JSPS ASIA AND AFRICA SCIENCE PLATFORM PROGRAM

Geomorphological Comparative Research on Natural Disaster Mitigation in the Coastal Regions of Tropical Asia

PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON

COASTAL ENVIRONMENT AND MANAGEMENT

FOR THE FUTURE HUMAN LIVES IN COASTAL REGIONS

MARCH 2009
NAGOYA UNIVERSITY, JAPAN

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PREFACE

We are pleased to publish the proceedings of the International Conference on "Coastal Environment and Management: for the Future Human Lives in Coastal Regions", as a part of the Asia and Africa Science Platform Program on "Geomorphological Comparative Research on Natural Disaster Mitigation in the Coastal Regions of Tropical Asia", which was supported by the Asia and Africa Science Platform Program, Japan Society for the Promotion of Science (JSPS).

The conference was held in the region including Nagoya, and Shima and Nishiki, Mie Prefecture, central Japan during the period between February 22 and 24, 2009, and the topic of the conference was focused on the coastal environment and management. This was the final conference of the Asia and Africa Science Platform Program on "Geomorphological Comparative Research on Natural Disaster Mitigation in the Coastal Regions of Tropical Asia", which was held during the time from FY2006 to FY2008. The conference was organized in two parts: first was a workshop, which was held at Shima Central Hotel SOCIA, Mie Prefecture, Japan, for a full day of March 23, 2009. The second was field excursions to coastal Nagoya City and its vicinity on March 22, and to southern Mie Prefecture, in particular Nishiki of Taiki Municipality on March 24, focusing on the coastal environment and/or disaster management concerning the localities, respectively.

There are a variety of serious environmental problems in the coastal regions across the tropical Asian countries. Thus, coastal management increasingly becomes an important and urgent issue for the future environmental conservation at the political and practical levels. According to the aim of the conference, specialists from Asian countries including Japan were invited to southern Mie Prefecture, one of disaster-concerned regions in Japan. We discussed various problems ranging from coastal ecosystem, de/re-forestation, coastal erosion, sediment discharge, sea level rise and environmental degradation, to natural hazard and preparedness, and environmental management and planning for the future sustainable and comprehensive community developments, including research methodologies such as geographical information systems and/or remote sensing at the conference from the perspectives of natural and social sciences.

Further, we have to mention that the reason why we originally intended to organize this program was closely related to the world-wide catastrophic tragedy of the 2004 Indian Ocean Tsunami, and that we eventually set one session discussing coastal disasters including a tsunami and its management, inviting Indonesian colleagues of the JSPS Bilateral Joint Research Project on "Disaster Preparedness of the Coastal Lowlands Community and Verification of the Plan in the Tsunami Affected Areas".

We think that the conference provided very good opportunities to exchange our experience and knowledge about those topics with each other and brought very fruitful results. This publication is a compilation of some papers presented at the conferences. We expect that the publication will be beneficial for the consideration about the coastal issue in the tropical Asia. As we esteemed the originality of the authors, we only changed and edited the format of the articles.

Finally, we would like to express our sincere thanks to the all participants of the conferences. We also would like to express our gratitude to Ms Ayako Maesawa, Head of Asian Program Division, Japan Society for the Promotion of Science (JSPS), and Professor Shin-ichi Yamamoto, Vice-president for Research, Nagoya University, who both gave addresses at the conference.

Professor Masatomo UMITSU (Project Leader, Department of Geography, Nagoya University)
Professor Makoto TAKAHASHI (Secretariat, Department of Geography, Nagoya University)

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Coastline Change Analysis in the Post Tsunami Disaster with Landsat-ETM Satellite Image: a Case Study in Northern Coast of Aceh

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ABSTRACT

On the last December 26th 2004, there were earthquakes with the power of 8.7 on the scale of Richter in the Ocean of Hindi and caused 10 meters height of Tsunami headed to the shore as far as 3 to 10 km from the coastline. This caused the damage of ecosystem and the displacement of coastline in the area of Nangroe Aceh Darussalam (NAD). The coastline itself plays a very important role, such as the physical boundaries between the land and the ocean, the borders of administration, the determination of sea boundaries delimitation, etc. The coastline monitoring is essential because it manage to detect certain changes which will lead to environmental destruction, or the problems in determination of region's authority. Thus, region's government or an influenced authority needs to renovate the situation of unambiguous coastline after the Tsunami. Remote sensing technology can monitor the displacement of coast line because it provide an up to date physical information, multi temporal and contiguous data and also can cover wide area. This study discusses about how far remote sensing can contribute in determination of coastline's displacement. The study is in a form of analysis for the displacement of coastline before and after the Tsunami Northern coast of Aceh. The data used are multitemporal Landsat-ETM satellite images combined with tidal and topography data for validation. The result showed that displacement of coastline occurred in several location in Northern coast of Aceh. The alteration of maximum distance for the coastline after the Tsunami as much as 1615.81 m.

Keyword: Tsunami disaster, the displacement of coastline, Landsat-ETM

1. INTRODUCTION

An earthquake with a magnitude of 8,7 Richter Scale which happen at 26 December 2004 has destroyed buildings in Banda Aceh, including other cities in the western coast of this province and North Sumatera. This earthquake ignited a tsunami with the height of more than 10 meters and entered the land until 3 – 10 kilometers from the coastline. This disaster caused an environmental damage in NAD, especially in the coastal area. Almost all of the coastal area were desolate due to the Tsunami which causes sediment transport.

Sediment transport, besides being influenced by water mass, it is also affected by the tsunami's current and tidal waves, which then resulted in the displacement of coastline border. There is a need to study this displacement which will be utilised as an input for policy or action in defining current NAD's coastline border.

There are several methods to measure the coastline displacement, i.e., terrestrial measurement, GPS, photogrammetry and remote sensing based measurement (Djunarsjah, 2000). Despite being more accurate in measurement, the terrestrial, GPS and photogrammetry method are known to have weaknesses in result and processing time ratio. Those methods can not achieve accurate information for relatively large area in rapid time. Remote sensing method offers an alternative method to quickly measure the coastline displacement in a large area and yet give relatively accurate information.

2. STUDY AREA AND DATA

The research study area is in the coastline area of Northern Aceh which includes Banda Aceh, Lhok Nga, Indrapuri, Krueng Raya, Lamno and Lhok Kruet. Satellite imageries used in this research are two sets of Landsat ETM+ (Mei 8, 2000 (pre-disaster) and December 29, 2004 (post-disaster)). These imageries were received from LAPAN. The pre-disaster image were rectified to UTM projection (Universal Transversal Mercator Zone 47) and datum WGS 84 (World Geodetic System 1984). The post-disaster image was registered using the pre-disaster image. Another data used in the research are topographical maps scale 1:50.000 from Bakosurtanal and tidal data from DISHIDROS – TNI AL (year 1995, 1996 and 1997).

3. METHODS

Several methods in this research were applied to extract the border between land and sea, i.e., image composition (RGB 542), image enhancement, BILKO method and AGSO method.

3.1. RGB Composite

The best image composite to extract the border between land and sea was achieved visually using RGB composite 5,4,2 (Alfaizal, 2001). Band 4 has a more clear contrast between land and sea than another band. Band 4 is a near infra red channel that has lower reflection to water and higher reflection to land. This characteristic makes Band 4 can be used to differentiate water body and land.

