EFFECTS OF THE DECEMBER 2004 TSUNAMI AND DISASTER MANAGEMENT IN SOUTHERN THAILAND

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ABSTRACT

A quake-triggered tsunami lashed the Andaman coast of southern Thailand on December 26, 2004 at around 9.30 am local time. It was the first to strike the shorelines of southern Thailand in living memory. Coastal provinces along the Andaman coast suffered a total of 5,395 deaths – more than half of whom were foreign tourists, with another 2,822 reported missing. Of the 6 affected coastal provinces, Phang Nga was the worst-hit province with some 4,224 lives lost and 7,003 ha of land area devastated. Takua Pa District, which was a prime tourist area with numerous beach resorts, was the most severely affected area in Phang Nga Province.

Through the use of the aerial photographs and Ikonos images, it was found that 4,738 ha of Takua Pa District's coastal area were affected by the tsunami. The tsunami run-up heights of 7-8, 5-7 and 10-12 metres, were observed at, respectively, Ban Namkhem, Pakarang Cape and Ban Bangnieng in Takua Pa District. The tsunami caused heavy damage to houses, tourist resorts, fishing boats and gear, culture ponds and crops, and consequently affected the livelihood of large numbers of the coastal communities. The destructive wave impacted not only soil and water resources, but also damaged healthy coral reefs, sea grass beds and beach forests. The surviving victims faced psychosocial stresses resulting from the loss of their loved ones, being rendered homeless and fears of another tsunami. The tsunami effects on human settlements, livelihoods, coastal resources, natural environment together with the psychosocial well being of the coastal communities have contributed to the degradation of the coastal ecosystems.

Following the 2004 event, it has become apparent that the country's disaster management strategies need to be strengthened through the implementation of mitigation and preparedness options to enhance the community's resilience to natural events such as tsunami. The improved strategies are discussed in this paper.

1. INTRODUCTION

Southern Thailand, also designated as Peninsular Thailand, lies between latitudes 5^0 and 11^0 N, and longitudes 98^0 and 102^0 E. It covers an area of 7,153,917 ha and has over 2,705 km of shoreline. The mountain ranges form the backbone of this region, with the western coastline facing the Andaman Sea and the eastern coastline facing the Gulf of Thailand. Many so-call pocket beaches with short and narrow sandy beach nestled between head lands are found along much of the Andaman coast, whereas the Gulf of Thailand coast is characterized by long mainland beaches with associated landforms such as barriers, spits and sand dunes (Sinsakul, 2004). The peninsular area affords excellent access to the seas, with 12 of the 14 southern provinces having sea access. Southern Thailand, in general, enjoys a tropical climate that provides good moisture and humidity throughout the year. Its coastal areas are diverse, and contain productive ecosystems that sustain a large proportion of the coastal population, with plentiful flora and fauna. Pristine tropical rain forests on the uplands, beach forests and soft white sand beaches along the coastal shores and stunning marine life make Thailand's southern region one of Asia's top choice tourist destinations.

In response to the phenomenal growth of the tourism and fishery, including aquaculture industries, tourist resorts, culture ponds, and aquaculture infrastructure have replaced much of the mangrove and beach forests along the coastal shores (UNEP, 2005). Many of the coastal sand dunes that act as natural barriers against incoming waves have been removed to make way for the construction of beach resorts, walkways and roads. Most of the fisher folks and impoverished local populations that made a living in tourist-related activities live in weakly-constructed and unplanned settlements in low-lying areas close to the shores. As a consequence, the coastal areas of southern Thailand have become highly vulnerable to the occurrence of natural disasters caused by extreme events.

