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The role of coastal vegetation in case of the Indian Ocean tsunami -Coastal area of Thailand and Sri Lanka-

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Abstract: Based on the field survey of coastal area in Thailand, Sri Lanka and Male in Maldives as wave brakes. It was observed 13 forest types, 14 bush and herbal communities of coastal vegetation. The coastal vegetation in devastated area is mainly *Casuarina equisetifolia* and *Cocos nicifera* in Thailand, in Sri Lanka is *Pandanus odoratissimus* and *Cocos nicifera* . Any trees along the beach, have fallen down very few and have not been lost, except most front line trees and herbal communities remained almost. The coastal vegetation area was observed only limited erosions, on the behinds in the forest sand sedimentation has been observed. By seawater salt, withered vegetation and temporal leaf drops has been observed. And the coastal vegetation has functions as wave breaks so help reduce water speed, changing pathway, and rescue effects such as trap effect, soft-landing effect and escape effect.

Further, coastal vegetation can not repress tsunami itself, that best and most possible disaster prevention under local economical situations is layout of coastal vegetation in tsunami protection, combined mangrove trees

Keywords: Coastal vegetation, sand hill, trap effect, soft-landing effect, escape effect

1. Introduction

The Indian Ocean tsunami and the Sumatra earthquake have occurred at December, 2004, and countries and peoples around the coastal area have extremely suffered and damaged, which they have never experienced. The disaster made two hundred thousand of people died or lost. Since having a long experience in research activity in Asian countries, we hurriedly organized research group included researchers from Sri Lanka and Thailand, and researched these damages. The survey has been held at 29 points along with West-side coast, about 200 km section between Phuket island and Ranong, Thailand, on January, 2005, and at 19 points, about 250 km section between West coast at the south side from Kolombo and the east coast in Kalmunai, on April, 2005. Also, on January, 2006, held in Male , Maldives.

The survey was focused on "how the seaside forests and Mangrove forest in devastated area are related with reducing damages." Since tsunami becomes larger in sand dune at curved coast geographically, a few Mangrove forests, which are mainly inside of Lagoons in Thailand and Sri Lanka, have directly damaged in tsunami. This paper states about coastal vegetation at sand hill area, which directly damaged in tsunami..

2. The type of coastal vegetation

The types of coastal vegetation in devastated area are mainly *Casuarina equisetifolia* forest and *Cocos nucifera* forest, which is artificial forest. Over 20-meter trees has been observed in the *Casuarina equisetifolia* forest.

Natural vegetations, which are *Terminalia catappa*, *Pandanus odoratissimum* and *Scaevora sercea*, are locally observed; however, there are a few examples which constructs a large coastal vegetation. In addition, the examples which developed herbal coastal vegetation are very few.

On the other hand, the types of vegetation in Sri Lanka are mainly constructed to natural vegetations, which are *Pandanus odorati- ssimum*, *Cocos nucifera*, or mixture of two. Also herbal coastal vegetaton, such as *Ipomoea pes-caprae*, *Spinifex littoreus*, or *Crinum asiaticum* have developed. The other hand, in Maldives with coral beach, *Messerschmidia argentea*, *Calophyllum inophyllum*, *Cordia subcordata*, *Guettarda speciosa* community have developed.

3. Damaged conditions of coastal forest and seashore vegetation

Casuarina equisetifolia and *Cocos nucifera*, which are really tall and no leaves at lower point, had a little damage because of tsunami waves had passed through under the tree. The middle or shorter trees which have

