THE ROLE OF SATELLITE REMOTE SENSING TO DETECT AND ASSESS THE DAMAGE OF TSUNAMI DISASTER

Absornsuda Siripong
Marine Science Department, Faculty of Science
Chulalongkorn University, Bangkok 10330, Thailand
sabsorns@chula.ac.th

PORSEC
Busan, Korea, 1-4 November 2006.

ABSTRACT. The tsunami from the megathrust earthquake magnitude 9.3 on 26 December 2004 is the largest tsunami the world has known in over forty years. This tsunami destructively attacked 13 countries around Indian Ocean with at least 230,000 fatalities, displaced people 2,089,883 and 1.5 million people who lost their livelihoods. The ratio of women and children killed to men is 3 to 1. The total damage costs US$ 10.73 billion and rebuilding costs US$ 10.375 billion. The tsunami's death toll could have been drastically reduced, if the warning was disseminated quickly and effectively to the coastal dwellers along the Indian Ocean rim. With a warning system in Indian Ocean similar to that operating in the Pacific Ocean since 1965, it would have been possible to warn, evacuate and save countless lives.

The best tribute we can pay to all who perished or suffered in this disaster is to heed its powerful lessons. UNESCO/IOC have put their tremendous effort on better disaster preparedness, functional early warning systems and realistic arrangements to cope with tsunami disaster. They organized ICG/IOTWS (Indian Ocean Tsunami Warning System) and the third of this meeting is held in Bali, Indonesia during 31st July to 4th August 2006. A US$ 53 million interim warning system using tidal gauges and undersea sensors is nearing completion in the Indian Ocean with the assistance from IOC.

The tsunami warning depends strictly on an early detection of a tsunami (wave) perturbation in the ocean itself. It does not and cannot depend on seismological information alone. In the case of 26 December 2004 tsunami when the NOAA/PMEL DART (Deep-ocean Assessment and Reporting of Tsunami) system has not been deployed, the initialized input of sea surface perturbation for the MOST (Method Of Splitting Tsunami) model was from the tsunamigenic-earthquake source model. It is the first time that the satellite altimeters can detect the signal of tsunami wave in the Bay of Bengal and was used to validate the output from the MOST model in the deep ocean.

In the case of Thailand, the inundation part of the MOST model was run from Sumatra 2004 for inundation mapping purposes. The medium and high resolution satellite data were used to assess the degree of the damage from Indian Ocean tsunami of 2004 with NDVI classification at 6 provinces on the Andaman seacoast of Thailand. With the tide-gauge station data, run-up surveys, bathymetry and coastal topography data and land-use classification from satellite imageries, we can use these information for coastal zone management on evacuation plan and construction code.

KEYWORDS: Tsunami, MOST Model, THAILAND, IOTWS.

1. INTRODUCTION

On 26th December 2004, the devastating Tsunami has severely damaged the land use / land cover of the coastal zones on the Andaman seacoasts of Thailand. Coastal environment has undergone severe damage as the mangroves, sea grass and corals are destroyed in many affected areas. The change will impact the ecological balance and adversely affect the life of local people and also tourism. This will take a long time to recover if unattended or unwell-planned rehabilitation.

There is a need to quickly map the changes and assess the economic damage. This information is very necessary for the decision makers to plan a strategy for restoration of ecology, reconstruction and rehabilitation.

The tsunami caused significant geomorphologic changes along the coastline, such as eroding sandy beaches, expand overwashed sediment and enlarging water channels. In this study, the damage of tsunami on the 6 provinces along the Andaman coast, were assessed from satellite data into 2 levels depend on data resolution.

2. DAMAGE ASSESSMENT BY SATELLITE

2.1 Classification effects of tsunami on medium scale

Two Landsat TM imageries (30 meter resolution) were used to compute the NDVI (Normalized Vegetation Difference Index) difference before (March 17, 2004) and after the Tsunami event (December 30, 2004). The assumption behind this analysis is that abrupt NDVI reduction in cloud free areas are normally due to a decrease in vegetation cover or to the presence of water, and can therefore be used as indicators of the potential impact of the Tsunami. All pixels showing a negative difference were grouped into three classes: "high tsunami impact" if the difference is bigger than 0.5 NDVI, "moderate tsunami impact" if NDVI is between 0.5 and 0.1 and "low tsunami impact" if NDVI value between 0 and 0.1.