At 0059 GMT on 26 December 2004, a magnitude 9.3 earthquake ripped apart the seafloor off the western coast of northern Sumatra, Indonesia. The sudden vertical rise of the seabed by several meters during the quake displaced massive volumes of water, resulting in a devastating tsunami. This seismic sea wave traveled thousands of kilometers across the Indian Ocean, and ravaged the Andaman coast of southern Thailand at 9.30 am local time. Coastal provinces including Phuket, Phang Nga, Krabi, Ranong, Trang and Satun (Figure 1) suffered a total of over 5,395 deaths–more than

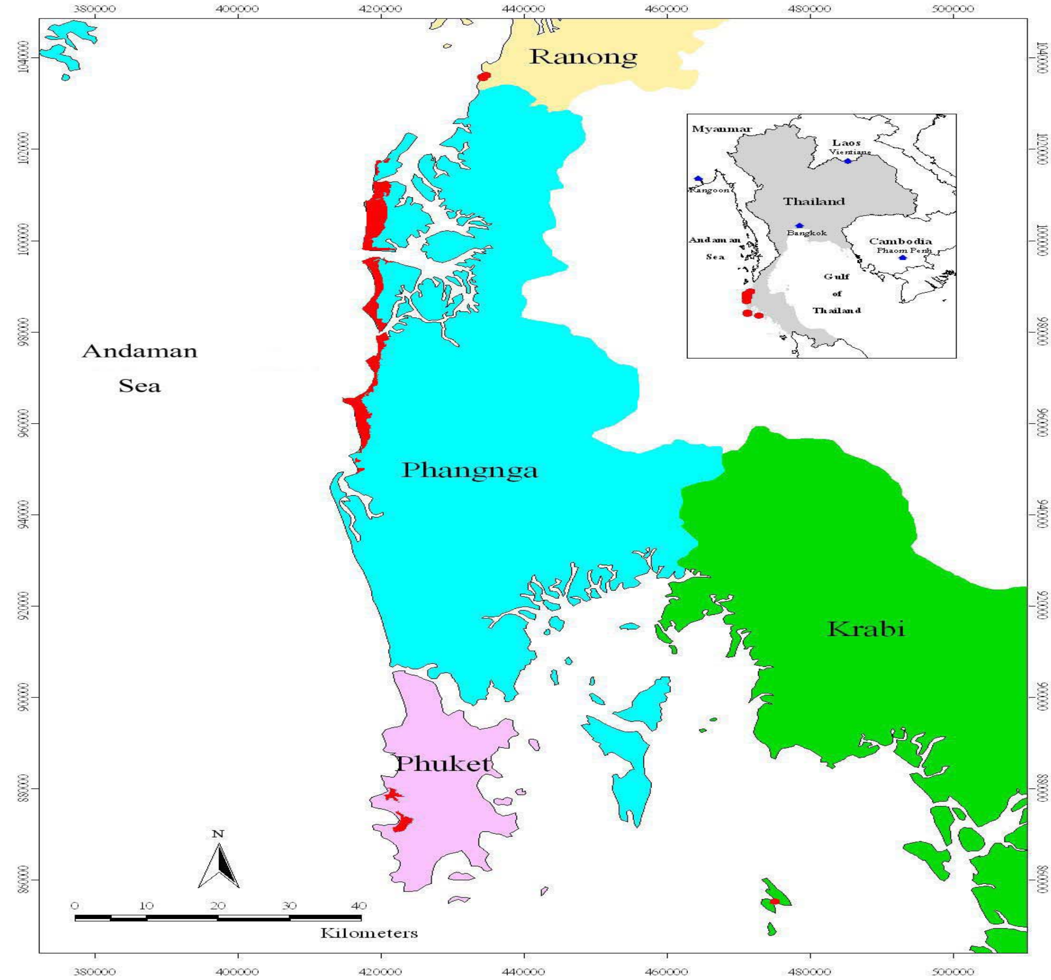

Figure 1. Tsunami affected areas along the Andaman coast, southern Thailand.

half of whom were foreign tourists, with another 2,822 reported missing (Department of Disaster Prevention and Mitigation, 2005). Of the 6 affected provinces, Phang Nga was the worst - hit with some 4,224 lives lost and 7,003 ha of land area devastated. Takua Pa District, which was a prime tourist area with numerous beach resorts, was the most severely affected area in Phang Nga Province (FAO, 2005). In this district, the tsunami destroyed lives, houses, livelihoods on a scale never before seen in Thailand.