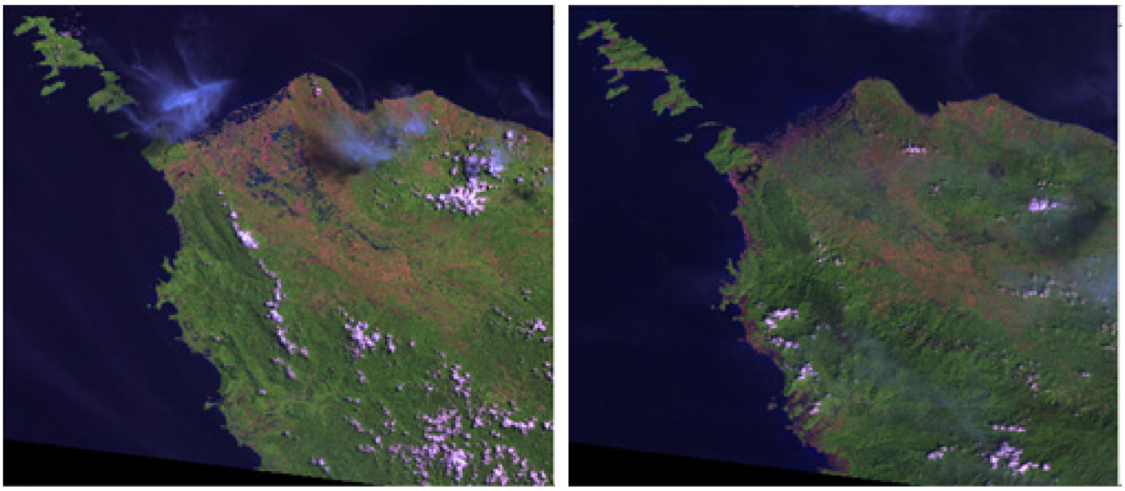

Figure 1. RGB composite of Band 5,4,2 pre (left) and the post (right) tsunami

3.2. Image Enhancement

Image enhancement is one method to modify the image digital number in order to highlight the most important value within. The objective of this process is only to make better visualization and to make the analyses easier. Image enhancement does not change the original value or the image brightness value, it only change the visualization. Image enhancement carried out after the image was geometrically corrected. It was conducted to better visualize the edge between land and sea. The image enhancement method in this study was contrast enhancement. It was carried out by stretching the greyness level on certain pixels. This contrast enhancement was employed on composite image (RGB) Band 5, 4 and 2.

3.3. BILKO Method

The border definition between land and sea was conducted using the brightness value (BV) of the land and sea. For this reason, the lowest BV of land and the highest BV of sea is needed. This BV will then be used in separation algorithm between land and sea BVs with nearest integer technique in 8 bit format.

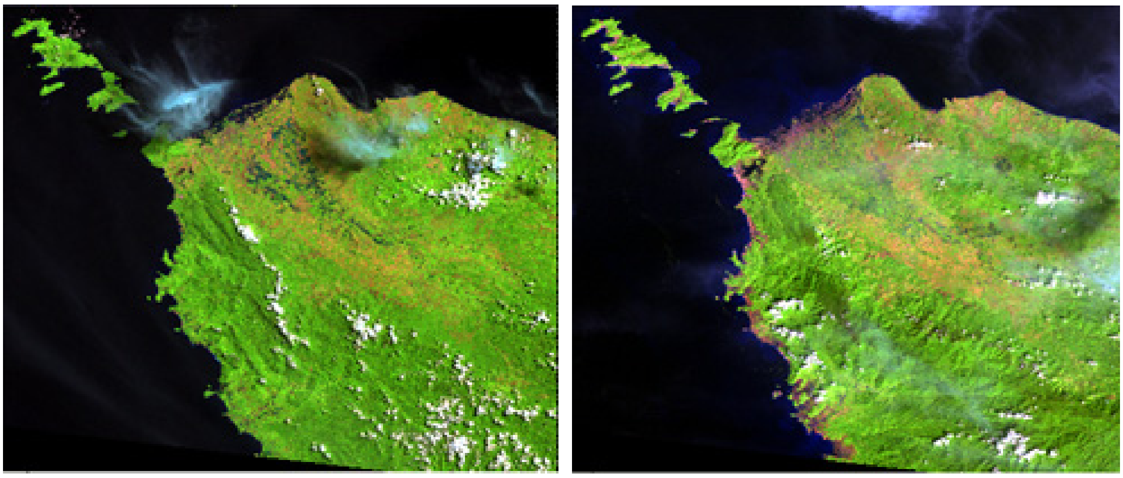

Figure 2. Enhanced images pre (left) and the post (right) tsunami

3.4. Metode AGSO

This method is basically a shallow water image mapping method develop by Australian Geological Surveys Organization (AGSO). AGSO formulation is mathematical formulation to describe the relationship between electromagnetic wave, propagation medium, particles in the water and the deep effect of water. This formula also describes the remote sensing application for water objects (Wardhana, 2003).

Based on the spectral characteristic, water has a higher reflectance for band between 0.3 – 0.7 micron. The bands within this electromagnetic ranges are called visible lights. On Landsat TM sensors, visible bands (Band 1,2 and 3) can penetrate water and reach the substrates. Besides being used to gain under water substrates reflectance, these three bands can also used to estimate the water depth (Bierwirth, 1993). The result from mathematical based image enhancement process with BILKO and AGSO method is shown in Figure 3.

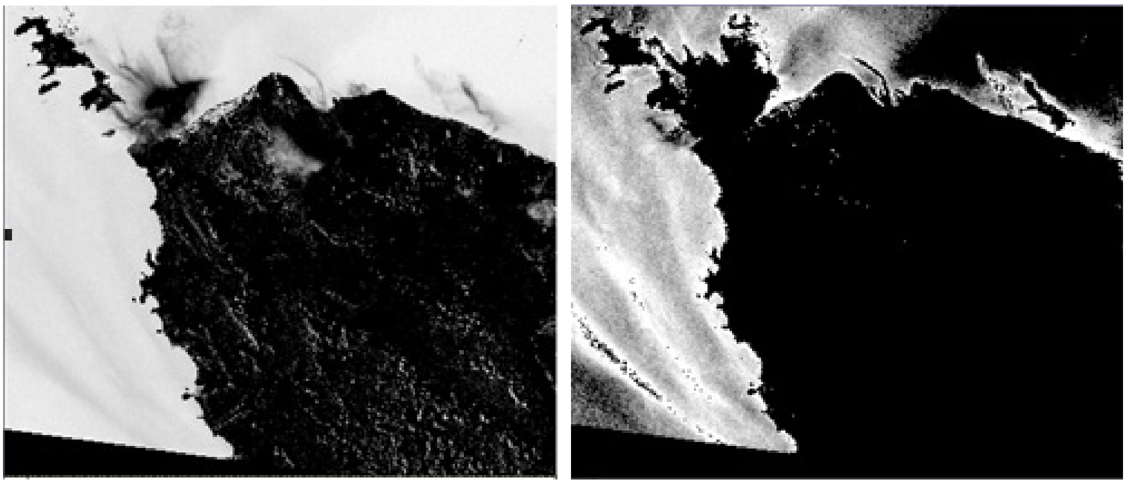

Figure 3. BILKO method (left) dan AGSO (right)

3.5. Delineation of land and water

From those techniques described above, we can get new image visualisation, which then will be digitized along the line that separates water body and land. The best method to visualise the border between land and sea was chosen before the digitasation process. There are two best methods: (1) composite image RGB 542 with contrast enhancement and (2) BILKO method. The first choice to better visualize the border between land and water is composite image RGB 542 with contrast enhancement. If this method fails then the second method (BILKO) will be used.

3.6. Tidal data processing

Tidal data along coastline from several tidal observation stations are actually needed to define the real coastline. For practical reason, data from the nearest tidal observation station can be used (Alfaizal, 2001). The nearest tidal observation station is located in Banda Aceh, so the tidal height along the study area is referenced to tidal height from this station. This is done because we could not get tidal data of study area from several stations.

Tidal data were taken from Malahayati Station in Krueng Raya, Banda Aceh. Tidal data from June until October 1996 was calculated using tidal data analyses with least squre methods to define the tidal harmonic component. The result from this calculation will be used to predict the tidal height when satellite image is recorded, i.e., at May 8, 2000 and December 29, 2004.

4. RESULTS

The result from satellite and tidal data processing were integrated to define the coastline before and after tsunami. The tidal calculation results coastline correction values, 3.26 meters (8 May 2000) and 2.91 meters (29 December 2004). These values are not significant in this research because it is below the spatial resolution of Landsat 7 ETM+ (30 m.). Due to this reason, the tidal calculation is only used to validate for the coastline displacement. Sea level refers to the time when satellite images were acquired, which is defined as instantaneous sea level (ILS) on 8 May 2000 and 29 December 2004 when Landsat satellite passes the equator at 10:00 a.m.