Our analysis indicates that the area affected by tsunami covers 144.15 sq. km. and were classified into 3 levels.

- High effects classified by land cover before and after tsunamis are completely change NDVI value before and after are very different (ΔNDVI). This type of classified cover 20,265,055.18 sq. km. along the Andaman coast of Thailand.
- Moderate effects classified by different NDVI value are moderate. This type of classified cover 93,154,535.79 sq. km. along the Andaman coast.
- Low effects classified by different NDVI value are slightly different cover 30,731,055.32 sq. km. along the Andaman coast.

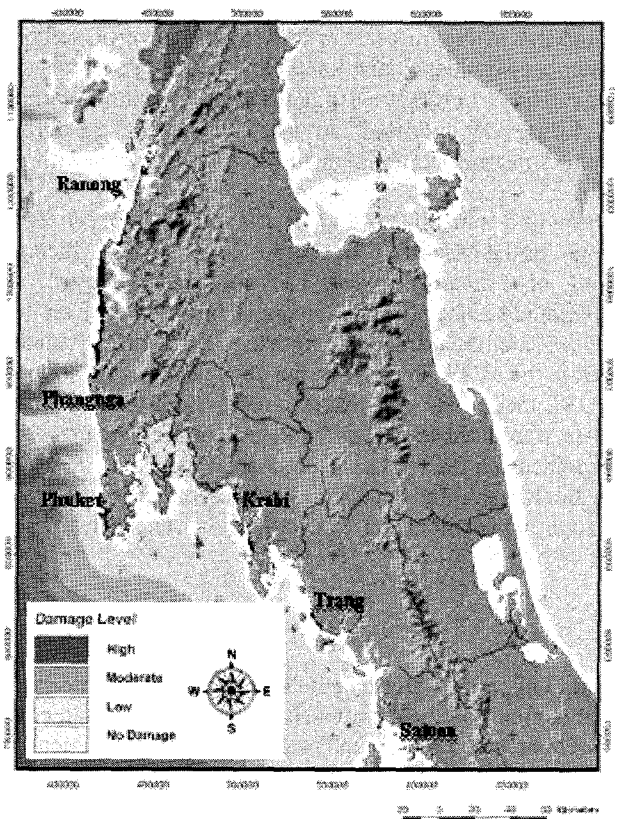


Figure 1. Tsunami damage assessment derived from Landsat TM image along the Andaman Sea Coast.

Phang-nga is the most damaged province. The highest run-up of 15.68 m was recorded at Laem Pakarang or Cape Coral (Figure 2 and 3).

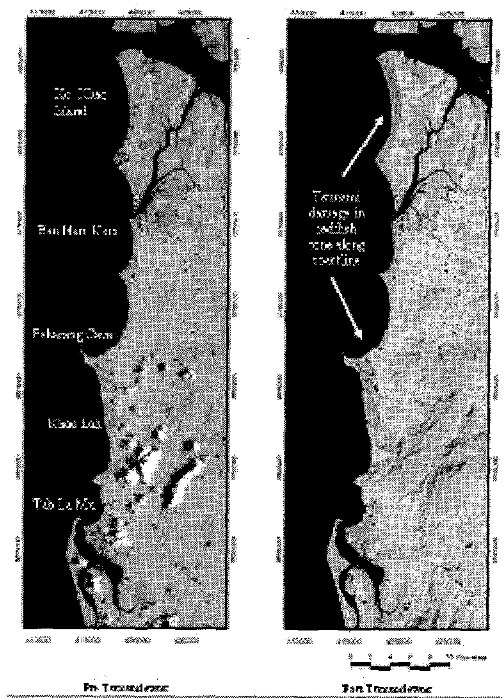


Figure 2. Landsat TM imageries of pre and post tsunami event during Andaman coast of Thailand (Ko Kho Island to Tab La Mu, Phang Nga province)

