Restoration of Coastal Ecosystems and Fisheries in Thailand after Northern Sumatra Earthquake and Tsunami Disasters

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Abstract

The 2004 Indian Ocean tsunami on 26 December severely affected six provinces (Ranong, Phang-nga, Phuket, Krabi, Trang and Satun) on the Andaman sea coast of Thailand. This paper presents the impact of the tsunami in the fishery and aquaculture sectors including the post rehabilitation. The immediate result of the tsunami was nearly the destruction of the local economy. The economic disaster was such that it led to a 0.8% reduction in the Thai national gross domestic product (GDP) growth rate for the year 2005. It was estimated that the total impact of the tsunami in the fishery and aquaculture sectors of the affected provinces is 6,481 million Baht, 40% of which (2,560 million) is the damage to assets and the remaining 60% (3,882 million) is the losses in production for the rest of the year. The livelihoods of many coastal fishery communities in Thailand were completely or partially destroyed by the tsunami. Economy at the community level was severely affected, which led to even deeper poverty. Preliminary assessment (after the tsunami attacked) reveals that the fishery resources decline by half. The price of marine animal also dropped within 3 months after the tsunami. There were more than 5,000 large and small boats damaged and sunk by the tsunami. In aquaculture, there are about 27,000 fish cage culture operators damaged by the tsunami impact, covering a total cage area of some 112 ha. The approved compensation rates are 20,000 and 14,000 baht for registered and nonregistered cage farms, respectively.

It was found that the assistance by compensation package in the monitory term was far from desirable. The way in which compensation was given caused serious problems, which led to serious conflicts within communities and among communities in tsunami-affected areas. Three main critical issues have to be solved, i.e. illegal fishing, democratization management, and constraint and need in continuing rehabilitation. In addition, lessons learned in the fishery rehabilitation phase for Thailand reveal several future sustainable works, such as creating supplementary income, training programs, marketing system development, financial support, strategic approach need, self-help focus, conflict management, and participatory approach.

1. Introduction

Southern Thailand, also known as Peninsular Thailand, lies between latitudes 50 and 110 N, and longitudes 980 and 1020 E. It covers an area of 7,153,917 ha and has over 2,705 km of shoreline, with the western coastline facing the Andaman sea and the eastern coastline facing the Gulf of Thailand (see Fig. 1). Due to rapid economic growth of tourism and fishing industry, the mangrove and beach forest along the coastal shores have been replaced by human-built infrastructures, such as aquaculture industries and tourist resorts (UNEP, 2006). As a consequence of no green belt, the coastal areas of southern Thailand have become particularly vulnerable to natural disasters, such as coastal erosion, tsunamis, storm surges, etc.

The earthquake that caused the tsunami was the world's fifth largest, with a magnitude of 9.3 on the Richter scale. It occurred at 00:58:53 (GMT) on Sunday, 26 December, 2004, with the epicenter at a depth of 30 km, just off the west coast of North Sumatera, Indonesia. The sudden vertical rise of the seabed by several meters during the quake displaced massive