As the Indian Ocean has several seismic sources, recurrence of the tsunami on the scale of the 2004 event can be anticipated in the future. According to NGI (2006), a tsunami generated by a magnitude 8.5 earthquake on the Sunda Arc would crash into the Andaman coast of southern Thailand and cause major loss of life and destruction of property again within 50-100 years.

The objective of this study were to (i) assess the effects of the December 2004 tsunami on the coastal ecosystem in Takua Pa District, the worst-affected area in the tsunami tragedy, and (ii) provide recommendations for the strengthening of disaster management strategies to enhance Thailand's capacity to manage a natural catastrophe of the nature and magnitude of the December 2004 event in the future.

2. MATERIALS AND METHODS

This study was based on both primary and secondary sources of data and information. The primary data was obtained through interviews of eyewitnesses, laboratory analysis of soil and water samples, measurement of tsunami run-up heights and interpretation of remotely sensed data and aerial photographs. The secondary data included information on 2004 tsunami impacts from local government agency offices and sub-district administrative organizations.

2.1 Materials

1) Topographic maps for the tsunami affected area on a 1:50,000 scale, published by the Royal Thai Survey Department in 2000.

2) Colour aerial photographs for the tsunami affected areas on a 1: 25,000 scale, acquired in February 2002, produced by the Royal Thai Survey Department.

3) Ikonos images, pertaining to the affected areas on a 1:4,000 scale, acquired on December 30, 2004, provided by the Geo-Informatics and Space Technology Development Agency (GISTDA).

2.2 Methods

In this study, Geographic Information Systems were used to develop two digitized thematic maps, one which defined the tsunami-affected area boundary, and a land use map of the tsunami devastated area. All GIS computation and coverage overlays were performed with PC ArcInfo software. The boundaries of the area studied were digitized from the 1:50,000 topographic maps. The tsunami affected areas were digitized from a map visually interpreted from the 1:4,000 Ikonos images, acquired 4 days after the December 2004 tsunami event. Land use coverage in the area of concern was generated in ArcInfo format by digitizing from land use maps visually interpreted from the 1:4,000 Ikonos images. The 1:25,000 aerial photographs, acquired in 2002, were used to assist in the classification of land use, and ground truthing was also conducted to validate the final results. Land use types in the tsunami affected areas were determined by overlaying land use coverage with tsunami affected area coverage.

Data on tsunami run-up heights were obtained through interviews of eyewitnesses. Water marks on houses, building and trees provided additional data on tsunami heights. To assess the effects of the tsunami on soil resources, three replicate samples of soil were collected from the worst-hit agricultural area in Takua Pa District, Phang Nga Province at 0-5 and 5-30 cm depths. The soil samples were air-dried, passed through a 2 mm sieve, and analyzed for electrical conductivity (EC) and pH. In addition, three replicate water samples were collected in 0.75 litre polyethylene bottles from the middle of the water column of surface water in the tsunami affected agricultural area in Takua Pa District. The samples were immediately analyzed for dissolved oxygen (DO) using a dissolved oxygen meter. The rest of the water samples were stored on ice and transferred to a laboratory for analyses of salinity and pH.

A field survey was also conducted to assess the impacts of the destructive waves on the psychosocial well being of tsunami affected populations. Takua Pa District, Phang Nga Province was selected for assessment as they experienced many and severe psychosocial problems. Interviews were conducted in a participatory manner with open-ended questions so as to allow the interviewees to guide the outcomes. A total of 128 surviving victims from two coastal sub-districts in Takua Pa District, namely, Bang Mueng and Kuk Khak Sub-districts, were interviewed.

