Remote sensing technology for Tsunami Disasters Along the Andaman Sea, Thailand

Supapis POLNGAM

Thanakorn Sanguantrakool, Ekkarat Pricharchon, Surassawadee Phoompanich
Geo-Informatics and Space Technology Development Agency (Public Organization)
196 Phahonyothin Road, Chatuchak, Bangkok 10900, Thailand
Telephone : (662) 940 –6420-9 Fax : (662) 561-3035, 562-0429, 579-5618
Email: supapis@gistda.or.th,
thanakorn@gistda.or.th, ekkarat@gistda.or.th

ABSTRACT

December 2004 Tsunami disaster is natural disasters which is caused by purely natural phenomena and bring damage in huge scale to 6 provinces along the Andaman Sea, southern of Thailand namely Ranong, Phang-nga, Phuket, Krabi, Trang, and Satun. The information gathering and applying geo-informatics technology have been used in phases of mitigation and recovery. Such an affected area interpolation can be executed successfully in multi-spatial, multi-temporal and multi-spectral characteristics. An affected and damage area as obtained from the interpolation of high resolution IKONOS and QuickBird are the main information sources. We found that main types of damage are coastal shoreline erosion and damage to constructions such as buildings, road network, bridges, shorelines, acquacultural cages, fishing vessels, and the environment as well.
Key words : Tsunami, Geo-informatics data

1. Introduction

The 9.0 magnitude Sumatra Andaman megathrust earthquake spawned a gigantic seismic waves or Tsunami in the Indian ocean at the end of December 2004 focused world attention once more on the large scale coastal flooding in various countries namely Sri Lanka, India, Indonesia, Bangladesh, Malaysia, and Thailand, etc. In Thailand, the affected area by tsunami was covering in southern part, six provinces including Ranong, Phang-nga, Phuket, Krabi, Trang and Satun, In Thailand alone, 5,393 people were killed, 8,457 injured and 3,062 missing, approximately 58,000 people or 12,000 households affected, 4,800 houses destroyed wholly or partially, 5000 fishing villages affected, 6,000 fish vessels destroyed. The environment has also greatly affected, marine and coastal parks were damaged, some coral reefs were also destroyed. In addition, coastal flood plain which is mostly narrow, caused damage to buildings, road networks, bridges, bay or inlets, coastline, etc. Moreover, an electricity supply and telephone lines were disrupted for a couple of days.

Currently, earth observation satellite data play a major role in quickly assessing the damage caused by both natural and man – made disasters like flood, landslide forest fire, earthquake and even tsunami. As for tsunami disaster monitoring, satellite data are very useful particularly in developing country as Thailand for base mapping, for emergency relief logistics, estimate of settlement and structure vulnerability, an affected area and damage mapping.

Immdiately after the disaster, the Thai government, in close cooperation with international communities, moved in quickly to provide relief and rehabilitation to the disaster victims and the affected areas. With all these efforts, some of the affected areas have begun to recover and the Government has been working tirelessly on longer term measures to help bring sustainable livelihoods to local communities and to help local business to recover fully as well. As for emergency preparedness, Thailand's National Disaster Warning Center was set up. The Center with give early warning to not only Tsunami disaster, but also to other types of disaster. The Center is linked to earthquake centers in Japan and Hawaii as well as to relevant Thai government agencies.

2. Satellite data for tsunami studies

Satellite data can be utilized in three phases of operation. They are mitigation phase, response phase and recovery phase. Tsunami disaster mitigation involves in risk reduction. Then, satellite data integrated with a geographic information system can be based and exposed as input to planning logistic for response scenarios, planning evacuation routes and public education program. Satellite data requirements are in multi-spatial, multi - temporal and multi - spectral characteristics.