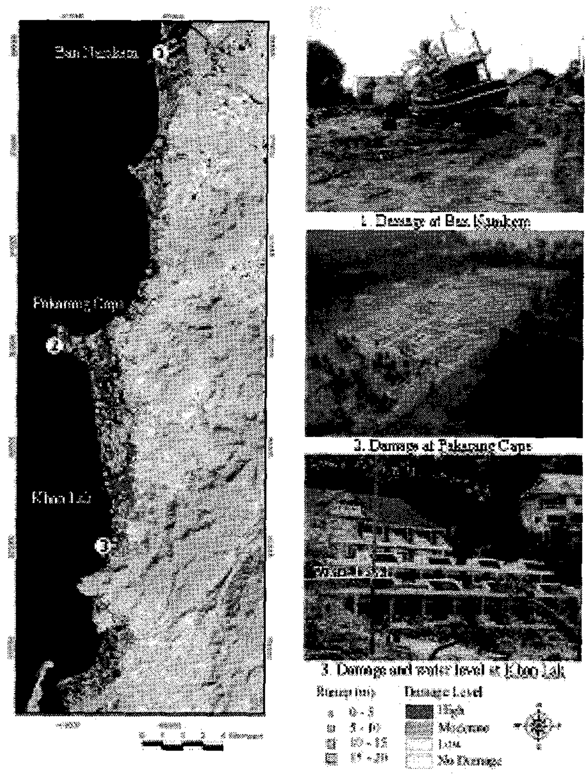


Figure 3. Damage Assessment from NDVI at Ban Num Khem, Phang-nga Province.

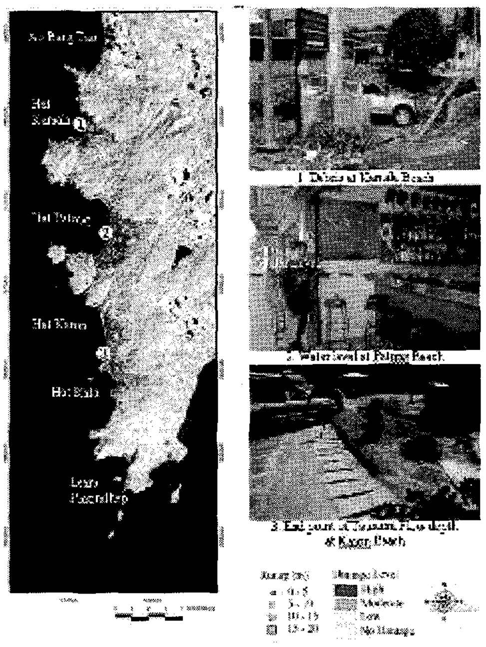


Figure 4. Tsunami run up level and damage assessment in Phuket Province (Bang Tao Beach to Prom Them Cape).

At Phuket, Patong Bay is the most damaged as shown in Figure 4.

2.2 Classification effects of tsunami on high level of details

High resolution satellite data (e.g. IKONOS, QuickBird) were used to prepare map of pre and post-Tsunami land use and land cover. Existing maps of land use, land cover, administrative boundaries, mangroves, aquaculture, plantations and forest will be input into GIS. In addition the socio-economic data will be integrated in GIS. Data received from different sources will be transformed to one standard and scale for compatibility and analysis. Maps will be generated at larger scale as the damage is generally located in a narrow strip of approximately 1 Km. All the generated maps will be supplemented by extensive ground-truth to incorporate attributes related to the damage including other information. All the data from satellite and other sources will be utilized to develop a map of changes in coastal ecology, marine ecology, coastal land use (office, residence, hospitals, hotels, etc.). In addition an assessment will be made in terms of the economic evaluation of the loss in the area.

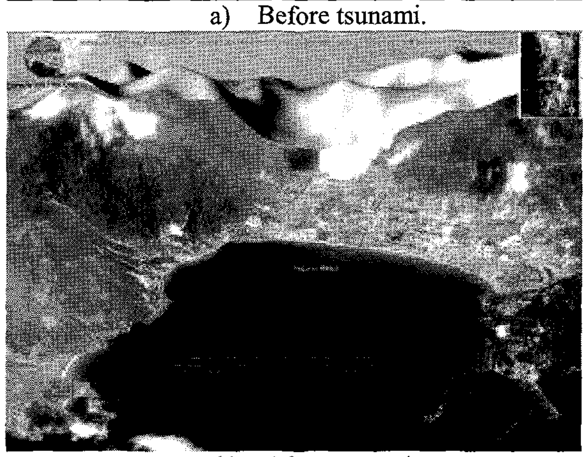
Study of tsunami effect in high level of satellite imageries especially for the area of Laem Pakarang (Figue 6), Phang-nga Province, and Patong Beach, Phuket Province (Figure 5). These of which are the areas that lives and properties were seriously affected most in Thailand.