3. RESULTS AND DISCUSSION

Through the interpretation of the aerial photos and Ikonos images, it was found that 4,738 ha of Takua Pa District's coastal area were affected by the devastating tsunami (Table 1). In this district, the affected areas stretched from the coastline of Ban Namkhem, which is located in the north of Takua Pa District close to the border with Myanmar, downward through Pakarang Cape in Ban Bangkaya, which are located in the central part of the district, through Ban Bangnieng, and then to Khao Lak Merlin

Resort, which is located on the coast in the southern part of the district. Of these affected areas, 848 ha or 18.7% were agricultural land, 600 ha or 13.2% were beach forests and 278 ha or 6.1% were urban and built up land (Figure 2 and Table 1). It should be noted that only 7 ha of the mangrove forests in the district were impacted by the tsunami (Table 1).

Based on the field visit, it was evident through interviews of eyewitness and measurements of watermarks on houses, buildings and trees, that Ban Namkhem suffered a tsunami run-up height of 7-8 metres. In this locality, the fishing

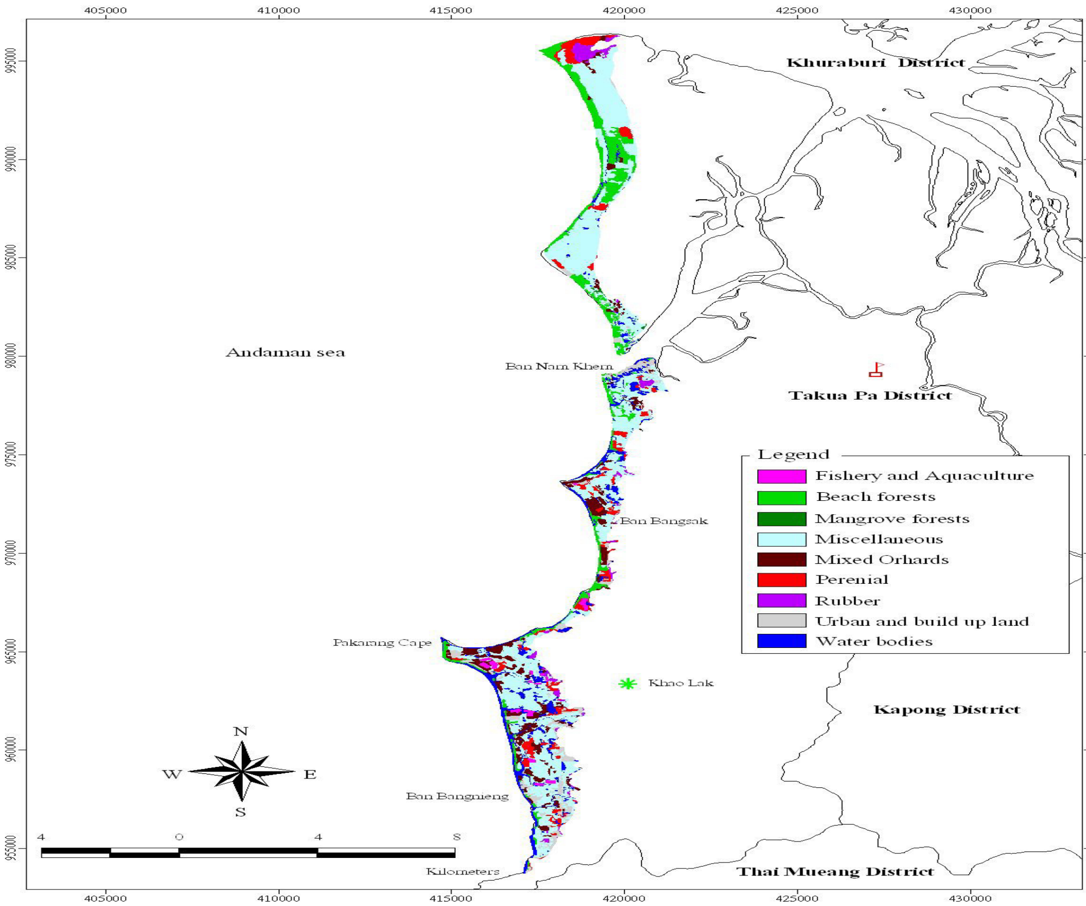

Figure 2 Land use in tsunami affected area in Takua Pa District.

