



**ASSESSMENT OF FORESTRY-RELATED REQUIREMENTS FOR
REHABILITATION AND RECONSTRUCTION OF TSUNAMI-AFFECTED
AREAS OF SRI LANKA**

MISSION REPORT

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1. Executive Summary

The December 2004 Indian Ocean Tsunami struck the island of Sri Lanka with devastating consequences. As a result, FAO mounted a mission to assess the impact of the Tsunami on forestry-related issues, and to plan for rehabilitation and reconstruction of the affected areas. The key features investigated included assessment of needs and opportunities where the forest sector can contribute to the relief and rehabilitation effort, collect information on ongoing forest-related activities, examine the availability of timber supplies for reconstruction purposes, assess the risk of forest pest outbreaks, and prepare proposals for rehabilitation and reconstruction efforts.

The impact of the Tsunami was most severe on the eastern and northern coastal areas, and somewhat less severe in the southern areas. The western areas were relatively unaffected. In addition to considerable loss of human life and destruction to homes and other infrastructure, the natural and manmade vegetation along the coastal areas was severely affected. The Tsunami exerted considerable force on the coastal areas and physically altered the coastline. Along weak coastal fronts, the waves tunneled their way inland for significant distances. The waves wiped out the ground and shrubby vegetation along the beachfront, and moved sand and marine sludge inland. Nevertheless, the intact vegetation front of trees, both natural and manmade, remained undisturbed. They were, however, breached where there was disturbance to the trees or the soil. Although the front line of trees may have been brought down by the force of the waves, the trees further up the coast remained virtually intact. This was especially evident with the wide belts of mangroves. Similar effects were apparent with sand dunes. These undisturbed sites remained intact while the others were easily overwhelmed. The result was that humans living behind these vegetation shelterbelts were well protected

from the wave damage, but the toll was considerable in exposed sites or where there were breaches. A further consequence was the damage to home gardens ringing the coastal areas. Here, the damage was not uniform and herbal and ground vegetation was completely lost. However, the tree crops behaved variably – most of the coconut palms were not affected by the inundation, but other palms and several timber and fruit trees began to dry, probably due to the high salinity of the soils. There were no signs of pest outbreaks as a result of the Tsunami damage to the vegetation along the coasts. There are appropriate conditions to meet the timber needs for reconstruction work through local supplies and imports. Similarly, the fuelwood needs of the people along the affected areas can be substituted with additional supplies from neighbouring inland areas, as well as through using alternative sources of fuel.

For the purposes of rehabilitation and reconstruction, the following proposals appear viable:

- An overall assessment, quantitative and qualitative, of the status of the coastal ecosystem and other physical barriers should be carried out, and their role in mitigating the impact of the wave surge.
- A simplified coastal area management guideline with attention to treatment of natural ecosystems should be developed.
- Coastal shelterbelts of exotic and indigenous species should be planted in appropriate sites, to be undertaken jointly by the Forest Department and the localities. The involvement of the local communities will ensure ownership and effective long-term maintenance of the shelterbelts.
- The redevelopment of home gardens in appropriate sites should be supported in order to meet the needs of homesteads.
- While most of the timber for reconstruction can be met, local facilities should be developed for processing the timber so the reconstruction work can be accelerated.

2. Background

At approximately 08.40 a.m. on 26 December 2004, the Indian Ocean Tsunami struck the east coast of Sri Lanka. A secondary wave struck around 20 minutes later. The 5–6.5 m wave surges hit most of the eastern, northern and portions of the southern coasts, causing extensive damage to all the coastal areas up to 3 m above sea level. In sum, the Tsunami affected two-thirds of the coastline of Sri Lanka (approximately 1 000 km), with sea water penetrating tens to hundreds of meters inland, and most of it drained away within 30 minutes. Close to 37 000 people died from drowning or debris impact. In addition, over 100 000 houses, much infrastructure, and thousands of vehicles were destroyed. The natural ecosystem took a heavy pounding.

A state of emergency was declared in all the affected areas, and emergency and security services were deployed. The donor community, international agencies, NGOs and government departments responded immediately to first provide emergency assistance to the affected people. This action was followed by assessment of the damage and the recovery and restoration needs by many different agencies, including the measures needed to bring back the livelihoods of survivors.

In addition to providing emergency assistance, FAO is sending various technical missions to assess the damage and recovery needs of several sectors, including fisheries, agriculture and forestry. This report is on the assessment of forestry-related requirements for rehabilitation and reconstruction of Tsunami-affected areas of Sri Lanka.

3. Key features of the Mission and approach

The Terms of Reference (TORs) of the mission are given in Annex 1. The key features of the mission are to:

- Assess the major needs and opportunities in the forest sector that can contribute to the Tsunami relief and rehabilitation efforts.
- Collect information on ongoing and planned programmes in forest-related assistance for the Tsunami recovery efforts undertaken by international, national and local agencies.
- Collect information from the national agencies and other relevant bodies on the availability of timber and other wood products in Sri Lanka to supply the demand for reconstruction of the infrastructure damaged and destroyed by the Tsunami.
- Assess the risk of forest pest outbreaks from debris left from the Tsunami.
- Prepare a forest-related project proposal for FAO's assistance to Sri Lanka for the Tsunami rehabilitation, and identify partners with whom these efforts can be carried out.

Following initial debriefings with the FAO Representative and staff, the Forest Department of Sri Lanka arranged all the field visits and appointments with all the relevant agencies. The report is based on discussions with technical experts from national and international agencies, a review of published material, and field visits to verify the various perceptions and viewpoints. The list of experts who provided both information and assistance for this study is given in Annex 2. The travel route and places visited are given in Figure 1 and Table 1.