The definition of coastlines before and after tsunami were carried out by on-screen visual digitation. For practical reason, the coastline will be defined to one of three coast types, i.e., shallow, rocky and vegetated coast. The coast covered by vegetation is bordered by the outer limit of the vegetation and for rock coast is bordered by hill edge while for shallow coastline is instantaneous sea level (ISL) (Alfaizal, 2001). The result of coast line definition between and after tsunami is shown in Figure 4.

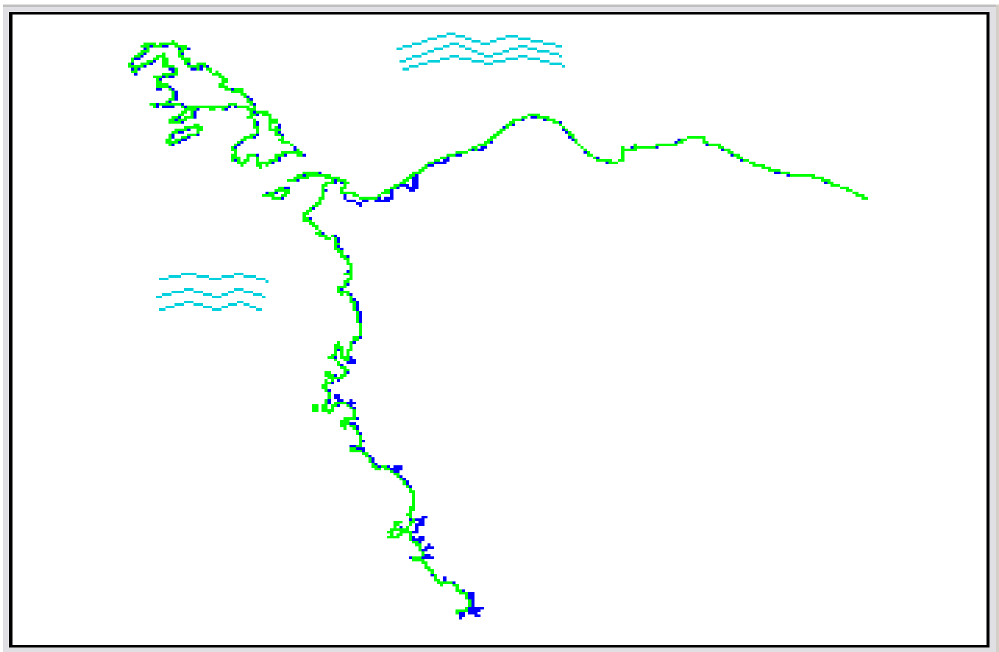

Figure 4. Digitizing results (pre (green-color) and the post (dark-blue) tsunami)

To know the displacement distance, we took sample points from the coastline before and after tsunami. These samples were chosen from the lines that have maximum displacement on administration boundaries in North Aceh. The significant coastline displacement only occurs in Banda Aceh, Aceh Besar, Pidie and West Aceh. Maximum displacement distance for each administration boundary is shown in Tabel 1.

Table 1. Maximum coastline displacement in the post tsunami

Administrative unit	Distance (m)
Banda Aceh	1,615.81
Aceh Besar	748.228
Pidie	128.3
Aceh Barat	1,553.42

The calculation for region with decreasing land after tsunami is shown in Table 2. This region were digitized as polygon (region) to calculate area size.

Table 2. The change of area size in the post tsunami

Administrative unit	Hectare
Banda Aceh	845.559
Aceh Besar	394.011
Aceh Barat	628.615
Kab.Pidie	602.644

5. CONCLUSIONS

The conclusions of this study are:

1. Landsat-7 ETM+ can be used to detect coastline displacement. The image does not to be acquisitioned in time when an event that makes coastline displacement occurs. The image processing can be combined with tidal calculation for more precise and accurate result.
2. The effective visual method to identify coastline before and after tsunami is by using RGB 542 Composite image with contrast enhancement and Bilko Method.
3. Tidal data calculation to define coastline displacement correction when the image was acquired is related to the spatial resolution. This correction is not acquired when the result is below the satellite image spatial resolution.
4. The observation result on coastline before and after tsunami shows there is coastline displacement in several locations in Norther coast of Aceh. This displacement makes the decrement of land area. The biggest coastline displacement is 1.615 meters in Banda Aceh.

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Multi-risk of Disasters in Cilacap City, Indonesia

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ABSTRACT

This research aims at analyzing the multi-risk potential of disasters, focusing on earthquake and tsunami potential in Cilacap city, Indonesia. Descriptive-qualitative method is used by integrating between tsunami risk analysis result and earthquake risk analysis result. Tsunami risk is assessed by using a worst-case scenario of Mw=8,5 earthquake magnitude at a specified epicenter in Indian Ocean. Earthquake risk is assessed by using McGuire equation to calculate the Peak Ground Acceleration (PGA) for selecting the maximum value at each measurement points. A multi-risk map is generated as the result of that integration, which informs a number of unified risks between earthquake risk and tsunami risk.

As a result of the integration between two risks, it can be synthesized that the high level of multi-risk potential is in 5 villages, i.e. Gunungsimping, Karangkadri, Menganti, Mertasinga, and Tegalkamulyan. The total fatalities for those villages are estimated as more than IDR 40 billion (USD 4 million), which consist of some selected mobile assets, buildings, and productive lands. The number of affected people is more or less 12.000 persons. In order to reduce that multi-risk of disasters in Cilacap city, the combination between hard engineering and social engineering will be necessary.

Keywords: multi-risk, tsunami, earthquake, worst-case scenario, Cilacap, Indonesia

INTRODUCTION

Indonesia and its surrounding areas are considered as one of the tectonically most active areas in the world. More than 460 earthquakes with M>4.0 magnitude occur annually (after Latief *et al*., 2003). Predominantly major earthquakes in Indonesia have caused serious damage and fatalities in historical time. Not all Indonesian area is prone to earthquake, although overall condition is categorized vulnerable to the disaster. There are a number of 'seismic gap' areas. Seismic gap area can be defined as an area which is located within the seismic zones, but it had not been hit by earthquake for more than 50 to 100 years. Based on the historical overview and the seismic theory, very strong earthquakes will probably occur within the seismic area which has seismic gaps (Kulikov *et al*., 2005; Zen, 2005). There are at least 4 seismic gaps in Indonesia, i.e. Sunda Strait, Southern Java, Bali Strait, and area near Alor Island (Hendrajaya, 2005; Zen, 2005).

The Southern coast of Java Island is a part of the Indonesia archipelago that faces directly the subduction zone between the India-Australian Plate and Eurasian Plate. The subduction zone is situated in the Indian Ocean. Collision between these plates results in the endogenic activity in that zone being very dynamic. As a consequence, this area is very vulnerable to earthquakes. If earthquakes take place under seawater and there is a vertical dislocation in the seafloor, it will result in tsunamis.

The effects of tsunami and earthquake are disastrous. Spatial plan without any consideration toward both earthquake and tsunami disaster create unsafe cities, thus it is necessary to assess hazard and risk factor of the coastal area. "A spatially oriented risk assessment has three main characteristics, i.e. multi-hazard oriented, only those risks with spatial relevance are considered, and only collective risks that threaten a community as a whole are relevant" (Greiving, 2006). Assessment processes utilize Geographic Information System (GIS) to determine multi-risk zones based on the certain scenario. Finally, arrangement of disaster mitigation utilizes data and information from the GIS database.

This research was conducted in Cilacap city, Central Java Province (Figure 1). It aims at analyzing the multi-risk potential of disasters, focusing on earthquake and tsunami potential in that region. Cilacap city is developed on alluvium which consists of coastal sediments and river deposits. Coastal deposits consist of unconsolidated sand deposited as regular beach ridges. These beach ridges form a more or less parallel banding along the coast in the Cilacap area (Sutikno, 1981). Recently, the ridges have been used as settlement areas and the lower parts for paddy fields. Cilacap area is characterized by former spit form, crescentic shoreline, and has swampy area. Additionally, this city is one of the cities in the southern coast of Java near the shoreline exposed to the Indian Ocean.