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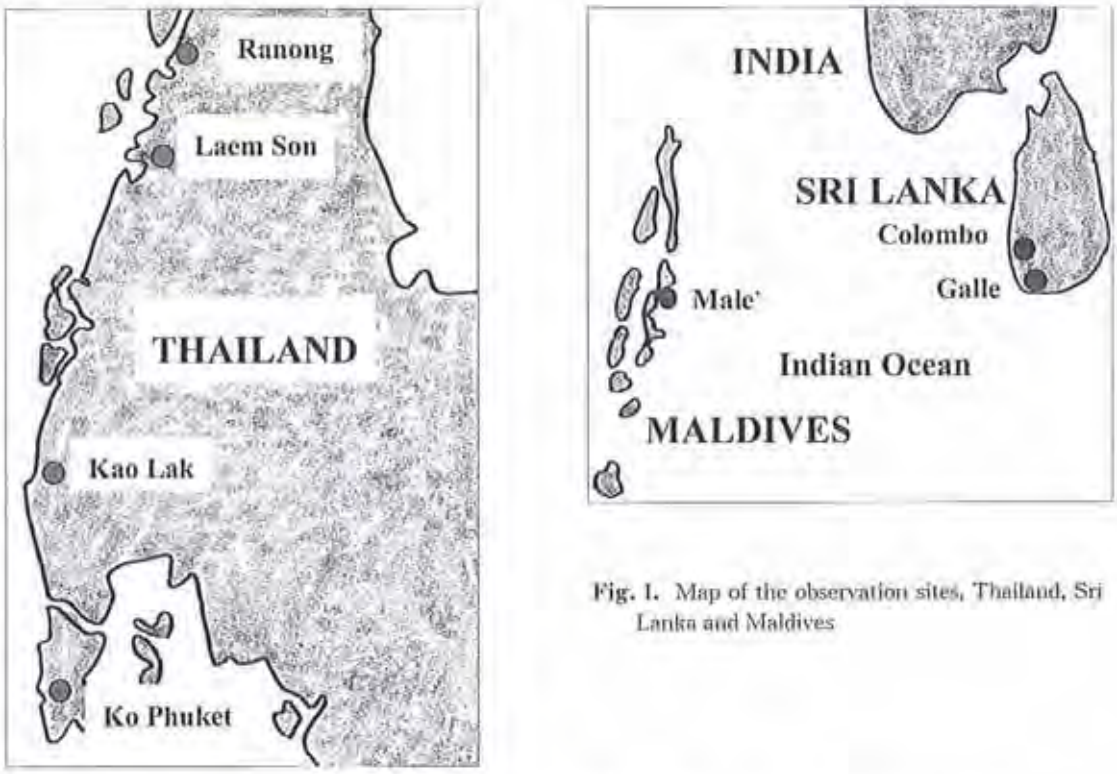

Fig. 1. Map of the observation sites, Thailand, Sri Lanka and Maldives

Table 1 vegetation types in coastal vegetation of each country

Forest community	Thailand	Sri Lanka	Maldives
Casuarina equisetifolia forest	much	some	some
Cocos nucifera forest	much	much	much
Syzygium gratum community	some	rare	rare
Pandanus odoratissimum community	some	much	some
Terminalia catappa community	some	some	some
Barringtonia asiatica community	rare	some	some
Cerbera odollam community	rare	much	some
Messerschmidia argentea community	rare	rare	some
Cordia subcordata community	rare	rare	some
Calophyllum inophyllum community	rare	rare	some
Guettarda speciosa community	rare	rare	some
Thespesia populnea community	much	some	some
Hibiscus tiliaceus community	much	some	some
Bush and herbal community			
Scaevola taccada community	some	much	much
Calotropis gigantea community	some	much	some
Premna integrifolia community	rare	some	some
Crinum asiaticum community	rare	much	rare
Clerodendron inerme community	some	much	some
Cassine balae community	much	some	some
Pemphis acidula community	rare	rare	some
Acanthus ebracteatus community	some	some	some
Opuntia vulgaris community	rare	much	some
Salvadora-persica community	rare	some	rare
Ipomoea pes-caprae community	some	much	much
Spinifex littoreus community	rare	much	rare
Canavalia lineata community	much	some	some
Sesuvium portulacastrum community	much	some	some

Fig. 2. Only surface sand has eroded by the tsunami at front of sand dune, *Cocos nucifera* forest, in Rekawa Sri Lanka