Figure 1. Map of Sri Lanka with main townships

Table 1. Coastal townships/villages visited for assessing the impact of the Tsunami in Sri Lanka

Province	District	Townships/villages
Western	Colombo	Dehiwala
	Kalutara	Moratuwa, Panadura, Maggona, Kalutara, Katukurunda
Southern	Galle	Bentota, Ahungalla, Ambalangoda, Hikkaduwa, Galle, Koggala
	Matara	Welligama, Matara, Tangalla, near Ranna
	Hambantota	Ambalantota, Hambantota, Wallodaya
Eastern	Ampara	Pottuvil, Komari, Tirukovil, Akkaraiputtu, Karaitivu, Kalmunai
	Batticaloa	Maruthamalai, Kalluthavillu, Dharmapuram, Palmunai, Kallady, Batticaloa, Kalkudah

4. Impact of the Tsunami

4.1 General overview

The Tsunami affected 135 townships (small and large) in 12 coastal districts in Sri Lanka (Table 2). This represents around 45 percent of the total townships in the districts. The total population in the area is just over 10 million. In an instant, 0.35 percent of them died or went

missing and over half a million (5 percent) have been displaced. Of the 2 million homes in the area, over 112 000 (5 percent) have been fully or partially destroyed. Almost half of the nearly 70 000 residences were lost in Ampara and Batticaloa.

The gravity of the situation becomes even more striking when these numbers are observed from the district level. In districts like Batticaloa, Ampara and Mullaitivu, between 1 and 2 percent of the population disappeared, and between 12 and 24 percent of the survivors have become homeless. Of the deaths, nearly two-thirds occurred in only three districts, Mullaitivu, Ampara, and Hambantota. Over half a million people have been displaced, most of them – 58 percent – in Ampara, Galle and Batticalao. Most of the affected groups belong to the already extremely vulnerable communities, the poor fishermen and farmers living close to the shore in simple shelters – they took the brunt of the impact. Overall, the percentage of the coastal population affected was highest in the northern and eastern districts – Ampara (78 percent), Trincomalee, Mullaitivu (80 percent), followed by southern districts – Galle, Kalutara (approximately 20 percent), while the western districts were mostly spared (e.g. Colombo, Gampaha). Nevertheless, there were pockets of severe damage in the latter districts.

Table 2. Impact of 26 December 2004 Indian Ocean Tsunami on lives and households in Sri Lanka

Affected districts	Present population	Impact on lives					Impact on property	
		No. of deaths	No. of injured	No. of missing	No. of families displaced	No. of people displaced	No. of homes damaged	No. of homes partially damaged
Gampaha	2,064,096	6	3	5	308	1,449	292	307
Colombo	2,234,289	79	64	12	5,290	31,651	3,398	2,210
Kalutara	1,060,800	271	401	174	6,905	24,693	2,780	3,116
Galle	990,539	4,218	313	554	864	121,934	5,970	6,529
Matara	761,236	1,342	6,652	612	2,779	11,672	2,362	5,659
Hambantota	525,370	4,500	361	963	3,334	17,742	2,303	1,744
Ampara	589,344	10,436	6,771	404	37,801	133,997	18,977	6,628
Batticaloa	481,000	2,840	2,375	952	12,494	62,236	15,477	5,541
Trincomalee	345,000	1,078	1,328	45	35,545	83,570	4,830	3,835
Mullaitivu	140,072	3,000	2,590	433	6,007	22,557	5,033	400
Killinochchi	153,721	560	670	1	318	1,603	1,250	4,250
Jaffna	968,000	2,640	1,647	540	10,639	40,117	6,084	1,114
Total	10,313,467	30,970	23,175	4,695	117,284	553,221	68,756	43,383

4.2 Natural habitats affected by the Tsunami

4.2.1 Sites visited

This preliminary assessment is based on discussions with staff of the Forest Department, the World Conservation Union (IUCN), and visits to the coastal areas in the western, southern and eastern provinces. The coastal villages/townships visited are indicated in Table 1. Owing to security reasons, it was not possible to visit sites in the northern districts of Trincomalee, Mullaitivu and Jaffna. While this may be a limitation, the conclusions drawn from observations in the southern and eastern districts would generally apply to the situation in the northern districts as well.

4.2.2 Coastal ecosystems

Sri Lanka's coastline is approximately 1 660 km long and plays a very important role in the economic production of the country. In addition to paddy fields, there are home gardens (with a variety of fruit trees, timber species and other plants for domestic use such as betel leaves, vegetables, and ornamentals), and plantations of coconut, palmyra (*Borrasus flabellifer*), *casuarina* and cashew. Infrastructure has also been built right up to the coast – the structures range considerably from townships, harbours and jetties to hotels, residential homes and hospitals. In some locations in the south, salterns were developed in the salt marshes. Numerous beach resorts were built right up to the water's edge, as are the fishing villages.

The natural coastal ecosystem is very diverse, comprising lagoons and estuaries, reefs, rocky shores, sandy beaches, sand spits, sand dunes, mangrove swamps, salt marshes, riverine vegetation of estuaries, scrubland and grasslands. The littoral or beach strand vegetation is found on the sandy beaches, and gradations of it are also represented in the related areas such as the rocky shores, salt marshes, and mud flats. However, the mangroves and the riverine vegetation are distinct ecosystems and differ considerably from the littoral vegetation along the sandy coasts.

The beach (strand) forests form a very narrow strip of woodland, rarely more than 2–30 m wide, usually less, along the sandy or gravelly beaches of the sea coast, above the level of all but the highest tides. While they occur across much of the coastline, they are extensively degraded and discontinuous, mainly because of heavy human disturbance. On the beaches, along the flat sand, creeper species belonging to *Ipomea*, *Ischaemum*, *Spinifex* and *Vigna* dominate. Just behind the flat beaches the scrubber *Barringtonia*, *Pandanus* and *Hibiscus* plants can usually be found. Mixed with these shrubs and moving upward from the water's edge are the taller trees. The predominant trees include species of *Calophyllum*, *Cerbera*, *Derris*, *Phoenix*, *Xylocarpus* and *Terminalia*. The invasive species such as the prickly pear cactus (*Opuntia dillenii*) and mesquite (*Prosopis*) can be detected along the beach fronts as well.