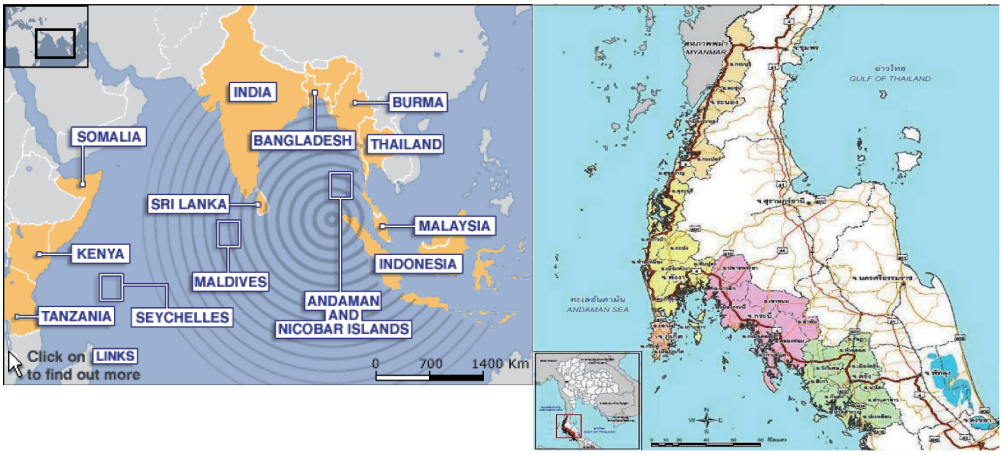

Fig. 1. Affected countries and provinces in Thailand

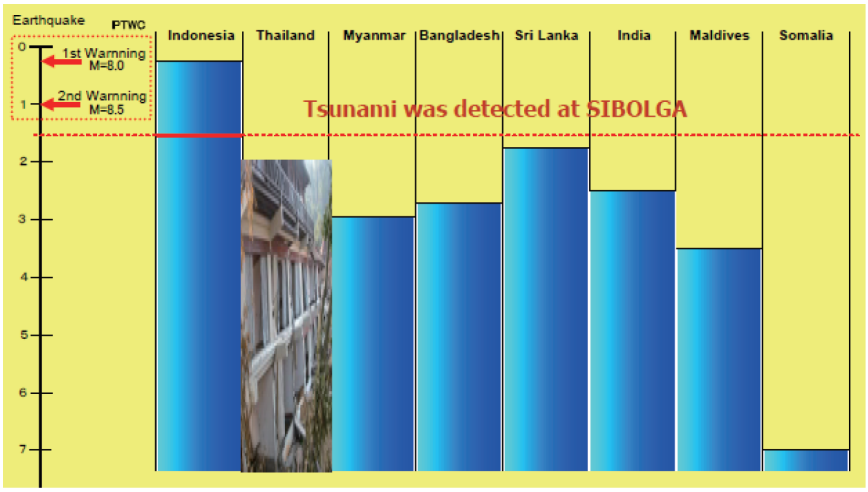

Fig. 2. The 2004 Indian Ocean tsunami time line

volumes of water, resulting in a devastating tsunami. This seismic sea wave traveled thousands of kilometres across the Indian Ocean, and ravaged the Andaman coast of southern Thailand at 10.00 am local time. The tsunami time line is shown in Fig. 2.

Thailand has been suffered from the 2004 Indian Ocean Tsunami in 6 provinces along the Andaman coastline. Immediately after the event, the Thai-Japanese tsunami expert group made a detailed survey on tsunami behavior. Due to the offshore bathymetry, the tsunami height varied by nearly a factor of 3-4 times with the maximum height of 19.6 m at Ban Tung Dap in Prathong island, 15 m at the popular Khao Lak resort area, and 5-6 m at the Patong beach in Phuket. The tsunami heights are shown in Fig. 3a). Unfortunately, since the tsunami arrived at high tide, it rode on top of the elevated tidal level (see Fig. 3b)) , causing more severity.

In Damaged areas, the number of deaths, missing and property damage is summarized by the DDPM (2005) and TEC (2005) in Table 1 and 2. As expected, many resorts in Kho Lak area with its low-lying coastal plane experienced serious destruction while several buildings with sliding glass doors or windows facing the sea suffered little structural damage. This is because the tsunami force broke through all the openings. In addition, most of the engineering-design reinforcement of concrete buildings with the good foundation could survive the wave attack. Due to the maximum attack wave height, Phang Nga had the largest number of fatalities or missing (more than 65 %) and also property damage (about 50 %).

2. Impact on fisheries, aquacultures and coastal habitats

The total estimated impact of the tsunami in the fishery and aquaculture sectors of the affected provinces is 6,481 million Baht, 40% of which (2,560 mil-