Damage assessment with high resolution imageries is present in Table 1 and classified into 9 categories: urban, aquaculture, open area, coconut, orchard, resort and hotel, sandy beach, water bodies and transportation, definition of each land cover are described in Table 1.

Table 1 Land cover group and definition

Land cover group	Definition of each type of land cover
Urban	Village, town and human resident
Aquaculture	Shrimp pond, and water dike
Coconut	Palm and coconut
Orchard	Rubber, Pine and orchard
Resort	Resort building near coast
Beach	Mud beach, sandy beach
Water bodies	Well, river, stream
Transportation	Road, walkways
Open area	Inundation area, area cover by grass and shrub, sediment deposit by tsunami wave

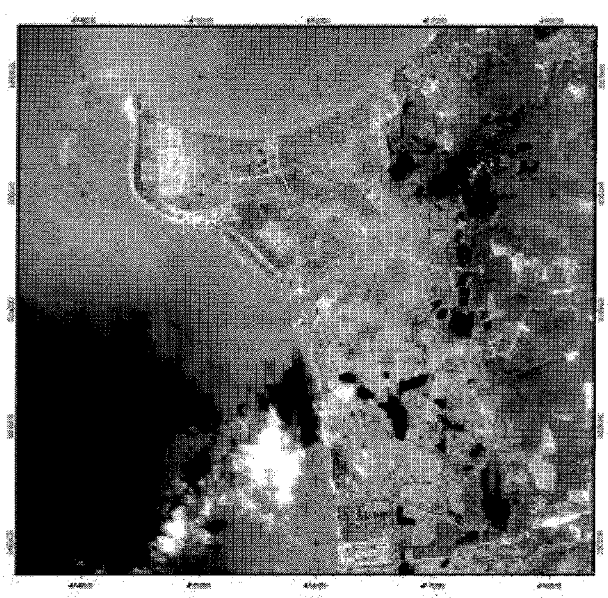
a) Before tsunami.



b) After tsunami.

Figure 5. Perspective view of IKONOS imageries in Patong Beach, Phuket Province

a) Pre tsunami February 11, 2004



2) Post tsunami December 29, 2004.

Figure 6. Comparing of pre and post IKONOS satellite images on Pakarang Cave, Phang Nga province.

3. CONCLUSIONS

The damage assessment from satellite data can be used for inundation mapping, evacuation planning and coastal zone management for tsunami disaster. The damage assessment at Phuket from MOST model as shown in Figure 7 can be used for hazard map, which showed that Patong, Kamala Bays and Mai Khao beach are the tsunami risk areas. The map of Cape Coral inFigure 8 can be used for inundation mapping and evacuation plan.

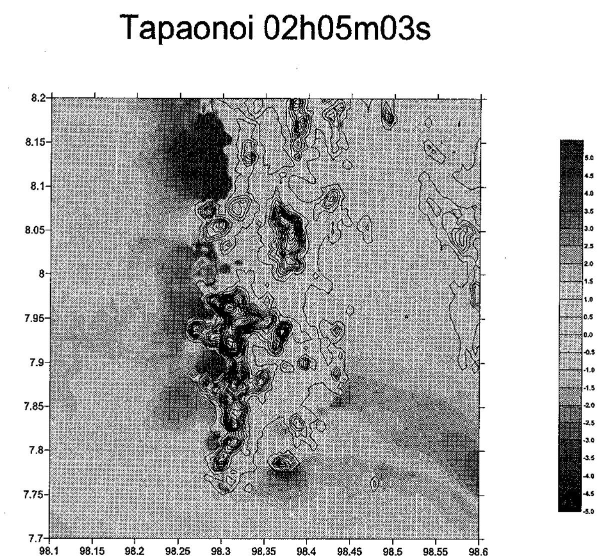


Figure 7. The damage assessment at Phuket from MOST model.

Figure 8. Cape coral.