Figure 1. Location of Cilacap in Java Island

METHODOLOGY

In order to assess a multi-risk potential, it is necessary to observe earthquake and tsunami hazard potential in a research area. If earthquake occur on the land, it becomes a direct hazard. If earthquake occur in the seafloor, it possibly generates tsunami. In combination with socio-economic data, both hazards will produce risk for each hazard. Integration between earthquake risk and tsunami risk will generate a more comprehensive risk assessment result, i.e. a multi-risk assessment (Figure 2).

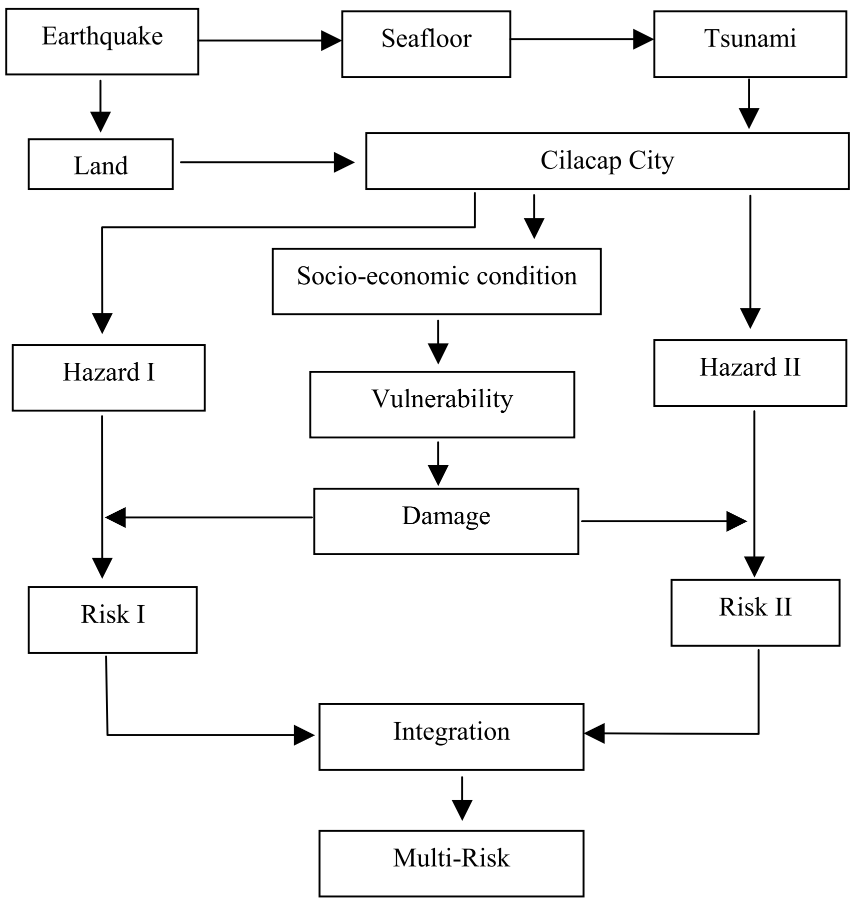

Figure 2. Theoretical Framework of the Research

The zones prone to earthquakes can be determined with regard to the possibility of earthquake occurrence in a specified area. The possibility is based on the past earthquake events, while past earthquake data can be easily accessed from USGS or BMKG (meteorology, climatology, and geophysics agency in Indonesia) websites. Earthquake data from USGS or BMKG inform the time of earthquake event, epicenter location, hypocenter depth, and body wave magnitude, without intensity and Peak Ground Acceleration (PGA) data. Thus, earthquake zones can be determined by using McGuire 1993 equation to calculate PGA (Fauzi, 2001).

$$x = b_1 10^{b_2 M_s} (R + 25)^{-b_3}$$

where:

b_1 = 472.3 ; b_2 = 0.278 ; b_3 = 1.301 ; x = PGA
Ms = surface wave magnitude
R = hypocenter distance (km)
= root of the last column quadrate added by DEP data (column 8th) quadrate
Ms = -0,845 + 1,201 Mb (Thenhaus et al, 1993)
Mb = body wave magnitude (column 9th of USGS table data)

Theoretically, earthquake disaster potential is getting higher if there is a high magnitude earthquake (> 5 Richter) in a certain location and its surrounding area, short distance of epicenter (100 km), and shallow hypocenter (< 100 km). Those three parameters provide a complete description of the possible disaster potential. Earthquake risk can be assessed by using McGuire method to calculate the Peak Ground Acceleration (PGA) for selecting the maximum value at each measurement points. Map of earthquake disaster potential is generated by utilizing McGuire method since that method provides sufficient parameters (PSBA, 2005). In addition, there is a vulnerability class for earthquake disaster (Table 1) which might be utilized for determining earthquake risk.

Table 1. Vulnerability class for earthquake disaster

No.	Vulnerability class	Criteria
1.	Very vulnerable	a. At shallow-focused earthquake zones (0-90 km) b. At active fault zones and potentially active c. Near active volcano d. Steep-slope topography or at denudational mountains, cinder cones, volcanic slopes, and structural mountains e. A flat coastal area, bay, surrounded by steep hills f. A coast adjacent to the earthquake epicenter in the sea floor
2.	Vulnerable	a. At shallow-focused earthquake zones (0-90 km) and middle-focused earthquake zones (90-150 km) b. At potentially active fault zones and uncertainly active c. At denudational hills, structural hills, karst mountain, volcanic foot-slopes
3.	Not vulnerable	a. At deep-focused earthquake zones (>150 km) b. At inactive fault zones c. At plain/flat topography areas d. Far from the coast and there is a natural or artificial shore protection

Source: after PSBA (2005), translated.

Tsunami risk is assessed by applying a worst-case scenario of Mw=8,5 earthquake magnitude at a specified epicenter (110.00 E - 9.50 S) in Indian Ocean (Mardiatno, 2008). Descriptive-qualitative method is applied to integrate tsunami and earthquake risk analysis result. This research applied a simple method to assess a multi-risk potential to disasters. Maps analysis is also carried out by merging earthquake risk map and tsunami risk map. A multi-risk map is generated as the result of that integration, which informs a number of unified risks between earthquake risk and tsunami risk.

Results and Discussions

In general, a whole area of Cilacap city is relatively flat. This city is situated less than 12 m above sea level. It has a flat-to-gentle topography, and is developed on soft material (river and marine alluvium). The terrain elevation is higher in the northern and north-eastern part and becomes lower in the western and south-western part. Considering some vulnerable objects to earthquake and tsunami, a number of objects were selected for multi-risk assessment purpose (Table 2). As shown in that table, the objects consist of building, population, productive land, and selected mobile assets. They are distributed in villages, thus the village is used for determining a multi-risk assessment unit.

For earthquake risk assessment purpose, firstly, earthquake data from UGS in between 1975 and 2004 (Table 3) is analyzed for calculating PGA (see equation in the previous section). As shown in Table 3, there are a number of significant earthquakes in Cilacap area. Although the earthquake magnitudes are not so high, however, the possibility of amplification factor should be considered due to material types in this area.

After calculating PGA, all results are plotted in the map and interpolated to create earthquake disaster risk map (Figure 3). As shown in Figure 3, high risk area to earthquake is mainly located within the city and adjacent to the shoreline. It is an initial warning for locals that their location might be possibly shocked by disastrous earthquakes. PSBA (2005) stated that McGuire method provides a more accurate map of earthquake disaster potential. Thus, that method is recommended to be applied for creating map of earthquake disaster risk in Indonesia since PGA data from direct measurement are unavailable. However, this method should be understood as an initial phase on a regional scale without considering micro-tremor occurrence possibilities. For smaller area, it is recommended to consider micro-tremor and local site effect influence.

