



i) Poly-pots and Potting Medium

Use standard poly-pots of 9 x 4 inch laid flat size, made of 300 gauge polythene. Use black polythene if the time in the nursery will be more than 5 months. Have three rows of three holes 8 mm in diameter in the bottom part of the pot.

Pots are usually filled with a mixture of top soil, sand and well rotted cow dung or compost normally in the ratio of 2:1:1. Use the top soil from an area with good chemical and physical soil properties. When collecting soil, first remove surface vegetation then dig out soil to a depth of 20-30 cm. If weed seed is a problem, carefully scrape off and discard the top 1 cm of soil with the surface vegetation. Break up lumps then pass the soil through a coarse (10-20 mm) sieve to remove stones, lumps and roots. Do this when the soil is dry. Sand should be clean and free from silt. Adding organic matter by way of compost will be beneficial to improve physical structure of the potting medium when good top soil is not available. When animal manure is available, it is better to be used with compost. It is not appropriate to use fresh manure it should be old and well rotted. Chicken manure mixed with rice straw in equal parts is acceptable.

When preparing the potting medium, pass the soil and sand through a sieve of 5 mm mesh. Put sand, soil and compost one on top of the other and mix them together with a spade. Turn the heap over and then back to where it was. Do this few times until there is thorough mixing. Store the mixture in the potting shed. When filling the mixture into poly-pots, rub the pot between the fingers to open it and fill the pot with the mixture. Use a trowel or locally made scoop. Add mixture and firm down in 3 or 4 stages. Do not fill the entire pot and then try to make the soil firm, as this will leave pockets of air. Fill to within one centimeter from the top of the pot. Be careful not to damage the top of the pot. Water the pots and keep them moist until seed is sown or seedlings are picked out. Fill pots as close as possible to the time of sowing or picking out.

Direct sowing into pots is however, the most suitable method for large seeds. Push the seed into the medium until it is covered by twice its own thickness but never more than 5 mm. When germination is complete, remove surplus seedlings to leave one per pot. Do not transplant the removed seedlings.

3.3 Method of Planting

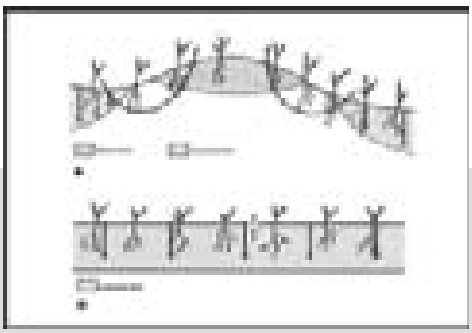
a) **Site Preparation**

The area available for planting on the beach is usually having the following characteristics;

- High salinity (the usual salinity level had been aggravated by tsunami)
- High evaporation
- The substrate (sand) is having low organic matter; tsunami has brought debris which has decomposed and therefore some organic matter is available on the beach

Therefore the following management practices are recommended;

- Growing salt-tolerant crops
- Reducing deep tillage by adopting *conservation tillage*, including *no-till* (deep tillage may bring salts up to the topsoil from deeper soil horizons)
- Returning manure and crop residues to the soil (increased organic matter improves the ability of soil to retain water, preventing it from moving into groundwater)
- Watering the plants much more than their requirement so that the salt will be flushed out
- *Levelling*
  Secondary salinization can occur from uneven distribution of irrigation water due to irregular topography. Microdepressions act as points of focused recharge; salts are leached from the recharge locations. Adjacent microknolls, however, act as points of focused evaporative discharge; salts accumulate and may cause salinity problems at the discharge locations. Levelling the site allows more even water distribution and avoids concentration of water and salts at specific places in the field.



b) Time of planting and Spacing

Just after the first monsoon rains either Maha or Yala depending on the site. In wet zone sites both rains can be utilized while in the dry/arid zone sites Maha rains are valid. This will give a great impetus for plant growth and ample water will be available for the initial growth.

Distance between plants. Choosing the correct spacing is important as individual trees depending on their species, size etc. needs different growing spaces for optimum growth and development.