Data from various satellite like TERRA and AQUA operating in low resolution with 250 – 500 meters, medium resolution of LANDSAT, IRS, SPOT-5 and RADARSAT and high resolution with 1 meters and 61 centimeters of IKONOS and QuickBird respectively of pre and post tsunami period were applied to monitor the damage. Usually, TERRA and AQUA – MODIS scene used to identified the regional level phenomenous and a comparison of TERRA and AQUA – MODIS operating in different period of tsunami event was indicated in Figure 1. Active tsunami wave shown as white color along Phangnga coastline (middle image) and coastal flooding are totally occurred and presented as sediment deposits in white – cyan color along the Andaman coastline from Ranong, Phang-nga, Phuket, Krabi, Trang and Satun provinces. High resolution data of IKONOS and QuickBird are suitable for pinpointing location, type of damage, the degree of damage and affected area as well. After identifying affected area from those data, a field investigation was carried out. Types of damage can be illustraed in Table 1 and displayed as summarized below.

2.1 Coastal shoreline erosion

Damage caused by tsunami is mostly severe at shoreline where boats, harbors, road networks, buildings, and utilities were destroyed. Besides, aquatic life, plants, animal and human in the near shore environment may also be devastated. Multi – date satellite data are found to be very useful to monitor a coastal shoreline changes (Figure 2 – 4). Figure 2 shows an affected area (red boundary) of IKONOS image of Patong beach, Phuket province. We found that the wave could reach in land area approximately 480 meters from the shoreline. Sand beach and beach erosion at lower part of Patong beach was enlarged and displayed the erosion as yellow vector in Figure 3. Also, river damage and sand bank damage, large run – off and strong waves caused erosion of river and beach bank at Kammala beach, Phuket province (Figure 4).

2.2 Damage to constructions

All constructions including buildings, road networks, bridges, aqua-cultural farms and ships were completely washed away by the Tsunami wave in many places such as Phang-nga coastal, West coast of Phuket island, Ranong, and Krabi province. At Tri Trang beach, Phuket province, where the wave washed the buildings, roads swimming pools, beaches and shrub forest away and damaged by huge sand and woods transported by wave (Figure 5) and Figure 6 shows severe Tsunami damage and many ships were dragged 600 - 700 meters from the coast at Ban Nam Khem, Phang-nga province. Detail of perspective IKONOS image is essential for reliable landscape of general affected area and effective in visualizing the affected area. From these images can make us more understand how the waves spread over the coastal flood plain. Phang-nga coastal plain is a shoreline of submergence, most of coastal is mostly narrow, flanked by steep slopes. The shoreline is usually quite irregular with many bays and inlets. Various of tin placer deposits are generally found on alluvium plains which originated from alluvium transported from eroded granite mountains and in shallow coastal sea and also, human settlement are possible and popular on those shorelines (Figure 7). Beach bank erosion and buildings submerged by the wave (water) and bridge and roads were washed away of South Sea Coral and Spa Resort, Phangnga province showing by IKONOS images (Figure 8). Figure 9 displayed an affected area by Tsunami with yellow boundary along Phang-nga coastal plain from natural color composite IKONOS images highlighting from Laem Krang Yai to Ban Khao Lak. Some place as Ban Bang Sak, Bang Muang sub district, Takua Pa district, the wave could reach approximately 550 meters at elevation 10 meters above mean sea level as Figure 10. Figure 11 also, the wave reached 2,200 meters distance from the shoreline at Ban Bang Niang, Takua Pa district, Phang-nga province.

3. GISTDA activities in response to Tsunami disaster

Recognizing the significance of the Tsunami disaster and its devastating impact, Geo-Informatics and Space Technology Development Agency (Public Organization); GISTDA has acquired and processed satellite data from various sources both optical and microwave sensors operating from low medium and high resolutions then provide up-to-date and ready-to-use data integrated with GIS data immediately after the Disaster to users and other relevant information collected from field investigation as well. The Satellite Imagery based Information Center for Tsunami Recovery was established in order to supply satellite images, GIS data and relevant technology support for the recovery effort to the area affected by the tsunami disaster. GISTDA also published the Tsunami story book entitled Geo-informatic data for Tsunami monitoring and management in Thailand which it contains Tsunami story, Geo-informatic data for Tsunami monitoring, mitigation and recovery, field photos as well as Tsunami evacuation plan. In addition, technical consultations were provided to cooperate with requested agency in data utilization for recovery effort (http://tsunamirecovery.gistda.or.th).

At least 50 governmental agencies, private sectors and educational institutes have already been received and utilized satellite images as part of recovery missions.