Table 2. Number of objects in Cilacap which are used for multi-risk assessment

No	Village	Buildings	Population	Productive land (paddy field + dry farming) (Ha)	Selected mobile asset			
					Car	Livestock	House eq. (*)	Boats
1	Tambakreja	5 278	22 512	0.5	191	8 019	5 278	71
2	Tegalreja	3 050	13 512	0.0	35	4 136	3 050	0
3	Sidakaya	3 795	12 159	36.0	127	148	3 795	170
4	Cilacap	3 465	15 932	0.0	69	8 433	3 465	1 158
5	Tegalkamulyan	1 847	13 017	70.5	11	1 584	1 847	672
6	Lomanis	1 129	4 852	7.0	31	2 607	1 129	0
7	Donan	5 608	24 373	35.0	171	2 948	5 608	217
8	Sidanegara	7 010	30 188	65.0	290	2 556	7 010	0
9	Gunungsimping	3 074	14 218	25.0	200	1 049	3 074	0
10	Kebon Manis	2 026	9 936	96.1	268	3 741	2 026	2
11	Gumilir	2 782	13 584	124.1	293	12 074	2 782	23
12	Mertasinga	2 951	14 238	297.2	116	17 876	2 951	226
13	Tritih Kulon	3 426	15 756	233.5	123	42 050	3 426	108
14	Karang Talun	2 256	10 084	96.0	76	5 372	2 256	48
15	Menganti	2 177	9 899	523.9	19	24 378	2 177	8
16	Karangkadri	1 169	5 942	319.9	24	7 792	1 169	4
17	Kuripan Kidul	1 375	6 366	98.7	11	30 942	1 375	0
18	Tritih Wetan	1 524	7 862	180.2	68	9 190	1 524	127
	Total	**53 942**	**244 430**	**2 208.7**	**2 123**	**184 895**	**53 942**	**2 834**

Source: BPS Cilacap (2004); (*) refer to number of buildings, but it will have different value

Table 3. Earthquake data (USGS) in Cilacap and its surrounding (1975-2004)

CAT	YEAR	MO	DA	ORIG TIME	LAT	LONG	DEP (km)	MAGNITUDE	IEFM NFPO TFS	DTSVNWG	DIST km
PDE	1975	08	20	163720.90	-8.19	109.10	102		.. .	....	49
PDE	1977	01	01	173554.90	-7.89	109.01	113	5.70 mb GS	.. .	....	14
PDE	1977	08	08	014255.60	-7.78	109.20	113	5.20 mb GS	.. .	....	21
PDE	1977	11	28	103554.60	-7.58	108.64	114	4.70 mb GS	.. .	....	43
PDE	1980	04	16	121820.60	-8.08	108.79	84	5.80 mb GS	.D .	....	43
PDE	1980	04	16	122348.30	-8.11	108.74	80	5.70 mb GS	.. .	....	48
PDE	1982	10	26	124421.90	-7.40	108.74	153	5.60 mb GS	.. M	....	47
PDE	1982	10	28	153014.74	-7.99	109.09	96	5.20 mb GS	.. .	....	28
PDE	1983	09	10	024730.43	-7.69	108.61	126	4.60 mb GS	.. .	....	43
PDE	1985	03	14	070225.51	-7.76	108.79	164	4.30 mb GS	.. .	....	23
PDE	1985	09	11	085744.98	-8.02	108.85	96	5.10 mb GS	.. .	....	33
PDE	1987	11	18	013400.14	-8.09	108.79	65	5.50 mb GS	.. M	....	44
PDE	1988	04	20	214307.17	-8.05	109.01	99	4.60 mb GS	.. .	....	32
PDE	1990	05	21	132436.69	-8.14	109.04	27	5.50 mb GS	.. M	....	42
PDE	1990	12	24	045521.67	-7.92	108.79	45	4.90 mb GS	.. .	....	30
PDE	1992	01	25	093455.67	-7.45	108.74	33	4.40 mb GS	.. .	....	43
PDE	1994	07	01	015757.16	-7.96	109.14	101	5.10 MwHRV	.F M	....	27
PDE	1995	06	16	093524.22	-8.04	109.12	127	4.80 mb GS	.. .	....	34
PDE	1995	08	18	000526.34	-7.66	108.61	117	4.50 mb GS	.. .	....	43
PDE	1996	11	11	164757.94	-8.00	109.08	130	4.50 mb GS	.. .	....	28
PDE	1997	04	30	214409.27	-7.83	109.20	100	4.20 mb GS	.. .	....	23
PDE	1998	06	23	074443.30	-7.54	108.91	123	4.60 mb GS	.. .	....	25
PDE	1998	06	28	201853.05	-7.97	108.82	100	4.60 mb GS	.. .	....	31
PDE	1998	09	27	085006.60	-8.05	108.85	127	3.70 mb GS	.. .	....	36
PDE	1999	05	11	050849.14	-8.07	108.71	33	4.70 mb GS	.. .	....	47
PDE	1999	07	27	191712.13	-7.93	109.31	118	4.50 mb GS	.. .	....	39
PDE	2000	05	30	182409.13	-7.55	108.67	231	4.50 mb GS	.. .	....	42
PDE	2001	03	14	152630.64	-7.98	109.05	33	4.40 mb GS	.. .	....	25
PDE	2001	05	06	142110.38	-7.82	109.14	100	4.70 mb GS	.. .	....	17
PDE	2002	02	11	162215.85	-7.94	109.09	33	4.30 mb GS	.. .	....	23
PDE	2003	02	25	075743.03	-7.75	108.82	92	4.60 mb GS	.. .	....	20
PDE	2003	11	28	225032.56	-7.95	109.25	127	4.30 mb GS	.. .	....	34
PDE	2004	02	27	102019.91	-7.72	109.33	129		.. .	....	37
PDE	2004	05	13	133847.17	-7.89	109.02	63	4.40 mb GS	.. .	....	16
PDE	2004	05	16	060916.48	-7.96	108.80	100	4.50 mb GS	.. .	....	32

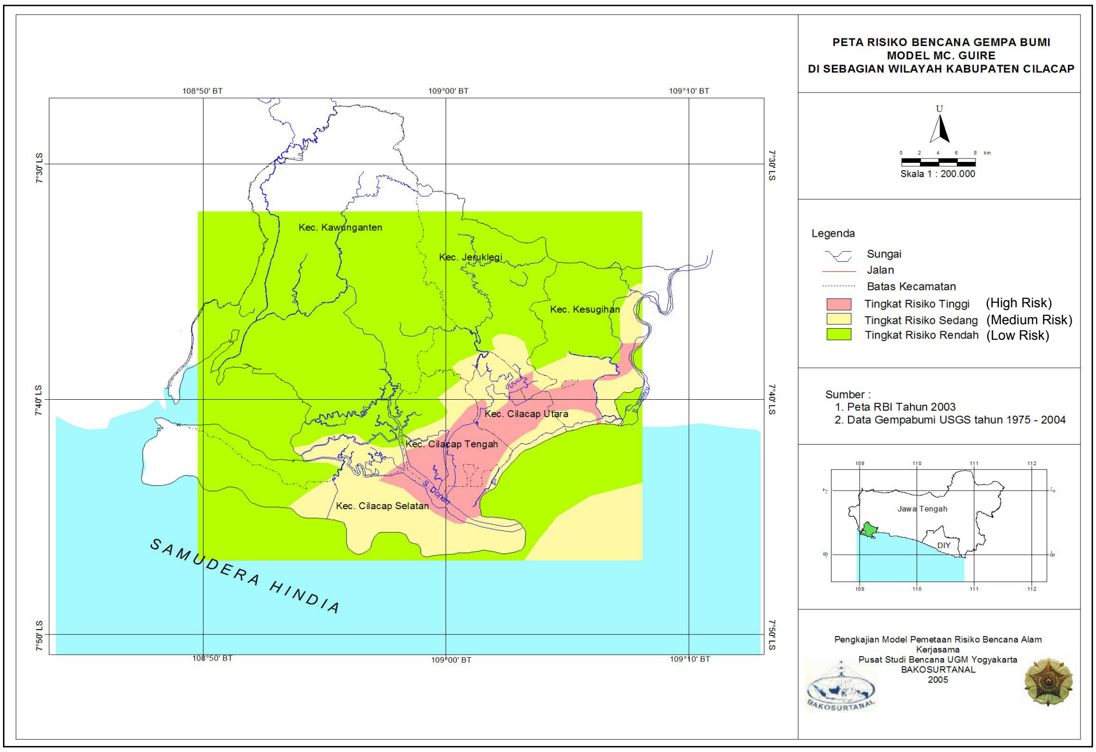

Figure 3. Earthquake disaster risk map of Cilacap city (PSBA, 2005)

For tsunami risk assessment, a map of tsunami hazard potential must be generated at first. That map informs some possibilities of inundated area as a worst-case scenario. Furthermore, by integrating a number of considerations, the tsunami risk in Cilacap can be constructed regarding the worst-case scenario of hazard and damage potential. It is important to consider the marine landforms arrangement which confirms the boundary of marine processes in the past as the possibility of paleo-tsunami influence. It is the easiest way for mitigation to tsunami hazard, though this approach should be applied only in the first step of a hazard analysis.