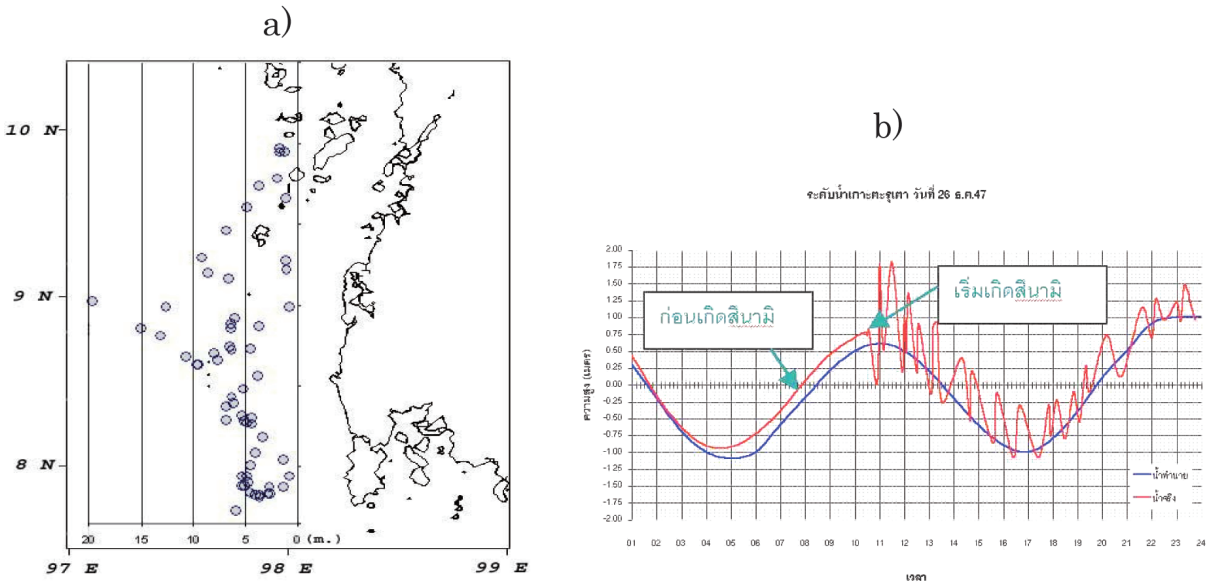

Fig. 3. Surveyed tsunami heights and tidal record

Table 1. Damage in case areas and people affected from Indian Ocean tsunami

No.	Province	Devastated Area			House Damage		Number of affected	
		District	Tambon	Village	Partly	Totally	Person	Household
1	Phang Nga	6	19	69	1641	626	19,509	4,394
2	Krabi	5	22	112	1343	357	15,812	2,759
3	Phuket	3	14	58	601	393	13,065	2,616
4	Ranong	3	10	47	111	255	5,942	1,509
5	Trang	4	13	51	156	33	1,302	1,123
6	Satun	4	17	70	69	102	2,920	414
Total		25	95	407	3921	1766	58,550	12,815

Table 2. Number of death, injured, missing and property damage

No.	Province	Number of affected people			Property Damage, US Dollar			
		Death	Injured	Missing	Fishery	Livestock	Agricult.	Business Establish
1	Phang Nga	4,225	5,597	1,655	22,830,462	341,515	61,466	161,402,125
2	Krabi	721	1,376	544	4,792,413	8,131	8,572	67,091,295
3	Phuket	279	1,111	608	8,622,779	7,591	4,603	98,852,073
4	Ranong	159	246	9	4,268,450	76,228	15,902	20,750
5	Trang	5	112	1	374,500	1,085	45,967	165,000
6	Satun	6	15	-	2,984,843	6,090	29,125	-
Total		5,395	8,457	2,817	43,873,447	440,640	165,635	327,531,243

lion) is the damage to assets and the remaining 60% (3,882 million) is the losses in production for the rest of the year. Detailed impacts are given as follows.

2.1 Impact on fisheries

The most seriously affected economic sectors were tourism and coastal fisheries. (Tanyaros and Crokall, 2011). The immediate economic impact of the tsunami was felt most acutely in the tourist industry, and to a lesser extent in the fishery sector. Prior to the 2004 tsunami, the tourism and fishing industries provided most of the livelihoods in the affected areas along the Thai Andaman coast. The immediate result of the tsunami was nearly the destruction of the local economy. The economic disaster was such that it led to a 0.8% reduction in the Thai national gross domestic product (GDP) growth rate for the year 2005, compared to the rate that would have existed without the tsunami (Israngkura, 2005).

The tsunami caused major losses in the fishing industry and coastal aquacultures in terms of fishing boats and gear, culture ponds, cages and shrimp hatcheries. Seventy-four affected sub-districts and 386 villages reported losses for fisheries and aquacultures (DoF, 2005). The estimated damage, as reported by the Fisheries Rescue Coordination Centre is summarized in Table 3 (FAO-MOAC, 2005).