- Factors governing the spacing
  - Rate of growth of species
    - Fast – wide spacing
    - Slow – close spacing
  - Branching habit
    - Number of branches high – wide spacing
    - Number of branches low – close spacing
  - Height of trees
    - Tall trees – wide spacing
    - Short trees – close spacing
  - Site factor
    - Dry areas and areas with high weed invasion close spacing
  - Fruit trees
    - Wide spacing

c) The technique of planting the seedlings in the field

1st step

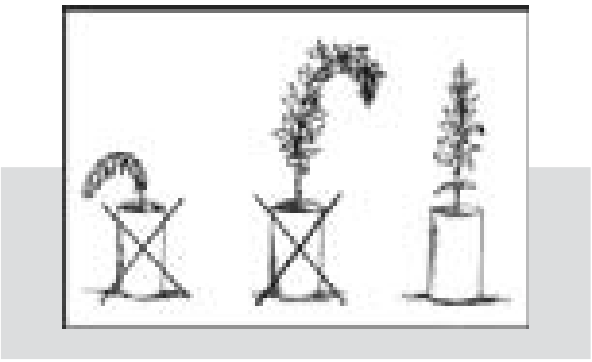
Prepare the planting holes about 18" long and 9’ wide. Place the soil on either side of the planting hole. The rule of the thumb is that the length of the planting hole should be twice as long as the length of the polypot.

2nd step

Select a suitable plant. The following are not suitable for planting;

- Very small seedlings which does not show height growth
- Seedlings showing signs of pest or disease infestation
- Plants which are showing unusual height growth (etiolated)

  The suitable plant should be about 12-15" high with straight, strong stem with healthy appearance.



3rd step

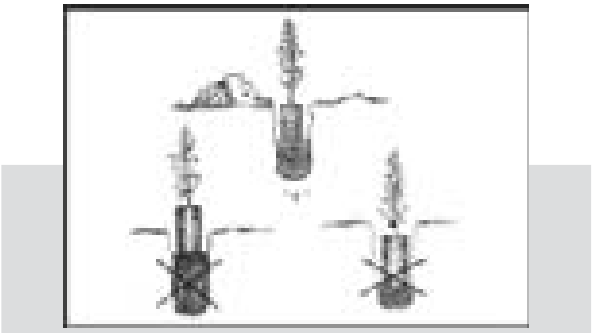
Fill the planting hole with soil upto about 9". This should be done with the surface soil which was removed when the hole was made. Mix the soil with some compost or dried cowdung.

4th step

Remove the polythene of the bag using a sharp blade. Prior to the removal, tighten the soil in the polybag with both hands so that when opening the soil will not be spilled

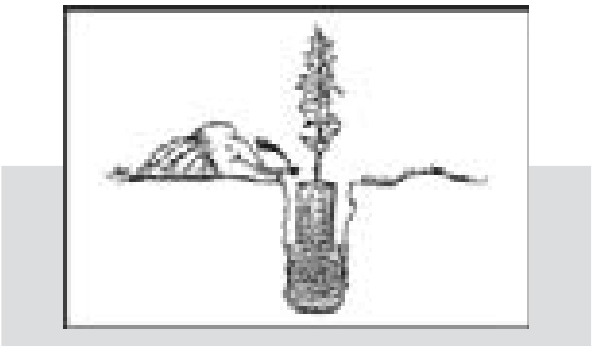
5th step

Place the seedling with the ball of soil on the soil of the planting hole. Make sure that the base of the seedling is on the same level as the soil. The best time to plant is the evening when the sunlight is mild.



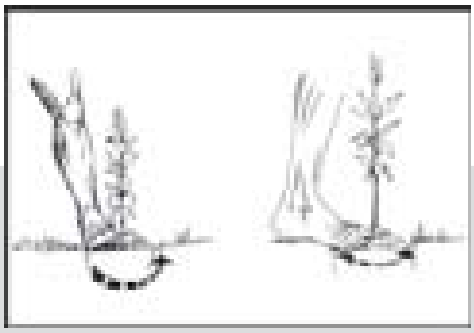
6th step

Place the remainder of the soil on the planting hole making sure that the seedlings is upright in the middle. The soil should be properly stacked so that air spaces are not abundant



7th step

Press the soil around the plant hard with the fingers of the leg. This makes sure that there are no air spaces so that water will be accumulated in them and cause adverse effects to the plant.