4. Conclusions and Recommendations

The potential of high and low resolution satellite data and GIS technology, in addition to assessing and monitoring tsunami disaster and also offer excellent opportunities for creating a long term database on risk assessment and relief management. As for coastal shoreline erosion study, the satellite data should preferably belong to the low tide period. Because during low tide condition, maximum land is exposed and even low waterline, land-water boundary and high waterline are distinctly visible.

5. References

5.1 Alexander D., Natural Disasters. UCL Press Limited, London (1999).

5.2 A report of the CEOS Disaster Management Support Group (2000).

5.3 Clark John R., Coastal Zone Management Handbook (1996).

Table 1 Estimation of Tsunami areas by District/Province, Thailand

District/Province	Built-up Area		Agricultural Area		Forest Area		Water body Area		Miscellaneou s		Total	
	Area (ha)	Area %	Area (ha)	Area %	Area (ha)	Area %	Aera (ha)	Area %	Area (ha)	Area %	Area (ha)	Area %
Ranong Suk Samran	15 15	28.68 28.68	- -	- -	- -	- -	- -	- -	37 37	71.32 71.32	52 52	0.26 0.26
Phang-nga Ko Phra Thong, Khura Buri Ko Kho Khao, Takua Pa Ban Nam Khem, Takua Pa Khao Lak, Takua Pa Ban Khao Lak, Thai Muang	988 63 102 130 661 33	5.64 0.79 2.50 8.01 17.59 37.79	2,28 6 498 205 496 1,08 6 -	13.0 6 6.25 5.04 30.5 9 28.9 0 -	993 - 993 - - -	5.67 - 24.3 9 - - -	196 7 38 110 42 -	1.12 0.08 0.93 6.77 1.10 -	13,05 0 7,405 2,734 888 1,969 54	74.51 92.88 67.14 54.63 52.41 62.21	17,5 15 7,97 3 4,07 2 1,64 2 3,75 8 87	89.3 5 40.6 7 20.7 7 8.29 19.1 7 0.44
Phuket Hat Kamala, Kathu Hat Patong, Kathu	1,24 7 305 942	63.59 40.22 78.34	74 44 30	3.79 5.85 2.50	- - -	- - -	26 13 14	1.35 1.69 1.13	613 396 217	31.27 52.24 18.03	1,96 1 759 1,20 2	10.0 0 3.87 6.13
Krabi Ko Phi Phi, Muang Krabi	60 60	79.47 79.47	12 12	15.2 6 15.2 6	- -	- -	- -	- -	4 4	5.27 5.27	76 76	0.39 0.39
Total	2,31 1	11.79	2,37 2	12.1 0	993	5.06	223	1.14	13,70 4	69.91	19,6 04	100. 00

Miscellaneous: Includes beach, sand bar, mangrove forest, beach forest, standing tree, road, abandoned tin mining, and barren area