Fishing and aquaculture, although popular at present, were marginal activities some 30 years ago. Fishing developed steadily and tourism grew exponentially in the years leading up to the tsunami. In the fishery sector, artisanal fishers as a group earn the lowest income (Silvestre et al. 2003). The livelihoods of many coastal fishery communities in Thailand were completely or partially destroyed by the tsunami. Economy at the community level was severely affected, which caused 19,968 already poor fishers to fall into even deeper poverty (Paton et al., 2008). The small-scale and artisanal fishers are very vulnerable to coastal disasters such as the 2004 Indian Ocean tsunami.

2.1.1 Damage or loss of fishing boats

There are 5,431 fishing boats either damaged or totally wrecked, 93% of which were small-scale and artisanal fishing crafts and 7% commercial fishing ships. It was estimated that 2,923 fishery households were affected. Damage to fisheries alone amounted to 16.6 M USD (DoF, 2005). Table 4 shows the number of damaged fishing boats in each provinces. It was found that Phuket suffered the greatest losses for large boats, while small boats losses were largest in

Table 3. Damage (in units) caused by 2004 Indian Ocean tsunami

Damaged type	Numbers
1 Small fishing boats	3,174
2 Large fishing boats	1,199
3 Ecotourism boats	554
4 Public habours & pies	83
5 Fish & Shellfish cage farms	47,063
6 Shrimp farms	6,063
7 Hatcheries	573
8 Shellfish concession plots	17

Table 4. Number of damaged and sunk fishing boats

Provinces	Large boat		Small boats		Losses (USD)
	Damaged	Sunk	Damaged	Sunk	
Ranong	204	13	414	27	12,331
Phang-nga	322	124	754	46	915,546
Phuket	490	157	642	41	1,884,618
Krabi	147	1	808	54	19,269
Trang	1	-	648	-	-
Satul	35	6	552	49	20,520
Total	1,199	301	3,714	217	2,852,284

Krabi. The small fishing boats are most vulnerable.

2.1.2 Damage or loss of fishing gear

In practice, it is extremely difficult to make assessment on the loss of fishing gear. After the tsunami, vessels and fishing gear were assumed to have been lost together. Gear replacement is a lower-cost item, but its compensation can help them to return to their normal lives. It is assumed that they are able to repair damaged vessels themselves. In such circumstances, gear provision is likely to be significantly less costly than expenses for boat repair.

2.1.3 Impact on fishery resources

From 1976 to 2003, the DoF monitored the implementation of measures to conserve marine resources during seasons of fish spawning and nursing young fish along the Andaman

coast. This was to identify study areas and periods in order to implement conservation measures for spawning and breeding of mature economic shallow-water fishes and marine shrimps. Surveys were conducted and reported an abundance of marine fishes and shrimps in several study sites along the Andaman coast (DoF, 2005). Preliminary assessment, in early January 2005, of fishery resources along the Andaman Coast indicated declination by half in some areas after the tsunami (Bueno, 2005). It was also found that the price of marine animals dropped within three months after the tsunami, and then gradually climbed back to the normal level.

The DoF also reported that the density of marine resources decreased during the: month following the tsunami. However, if only economic fish species were counted, the density around Phang-nga Bay and adjacent areas decreased compared with a similar pre-tsunami period. In the two provinces of Trang and Satun, which were less severely hit by the tsunami, the catch increased (ONEP, 2006). The marine fish catch off the west coast of Phang-nga and Phuket Provinces decreased after the tsunami attack (pre-tsunami 72.69 kg/hr; post-tsunami 34.92 kg/hr). The juvenile fish catch increased after the tsunami attack; similar results were found in a fish larvae survey (Nootmorn, 2006). One of the main reasons for these differences is the change in the physical effect of water movement. The tsunami waves caused a huge undercurrent with massive movement of water, disturbing sediments at the sea bottom and stirring a water mass rich in nutrients at the pycnocline level in the deep sea, bringing them up towards the continental shelf. In this way, the tsunami moved great amounts of nutrients from the Sundra trench and water mass from the deep sea up to fishery areas along the Andaman coast. The food chain was thus impacted, with links from water movement through plankton and young marine animals to increased juvenile fish catch. Whanpetch et al. (2010) have shown that the patterns of temporal change in abundance and diversity of macrofaunal assemblages before and after the tsunami varied greatly from site to site, and that the degree of temporal changes in assemblage structure was not solely related to the magnitude of the tsunami. More importantly, the presence or absence of seagrass vegetation altered the patterns of temporal change in macrofaunal assemblages and recovery processes after a tsunami.