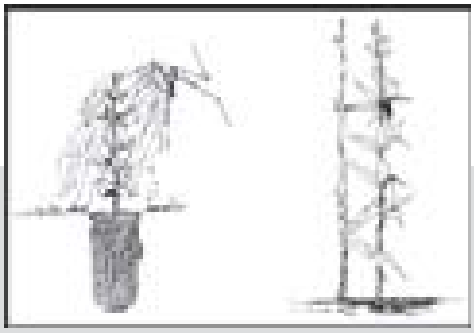


8th step

Water the plant thoroughly. To reduce evaporation loss, place leaf mould or straw around the seedling. This will help the plant in several ways;

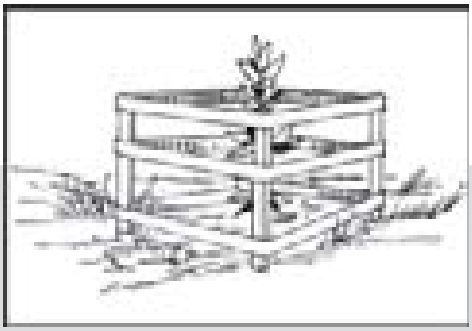
- Keep the moisture around the seedlings for a long time
- Reduce the soil temperature around the seedling even when the temperature in the surroundings are high
- Reduce the growth of weeds

To avoid the plant from sagging. A stick can be held parallel to it to provide support. This will provide support against strong winds



9th step

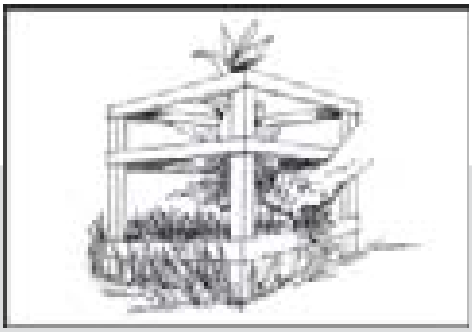
To protect the plant from animal and other disturbances, it is necessary to have a guard around it. This can be made out of sticks, tar barrels or any other suitable material



10th step

Weeding

It is necessary to remove the weeds at least in the initial stages of the seedlings until it gets established on the soil. Otherwise it will be throttled by the weeds in no time and die.



11th step

Fertilization

It is appropriate to use cow dung, leaf mould or compost to the plant for fast growth and establishment

12th step

In the event of seedlings not surviving, it is necessary to fill the gaps with similar aged seedlings taken from the nursery.

Annex VII

Setback Standards for Development Activities in the Coastal Zone by Segment and Vulnerability