Fig. 3. Rare case of coconuts trees has been fallen to sea side by backflow of tsunami, In Rekawa, Sri Lanka

leaves even in lower points, such as *Terminalia catappa*,, *Pongamia pinnata*, *Pandanus odoratissimum*, *Anacardium occidentale*, have fallen down very little. Fallen vegetation are concentrated on the most front vegetations even in the area, where experienced larger tsunami and greatly damaged. In these cases, fallen trees are mainly in the side road of water flows such as rivers or small waterways, and it results in soil erosion at these roots. The vegetations in Rekawa, Sri Lanka have been fallen backflow of Tsunami, fallen to seaside. However, fallen trees have not been lost from the point by tsunami.

Fig. 4. Rare case of *Casuarina equisetifolia* young trees has been fallen by the tsunami at front of sand dune, but don't flow out in Rekawa, Sri Lanka

Fig. 5. *Alstonia macrophylla* (left) and *Azadirachta indica* (right) has been died by the tsunami in Sri lanka

4. Rhizomes of trees constructed the coastal vegetation

Regardless of huge tsunami, the coastal vegetation have very few fallen or lost by flown-out. These results points out strength of the tree trunk and the strength of the roots.

5. The damage from salt by flowing seawater

A large amount of seawater has been flowing even deeper inlands by tsunami attack. In the example of Sri Lanka, seawater has reached 1 to several kilometers inland from the coastline. The seawater flowing to inland is considered to influence to groundwater, and its well-water quality has dramatically changed. In addition, many examples of withered vegetation by seawater salt, and temporal leaf drops have been observed. Each species

Table 2 The Tolerance range for salinity

Familie	Sci. name	Thailand	Sri Lanka	Tolerance
Palmae	*Cocos nunifera*	+++	+++	○
	Borassus flabellifer	+++	++	×
Casuarinaceae	*Casuarina equisetifolia*	+++	++	○
Anacardiaceae	*Mangifera indica*	+++	+++	×
	Anacardium occidentale	+++	+	△
Lecythidaceae	*Barringtonia asiatica*	++	+++	○
Apocynaceae	*Phumeria obtuse*	+++	+++	△
	Alstonia macrophylla	++	+++	×
Meliaceae	*Azadirachta indica*	++	++	×
Myrtaceae	*Psidium guajava*	++	++	×
Moraceae	*Artocarpus communis*, *altilis*	++	++	△
	Ficus hispida	++	+++	△
	Ficus microcarpa	++	++	○
	Ficus religiosa	+++	++	○
	Artocarpus heterophylla	++	++	△
Graminae	*Bambusa* and *Dendrocalamus*	++	++	○
Apocynaceae	*Cobera manga*s	+++	+++	○
Guttiferae	*Calophyllum inophyllum*	++	++	○
Rutaceae	*Limonia acidissa*	+	++	○
Malvaceae	*Hibiscus tiliaceus* (*macrophyllus*)	+++	+++	○
	Thespesia populnea	++	+++	○
Combretaceae	*Terminalia catappa*	+++	+++	○
Verbenaceae	*Tectonia grandis*	+++	++	×
	Premna intergifolia	++	++	○
Rhizophoraceae	*Avicennia marina, alva*	+++	+++	○
	Rhizophora apiculata,mucronata	+++	+++	○
Myrtaceae	*Eucalyptus camaldulensis*	++	++	○
Musaceae	*Musa sapientum*	+++	+++	○
Leguminosae	*Samanea saman*	++	+++	○
	Acacia auriculiformis	+	+++	△
	Cassia bakeriana	+	+++	○
	Erythrina indica,stricta, variegata	++	++	○
	Manikara hexandra	+	+++	○
	Zizyphus jujuba	+	+++	○
	Moringia calabura	+++	++	×
	Bauhinia racemosa	+	++	○