Mangrove forests are confined to muddy shores, lagoons, and estuaries of tidal rivers. Sri Lanka has around 10 000 ha of mangroves, discontinuously distributed in patches along the sheltered parts of the coastline. The most extensive mangrove areas are in Puttalam, with over 2 000 ha, while Batticaloa and Trincomalee Districts have 1 000 ha each. The ecosystem is rapidly diminishing due to over-exploitation and conversion. The poor tenorial arrangements, with the ecosystem being neither on land nor sea, have partly led to this situation. The vegetation is simple in structure, 5 to 20 m in height depending on the community, with comparatively even canopy and almost no understorey. A few species usually dominate a mangrove stand. Based on the floristics, mangroves are characterized as *Rhizophora* dominated stand, *Lumnitzera* dominated stand, *Avicennia* dominated stand, *Ceriops* dominated stand, or sometimes, for example, as *Rhizophora-Bruguiera-Excoecaria* mixed stands. Other major genera found in these forests include *Excoecaria*, *Sonneratia* and *Terminalia*. Ferns such as *Acrostichum* act as pioneers and colonize disturbed mangrove sites.

Along the banks of estuaries, rivers and streams, narrow strips of riparian vegetation thrive. Their structure and floristic composition varies considerably. Generally, those at the mouth of the river are somewhat salt tolerant, while further upstream the plants are in more brackish conditions. The vegetation is extremely varied, but the thatching palm *Nypa fruticans* is usually common. Other common genera include *Cananga*, *Cerbera*, *Excoecaria*, *Ficus*, *Intsia*, *Dillenia* and *Terminalia*. Palms including rattans can be found in the ecosystem. They include *Barringtonia*, *Oncosperma*, *Calamus*, *Licuala* and *Zalacca*. Many types of sedges

can also be found in the ecosystem. With some exceptions these riparian forests are not of much economic significance.

In addition to the natural ecosystems, it has been pointed out that the coastal areas are of enormous economic importance. Humans have concentrated their activities along the coast and have changed the ecosystem considerably. Large areas have been converted to paddy fields, coconut, palmyra, cashew and other economic cash crops. An important timber plantation along the coastal areas is *Casuarina equisetifolia*. This is an exotic species that has been planted for fuelwood, coastal shelterbelts, erosion protection and as avenue trees. Its popularity is mainly because it propagates easily, grows rapidly, and is hardy enough to withstand the saline and windy conditions by the sea.

Another important managed ecosystem is the home gardens of Sri Lanka. These are a traditional system of tree cropping with a wide range of economically valuable species. The typical home garden ranges from 0.4 to 2.0 ha. The most important crops include the betel nut, jack fruit (*Artocarpus* spp.), mango, teak, coconut, palmyra, banana, coffee, cardamom, ginger and black pepper (*Piper nigrum*). With the moratorium of harvesting timber from natural forests, the home gardens have become a rapidly increasing and valuable source of wood. Currently around 70 percent of the domestic timber supply for construction and industrial wood comes from home gardens. (This figure includes wood from rubber and coconut plantations.) The home gardens are the principal source of fuelwood in most rural areas.

5. The impact of the Tsunami on natural and manmade ecosystems

Overall, the Tsunami impacted over 1 000 km of the coastline. The wave surge rose up to 5–6 m in height, and penetrated inland, causing considerable damage to areas up to 3 masl. The northern and eastern coastlines appear to have received the brunt of the impact, the damage extending as far as 3 km inland. In the southern and western coastlines, except in small pockets, the incursion in general appears to be less than 500 m inland. The wave surges of varying speeds (up to 20 km per hour), with varying amounts of silt, sand and organic matter, moved inwards. As the wave moved inland, it carried with it additional debris (from broken houses, other infrastructure and uprooted trees), compounding the damage away from the shore.

The impact and the resulting damage from a tsunami are not uniform. They are determined by several factors: (i) the orientation of the coastline with respect to the direction of the Tsunami wave propagation; (ii) the topography of the land and sea bed; and (iii) land cover. Local variations in these factors led to some sites being devastated while other adjacent areas remained intact.

5.1 Coastlines

According to local forestry staff, the Tsunami came with such significant force as to considerably alter the coastline. In some locations the sandy beaches were eroded, resulting in reduction of beach width. In addition, there is also evidence to indicate that along weak beach fronts, the Tsunami tunneled its way underneath the sand and emerged 100–200 m inland in a large spout, destroying everything above ground. Occasionally, the Tsunami gouged out long trenches or pits in the ground. When the Tsunami came to narrow entrances such as small tidal inlets, river mouths or artificial canals, the wave underwent a funnelling effect, and caused considerable damage inland. The impact caused massive damage inland to the vegetation or any other man-made structures. Concrete bridges that withstood large floods on previous occasions were washed inland far from their original position. In contrast, broad estuaries and lagoons appeared to have done the reverse, absorbed the seawater and the

sediments brought in by the waves, and the impact on the managed landscape and human settlements was considerably softened. Similarly, beaches that had a rocky front and deep water appeared to have reduced the energy of the Tsunami, and its impact inland was less damaging. The lagoons were particularly affected by the Tsunami. In some cases the channels in the lagoon mouth have been deepened, or the sandbars preventing seawater from coming in were swept away. The department staff pointed out that as a result, salinity inside the lagoon has increased, and the salty water may intrude into the paddy fields.

Mature and intact sand dunes (old and broad dunes covered with vegetation) turned out to be effective barriers against the force of the Tsunami. Settlements behind these sand walls were relatively well protected from the waves. Wherever the dunes were disturbed either from sand exploitation or removal of vegetation (cutting of trees and removal of ground creepers), they became unstable, and the Tsunami breached this barricade and swept up all settlements in their path. The evidence is striking – where the dunes were broken, the buildings behind the weak spot were wiped out. In the neighbourhood, the well protected areas showed little signs of disturbance.

When the Tsunami burst onto the beach front, it wiped out the seashore vegetation. The pandans, creepers, and the invasive species were wrenched from the ground, and some were carried inland beyond 1 km. The remaining roots of pandans and plant remnants clearly indicate severe tearing and tossing of the trunks at the base. Sand and marine sludge still covered some of the grasslands and salt marshes. Most of the palm trees (coconut, palmyra and areca) showed no sign of Tsunami damage – the wave surge apparently passed by the round, small and smooth trunks without bringing them down. In most of the sites examined, the fully grown trees apparently remained untouched. The trees that were greatly damaged – roots exposed, uprooted trees, leaning trunks – seem to be found where the ground had been previously altered by human activity. Wherever the ground was dug up, channels were formed or other such modifications made, which appeared to have created an unstable condition for the tree. The Tsunami then took down the destabilized tree. Such modifications of the seaward environment worsened its impact. Others (e.g. IUCN, 2005) have reported on damage to coconut trees –most probably the result of excessive disturbance to the ground. The evidence often seems to point to a strong relationship – the severity of the Tsunami impact appears tied to the extent of modification of the seaward environment. However, young trees whose crowns were underneath the Tsunami wave rarely survived it.