Segment No.	Area	Source Map (one inch)	Level of Vulnerability	Setback Distance in (m)		Total Setback Area (m)
				Reservation Area	Restricted Area	
1	Kala Oya River mouth to Kandakuliya	Kalpitiya	Medium (-)	15	30	45
2	Kandakuliya to Uddappu South	Puttalam Battulu Oya	Medium (+)	20	30	50
3	Uddappu South to Sinna Karukkapone	Battulu Oya Chilaw	Medium (-)	15	30	45
4	Sinna Karukkapone to Toduwawa North	Chilaw	High	20	35	55
5	Toduwawa North to Mudukatuwa	Chilaw Kochchikade	Low (+)	15	25	40
6	Mudukatuwa to Porutota	Kochchikade	Medium (+)	20	30	50
7	Porutota to Kamachchode	Kochchikade Negombo	Low (+)	15	25	40
8	Kamachchode to Duwa	Negombo	High (+)	25	35	60
9	Duwa to Uswatekeiyawa	Negombo	Medium (-)	15	30	45
10	Uswatekeiyawa to Mount Lavinia Hotel	Negombo Colombo	High (-)	20	35	55
11	Mount Lavinia Hotel to Pinwatta Railway Station	Colombo Kalutara	Medium (-)	15	30	45
12	Pinwatta Railway Station to Tangerine Hotel	Kalutara	Low (-)	10	25	35
13	Tangerine Hotel to Sinbad Hotel	Kalutara	High (+)	25	35	60
14	Sinbad Hotel to Payagala South	Kalutara Aluthgama	Medium (+)	20	30	50
15	Payagala South to Maggona Bridge	Aluthgama	Low (+)	15	25	40
16	Maggona Bridge to Confifi Hotel	Aluthgama	High (+)	25	35	60
17	Confifi Hotel to Yakgahagala to Induruwa	Aluthgama	Low (+)	15	25	40
18	Yakgahagala to Kosgoda River Mouth	Aluthgama	Medium (+)	20	30	50
19	Kosgoda River Mouth to Wellawatte Balapitiya	Aluthgama Balapitiya	Low (-)	10	25	35
20	Wellawatte Balapitiya to Coral Gardens Hotel, Hikkaduwa	Balapitiya Ambalangoda	Medium (-)	15	30	45
21	Coral Gardens Hotel, Hikkaduwa to Devapatiraja Maha Vidyalaya, Ratgama	Ambalangoda Galle	Low (-)	10	25	35
22	Devapatiraja Maha Vidyalaya to Gintota River	Galle	Medium (+)	20	30	50
23	Gintota River to Maha Modara	Galle	Medium (-)	15	30	45
24	Maha Modara to Cement Factory, Galle	Galle	High (-)	20	35	55
25	Cement Factory, Galle to Welle Dewalaya	Galle	Low (+)	15	25	40
26	Welle Dewalaya to Koggala Housing Scheme (129km)	Galle	Low (-)	10	25	35
27	Koggala Housing Scheme (129km) to Kataluwa Bridge	Galle	Medium (-)	15	30	45
28	Kataluwa Bridge to Midigama	Galle Matara	High (-)	20	35	55
29	Midigama to Walliwala East (140km)	Matara	Low (-)	10	25	35
30	Walliwala East (140km) to Palana	Matara	High (+)	25	35	60
31	Palana to Madiha East	Matara	Low (+)	10	25	35
32	Madiha East to Devinuwara	Matara	High (-)	20	35	55
33	Devinuwara to Goyambokka Peace Haven Hotel	Matara Tangalle	Low (-)	10	25	35
34	Goyambokka to Kapuhena	Tangalle	High (+)	25	35	60
35	Kapuhena to Henagahapugala	Tangalle	Low (+)	15	25	40