2.2 Impact on aquacultures

The Andaman coast of Thailand has significant amounts of coastal aquaculture based in and around mangrove areas, especially in the creeks and delta mouths. Several types of aquaculture were affected by the tsunami, e.g. fish cages, shrimp ponds, hatcheries and shellfish.

2.2.1 Cage culture

In the pre-tsunami period, the system of cage culture was like open access. Whoever came to set cage first could reserve that place. They normally set up their cages near their houses. After the Tsunami, some fishers could start to set up cage culture with their own money earlier than other fishers who did not have enough money. However, according to the consensus among people, they set up their cages at the same place as it was before to avoid conflict with others.

Cage culture was one of the primary occupations for those living in the coastal communities devastated by the December 2004 tsunami. The typically fragile construction of cages made them particularly vulnerable to the tsunami, which resulted in the breakup of cages and escape of the stocks (see Fig.6). Some 5,568 cage culture farms, covering a total cage area of some 112 ha, were reportedly affected by the tsunami, with a total of 15,802 cages damaged (Table 5). The government (DOF, 2005) estimated losses from aquaculture cages to be 20 M USD.

Fig. 6. Damaged cage culture farms (Tanyaros and Crokall, 2011)

Table 5. Damage to aquaculture (DOF, 2005)

Province	Fish cage farms	Shrimp pond (ha)	Hatchery farms	Shellfish (ha)
Ranong	677	1. 61	-	3.41
Phangnga	3,008	16.88	180	64
Phuket	315	5.84	209	58.02
Krabi	389	18.24	-	4.86
Trang	243	-	144	0.84
Satun	966	-	40	-
Total	5,568	42.57	573	131.13

2.2.2 Shrimp farm

Though many shrimp farms exist on the Andaman coast, little damage to shrimp farm operations has been reported. This is due to the smaller number of farms located near the coast, as compared with the Gulf of Thailand coast. The DoF (2005) reported that only 42.56 ha of shrimp ponds in four provinces were totally damaged by the tsunami. The most damaged farms were located in the immediate vicinity of the shore in low-lying area.

2.2.3 Fish and shrimp hatcheries

Only one private fish hatchery was reported to have been damaged, while the government stations were reported not to have incurred any significant damage. However, destruction of shrimp hatcheries considerably reduced production. The six affected provinces are the main areas in Thailand for marine shrimp fry production. The 573 shrimp hatcheries damaged accounted for a 30% loss in seed production, which translates into 70,000 metric tons of cultured shrimp for only one crop (Bueno, 2005). It was estimated that it would take at least six months to get most of the hatcheries back into operation. The industry speculated that this would be an additional lost opportunity of more than 28 M USD and would inevitably lead to shrimp seed scarcity and its higher price.

2.2.4 Shellfish concessions

Shellfish consist principally of cockle beds, green mussels, oyster and land-based abalone operations, all of which suffered some damages.

2.3 Impact on coastal habitats

The coastal habitat and environment were impacted in various ways. In some coastal areas,coral reefs and seagrass beds were damaged or destroyed, greatly degrading fisheries resources and thus fishers' livelihoods. Both coral reefs and seagrass have been able to recover to a certain extent. From a rapid assessment (3 weeks after the event), only about 13% of the coral reefs in the Andaman sea were found to be severely damaged (>50% of corals destroyed), while almost 40% showed no measurable impact by the tsunami (DMCR, 2005; Brown, 2005; Wilkinson et al. 2006). A study on coral recruitment and recovery after the 2004 tsunami by Sawall et al. (2009) near the Phi Phi Islands (Krabi Province) and Phuket found rapid recovery to be the norm, suggesting that the duration of disturbance, degree of sorting and hence stability of coral rubble are key determinants of recruitment success. The tsunami-impacted coral

reefs have now revived to a certain degree as a result of rehabilitation activities instituted by government agencies, private groups, communities and NGOs.