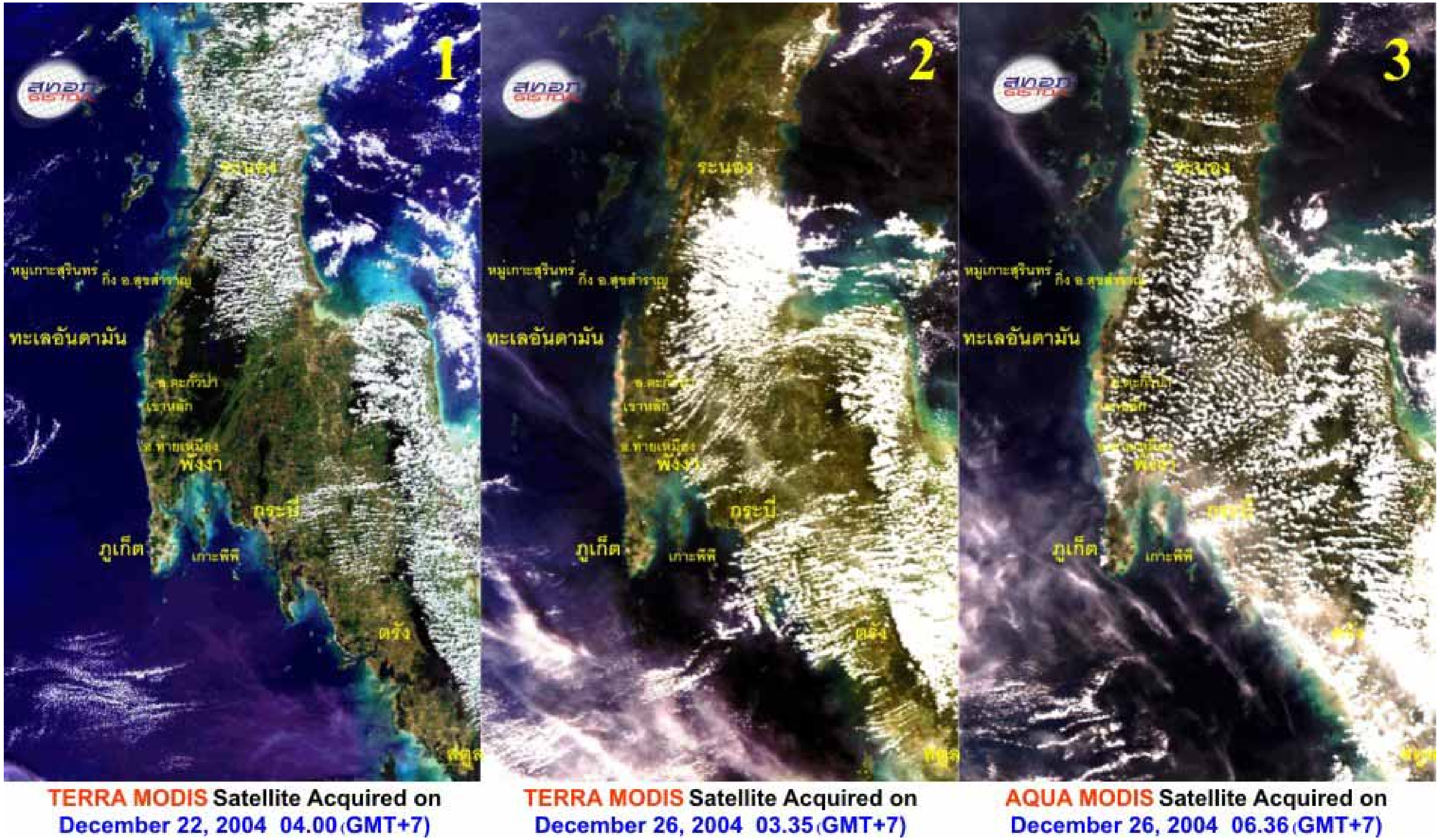


Figure 1 Comparison of TERARA and AQUA – MODIS during tsunami event, left image was taken on December 22, 2004 (before), middle and right images of December 26, 2004 at 10 :35 and 13:35 local Thai time were captured during and after the event respectively.