Based on hazard potential assessment, all villages are under tsunami threat. Thus, all villages have a various risks as well. Map of tsunami risk in Cilacap can be seen in Figure 4. According to that figure, it is clear that Tegalkamulyan village should be considered as the most priority village in case of tsunami. All objects in this village are mainly categorized in a high to very high risk since their risks are at a high percentage. This village is also located adjacent to the shoreline in the centre of the Cilacap city coast. Other villages, such as Gunungsimping, Karangkadri, Menganti, and Mertasinga have a various percentage of risk level, though they can be categorized in high and very high risk to tsunami. On the other hand, some villages can be neglected from tsunami risk due to low or very low level of risk. Thus, for multi-risk assessment purpose, only twelve villages will be considered.

After earthquake and tsunami risk assessment, both maps are analyzed comprehensively. As a result of the integration between earthquake risk and tsunami risk, the high level of multi-risk potential can be found in 5 villages, i.e. Gunungsimping, Karangkadri, Menganti, Mertasinga, and Tegalkamulyan (Table 4). A multi-risk potential map of Cilacap is shown in Figure 5. The total fatalities for those villages are estimated as more than IDR 40 billion (USD 4 million). The number of affected people is more or less 12.000 persons. In order to reduce the multi-risk of disasters in Cilacap city, a combination between hard engineering and social engineering will be necessary.

A hard engineering approach should be applied with regard to some considerations. Buildings and infrastructures renovation should be done with regard to local capacity. It should be noted here that some selected existing buildings or infrastructures can be utilized for multi-risk reduction program (Figure 6, left). New buildings or infrastructures development should be avoided in order to eliminate development cost, though this way can only be carried out in consideration to local government program. All buildings and infrastructures for multi-risk reduction program are local assets which should be utilized as multi-functional assets. This way is an alternative to eliminate assets inefficiency, thus all selected objects can be utilized for more productive activities during pre-disaster phase.

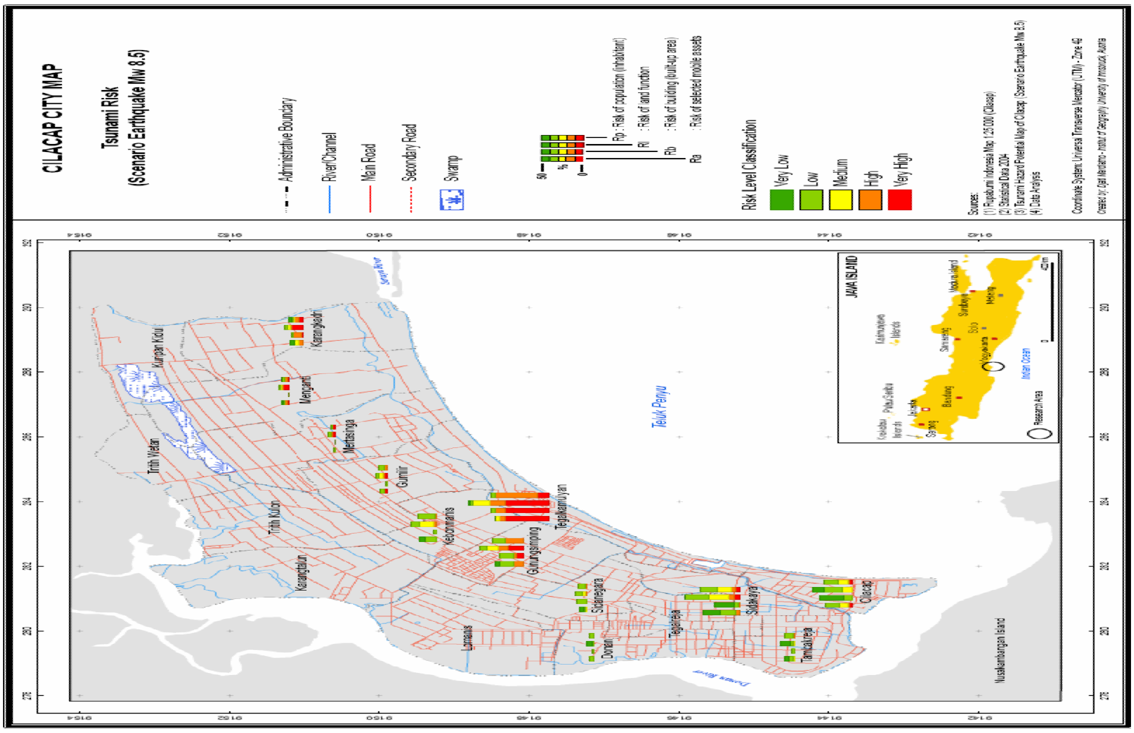

Figure 4. Map of tsunami risk in Cilacap based on earthquake Mw=8.5 scenario (Mardiatno, 2008)

Table 4. Multi-risk potential (earthquake and tsunami) in Cilacap city

Villages	Earthquake Risk	Tsunami Risk	Earthquake-Tsunami Risk (merged)	Multi-Risk Potential
Cilacap	H	L	H-L	M
Donan	H	L	H-L	M
Gumilir	H	L	H-L	M
Gunungsimping	H	H	H-H	H
Karangkadri	M/H	VH	M/H-VH	H
Karangtalun	M	None	n/a	n/a
Kebonmanis	H	L	H-L	M
Kuripan Kidul	M	None	n/a	n/a
Lomanis	H	None	n/a	n/a
Menganti	M/H	VH	M/H-VH	H
Mertasinga	M/H	H	M/H-H	H
Sidakaya	M	L	M-L	M
Sidanegara	H	L	H-L	M
Tambakreja	H	L	H-L	M
Tegalkamulyan	M	VH	M-VH	H
Tegalreja	H	None	n/a	n/a
Tritih Kulon	M	None	n/a	n/a
Tritih Wetan	M	None	n/a	n/a