Seagrass shows a similar picture. Only some 5% of seagrass beds and 321.6 ha of mangrove forests were damaged or destroyed (ONEP, 2006). A comparative analysis (Nakaoka et al., 2007) of seagrass biomass and coverage before and after the tsunami revealed that seagrass beds were severely affected by the tsunami. A broad-scale coastal census after the tsunami showed that the effects on seagrass beds were spatially variable; some seagrass beds disappeared completely, whereas others were only negligibly impacted. The ecology of seagrass beds in all areas hit by the tsunami was able to survive and regain to a previous level within a year without replanting (DMCR, 2005).

3. Post rehabilitation

After the tsunami, several Thai government agencies, the private sector, NGOs and international organizations set up a wide range of projects for emergency assistance and long-term rehabilitation, in both fisheries and aquaculture sectors, with the aim of enhancing the quality of life for all victims. It appears that local people were satisfied with the level of resilience of natural resources, such as mangrove forests, beach forests, seagrass beds and coral reefs. Local perception, gathered from personal interaction, is that the rehabilitation of coral reefs was successful to a certain extent. People thus requested continued efforts to restore the natural resources back to the original state of abundance (ONEP, 2006).

3.1 Fisheries sector

A first step in the assistance plan was swiftly implemented by the DoF; its primary goal was to establish a Fisheries Rescue Centre (FRC). The centre coordinated and collected of damage and loss information from the six affected provinces. Damage was caused down to the affected villages, and it was possible to identify significant losses at sub-district and even village levels. This data set can therefore be used as an indicator to assist in identifying the most affected areas.

The second stage of the DoF emergency plan was to compensate the victims in cash for their losses or damaged boats, fishing gear and aquafarms. This compensation aims to assist victims to start up their fishing and aquafarming activities as soon s possible and to restore their livelihoods. The full Cabinet of the Thai Government approved a tsunami response budget of 5,252 M THB. Out of this budget, 1,343 M THB was allocated to assist 27,828 fishermen. This included the repair of 3,426 small fishing boats (under 10 metres in length) and 544 larger fishing boats (DoF, 2005). Boat owners (registered) were required to inform the loss within 15 days in the area. The Provincial Fisheries Office (or District Fisheries Office) had to collect the documents and check for accuracy before sending to the DOF within 120 days. Typical documentary evidence required for compensation was the vessel registration or permission to fish document (with date). Since the majority of vessels that were damaged or lost were in the small-scale category, very few actually had registration documents.

3.1.1 Compensation for fishing vessels

Table 6 shows damaged categories and compensation package for fishing vessels. These aim to support the recovery of a vessel (i.e., re-floatation, or movement of the vessel, as many had been swept some distance inland), support repairs of a damaged vessel, and compensate for loss or damage beyond repair.

Table 6. Compensation (THB) package for fishing vessels (DoF, 2005)

Type	Compensation per vessel	
	< 10 m	> 10 m
Retrieval	10,000	25,000
Repair	20,000	70,000
Vessel lost	66,000	200,000

3.1.2 Compensation for fishing gear loss

Vessels and fishing gear are assumed to have been lost together. Small-scale artisanal gear may be re-constructed (such as fish and crab traps). Larger gear such as nets, require purchase. Loss of fishing gear was compensated at a relatively low rate (about 3,000 THB per case). Table 7 shows the government compensation for the loss of fishing gear.

3.2 Aquaculture sector

Loss or damage of aquaculture facilities was compensated by the Royal Thai Government to assist the farmers to re-start their farming activities. Two broad targets for compensation were aquaculture holdings and fish cage culture operations.

3.2.1 Compensation for aquaculture holdings

Information regarding loss from aquaculture holdings does not appear to have been announced, however the document made available to the mission containing the dates of compensation also included rates for aquaculture. Compensation was payable in the case of:

1) Loss of fish stocks, 1,400 baht per rai (for a total area not exceeding 5 rai).

2) Loss of shrimps and crabs, 3,800 baht per rai (for a total area not exceeding 5 rai).

3.2.2 Compensation for fish cage culture operations

Compensation was payable in the cases of fish culture in a cage, cement tanks or other

(e.g. aquarium fish, frogs, soft-shelled turtle). The rate was 150 baht per square metre of production up to an area not exceeding 80 square metres. The Thai government provided funding of over 111.6 M THB through the DoF to restore the cage farms on the coast of the Andaman sea after the tsunami (DoF 2005). Several types of assistance were provided from private sectors (NGOs and philanthropic foundations) for the cage farmers, including provision of cash funds, materials for cage re-construction and fish seed. The loss of aquaculture operation systems was supported through emergency assistance from the government as illustrated in Table 8.