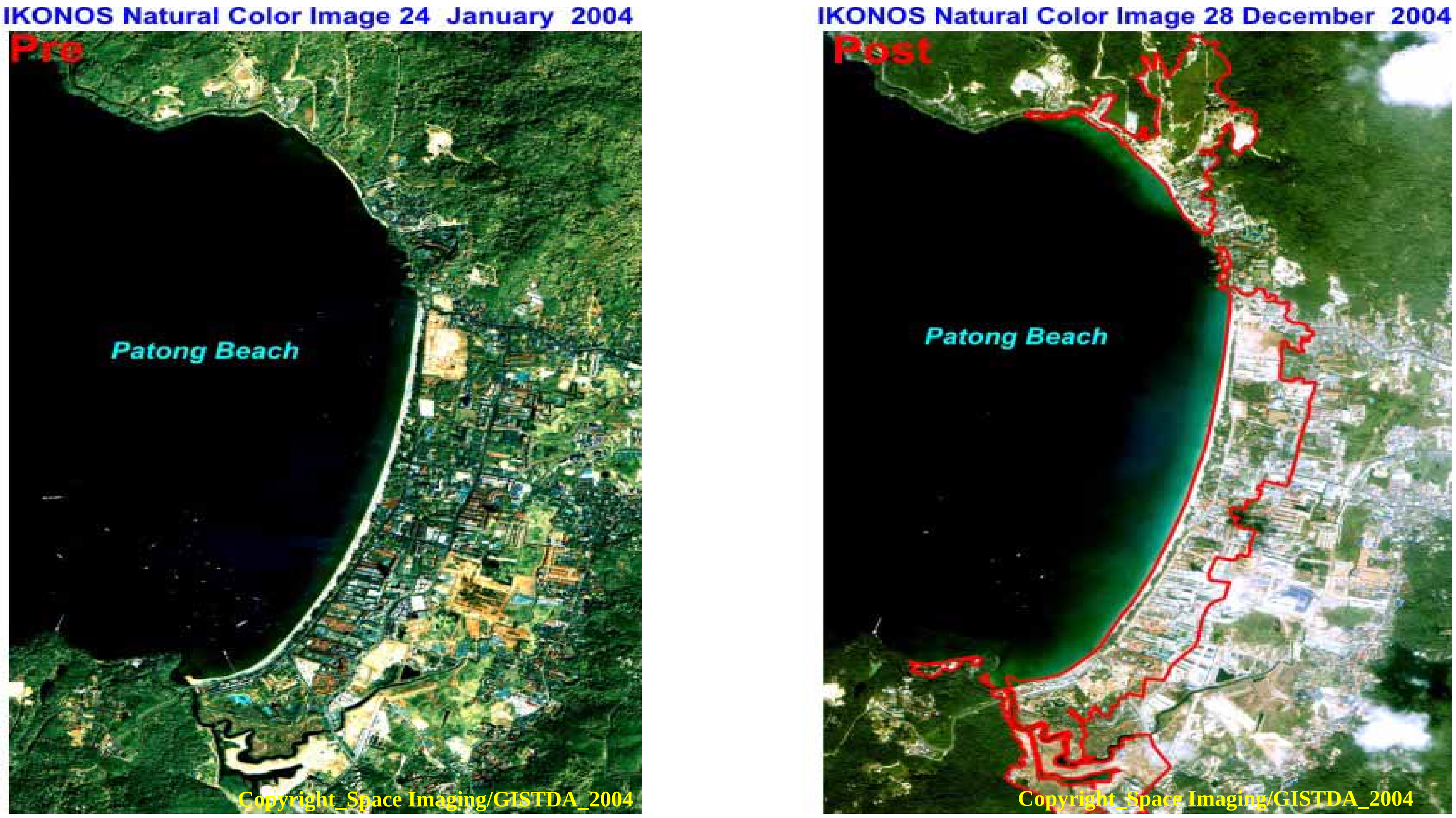


Figure 2 Pre (24 January 2004) and Post (29 December 2004) tsunami event of IKONOS images of Patong beach, Phuket province. Red boundary responses to an affected area.

1= The Seaview Patong

Figure 3 Two period natural color composite IKONOS images (24 and 28 December 2004). Yellow vector indicates sand beach and beach bank erosion at lower part of Patong beach, Phuket province.

Figure 4 Pre and post natural color composite IKONOS images of Kammala beach, Phuket province taken on January 24, 2004 and December 29, 2004 showing before and after shoreline and river bank erosion in red and yellow respectively.

1= The Merlin Beach Resort

Figure 5 Pre and Post images of IKONOS showing a changed area of Merlin Beach Resort at Tri Trang beach, Phuket province. Also damages to buildings, swimming pools, roads, shorelines and shrub forest