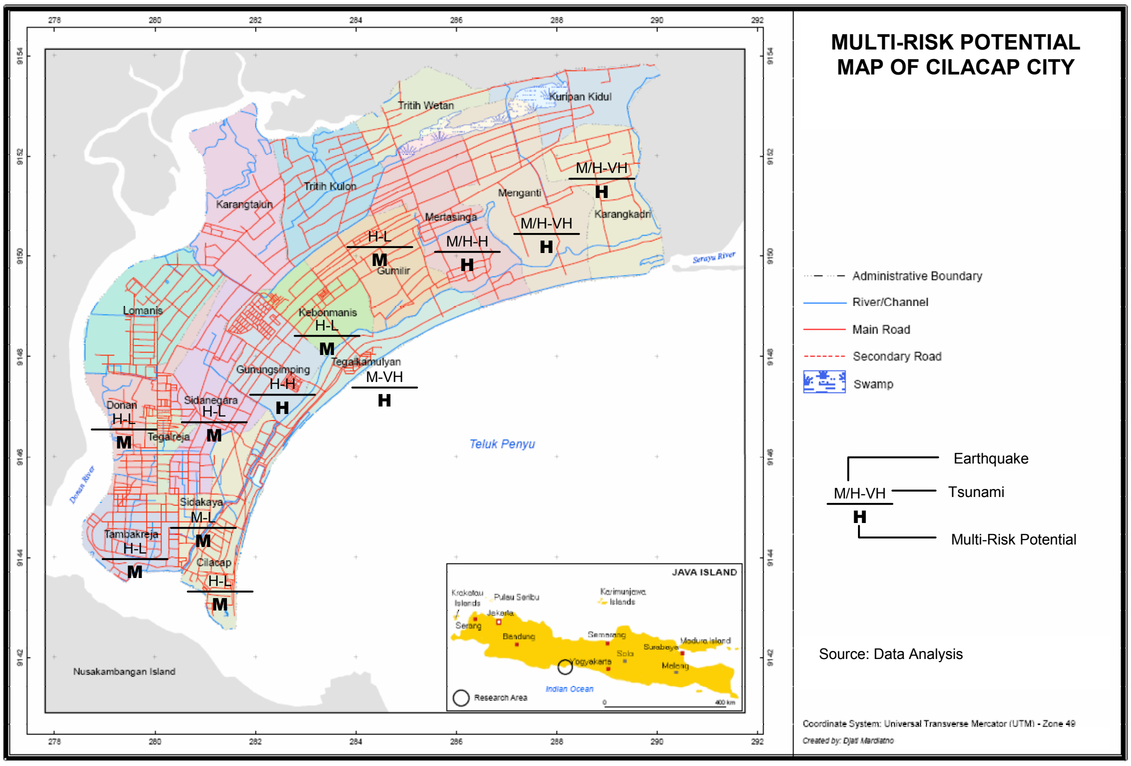

Figure 6. Multi-Risk Potential Map of Cilacap city

A social engineering method can be carried out by capacity building program, such as Training of Trainers (ToT) program for locals as well as an education for increasing people awareness to multi-risk. As PSBA (2007) did in some pilot project locations, ToT program is very useful to prepare local people in case of earthquake as well as tsunami (Figure 6, right). This program and followed by a drill is able to change people perception to disaster and increase their awareness. Socialization using such pamphlets, brochures, posters, and simple guide books as well as films about disaster is quite effective to educate local people in order to open their mind about disasters and multi-risk phenomena. In addition, the disaster education programs are more effective for children as they will easily accept all interesting information.

Both risk reduction programs should be done as a complementary program, thus a multi-risk assessment is able to provide a more complete description about related risks. Multi-risk reduction program will be more valuable in supporting regional development program. However, for this purpose, scale of analysis should be considered since this method should be applied in appropriate scale to avoid some inaccuracy of multi-risk of disasters mapping. It is recommended to apply this method within various levels, from regional level up to village level with regard to statistical data availability.

CONCLUDING REMARKS

The research on multi-risk assessment to disasters in Cilacap was accomplished. Based on the results, it can be concluded that a part of Cilacap city is threaten by multi-risk of disasters, i.e. earthquake and tsunami. A number of efforts should be carried out in order to reduce those risks, for instance by renovating some infrastructures, trainings for local people, and disaster education.

ACKNOWLEDGMENTS

The authors would like to thank to Research Centre for Disaster (PSBA) Gadjah Mada University for data support. Special gratitude is provided to Professor Masatomo Umitsu, Professor Makoto Takahashi, and all colleagues from Nagoya University, Japan for their invaluable supports for us.

Figure 6. Hard engineering (left) and social engineering (right) approach to reduce multi-risk of disasters (photos from PSBA and Mardiatno)

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Potential Loss Estimation of Agricultural Production Due To Tsunami Hazard

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ABSTRACT

Southern coastal area of Java is characterized by a high potential tsunami hazard. The devastating tsunami occurred on the southern coastal area of Java in 1994 and 2006 caused severe destruction and serious damage to building, agricultural land, and ecosystem. Parangtritis is located on the coastal area of Bantul District, Yogyakarta Province (South of Java Indonesia). This area is considered as high vulnerable area due to tsunami. The coastal area of Bantul has multi-land use purposes, as tourism, residential, and agricultural areas which leading to the vulnerable area to tsunami hazard. This research is aimed at analyzing scenario of tsunami hazard, mapping the potential agricultural land within the coastal area of Bantul and assessing the potential loss estimation of agricultural production under the scenario of tsunami hazard. Several methods will be applied including image interpretation to analyze and to map agricultural land use, generating the tsunami hazard map based on the water depth scenarios, and assessing the potential loss of agricultural production due to tsunami hazard scenario. Geographic information technology based on raster format will be applied to generate the pattern of the inundation. The superimposed technique between hazard model and agricultural land use map will be carried out to have the understanding of the potential impact of tsunami to agricultural land production. The research revealed that the coastal area of Bantul is very vulnerable to tsunami hazard. Under the scenario of tsunami inundation, large part of the Bantul coastal area will be covered by water leading to the loss of the agricultural production.

Keywords: risk assessment, tsunami hazard, agricultural production, GIS technology.

INTRODUCTION

Last tsunami in 1994 and 2006 in Java, Indonesia gives huge impact to the loss of property and agricultural production. From an agricultural point of view, the area affected the most by this hazard is the paddy field that is located on the lowland and coastal area. The tsunami hazard caused serious damage included loss of plants, increased plant disease, and delays in harvesting.

Papathoma and Dominey-Howes (2003) has examined the published tsunami risk maps, and generally, those maps indicate that tsunami flood risk is traditionally assumed uniform within the expected flood zone. However, Papadopoulos (2003) has also revealed that the population, infrastructure and land use within a given flood zone are not uniformly at risk. This is because risk is closely related to vulnerability, which measures the potential of loss and damage. Therefore, the vulnerability value is also different for each of element at risk. In term of the agricultural land, which is one of the most vulnerable land use due to the tsunami inundation, estimation of risk can be calculated by determining the type of the agricultural activities (ex., type of crop, etc) in order to have the detail estimation of the loss of production due to tsunami inundation.

Indonesia is considered one of the most tectonically active zones in the world, since this region has very complicated plate-convergences consisting of subduction, collision, and back-arc trusting (see Figure 1). At least some of the coastal areas in Indonesia are subject to tsunami hazard, which is caused by earthquake in a shallow region at subduction and plate boundaries. At least 105 tsunami has occurred throughout the Indonesian coastal areas since 1600, and 90% of this destructive event was generated by earthquake (Hamzah, et al. 2000). Although tsunami hazard, which is considered as the most devastating hazard, occurred frequently and attacked the coastal area of Indonesia, their regional characteristics are not well known. There is still limited study about the tsunami characteristics, hazards and tsunami-risk reduction strategies. One of the important issues pertaining to the risk reduction program is the generating of the hazard map, identification of the element at risk and the estimation of the potential damage due to the hazard.

Due to the changes in density of agricultural land use pattern of the southern coastal area of Central Java, it has recently been suggested that the potential impacts of future tsunami hazard are likely to be much greater than in the past. To what level selected coastal segments of Central Java (Parangtritis coastal area, Bantul regency) are at risk from, and vulnerable to, tsunami inundation and impacts are the most imperative questions to be answered. Estimation model and calculation is therefore considered as an important task to be done in the near in order to give the preliminary assessment of the potential damage due to the scenario of tsunami hazard.

A remotely sensed approach in combination with the Geographic Information System (GIS) might be more useful for establishing the spatial extent of potential hazard inundation (Marfai and King 2008a, Marfai and King 2008b) as well as to calculate the spatial agricultural damage over large areas (Lillesand et al.2004). Nowadays, the technology of the satellites images are increasing rapidly in term of the technology development and technology application. As example, data acquired by satellite sensors for land use determination, especially at coastal agricultural land use, is becoming an increasingly important source of information for precision farming. A Hyperspectral sensor such as IKONOS has dramatically increased spatial, spectral, and temporal frequencies that make them appealing to applications in precision agriculture. However, due to the large synoptic view provided and reasonable spatial resolution, the Landsat and ALOS satellites are also of equal importance in precision farming.