36	Henagahapugala to Lunama	Tangalle	High (+)	25	35	60
37	Lunama to Wanduruppa	Tangalle	Low (+)	15	25	40
38	Wanduruppa to Godawaya	Hambantota	High (+)	25	35	60
39	Godawaya to Mirijjawila	Hambantota	Low (+)	15	25	40
40	Mirijjawila to Koholankala	Hambantota	High (+)	25	35	60
41	Koholankala to Parawamodaragala (Yala National Park)	Hambantota Tissamaharama	High (+)	45	80	125
42	Parawamodaragala to Murugatena Lagoon	Yala Panama Potuvil	Low (-)	20	30	50
43	Murugatena Lagoon to Kandaraj	Potuvil	Medium (-)	30	50	80
44	Kandaraj to Tambiluvil	Potuvil Tirukkovil	Low (+)	25	40	65
45	Tambiluvil to 228 Mile Post, Cemetery	Tirukkovil	High (+)	45	80	125
46	228 Mile Post to Periya Kallar	Tirukkovil Kalmunai	Low (+)	25	40	65
47	Periya Kallar to Ondachchimunai	Kalmunai	High (+)	45	80	125
48	Ondachchimunai to Kallady	Kalmunai Batticaloa	Low (-)	20	30	50
49	Kallady to Bar Light House, Batticaloa	Batticaloa	High (+)	45	80	125
50	Bar Light House, Batticaloa to Kalkudah	Batticaloa Kalkudah	Medium (+)	30	50	80
51	Kalkudah to Pulsri Point	Kalkudah	Low (+)	25	40	65
52	Pulsri Point to Foul Point, Kevuliya	Kalkudah Vakaneri Kathiramalai	High (+)	45	80	125
53	Foul Point, Kevuliya to Fort Frederick	Trincomalee	Low (-)	20	30	50
54	Fort Frederick to Alles Garden	Trincomalee	High (-)	40	70	110
55	Alles Garden to Thavikallu	Nilaweli	Low (-)	20	30	50
56	Thavikallu to Kokilaikanni	Nilaweli Padaviya	Medium (-)	30	50	80
57	Kokilakanni to Thumpalai	Kokilai Mulathivu Eranamadu Elephant Pass Point Pedro	High (+)	45	80	125
58	Thumpalai to Thiruvadeniya	Jaffna Point Pedro	Low (-)	20	30	50
59	Thiruvadeniya to Mandathivu	Jaffna Delft	Medium (-)	30	50	80
60	Delft Islands to Nayinativu, Karaitivu and other Islands	Jaffna Delft	Medium (+)	35	60	95
61	Kalmunai to Devil Point	Pooneryn	Low (-)	20	30	50
62	Devil Point to Weeramandimunai	Thunakkai	Medium (-)	30	50	80
63	Weeramandimunai to Sinnativu	Thunakkai	High (-)	40	70	110
64	Sinnathivu to Periya Aru	Thunakkai	Low (+)	25	40	65
65	Periya Aru to Padavithurai	Manthai	High (-)	40	70	110
66	Padavithurai to Nayatumunai	Manthai	High (+)	45	80	125
67	Nayatumunai to Manthai	Manthai	High (-)	40	70	110
68	Mannar Island	Murukkan Talaimannar	Medium (+)	30	50	80
69	Manthai to Aruvi Aru River mouth	Murukkan	High (+)	45	80	125
70	Aruvi Aru River mouth to Kala Oya River mouth (Wilpattu National Park)	Murukkan	High (+)	45	80	125

Classification of Coastal Segments by Vulnerability and Setback Distances (m)

Level of Vulnerability	Coastal Segment Nos 1-40			Coastal Segment Nos 41-70		
	Reservation Area	Restricted Area	Total Setback	Reservation Area	Restricted Area	Total Setback
Low (-)	10	25	35	20	30	50
Low (+)	15	25	40	25	40	65
Medium (-)	15	30	45	30	50	80
Medium (+)	20	30	50	35	60	95
High (-)	20	35	55	40	70	110
High (+)	25	35	60	45	80	125
	Protected Areas		300	Protected Areas		300

Annex VIII

Coastal Plant Communities of Sri Lanka

The different groups of plants which make up the natural coastal vegetation warrant description here, as they constitute the most effective wave barriers, erosion control devices and wind shelter belts, naturally adapted to the vagaries of the coastline climate, while being a prerequisite for conservation or creation of indigenous character where necessary in the interests of tourism. There are three broad categories of such **Coastal Plant Communities**:

- Mangrove Communities in river estuaries and lagoons,
- Salt Marshes on sandy/muddy flats in the two arid zones of the country (northwest and southeast), including dry saline communities on higher ground occasionally subject to tidal inundation,
- Sea Shore Vegetation (along most of the coastline), on gentle broad shores, steep shores, eroding shores and sand dunes.

Usually these communities merge gradually with the natural inland vegetation type of the area just behind them (unless the latter is already greatly disturbed or destroyed), e.g. the Dry Monsoon Forest in many dry zone regions such as certain parts of Trincomalee District, and the Thorn Scrub in Wilpattu and Hambantota.

