# THE POSSIBILITY OF USING MANGROVE FORESTS AS NATURAL FORTRESS TO TSUNAMI IMPACTS ON INDONESIAN COASTS: A PRELIMINARY STUDY

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## Abstract

There are many prevention and warning systems for tsunami impacts that can be used along Indonesian coasts. One of them is a natural fortress – mangrove forests, which can absorb, diffract and dissipate energy of incidental big waves, such as those from tsunamis.

This research is presented in two major parts: numerical simulation and physical experimentation. Models are based on KdV-based solitary wave theory, producing a moderate tsunami, ($3m<\eta<5m$), with typical Indonesian beach characteristics considered. Both schemes can provide information on the dimensions and forms of mangrove forest which we believe will have the highest chance of reducing wave energy.

After those two parts are completed, implementation should be carried out on beaches. However, the open ocean can be a challenge for mangroves. We can perhaps solve this through the use of temporary organic dams of bamboo. Hopefully, mangrove forests can give us a chance to ensure that this hazardous event causes fewer casualties than we have seen.

## Tsunami History in Indonesia

Tsunami, as a word, is generally used to describe huge waves generated by earthquakes or the movement of tectonic plates. Tsunamis have been reported since ancient times, especially in Japan and Mediterranean seas. The first tsunami was recorded on the coast of Syria in 2000BC. The Indonesian region, which has experienced many big earthquakes during the last 400 years (from 1600-January 2008), has been struck 109 times by tsunamis (Diposaptono, 2008) – roughly one tsunami every four years. Based on this data, Latief et al (1999) at DCRC Tohoku University, created a Tsunami Catalog and divided Indonesian Archipelago into six zones. They are Zone A (West Sunda Arc), B (East Sunda Arc), C (Banda Arc), D (Makassar Strait), E (Malucca Sea) and F (North Papua). Within the six, zone A and B have experienced 64% of the earthquake-generated tsunamis – a total of 22 events over the past 40 years.

To reduce fatalities in the future, the Indonesian Government developed three Tsunami Preventing Systems. They are:

1. Regional/Sub Regional Warning System: uses buoys and gauges all around Indonesian waters, combined with two major tsunami warning systems, the Pacific and Indian Ocean. So far, this scheme has not worked as well as predicted, because of the lack of maintenance, understanding of the beach society, etc.
2. Traditional/Tribes Warning System: long before Haas (1978) separated tsunamis into four types, depending on tremors humans felt during quakes, people in a couple of fishing villages at the Polmas district (West Sulawesi, Indonesia) have had a strong belief that when the land shocked a coconut tree so much that a coconut fell in the ground, it meant that they had to drag their boats 50 to 100m back from the shoreline, to avoid flooding by waves from the sea. Researchers are studying the times between shocks and flooding events because of this tradition.
3. Natural Fortresses: coral reefs are commonly known as regular wave absorbers (Dahuri et al, 1996), and they can be as useful as breakwaters. In some earthquake-prone coasts in Philippines Archipelago, there are many cases involving coral reefs as natural breakwaters, protecting the coasts from tsunamis. Palm and Coconut trees, so-called Palm Forests, may offer some protection against tsunami surges in some instances. Groves of trees alone, or as supplements to shore protection structures, may dissipate tsunami energy and reduce surge height. Groves of coconut palms may withstand a tsunami surge but may be sheared off by debris carried forward by the tsunami. Other types of trees may be easily uprooted and flattened. Matuo (1934) calculated that trees could be broken by water velocities of 2m/s or greater, but did not analyze specific types of trees. He indicated that trees broken off by higher velocities might add debris to the surge and increase the damages resulting from the surge. On Indonesian waters, there are several beaches now in a program of mangrove reforestation, which may be capable of reducing and dissipating tsunami energy.

## Mangroves Forest

The word Mangrove is derived from a combination of the Portuguese word for tree (**mangue**) and the English word for a stand of trees (**grove**) (Dawes, 1981). The term is ecological and is used to include both shrubs and trees that occur in the intertidal and shallow sub tidal zones of tropical and subtropical tidal marshes. Mangrove forests contain more than one species of plants. In Indonesia, there are seven common Genera of mangrove plants, i.e., *Rhizopora* spp, *Avicennia* spp, *Sonneratia* spp, *Bruguiera* spp, *Xylocarpus* spp, *Ceriops* spp, and *Exoecaria* spp. Mangroves are usually found in saline lagoons. They grow most commonly in estuaries such as those produced by tropical rivers. Mangroves are shallow-rooted and lack well-developed taproots as a result of high salt concentrations as well as the water-saturated, organically rich anaerobic substratum (Dahuri et al, 1996).

On a Boxing Day tsunami event, which produced 35 metre maximum run ups, many mangrove forests lying directly in the path of the impacting wave were washed away, producing debris that made the impact even worse. However, middle tsunamis (3 – 5 metres maximum run ups), mangrove forests hypothetically will be effective in reducing the energy impact.