The Forest Department, as well as other agencies, had planted *Casuarina equisetifolia* along the sandy coasts as a means to rehabilitate the area. They were planted in large blocks up to 200m inland from the shore, in rows coasting the beach, as avenue trees by roadsides, and on top of the sand dunes. These plantings best exemplify the benefits of creating shelterbelts against wave surges and cyclonic winds. Wherever mature stands stood, they provided effective barriers against the Tsunami and the settlements beyond remained practically unharmed. Wherever there were gaps in the planting, the Tsunami swept inwards with much greater force and tore down every construction in its path. Sections of roads protected by trees on the beachside remained intact, but the next segment without such a protection was practically gouged out of the ground.

Mangroves were generally quite resistant to Tsunami wave surges. When seawater was funnelled through the estuary, the mangroves facing the sea took the full force, and many plants were severed from the ground. But the rest of the mangroves, other vegetation and settlements further away were relatively undisturbed. The front-line mangroves acted as a buffer, reducing damage inland. However, where there was considerable disturbance from human encroachment, the Tsunami waves flattened the vegetation and penetrated inland with much greater force. This could explain reports of some mangrove trees being uprooted and

lying far inland. The mangroves were also effective at trapping much of the rubble and debris. The other riverine vegetation also showed similar effects on the mangroves. Here again, disturbance to the vegetation and cutting down trees made them ineffective as barriers against the Tsunami waves.

5.2 Home gardens

A World Bank report (2005) states that some 2 500 home gardens, mainly in the north and east, were washed away. The present mission, undertaken seven weeks after the Tsunami, may have the disadvantage of making observations under altered circumstances: most of the debris has been removed and some of the vegetation has begun to recover from the damage. The home gardens were not entirely barren of vegetation. Most of the mature trees and palms appear to have held firm. However, smaller trees whose branches were engulfed by the wave have been toppled or washed away. Many of the crops raised below the trees (vegetables, ornamentals) were washed off. There is evidence that mature trees including the palms were brought down by the Tsunami. Here again, more careful observations continuously point to the fact that this occurred when the ground beside the tree was disturbed (e.g. soil was removed, trenches dug up). However, some of the standing trees are beginning to show dieback – the crowns are beginning to dry up and in some case there were no more leaves left. The mango trees and palmyra palms appear to be particularly affected. The only explanation is that these plants are less tolerant to saline conditions caused by the incursion of sea water as a result of the Tsunami. Some heavy rains in the next couple of months may reverse the process for some trees. However, the palmyra palms appear to be beyond the point of recovery.

The low-lying coastal paddy fields were inundated with saline water and marine sludge deposits. The original estimate was that around 2 300 ha of paddy lands, 600 ha of other field crops, and 500 ha of vegetable crop areas were destroyed. More recent studies have modified the losses considerably – an FAO study (Kielen 2005) suggests only around 400 ha of the paddy fields in the low-lying coastal areas have been severely damaged by saline water incursion. Many of the areas appeared to have recovered following the heavy rains since the first estimates were made.

5.3 The role of coastal ecosystems in mitigating Tsunami impacts

One important objective of the assessment is to find out whether forest ecosystems have been able to reduce the impact of the Tsunami on the landscape, both human settlements and agricultural areas. From this quick assessment, there appears a clear link between human modification of the natural ecosystem and the severity of the impact inland on human settlements and constructions (Table 3). This was especially the case when sand dunes, beachfront vegetation and mangroves were disturbed, narrow artificial canals created, and inappropriate construction of houses and hotels was carried out right up to the waterfront or along other sensitive areas.

Table 3. Influence of coastal natural ecosystems and manmade features on the severity of the Tsunami impact inland

Tsunami impact	Features of coastal natural and manmade ecosystems
High	<ul style="list-style-type: none"> • Narrow beach, low in height; • Original beach scrub vegetation and trees removed; • Heavy encroachment and disturbance to original mangrove and riparian vegetation; • Narrow natural and manmade outlets linked to the sea (bays, estuaries, lagoons, artificial canals); • Low stature and immature sand dunes, modified or exploited and converted to other land uses; • Houses and tourist hotels constructed to the beachfront or in sensitive areas (bordering estuarine/lagoon outlets), with beach front vegetation degraded or removed.
Low/Nil	<ul style="list-style-type: none"> • Mature, broad and deep sand dunes; • Intact stands of broad mangrove swamps, sandy beach vegetation, broad estuaries and lagoons; • Rocky beaches with deep seafront; • Beach stabilized with mature plantations of <i>Casuarina</i> and other trees, either in blocks or rows in the beachfront areas.

Nonetheless, there are circumstances when little can be done to minimize the wave impact, such as with narrow estuaries, bays, and outlets to lagoons. Here too, when the mangrove and other riparian vegetation are left intact, they are able to absorb the force of the waves and minimize damage to other vegetation and human settlements. IUCN (February 2005) came to similar conclusions based on a more quantitative survey of the southern coastal areas of Sri Lanka.

It is also clear that several mitigation measures can be undertaken to minimize the impact of the Tsunami. These include planting of *Casuarina* and other beach vegetation which, when done well, appear to provide protection to the human settlements and farms beyond the coasts. Another certain conclusion emerging from the assessment is that disturbance to the coastal ecosystems – the sandy beach vegetation, mangrove swamps, freshwater swamps, other physical features – should not be allowed or should be carefully managed so the ecosystem can provide the mitigation functions.