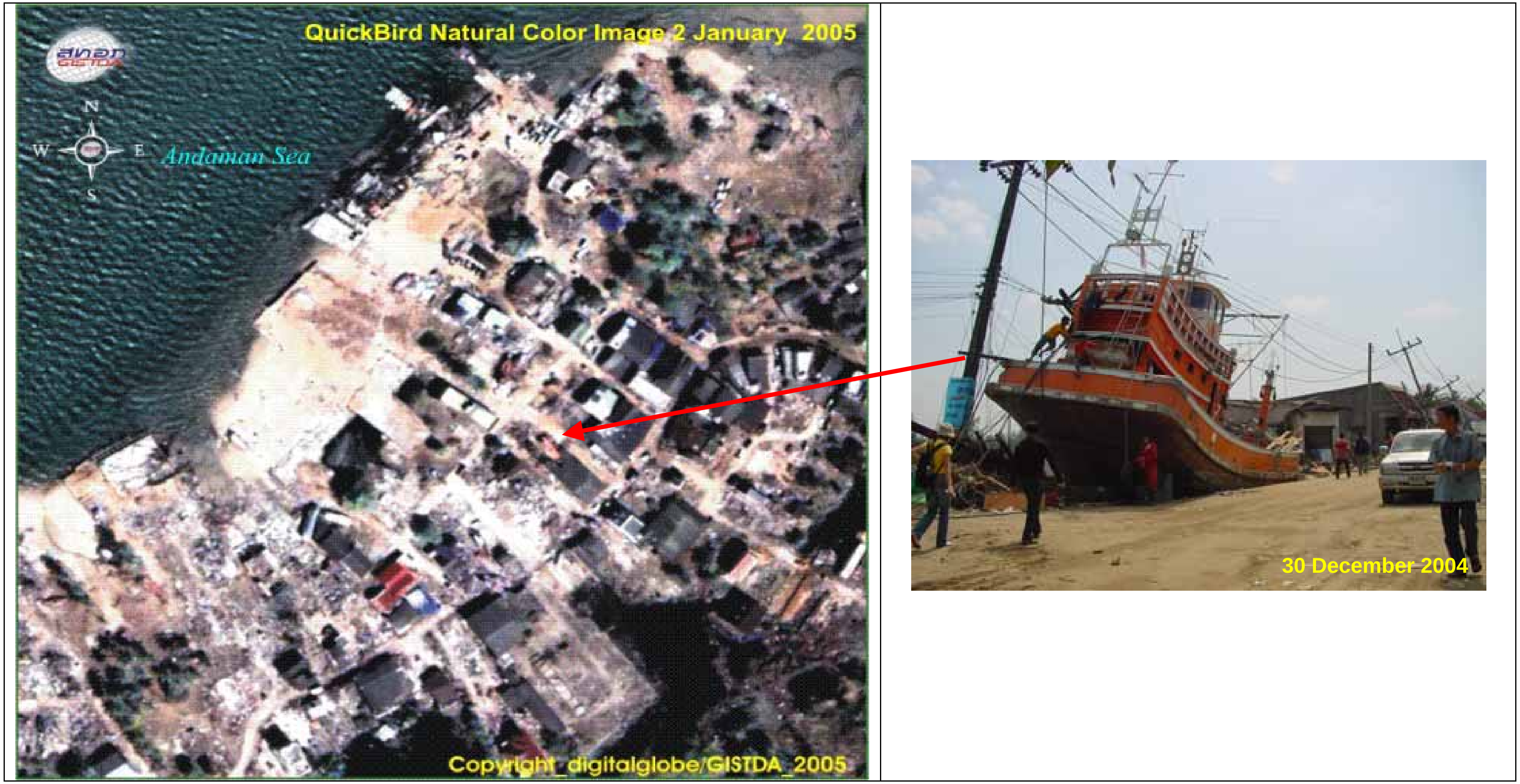