It was found that 69.7% of the main financial sources supporting the farmers in the affected areas came from government organizations. Non-governmental organizations, at the Thai national and international levels, also played an important role in assisting the affected farmers. About 31.3% of the farmers received assistance, and each of those obtained 30,000 baht from these organizations (Anantasuk et al., 2008). The DoF was the main body supporting aid to the farmers; more than half of the farmers received

Table 7. Budget for emergency assistance for the fishery sector (DoF, 2005)

Type	Unit	Total USD budget	Max. USD compensation /victim		
			Retrieval	Repair	Replacement
Small fishing boat	3,426 boats	6,676,308	256	512	1,692
Large fishing boats	1,222 boats	7,050,000	641	1,795	5,128
Bamboo trap (legal)	421 fisherman	107,949	-	-	256
Other traps	13,690 fisherman	3,510,256	-	-	256
Nets	1,871 fisherman	479,734	-	-	256
Total		17,824,247			

Table 8. Budget for emergency assistance for the aquaculture sector (DoF, 2005)

Type	No. of farmer	Total USD budget	Max. repair & seed for restocking / farmer
Cage	27,828	14,270,769	513 (cage & seed)
Shrimp pond	42	21,538	513 (pond & post larval)
Hatchery	573	293,846	513
Shellfish farm	80	40,770	-
Total	28,523	14,626,923	

Table 9. Source of materials support (Anantasuk et al., 2008)

Target	Source percentages	
	DoF	NGOs
Material for cage construction	55.6	47.6
Seed	11.1	18.3
Fishing gear	31.1	13.4
Fishing boats	2.2	20.7
Total	100%	100%
Proportion from each source	57.1%	42.9%

materials for cage re-construction, seeds, fishing gear, and boats. Table 9 gives the percentage of farmers who obtained materials from the DoF and various NGOs.

4. Conclusions and future recommendations

The Andaman Sea coast has seen a substantial decline in fisheries resources. The tsunami event of December 2004, the fuel crisis, the violation of regulations and illegal fishing all have impacted fisheries negatively. This situation will not only cause an increasing problem for the fishers but it will also lead to serious degradation of all marine resources, thus threatening the sustainable management and health of the Andaman sea as a whole.

It was estimated that the total impact of the tsunami in the fishery and aquaculture sector of the affected provinces is 6,481 million Baht, 40% of which (2,560 million) is damage to assets

and the remaining 60% (3,882 million) is the losses in production for the rest of the year.

The livelihoods of many coastal fishery communities in Thailand were completely or partially destroyed by the tsunami. Economies at the community level were severely affected, which led to even deeper poverty. However, there are difficulties involved in the estimation of replacement values of boats and fishing gear since no comprehensive registries are available. The number of boats and gear used in the estimation of damage only represents the number of units that the fishermen reported in order to obtain compensation from their authorities. Since compensation rates are low, some fishermen did not bother to report their loss of assets, and some large boats went also unreported because they have private insurance arrangements. For the estimation in the aquaculture sector, the same difficulty arises again in that the owners only reported their damage bearing in mind possible compensation from the authorities, and not all aquaculture facilities are duly registered with full information as to size and capacity.

So far we have mentioned only the assistance by compensation package in the monitory terms. However, on the ground, the results of money compensation were far from desirable – due to both internal and external factors. Internal factors include greed and family structure; external include distribution methods. Several constraints have to be solved and we should make suggestions as to how they may be alleviated, for the benefit of all and in such a manner as to avoid hardship on those who must give way to better, even best, practices. The way in which compensation was given and monitored directly or indirectly caused serious problems, which in turn led to serious conflicts within communities and among communities in tsunami-affected areas. Three main critical issues have to be solved, i.e. illegal fishing, democratization management, and constraint and need in continuing rehabilitation. In addition, lessons learned in the fishery rehabilitation phase for Thailand reveal several future sustainable works, such as creating supplementary income, training programs, marketing system development, financial support, strategic approach need, self-help focus, conflict management, and participatory approach.

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