Indeed, based on a rapid post-Tsunami environmental assessment of Sri Lanka, the United Nations Environment Programme (UNEP) (January 2005) makes similar recommendations. The report concludes that “intact coral reefs, vegetated dune systems, deep stands of mangrove forest and other natural barriers, as a first line of defence, appear to have afforded significant protection to the coast beyond them.” It further states that reefs and mangroves are robust, structurally complex ecosystems that are able to absorb wave energy and that sand dunes bound by roots are much more resistant to water and wind. If these natural defences had not been compromised, as with mining of sand dunes and coral reefs, the Tsunami might have done far less damage. The report, taking into consideration the very heterogeneous nature of the coast in terms of terrain, natural ecosystems, and human pressures, states that there will be no single solution that can be applied everywhere. A number of options may be applied, including the following:

- Relocating settlements – some locations, if inherently indefensible, should be excluded from construction and settlements;

- Construction design – if there are no obvious natural protections, buildings may be allowed if they can be designed to resist the force of the Tsunami waves;
- Building artificial breakwaters – where costs can be justified, sea walls and harbour moles can be built that can break the force of the Tsunami waves;
- Creating artificial coral reefs – artificial structures can be introduced to hasten development of coral reefs that reduce the force of the Tsunami wave;
- Creating sand dunes – natural broad and deep dunes stabilized with vegetation are able to stop major waves;
- Planting mangroves – a deep band of mangroves (>20 m) can absorb the strong wave energy and protect the coast beyond. In addition, they also sustain productive fisheries;
- Planting other vegetation – planting coastal vegetation such as *Casuarina* stands, *Pandanus* hedges and other coastal plants, needs to be assessed for their value in mitigating the impact of the Tsunami waves.

While individually none of them are perfect defences against extreme natural disasters, together they offer a strong measure of protection. Based on a thorough understanding of the local environment, local authorities should be given the task of undertaking these mitigation measures. With technical and financial support from the federal government and international agencies, these measures can be implemented effectively. The work should be integrated through a participatory process that also incorporates livelihood issues of the Tsunami-affected people. Above all, the cheapest and most effective measures are those that exploit the natural ecosystems to act as barriers against the Tsunami's force.

5.4 Rehabilitation of coastal ecosystems

While a number of Tsunami mitigation measures can be taken, some of which can be costly and even unreliable, rehabilitation of the natural ecosystem may be the best measure under many circumstances. Allowing nature to take its course – eliminating or minimizing disturbance and letting natural rehabilitation processes work – may be the most economical and guaranteed means to revive the protection benefits of the coastal ecosystem.

The effect of the Tsunami on the coastal ecosystem is given in Table 4, along with the appropriate type of intervention to accelerate its rehabilitation. The emphasis with such rehabilitation work is on adequate planning and on more consideration for the ecological factors. Where the natural regeneration or rehabilitation processes are too slow or unlikely, these processes can be assisted with limited planting of trees, shrubs and creepers. The priority of interventions should be to remove or minimize disturbance and then allow natural regeneration processes, followed by judicious plantings.

Table 4. Impact of Tsunami on coastal ecosystems and appropriate intervention for accelerating rehabilitation (adapted from IUCN, 2005)

Ecosystem	Impact of the Tsunami	Rehabilitation
Mangroves	Undisturbed stands partially affected; Young and disturbed stands severely damaged	<ul style="list-style-type: none"> Remove all forms of disturbance and allow natural regeneration to proceed. Reforestation is needed only if natural regeneration is unlikely.
Freshwater swamps	Sedimentation, changes to drainage patterns, changes to salinity	<ul style="list-style-type: none"> The system most likely will recover naturally over time.
Riparian vegetation	Sedimentation, damage to vegetation facing seacoast	<ul style="list-style-type: none"> The system most likely will recover naturally over time.
Sand dunes	Immature dunes were washed out; sites that were disturbed were further breached by the wave	<ul style="list-style-type: none"> Remove further disturbance to sand and vegetation. These can be stabilized further by planting <i>Casuarina</i> and ground creepers.
Coastal forests	Trees relatively unaffected, except where ground disturbance is evident; low stature plants were completely wiped out.	<ul style="list-style-type: none"> Natural regeneration may be too slow to achieve perceivable results. Planting with <i>Casuarina</i> and other coastal species can accelerate rehabilitation.
Coastal plantations (e.g. coconuts)	Damage depends on topography, level of soil disturbance, etc; Able to withstand moderate waves.	<ul style="list-style-type: none"> This depends on economic significance.
Farms and other aquaculture	Sedimentation, salinization, mechanical destruction, pollution	<ul style="list-style-type: none"> Natural regeneration processes will occur. Plant shelterbelts in appropriate sites. Modifications are possible with increased ecological measures.
Agricultural ecosystems	Can be damaged by erosion, sedimentation and salinization	<ul style="list-style-type: none"> Coastal strips must be reverted to natural/protection vegetation. More planning is needed on development of agriculture along coastal areas.

As with all these mechanical and ecological interventions in the past, the social and economic issues were not given adequate attention. First, it is vital that the affected communities be brought in from the start of the planning stage. Due consideration should be given to local knowledge and community management systems over unfamiliar practices. While livelihood issues should be linked to the rehabilitation work, to a large degree ownership should remain with the communities. This will minimize difficulties with illegal encroachments in the future and reduce maintenance and monitoring costs. Finally, having witnessed the tragic consequences of the Tsunami, people living in the coasts understand the value of keeping the

natural ecosystems intact and the importance of maintaining shelterbelts along the coasts. Whole villages have attributed their survival to the presence of large stands of trees that acted as a buffer between their homes and the sea. The mood is very much in favour of planting trees. Under the prevailing mood, rehabilitation initiatives will receive much support and cooperation from the local communities. Nevertheless, arbitrary decisions by the government, in terms of relocation of homesteads and community centres, schools and buffer zones, etc. should be done in a joint exercise and not by government decrees.