+++ : common ++ : some + : rare ○ : height △ : middle × : low

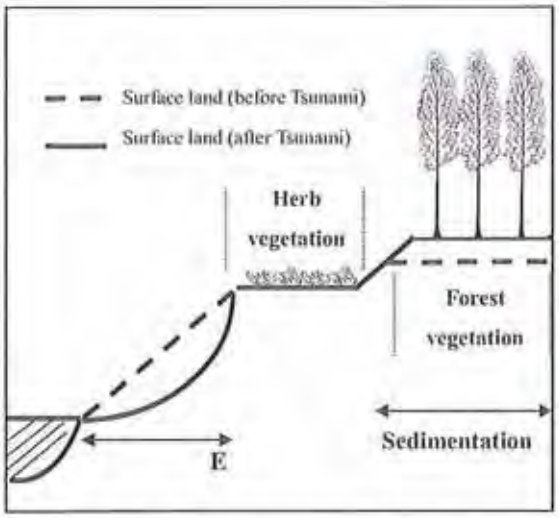

Fig. 6. Erosion and sedimentation of each region on the dune

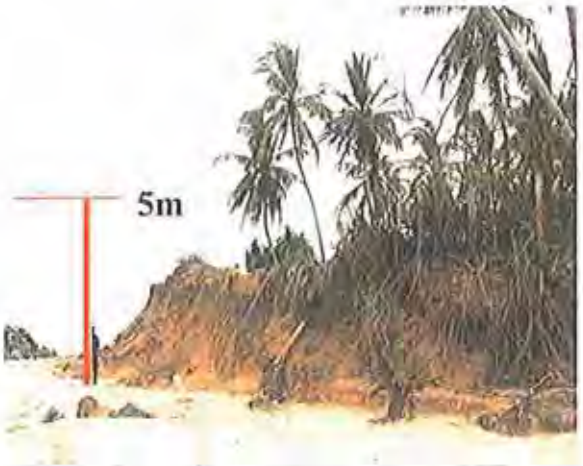

Fig. 7. At the river mouth has been strong eroded by the tsunami wave, in Rekawa, Sri lanka

damaged differently from them. Especially, many of *Alstonia macrophylla* and *Mangifera indica* have withered.

6. Effects of reducing damages by coastal vegetation.

Many examples of coastal and sand erosions by tsunami have been introduced, and many examples of coastal sandbar lost has been reported.

6-1 Erosion and sedimentation

Erosion, separated Laem Son island in Thailand, has occurred. In Khao Lak, Thailand, over 1 meter erosion has been observed in less vegetated area. In Sri Lanka,

Fig. 8. In the *Casuarina equisetifolia* forest has been deposited sand by the tsunami , in Laem Son, Thailand

Fig. 9. Caostal vegetation can change tsunami way, In this case is *Casuarina equisetifolia* forest, in Laem Son, Thailand.

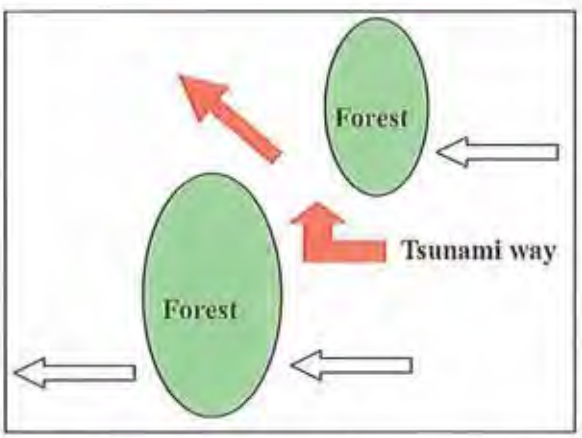

Fig. 10. Coastal vegetation can change tsunami way, In this case is *Casuarina equisetifolia* forest, in Laem Son, Thailand.