Table 1 Land use types in tsunami affected areas in Takua Pa District.

Land use type	Tsunami affected area	
	Ha	%
1. Urban and built up land	278	6.1
2. Mangrove forests	7	0.2
3. Beach forests	600	13.2
4. Mixed orchard	400	8.8
5. Perennial	316	7.0
6. Rubber	132	2.9
7. Fishery and aquaculture	63	1.4
8. Water bodies	468	10.3
9. Miscellaneous	2,276	50.1
Total	4,540	100.0

communities, living in weakly-constructed houses near sea level, were completely wiped out and lost two-thirds of their inhabitants in the tsunami tragedy. The powerful wave washed away fishing boats and gear, destroyed culture ponds and damaged aquaculture infrastructure. A couple of large fishing boats were even thrown violently inland and deposited in a residential area of Ban Namkhem (Figure 3). At Pakarang Cape, Ban Bangkaya, the maximum tsunami run-up measuring up to 5-7 metres was observed. In this locality, intense beach erosion and severe damage to coral reefs and beach forests were observed (Figure 4), and almost all the luxury hotels and fisher folk villages in close proximity to the seashore lay in ruins. Agricultural land was salinated, and wells and ponds were contaminated with intruding sea water. The powerful wave also damaged coconut and oil palm plantations as trees were uprooted by the action of the wave. The ravages of the destructive wave extended up to 2 kilometers inland.

The tsunami wave of 10-12 metres and inland penetration of wave of 1 kilometres badly damaged Ban Bangnieng, which is one of the important tourist attractions south west of Pakarang Cape. Khao Lak beach, a newly constructed tourist spot, suffered a run-up height of 8-12 meters. The beachfront hotels, tourist resorts and tourism infrastructure along the shore were demolished. At this locality, approximately half of the 400 guests in a luxury beachfront resort perished in the ground-floor rooms, swamped by the force of the giant wave. The loss of life and damage to the property at Khao Lak beach was extensive because the beach was surrounded by elevated ground and hills. With run-up height of 5-6 metres, the tsunami also caused major loss of life and destruction of infrastructure to Khao Lak Merlin Resort. At this locality, the trail of destruction left by the devastating wave extended up to 1 kilometer inland.

Figure 3 A group of resort buildings lies in ruins (left) and a fishing boat rests on shore (right).

Figure 4 Views of the coastal shores in Takua Pa District after the 2004 tsunami.

Prior to the 2004 tsunami, the tourism, fisheries and agricultural industries provided most of the livelihoods in the affected areas along the Andaman Coast. The tourism sector was the most important source of revenue and the biggest provider of livelihoods (UN, 2006). As noted earlier, the field survey conducted after the tsunami revealed that most of the beachfront hotels, tourist resorts and tourism infrastructure in coastal areas of Takua Pa District were totally or partially affected by the catastrophe. Following the powerful tsunami, the fishing industry, including coastal aquaculture, suffered major losses in terms of fishing boats and gear, culture ponds, cages and shrimp hatcheries, thus destroying the local economy.

It was observed during the field visit that the tsunami flooded costal areas up to two kilometers inland. It traveled upstream through coastal estuaries and rivers, extending the devastation well inland from the coast in these areas. Hence, deposition of salts from intruding sea water in soil is expected to occur in the inundated areas. Of seven soil samples collected from the worst-hit area in Takua Pa District in January 2005, six samples at 0-5 cm depths had high EC values (Table 2), rendered it unsuitable for cultivation. Damaged crops included mixed orchards, rubber, oil palms and coconut trees. Likewise, the water quality in wells, ponds and canals in tsunami affected coastal areas was deteriorated due to sea water intrusion as well as sewage-related contamination. Of the six water samples collected from the Takua Pa area, five samples contained high salt levels (Table 3), thereby affecting irrigation options. The impacts of the tsunami on the major economic sectors such as tourism, fisheries and agriculture directly affected the livelihoods of the coastal population.