Considering how favourably people have begun to view the role and importance of the natural and manmade vegetation in protecting life and assets, this would be an opportune moment to introduce appropriate management regimes and rehabilitate the ecosystems. The communities have expressed great interest in this rehabilitation work, and under joint management, the projects are likely to succeed. The following would constitute high priority work for the management and rehabilitation of the coastal areas of Sri Lanka:

- i) **Overall assessment** – There is an urgent need to undertake an overall assessment, both qualitative and quantitative, of the post-Tsunami status of the coastal ecosystem and other physical barriers, and the role they played in mitigating the impact of the wave surge. This would provide the definitive evidence on the importance of the coastal vegetation and the baseline information for other development work in the coastal areas.
- ii) **Management guidelines** – Although several ministries oversee the development and management of the coastal areas, there is no comprehensive and uniform set of guidelines on the management of the coastal forest ecosystems. With uniform management guidelines, differences between the various ministries in the implementation of activities would be minimized. It would also allow for more holistic and coordinated development of the coastal region.
- iii) **Planting coastal shelterbelts** – The technique for planting exotic *Casuarina* and other native littoral species as a coastal shelterbelt to protect the inland from Tsunami waves and cyclones has been well worked out. The Forest Department envisages planting a 100- or 200 m-wide belt for an overall targeted length of 60 000 m. The planting and follow-up maintenance would be undertaken jointly by the local communities and the Forest Department, guaranteeing continued maintenance of the shelterbelt.
- iv) **Rehabilitation of home gardens** – A large number of home gardens have been damaged or completely destroyed. This is a vital support system for rural communities and it is critical they be rehabilitated as quickly as possible. The government is planning to provide alternative home garden sites for families who have to be relocated. A mixture of timber and fruit trees would be planted. The Forest Department would supply quality seedlings, while planting and future management would be entirely undertaken by the homestead owners. The Forest Department proposes that support be given for establishing or rehabilitating around 10 000 home gardens in the affected coastal areas.
- v) **Extension programme** – The ongoing and planned rehabilitation activities of the Forest Department should be further augmented with an extension programme that disseminates valuable information and management tools to the coastal communities on the important role of coastal forest ecosystems and their care.

5.5 Forest pest outbreaks and debris

The force of the Tsunami lifted practically every construction in its path. This created an enormous amount of debris, especially from destroyed buildings, household goods and

furnishings, vehicles and boats, destroyed roads, bridges, sea sludge, and vegetation material. UNEP (February 2005) estimated that some 500+ million kg of rubble and waste material has been strewn about everywhere. They were deposited in swamps, lagoons and farmlands, and on beaches and sea coasts, even some 3 km inland. A concern, although unrelated to forestry, is the potential for such debris and rubble to become spawning grounds for mosquitoes, which can lead to deadly disease conditions. The forestry-related issues concerns insect pests and other micro-organisms: if the debris cannot be disposed of properly and in time, it may become a source of insect pests and other micro-organisms that can infect the agricultural crops, timber plantations and even the natural forests. The impact of the Coconut rhinoceros beetle (*Oryctes rhinoceros*) was highlighted as a case. The debris and rubbish all over the coasts can become breeding ground for beetles to multiply their populations rapidly. The emerging adults will infect the coconut plantations and may become a pest of other palms in forested areas as well. With such a debris situation, several other potential pests may emerge as well.

Seven weeks after the Tsunami disaster, observations of much of the coastal areas from Colombo to Batticalao clearly point to the fact that most of the rubble and debris have been removed. There is still some left in isolated places where settlements are not dense. It generally appears as if the debris problem has been managed effectively by local communities, with assistance from numerous NGOs, volunteers and the municipalities. The manifestation of pest problems was nowhere apparent, nor were there any complaints that such pest incidences were rising. The staff of the Forest Department gave assurances that it would not be a problem.

5.6 Timber availability for reconstruction

In addition to loss of human life, the next most visible impact of the Tsunami is the destruction of houses, public and commercial buildings, bridges, roads, and railways. There is great urgency to house the people first. The reconstruction will take two phases: an initial emergency phase to build temporary shelters, followed by the erection of permanent houses. This alone would place an extraordinary demand for natural resources, especially wood. If the sourcing and distribution is not well planned and coordinated, it can result in illegal encroachment into natural forests and timber plantations. Next, if the supplies are not properly estimated and adequate quantities made available, there will be abnormal price increases. All these factors would ultimately lead to delays in implementation and further hardship to the homeless people.

In view of the above, data on Sri Lanka's timber production potential and its current needs was collected from the State Timber Corporation (STC) and the Forest Department (FD). According to government statistics, around 12 percent of all building units in Sri Lanka were located in the coastal divisions affected by the Tsunami. Within the 500 m of the coast, some 70 000 houses were destroyed and another 44 000 damaged. This represents around 13 percent of the entire housing stock of the affected coastal divisions. A typical house in the coastal area has a single on-ground floor, cement and brick walls, and wooden roof supports under tiles or cement asbestos roofing sheets. There were many more modest dwellings with plank or palm leaf walls and simple roofing.

According to STC, they have been given the responsibility to build 30 000 temporary houses, to be followed up with another 30 000 permanent houses. Each temporary house would require between 0.5 and 0.7 m³ of wood. This would amount to around 20 000 m³ of wood, considering wastage and losses in the construction process. The timber for these temporary constructions, light hardwoods that may not be very durable, can be sourced from home gardens. The most common timber being used is *Paraserianthes falcataria* (formerly known as *Albizia falcataria*). At present, production from home gardens, rubber and coconut

plantations, and other plantations (outside forests) is estimated to be around 800 000 m³ annually. This suggests that Sri Lanka would be able to meet its needs for temporary housing. However, there are some limitations. The construction industry would have to cope with a large variety of timbers that includes coconut, palmyra, *Albizia*, mango, jak, *Gmelina*, and rubber. Next, for speedy construction work, the timber needs to come in specific forms, such as planks (for flooring and side walls), squared beams (for roof trusses and pillars) and plywood (for walls and ceiling). Such processing capacity may be limited in Sri Lanka. Currently, the available mills are medium-sized with outmoded machinery serving large areas. The system is unlikely to cope with the current demand, unless smaller mills located in the villages can turn the wood available locally at very low costs. In addition, STC only has plywood production capacity (using pine logs from plantations) to meet approximately 5 percent of the estimated plywood needs for the rebuilding phase. Considering all the above, the management of STC is considering importing the rest of the plywood from traditional sources, such as Southeast Asian countries, Australia and South Africa to meet this unexpected demand.