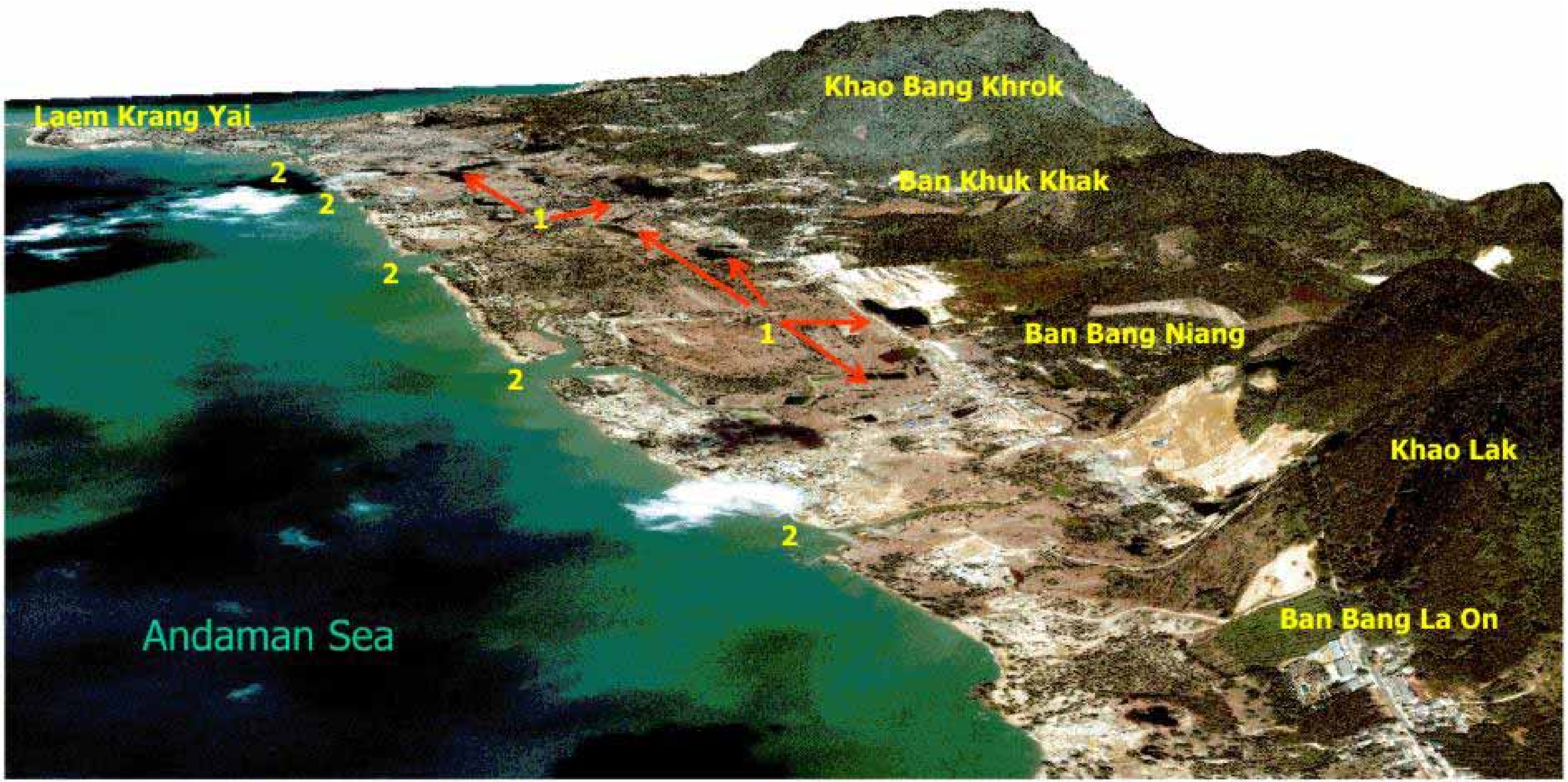