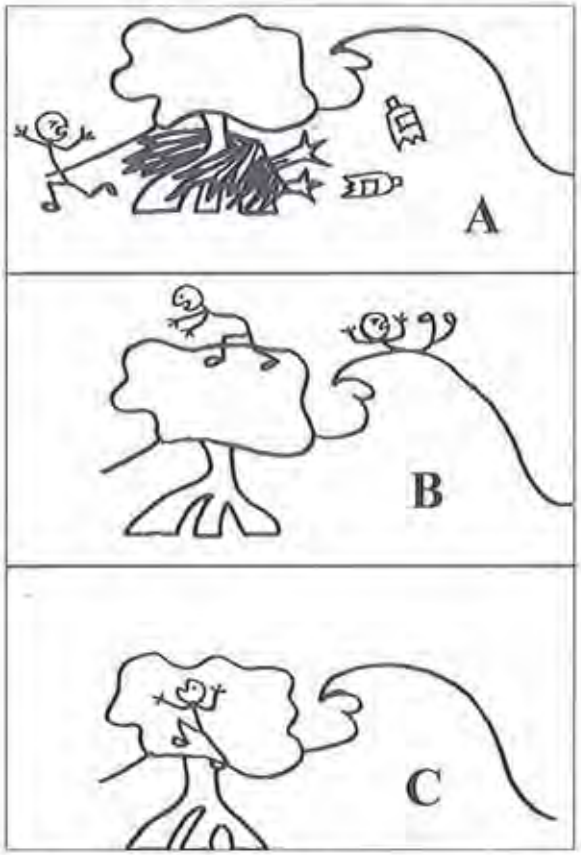

Fig. 11. Rescue effect by coastal vegetation
A : Trap Effect
B : Soft-landing Effect
C : Escape Effect

sand hill has been eroded and almost connected to backward Lagoons. Those areas are also less vegetated areas. On the other hand, the sand hill area, where plant colonies such as *Ipomoea pes-caprae* and *Spinifex littoreus* have developed, have limitedly eroded within 10 to 20 cm. On the behinds of these vegetations, in *Casuarina equisetifolia* Forests, sand sedimentation has been observed in Laem Son, Thailand.

6-2 By path effect

Vegetations have no ability to repress tsunami, but they will work as wave resistance or changing pathway of tsunami.

Tsunami passing through forests such as coastal vegetations changed its way to less resistant, or less vegetated area.

7. Rescue effect by coastal vegetation

As the result of interview or survey with peoples in devastated area, many people have been rescued by existence of coastal vegetation. These rescue effects can be arranged by following:

1. Trap Effect: coastal vegetations have effects to filter hazard outflow such as debris or scrapped boards.
2. Soft-landing Effect: people flown out by tsunami have injured or died by hitting harder buildings, but some of them have rescued by being thrown to softer coastal vegetation.
3. Escape Effect: compared with flown-out houses, coastal vegetation has not fallen or flown out, and people could escape by going up coastal vegetation.

8. Disaster prevention in coastal area.

What is the best and most possible disaster prevention under the local economical situations? Since international alert system for disaster prevention is also necessary, its effectiveness in local remoted area still have some problems. Also, in Okushiri island in Hokkaido, Japan, and the Maldives islands in Andaman Sea, modern seawall has been constructed for tidal or tsunami prevention.

However, these examples are not appropriate in developing country, because of its costs and landscapes. These methods may be limited in more populated area as well as city. Coastal vegetations in tsunami protection are eternal, low-cost, and environmental constructions; even in usual time, these have many advantages at the environmental points of view, such as wind prevention, sand prevention, ecology, or water purifications. Coastal vegetation for tsunami protection cannot repress tsunami itself. However, layouts of coastal vegetation in tsunami protection, double-layer construction, and de-fragmentation of vegetation species, provide disaster prevention effects. The suggested coastal vegetation in tsunami protection in this research will effectively bring out rescuing people and wrack-trap effect. Construction of coastal vegetation in tsunami protection, combined mangrove trees in back ground wetland area and lagoon, which is highly dense, multiple layered vegetation structure, will achieve symbiosis with coastal fishing, landscapes, and sightseeing in the area.

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