For building more permanent structures, the FD and STC are first looking at all other available building material such as cement and brick, steel and aluminum. In this way, it would be possible to minimize the wood requirements to around 1.2 m³ per unit. For 100 000 units, the estimated wood requirement is 120 000 m³. STC's annual production of 15 000 m³ can only meet around 10 percent of the requirements. The FD's 2005 production of 61 000 m³ of eucalypt logs from their plantations would be used mainly for railway sleepers, and little is expected for sawn timber. A crude estimate by the FD is that the combined production from home gardens and plantations would only meet around 10 percent of the total timber needed for rebuilding both the houses and other infrastructure. Moreover, the milling capacity (sawmills and plywood mills) is not sufficient to turn the wood into the appropriate form and structure for house construction. The government has therefore decided that all additional timber would be met through imports from traditional sources. Considering that most of the timber for the rebuilding phase would be met through imports, FD and STC have concluded that there would be no need for expert advice on both estimating and sourcing the wood needs for the country.

The Vocational Training Institute of Sri Lanka has another proposition to assist the building programme, however. For constructing 70 000 houses, in addition to the planks, plywood and poles, one would need 560 000 door frames and window frames (based on a design for an average-sized house in Sri Lanka). The existing mills cannot produce the supplies in the limited time available. One possible way to expedite the production of the door and window frames is through setting up small private sector enterprises at the village level. The Vocational Training Institute is proposing the establishment of 300 selected *samurdhi* (community enterprises) to set up production cells throughout the country. These production cells would be linked to the 69 Vocational Training Institutions in the country. Each cell can be set up as a backyard operation, with one cross-cutting machine manned by three workers. The Institute would provide the training and back-up support. Such a unit would become self-sufficient after the first few months of production and the profits would go into other community support activities. Such a scheme meets both the timber production needs and livelihood issues. It would be in the right location to use the home garden output more efficiently as well.

5.7 Fuelwood

Almost 65 percent of the energy consumption in Sri Lanka comes from bio-energy, fuelwood being the most important source. The share of the bio-energy by rural households is above 80 percent. In most rural areas fuelwood is collected from home gardens, cash crop plantations and natural forests. There was concern that with the Tsunami destroying the home gardens

and other natural fuelwood sources, many of the affected communities would face shortages. The FD reviewed the case and found no evidence that home gardens and other sources have been completely wiped out and therefore unable to continue providing fuelwood. Moreover, there is plenty of debris wood that can be utilized for cooking and other uses. The townships may begin to face some shortages as a result of lack of collections and disruption in transport services. The FD pointed out that the urban areas are increasingly converting to gas and kerosene for fuel. Some big consumers such as brick and tile makers, restaurants, tobacco processors and bakeries might face a shortage, but this is viewed as temporary. Once the roads become operable, it would be possible to move fuelwood from their source to the townships without further obstacles.

6. Project proposals:

Project 1:

Project Title: <i>Integrated management of coastal natural and man-made ecosystems</i>		
Implementing Agency: Forest Department		
Geographic Coverage: Sri Lanka	Duration & Start Date: August 2005; 2 years	Target Groups: Coastal zone communities
<p>Background: The extent of damage caused by the Tsunami to the natural and man-made coastal forest ecosystems needs to be evaluated fully. This would form the basis for understanding the complex interactions between the Tsunami wave surges and the coastal forest ecosystems, and further explain how the latter can mitigate the force of the Tsunami and protect both human life and assets inland. Such an understanding would further assist in developing cost-effective coastal tree shelterbelts against wave surges and typhoons. A further component of the project is to assist in developing home gardens in order to enhance the livelihoods of the affected communities through forestry. To ensure that the coastal forest ecosystems are managed on a sustainable basis, integrated coastal management guidelines would be developed as part of the project through a participatory process and multi-sectoral considerations. The Forest Department would further promulgate these guidelines through an extension programme.</p>		
<p>Objectives:</p> <ul style="list-style-type: none"> • To assess the impact of Tsunami wave surges on the coastal forest ecosystems in order to establish their mitigating influence; • To develop a coastal tree shelterbelt of exotic and native tree species in an efficient and cost-effective manner; • To develop integrated coastal forest management guidelines and promote their use by the public agencies and the coastal communities; • To enhance livelihoods of coastal communities through forestry practices. 		
Components:		Cost (US\$)
i.	Assessment of impact of Tsunami on coastal forest ecosystems	50,000
ii.	Developing integrated coastal forest management guidelines	30,000
iii.	Planting coastal shelterbelts for mitigating Tsunami impacts (60 km length (= 600 ha @ \$2,100/ha)	1,260,000
iv.	Rehabilitation of home gardens (10,000 home gardens @ US\$20 each)	200,000
v.	Extension programme	25,000
Total		1,565,000
<p>Beneficiaries: The main immediate beneficiaries of this project will be the coastal communities whose lives and assets will be better protected through improved coastal forest management.</p>		
<p>Expected Outputs:</p> <ol style="list-style-type: none"> i. Assessment of the impact of the Tsunami wave surges on coastal forest ecosystems and an understanding of their mitigating influence on the Tsunami. ii. Integrated coastal forest management guidelines developed that are recognized by the various public agencies and local communities. iii. 60 km of tree shelterbelts established in the most vulnerable coastal areas of the island. iv. 10,000 families in Tsunami-affected areas given assistance to establish home gardens with timber trees and other crops of economic value. v. An extension programme initiated by the Forest Department for promoting the integrated management of coastal forest ecosystems. 		