Figure 6 Severe tsunami damage at Ban Nam Khem, Phang-nga province. Many ships were dragged 600-700 meters away from the coast.



1 = Tin placer deposites
2 = Inlets

Figure 7 Perspective views of Phang- nga coastal plain generated from IKONOS natural color composite taken on December 29, 2004

Figure 8 Pre and Post IKONOS images of the Resort, Phang-nga province acquired on January 30, 2003 (Left) and December 29, 2004 (Right) showing before and after shoreline, river bank erosion in red and yellow respextively, damages also to buildings, roads, bridges, and aquacultural farms.

Figure 9 Natural color composite IKONOS image (29 December 2004) overlay with affected area in Phangnga coastal plain (yellow boundary) covering, Laem Krang Yai, Ban Khuk Khak, Ban Bang Niang, Ban Bang La On and Ban Khao Lak.

Figure 10 Natural color composite of QuickBird (2 January 2005) image of Ban Bang Sak where wood were transported and deposited around 550 meters at elevation 10 meters above mean sea level.

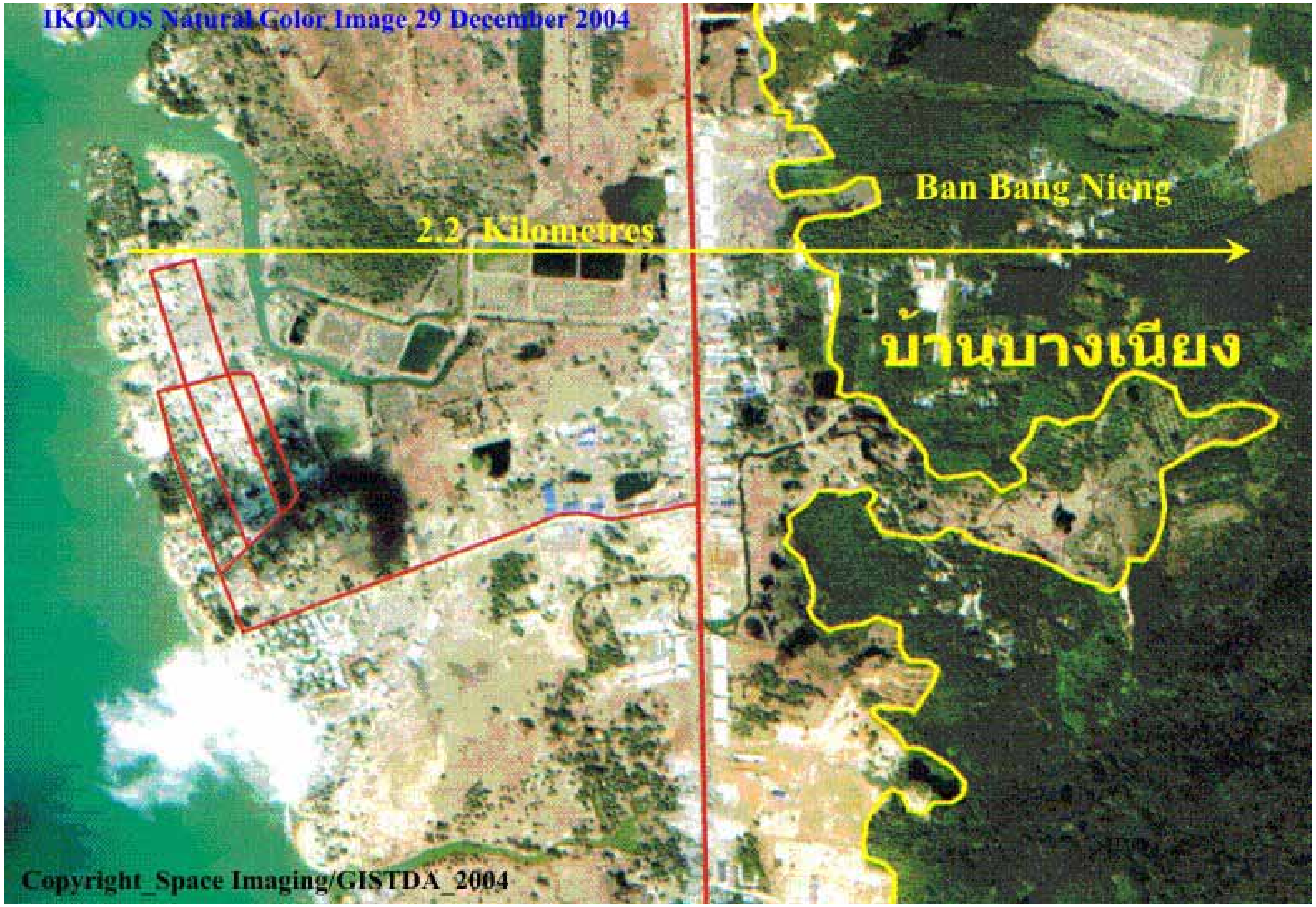


Figure 11 Natural color composite of IKONOS (29 December 2004) of Ban Bang Niang where sediment deposited about 2,200 meters far from the shoreline (yellow boundary).