## Previous Research

There were several previous studies regarding the possibility of implementing mangroves as natural fortresses from middle tsunami impacts. The three most important studies are from Massel et al (1999), Harada and Kawata (2004) and Kongko (2005). In Massel et al (1999), the important point was determination of the effect of mangroves' geometrical dissipation of energy from waves. Harada and Kawata (2004) research gave an understanding of the effect of forest reduction wave energy scheme, but was based on typical Sendai Bay trees instead of mangroves. It also gave a basic numerical simulation of tsunami impact from 1, 2 and 3metre high tsunamis. Kongko (2005) gave a basic method for mangrove forest formation to find the most promising formation to dissipate tsunami energy. It also gave a basic method for planting mangroves forests in several typical beaches in Indonesia.

## Research Project Scheme and Goals

This research will be conducted in two major phases:

1. Numerical simulation: will be based on IOC Manuals and Guides of Numerical Method for Tsunami Simulation and from Tsunami Modeling Manual, but with changes on the types of wave setups. The numerical simulation will be based on KdV-based Solitary Wave Theory, with three possibilities of transformations of tsunamis as they reach beach areas. Formation of mangrove forests will be based on conclusions of Massel et al (1999) and Kongko (2005), and will then be dynamically changed to other possible formations. This simulation will tend to find the amount of energy dissipated and absorbed by mangrove forests at beaches. The exact location for the simulation will be the beaches at west side of South Sulawesi, Indonesia; which is one of several potential prone areas of a tsunami disaster.
2. Physical experiments; will be performed on a 14m glass sided flume at Graduate School for IDEC, Hiroshima University (see Appendix). The wave maker is a plunger with a ¼ circle-side type. There will be at least three wave gauges, which will be set in several positions of the tsunami model propagation. A mangrove forest model will also be based on Kongko (2005), but with several types of density and dimensions. The experiments tend to find the best tsunami-reducing mangrove forest formations.

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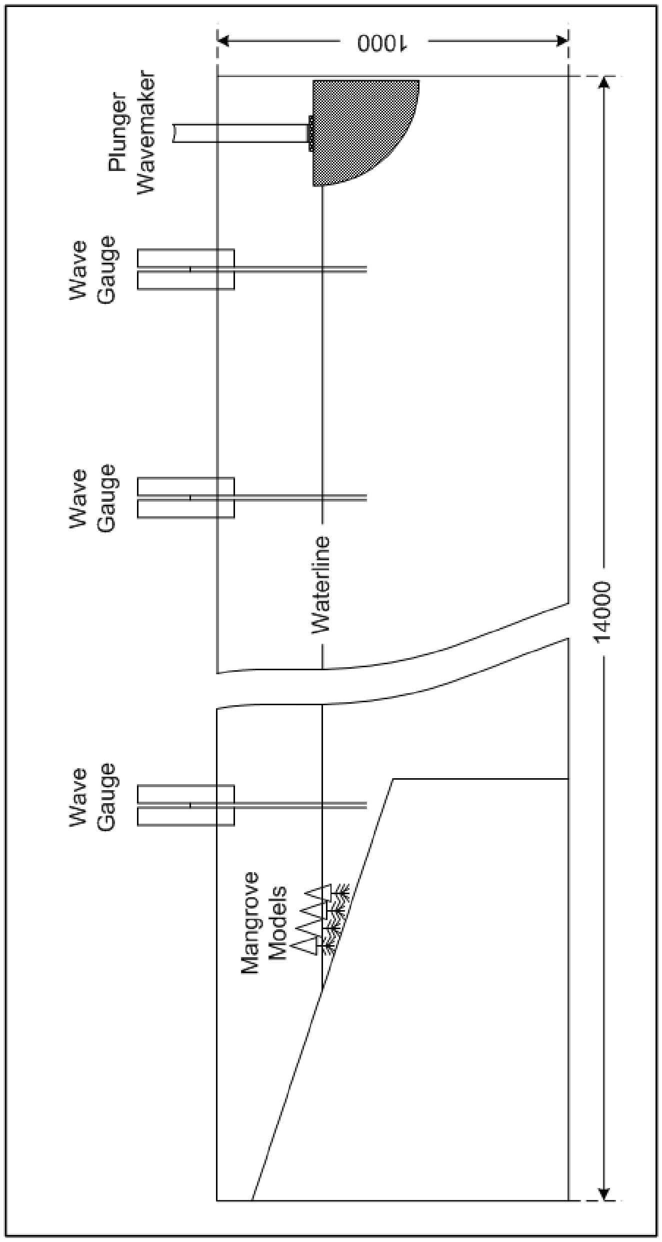
Plunger Wavemaker
Wave Gauge
Wave Gauge
Wave Gauge
Waterline
Mangrove Models
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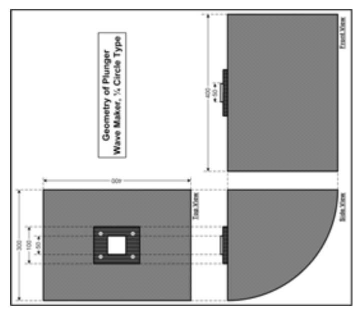
Geometry of Plunger Wave Maker, ¼ Circle Type