Table 2 Values of EC and pH of soil samples collected from Takao Pa District

Location	Coordinates	EC		pH	
		0-5 cm.	5-30 cm.	0-5 cm.	5-30 cm.
Ban Nam Khem	0419982 E 0979678 N	4.17	0.81	7.71	6.72
Ban Bangsak	0419390 E 0972754 N	13.94	8.28	8.14	8.66
Kuk Khak Beach	0419362 E 0976550 N	11.67	4.59	9.49	9.20
Ban Kuk Khak	0417119 E 0961439 N	8.28	3.12	8.66	8.73
Ban Pak Veep	0418509 E 0967451 N	6.36	0.83	7.93	6.96
Ban Bangnieng	0417409 E 0958291 N	3.21	2.40	9.13	7.86
Khao Lak Merlin	0416645 E 0948363 N	12.34	8.64	8.25	8.33

Table 3 Values of salinity, DO and pH of water samples collected from Takao Pa District.

Location	Coordinates	Salinity (ppt)	DO (mg/l)	pH
Ban Nam Khem	0419982 E 0979678 N	24.5	4.02	8.19
Ban Bangsak	0419390 E 0972754 N	17.9	6.75	8.35
Kuk Khak Beach	0419362 E 0976550 N	3.70	4.42	7.68
Ban Kuk Khak	0417119 E 0961439 N	24.8	7.17	8.62
Ban Bannieng	0417409 E 0958291 N	28.1	4.59	8.39
Khao Lak Merlin	0416645 E 0948363 N	32.9	4.90	8.06

The field survey also revealed that the December 2004 event also caused substantial deterioration to the natural environment. The destructive wave damaged healthy coral reefs, sea grass beds and beach forests along the impacted coastlines. It was reported, however, that extensive areas of mangroves and other coastal forests had played an important role in mitigating the effects of the 2004 tsunami disaster (FAO, 2005). The catastrophe also caused significant geomorphologic changes along the Andaman coastline, such as eroding sand beaches and enlarging the mounts of the rivers to the sea (Figure 5). The devastating wave has in fact literally redrawn the shorelines of the Andaman coast of southern Thailand.

Source : Space Imaging/crisp-Singapore.
Figure 5. Pakarang Cape before (left) and after (right) the 2004 tsunami, showing beach erosion.

Through interviews of surviving victims, it was found that the majority of them faced a number of psychosocial stresses resulting from the loss of their loved ones and community members, being rendered homeless, fearful of more tsunamis, suffering from a loss sense of safety and security, and lost livelihoods. For those who survived the tragedy, most of them suffered most from phobic disorders, followed by depressive and anxiety disorders. It will take months and years to restore lives to pre-tsunami levels of functioning. The interview results also showed that many tsunami victims, whose houses were washed away, lost their land ownership right in the aftermath of the tsunami disaster. These critical issues have led to a decline in the quality of life of the affected coastal communities.

The adverse effects of the tsunami catastrophe on coastal resources, natural environment, human settlements, and livelihoods together with a decline in life quality values of the coastal population have contributed to the degradation of the coastal ecosystems. There is therefore a profound need for a rehabilitation of the damaged ecosystems to restore sustainable livelihoods to the people of the affected communities in the coastal areas.