Project 2:

Project Title: <i>Development of village timber milling facility</i>		
Implementing Agency: Vocational Training Authority of Sri Lanka		
Geographic Coverage: Sri Lanka	Duration & Start Date: August 2005; 4 months	Target Groups: Coastal zone communities
<p>Background: The Tsunami of December 2004 destroyed approximately 70,000 homes along the coastal areas of Sri Lanka. The Government, with support from both international donor agencies and NGOs, is embarking on building houses for the displaced families. This would require a huge demand for processed timber. Sri Lanka is able to obtain around 10 percent of the required timber from local sources (home gardens and plantations). The rest would be imported from traditional sources (mainly Southeast Asia). However, the local processing mills will be unable to produce the 560,000 door and window frames and other related material for house building in time. Importing processed timber would raise the building costs. One simple and effective way to overcome this constraint is to build village timber production units, linked to the Vocational Training Institutes throughout the country. With a simple cross-cutting machine in a backyard operation, production can begin. Training and back-up would be provided by the Institute. Each of the production cells can become self-sufficient following the initial investment. A further advantage is that such a scheme can enhance livelihoods in the rural areas, while making greater use of local resources. The plan is to provide such village-level timber mills to ten communities. This would provide a model for replication in other villages through private sector funding.</p>		
<p>Objectives:</p> <ul style="list-style-type: none"> • To meet the emergency demand for cheap housing components using village milling facility; • To enhance livelihood and technology transfer to village communities. 		
Components:		Cost (US\$)
i.	Purchase and assembly of cross-saws (\$16,500 x 10 units)	165,000
ii.	Training and support services (1 month)	15,000
Total		180,000
<p>Beneficiaries: The main immediate beneficiaries of this project will be the coastal communities who will acquire knowledge and skills to operate small wood industries.</p>		
<p>Expected Outputs:</p> <ul style="list-style-type: none"> i. Small village-level wood-working mills installed and operating in 10 villages. ii. Production of housing wood components stepped up to meet the heavy demand for reconstruction work. 		

7. References

IUCN. 2005. *A report on the terrestrial assessment of tsunami impacts on the coastal environment in the Rekawa, Ussangoda and Kalametiya (RUK) area of Southern Sri Lanka.* The World Conservation Union (IUCN), Sri Lanka Country Office, Colombo, Sri Lanka.

Kielen, N. 2005. *Assessment of Tsunami damage on crop production, land and irrigation water resources and suggestions for short- and medium-term activities in general agriculture.* FAO report (unpublished).

United Nations Environment Programme (UNEP). 2005. *After the Tsunami: Rapid Environmental Assessment.* Nairobi, Kenya. February 2005.

World Bank. 2005. *Sri Lanka – 2005 Post-Tsunami Recovery Program: Preliminary Damage and Needs Assessment.* Prepared by the Asian Development Bank, Japan Bank for International Cooperation and World Bank. Colombo, Sri Lanka, January 10 – 28, 2005.

Terms of Reference

From 10–24 March 2005, the Reporting Officer will travel to Sri Lanka, and with the logistical support and overall guidance of the FAO Representation of Sri Lanka, will conduct field visits to the Tsunami-affected area and meet with relevant governmental bodies and organizations in Colombo to carry out the following tasks:

- Interact with Forest Department and the Department of Wildlife Conservation of the Ministry of Environment and Natural Resources to collect information on opportunities to address the needs of affected populations through forest-related initiatives and on possibilities for forest rehabilitation and reconstruction in response to the Tsunami.
- Interact with UN agencies, international organizations, financing institutions, donor countries, national and international NGOs and any other relevant bodies to collect information on their proposed and ongoing programmes in forest-related assistance for the Tsunami recovery efforts in Sri Lanka, in particular concerning:
(i) rehabilitation and restoration of mangroves and other coastal forests; (ii) integrated coastal zone management; (iii) rehabilitation of home gardens and other agroforestry systems; and (iv) forest-based income-generating opportunities to assist local people regain their livelihoods;
- Collect information from the State Timber Corporation and other relevant bodies on the availability of timber and other wood products in Sri Lanka to supply the demand for reconstruction of infrastructure damaged and destroyed by the Tsunami;
- Assess the risk of forest pest outbreaks from debris left from the Tsunami;
- Identify the major needs and opportunities in the forest sector to contribute to the Tsunami relief and rehabilitation efforts;
- Prepare a project/programme proposal for FAO's assistance to Sri Lanka for the Tsunami rehabilitation as an input to FAO's comprehensive programme in Sri Lanka, the elements of which might include, *inter alia*: forest rehabilitation, reforestation and afforestation within the context of integrated coastal zone management and coastal ecosystem rehabilitation; rehabilitation of home gardens and agroforestry systems; employment-generation opportunities and other forest-related contributions to local livelihoods; forest health (including measures to be taken to minimize pest outbreaks); technical assistance to Sri Lanka to assess and help meet the wood demands for reconstruction, taking into consideration current forest policies; and capacity building in the above-mentioned areas, as appropriate. Identify partners with whom these efforts might be carried out.

List of experts consulted during the mission

Agency, name and position	Subject discussed
<p><u>FAO Representation:</u> Mr. Pierre Gence (a.i. FAO Representative) Mr. James Breen (Agronomist)</p> <p>Mr. Kurupuracchi (Assistant Programme Officer)</p> <p>Mr. J. Nightingale</p> <p>Ms. H. Clarke (Information Officer)</p>	<ul style="list-style-type: none"> • overall direction of mission and expected results, followed by debriefing, and discussion of additional issues that need attention; • logistics, security arrangements and experts to consult • fuelwood studies and findings; • information provided on the status of mangroves and other coastal vegetation and their Tsunami mitigation role.
<p><u>Forest Department:</u> Sarath Fernando Ariyadasa J.E. Munasinghe Anura Sathurasinghe A. Wijesuriya Pushparaja Murugesu M.A.A.M. Jayaratne (DFO, Hikkaduwa) D.H.S. Kumarasiri (DFO, Matara) Mr. Dissanayake (DFO, Hambantota) M.A.I. Suhood (DFO, Ampara) Mr. Rangunathan (DFO, Batticalao) Mr. Steve Hunt (Consultant)</p>	
<p><u>State Timber Corporation</u> Mr. Paramahewa (Acting GM)</p>	
<p><u>Urban Development Authority</u> Dr. Hestor Basnayake</p>	
<p><u>Asian Dev. Bank</u> Dr. Manjula Anurasinghe</p>	
<p><u>Coastal Conservation Department</u> Dr. Anil Premaratne</p>	
<p><u>Vocational Training Institute</u> Eng. Lionel Pinto (CEO) P.A.G. Premasri (DG)</p>	
<p><u>World Bank</u> Dr. Sunith Pilapitiya</p>	