Mangrove Vegetation

Mangroves are purely tropical communities, found only in belts of the coast lying between high and low tides, exposed to seasonal or perennial inundation by sea water. In Sri Lanka, they occur in river estuaries, shallow lagoons and shores of deeper lagoons in Jaffna, Mannar, Puttalam, Negombo, Gintota, Koggala, Tangalle, Hambantota, Batticaloa, Trincomalee and Mullaitivu. In such habitats, the soil is water-logged, poorly aerated, blackish, and regarded as “humic clays”. The water is brackish all the year round, but there is seasonal variation in salinity and acidity owing to tidal fluctuations. In smaller, shallower lagoons (less than 3m in depth), the daily and seasonal variations in temperature are very noticeable, e.g. Rekawa and Kalametiya near Ambalantota.

There are two kinds of mangrove species: ***true mangroves and mangrove associates.***

True mangroves have very special adaptations to mangrove conditions and are not found in any other habitats. Key species are those of the following genera: *Rhizophora* (Kadol/Kandal), *Avicennia* (Kanna), *Bruguiera, Ceriops* (Chirukandal), *Aegiceras* and *Lumnitzera* (Beriya/Tipparathai).

Mangrove associates normally occur in both coastal and inland habitats; examples of them are *Acanthus ilicifolius* (Katu ikili), *Calophyllum inophyllum* (Domba), *Acrostichum aureum* (Mangrove fern/Karan koku), *Hibiscus tiliaceous* (Belipatta), *Tamarix gallica* (Kiri) and *Terminalia catappa* (Kottamba).

There are differences between ***steep-shore mangrove communities and gentle-shore mangrove communities.***

Lagoons with steeply rising shores are characterized by a plant population composed purely of *Rhizophora* species, right at the water’s edge, followed by a zone of mixed mangroves (both true and associates), including *Bruguiera* species, *Aegiceras corniculatum*, *Acanthus ilicifoliius, Acrostichum aureum, Ceriops tagal, Lumnitzera racemosa* and *Sonneratia* species. On the higher ground above the zone which is frequently inundated by sea water, is a mixture of mangroves and species common in coastal habitats, such as *Calophyllum inophyllum* (Domba), *Clerodendron inerme* (Val Gurenda), *Hibiscus tiliaceous* (Belipatta),

Cerbera manghas (Gon Kaduru), *Tamarix gallica* (Kiri) and *Terminalia catappa* (Kottamba).

Lagoons with gentle shores are usually characterized by a mixed mangrove community of *Rhizophora, Avicennia, Sonneratia* and *Acanthus* at the water's edge, although in areas of frequent sea inundation, the other species, less tolerant than *Rhizophora*, are rare or absent. Moving inland, there is a gradual transformation of this mixed mangrove community into littoral woodland.

In certain mud flats, a mixed plant population consisting almost entirely of *Acanthus ilicifolius* and *Acrostichum aureum* is discernible.

In some mangrove areas in river estuaries and larger lagoons along the southern and southwestern coasts, there are pure or almost pure populations of *Nipa fruticans* (Marsh palm/Gin pol) along the water's edge (e.g. Gintota, Weligama, Waikkal).

Salt Marshes and Dry Saline Communities

These are found only in the arid extremes of the north-west (Puttalam, Mannar) and south-east (Hambantota, Ambalantota) coasts. The common species include

Arthrocnemum (T-kotanai), *Salicornia*, *Suaeda* (umiri), sedges, and certain grasses.

Salt marshes occur on high ground which is periodically inundated with sea water. These sandy and muddy flats dry out during the dry season, increasing aridity and salinity. An example is Mundel lake, where the salt marsh vegetation shows a very clear zonation.

Dry saline communities occur on high ground which is rarely subjected to sea inundation and they include a variety of communities. Communities dominated by *Arthrocnemum* are open in nature and are found on sandy, dry, flat plains. *Suaeda* communities occur along the coast as well as inland; the coastal communities are dominated by the dwarf, much-branched shrub *Suaeda maritima*, with a few scattered other *Suaeda* species, and (in smaller numbers), species such as *Cynodon dactylon* (Bermuda Grass), *Portulaca species* (Urugenda, Heen genda kola, Genda kola) and *Salicornia brachiata.* In Mundel area, the grass *Zoysia matrella* is also found. In stable depressions scattered in between *Arthrocnemum* and *Suaeda* communities there is a mixed vegetation of *Microcoleus, Cynodon* species, *Cyperus* species such as *Cyperus rotundus* (Kalanduru), and *Salicornia* all showing a clear division into zones.