Most of the fatalities along the Andaman coast of southern Thailand can be attributed to the government's failure to warn the coastal communities of the imminent arrival of the tsunami. In fact, thousands of lives could have been saved had a tsunami early warning system been established in the Indian Ocean (Alverson, 2005). Prior to the December 2004 tsunami disaster, there was no operational tsunami warning facility in place in Thailand because the kingdom had never been struck by a tsunami and this type of catastrophic event was considered to be extremely rare in the area (Tibballs, 2005). However, it is still questionable as to how effective this would have been in alerting the coastal communities of imminent danger in a country which has poor communication systems and no awareness of the danger. The lack of precautionary behavior of the coastal inhabitants, even when noticing the suddenly receding tide that provided a signal of the approaching tsunami, also contributed to the enormous loss of life. It is essential, therefore, to emphasize the urgent need to strengthen and improve disaster management strategies in order to enhance the country's capacity to cope with the impact of future tsunami disaster.

4. TSUNAMI MANAGEMENT STRATEGIES

Although the occurrence of an earthquake and ensuing tsunami cannot be prevented, the magnitude of catastrophic impacts in terms of loss of life and livelihoods, destruction of property and environmental damage can be kept within reasonable limits through an integrated approach to disaster management. Planning for disaster encompasses four different but related aspects, mitigation or prevention, preparedness, response and recovery. In Thailand, however, disaster management has primarily focused on the emergency period response and post-impact recovery. Following the December 2004 tsunami disaster, it has become apparent that such an approach is not sufficient to cope with the threat from the tsunami catastrophe. Much greater emphasis should be given to mitigation and preparedness measures.

In response to the 2004 tsunami, the Thai Government directed the establishment of the National Disaster Warning Centre to function as a centralized unit receiving, monitoring, processing and relaying critical information pertaining to impending natural disasters and issuing a public warning in such an event (UN, 2006). The centre also acts as a national clearing-house of disaster risk management information. In recognizing the fact that disaster response should be based not only on the warning systems, the Thai government has adopted and implemented vulnerability reduction programmes through work in two areas: disaster prevention and/or mitigation to reduce an area's susceptibility to the impact of the tsunami hazards, and preparedness to build tsunami resilient communities. These programmes include the following measures;

1. Mitigation measures.

1.1 Establishment of land use plan for coastal areas based on vulnerability assessments and risk analysis. Critical facilities such as schools, hospital, hotels or high occupancy buildings should not be built in vulnerable areas. Existing tourism facilities, shrimp farms and aquaculture infrastructure located in areas at risk should be relocated.

1.2 Provision of appropriate incentive packages and attractive livelihood opportunities to encourage coastal communities to abandon settling in vulnerable locations and/or living in poor-designed houses, particularly along low-lying areas of the coast.

1.3 Maintenance of environmental and ecological stability of the coastal areas through the enrichment of mangrove and beach forests to act as the first line of defense from tsunami waves (Figure 6), and rehabilitation of lost and degraded coral reefs and sea grass beds to help stabilize the coastline and prevent beach erosion.

1.4 Reconstructing removed coastal sand dunes and protecting the remaining sand dunes to act as a barrier against giant waves. Creating buffer zones along the coastlines to protect coastal communities from tsunami waves are established. The buffer zones or green belts can be created through the establishment of buffer strips of between 300-400 metres, planted with mixed vegetation.

2. Preparedness measures.

2.1 Installation of a local tsunami warning system, which includes siren towers at popular and crowded beaches (Figure 6), and a tsunami warning sensor floating offshore in the most vulnerable provinces along the Andaman coastline, not only to address the safety and security concerns of the coastal communities, but also to establish southern Thailand as a safe destination for foreign tourists.

2.2 Development of education programme through school and university curricula to educate vulnerable coastal communities about the nature and processes of the tsunami hazard and how to protect themselves at the time of impact as well as the importance of mangrove forests, beach forests and coastal sand dunes in mitigating tsunami effects.

2.3 Formulation of a detailed plan for emergency evacuation of vulnerable coastal communities as well as organizing evacuation drills in order to make the appropriate response more of an instinctive reaction, requiring less thinking during an actual emergency situation.

Figure 6 A tsunami warning tower (left) and re-planted beach forests (right) along the coastal shores.

2.4 Raising the awareness of coastal communities about the dangers posed by a deadly tsunami. Brochures, posters, calendars, and announcements on radio and television can be used to stimulate public awareness.

2.5 Construction of a tsunami memorial to commemorate areas devastated by the 2004 tsunami. The memorial would become a major attraction for both locals and visitors, helping them to understand the coastal geomorphology and ecosystems of the Andaman coastline, and to remind them of the disastrous consequences of the December 2004 tsunami events.

The disaster plans of action, including elements of disaster mitigation and preparedness activities as well as responsible agencies are shown in Table 4. It is essential that attention be given to coordinating and integrating mitigation and preparedness activities implemented by various government departments and non-governmental organizations so that the scarce resources available can be used in the most effective and timely manner. Moreover, local community involvement in planning and implementing the measures of hazard mitigation and emergency preparedness is needed to ensure continued interest and support during the implementation stage.

In light of concerns about the recurrence of the tsunami disaster in southern Thailand, more collaboration between international research communities to pool resources, scientific knowledge and expertise should be encouraged so as to bring about an increase in the capacities of the relevant authorities and vulnerable communities to cope effectively with such eventualities. Examples of research topics that should be undertaken are as follows;

1) Tsunami hazard assessment using Remote Sensing and GIS.

Table 4 Disaster plan, activities and responsible agencies for dealing with natural events.

Disaster plans	Activities	Responsible agencies
1. Mitigation	1.1 Risk assessment and vulnerability analysis.	1.1.1 Academic institutions. 1.1.2 Department of Disaster Prevention and Mitigation.
	1.2 Land use planning	1.2.1 Department of Marine and Coastal Resources. 1.2.2 Department of Town and Country Planning.
	1.3 Enrichment of beach forests, and rehabilitation of coral reefs and sea grass beds.	1.3.1 Royal Forestry Department. 1.3.2 NGOs. 1.3.3 Sub-district Administrative Organization.
2. Preparedness	2.1 Installation of warning system.	2.1.1 National Disaster Warning Centre.
	2.2 Development of education programmes.	2.2.1 Academic institutions and schools. 2.2.2 NGOs.
	2.3 Raising awareness.	2.3.1 Sub-district Administrative Organization. 2.3.2 NGOs.
	2.4 Organizing evacuation drills.	2.4.1 Department of Disaster Prevention and Mitigation. 2.4.2 Sub-district Administrative Organization.
	2.5 Construction of tsunami memorial.	2.5.1 Tsunami affected provinces. 2.5.2 NGOs.
	2.6 Disaster-related research.	2.6.1 Academic institutions.

2) Evaluation of tsunami risk in coastal areas based on hazard analysis and vulnerability assessment.

3) Community-based coastal resource management.

4) Creation of detailed digital terrain maps of coastal areas.

5) Determination of evacuation routes and safe places for the coastal communities to use in the event of an emergency.

6) Identification of less vulnerable areas for human resettlements and/or reconstruction of tourism facilities and aquaculture infrastructure.

7) Formulation of a coastal land use plan for coastal areas of southern Thailand.

8) Waste and wastewater management in tsunami affected areas.

9) Reclamation of arable land affected by sea water.

10) Rehabilitation of land destroyed by the actions of tsunami waves.

For successful implementation of disaster responses, mitigation and preparedness schemes should be integrated into the National Economic and Social Development Plan. Recognizing the difficulties of communications, transport and coordination of operations during times of emergencies, it is essential that responsibilities are decentralized and adequate resources for preparedness activities are allocated to the disaster management committees established at both provincial and districts levels. It is anticipated that the successful implementation of an array of the aforesaid options through people participation and local institutions will make a significant contribution to the resilience to adverse phenomena of the coastal communities that are so crucial to sustainable development in southern Thailand.

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