Seashore Vegetation

The immediate hinterland of the coastline could be deemed **RURAL** in areas where, despite a similar variation in landform to that in natural areas, the natural vegetation has been largely replaced by non-indigenous agricultural species such as *Cocos nucifera* (coconut palms) and *Borassus flabellifer* (palmyrah palms). In some cases, there might be crops such as *Anacardium occidentale* (cashewnut).a little further inland, and even patches of grassland used for grazing. In certain areas, such as Mundel, Waikkal, and Hambantota, aqua-culture (especially prawn farms) and salt-pans have replaced the original mangroves or salt marshes. Groups or strips of *Casuarina equisetifolia* (Kasa), which is also an introduced species although it may be considered as being naturalised in Sri Lanka, have been planted in many locations along both the wet zone and dry zone beaches for wind shelter or beach stabilization. Nevertheless, remnant pockets, patches and strips of natural plant communities still exist, albeit dispersed and fragmented.

It is appropriate to categorise as **URBAN** those coastal strips within or bordering urban settlements, usually including seaside parks, playgrounds, esplanades and marine drives, sometimes with seaside retaining walls and often bordered by artificial coastal protection structures such as rock revetments.

Tree and shrub vegetation closest to the high tide line would largely comprise combinations of indigenous species such as Mudilla, Mudukeyiya, Thakkada, Vara and Val gurenda, and species introduced to Sri Lanka such as Pol, Thal, Kottamba, Suriya, Casuarina, and Agave species. Although most of the natural strand vegetation would have been destroyed or removed, there could still be patches of creepers such as Mudu-bim-thamburu and Maha-ravana-ravula, and grasses such as Bermuda Grass and Manila Grass. Even mangroves persist in some urban areas, although extremely prone to (often unauthorized) filling and encroachment. Further inland within the designated coastal reservation there could be other species such as Domba, Palu, Kohomba, Madan, Fig family trees (e.g. Banyan), Letta-kochcha, Amba, Cashew, Kelani Tissa, Kaneru, Kahakaneru,Vadamal, etc.

Source: Guidelines for Coastal Reservation Greenbelts in Sri Lanka, Prepared by Ms Hesthor Basnayake, of UDA.

IUCN
The World Conservation Union

The World Conservation Union (IUCN) was founded in 1948 and brings together nearly 1,100 members (States, government agencies, NGOs and affiliates) and some 10,000 scientists and experts from 181 countries in a unique worldwide partnership. Its mission is to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. Within the framework of global conventions IUCN has helped over 75 countries to prepare and implement national conservation and biodiversity strategies. IUCN has approximately 1,000 staff, most of whom are located in its regional and country offices while some 150 work at its Headquarters in Gland, Switzerland.

In the context of IUCN's mission, the role of the IUCN programme in Sri Lanka is to be a facilitator of conservation action. It plays a catalytic role, and offers effective platforms to promote dialogue and discussion among the various partners engaged in conservation work. The emphasis of the Programme is to support sustainable natural resource initiatives of the Union's members and partners in Sri Lanka, in biodiversity conservation, conservation and management of critical habitats, environmental policy support, institutional support and environmental education and awareness. It also provides opportunities for the practical application of methodologies developed through the Union's scientific networks to support the conservation initiatives of members and partners of IUCN in Sri Lanka.

The in-country operations of IUCN in Sri Lanka commenced in 1988. In addition to the country office in Colombo, the programme has now expanded with four regional offices operating from the southern, eastern and central parts of the country.

The World Conservation Union

53, Horton Place
Colombo 07
Sri Lanka

Tel. +94 11 2682418
Fax. +94 11 2682470
E-mail. iucn@iucnsl.org

www.iucnsl.org

Sri Lanka Country Office