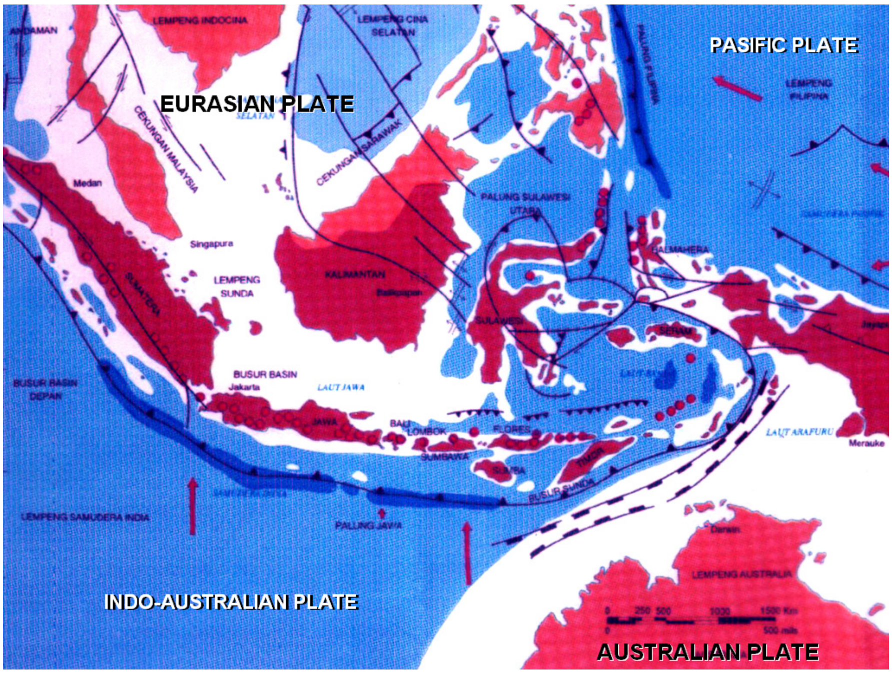

Figure 1. Plate tectonic surrounding Indonesia

This paper reports the results of an assessment of the impact of tsunami inundation for a coastal segment of Parangtritis-Bantul, South of Java coastal area in Yogyakarta Province, Indonesia. This study has been undertaken for three reasons: (1) the south of Java coastal area is one of the most vulnerable areas due to tsunami and has been identified as an area at risk from future tsunami occurrence (Marfai et al. 2008); (2) this research will develop the loss estimation due to tsunami to agricultural land in Parangtritis, since the detail data about the monetary loss in term of the agricultural production is still absent on the study area; (3) The local government are willing to formulate the local action plan for disaster risk reduction, and our results would be the valuable data to support the governmental program. Furthermore, to our knowledge, coastal land-use planning in general fail to considered the potential role of the extreme hazard facing on the coastal area. Figure 2 shows the vulnerability map due to tsunami around Indonesia, and Figure 3 shows the study area.

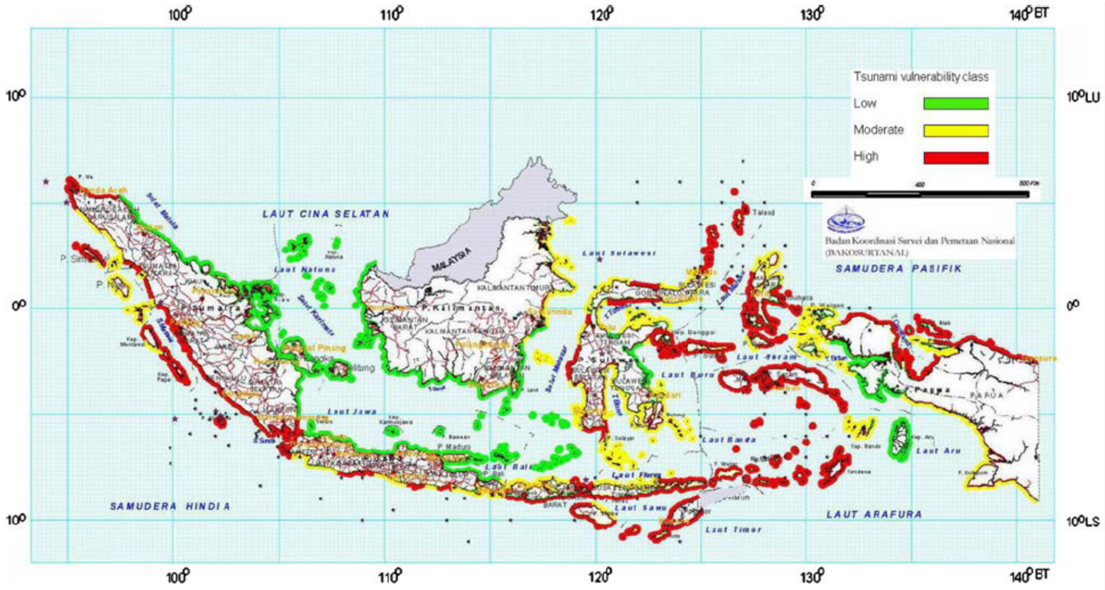

Figure 2. Tsunami vulnerability map of Indonesia (Bakosurtanal 2006)

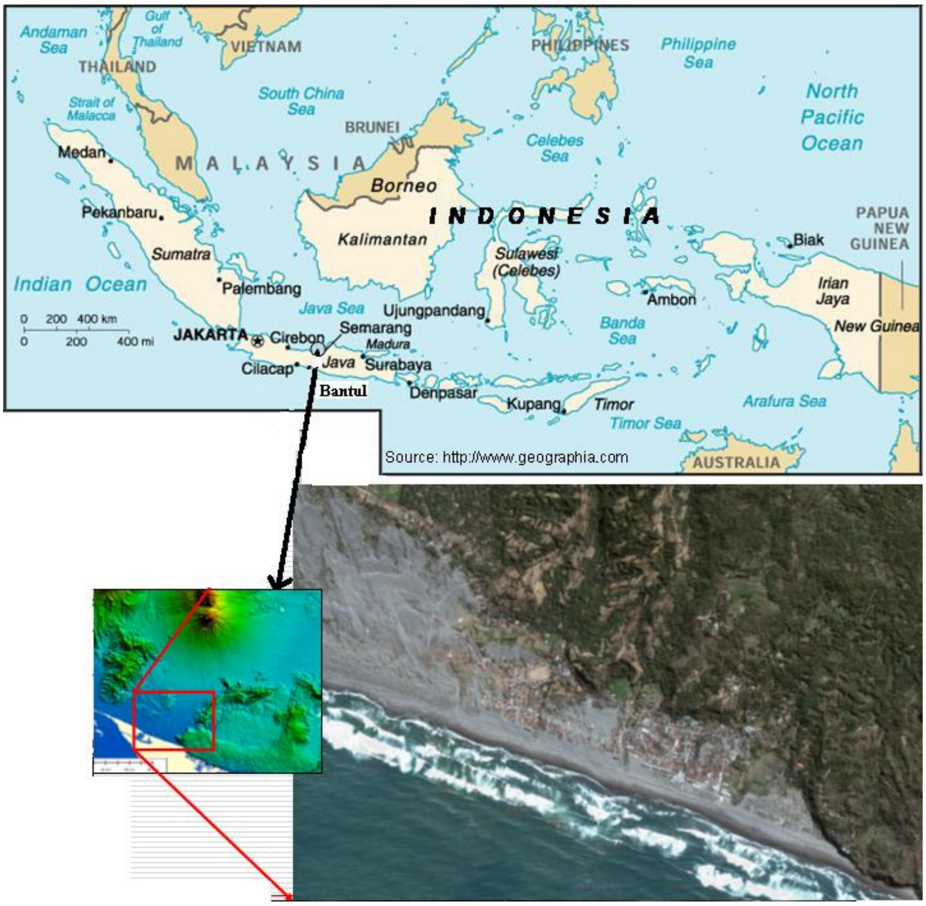

Figure 3. Study area

On 17 July 2006 the tsunami occurred in southern coastal area of Java. The huge damage happened in Pangandaran, one of the most preferred areas for tourism in Java. Lavigne et al (2007) has mentioned that the Indonesian Ministry of Health reported that more than 600 people died, more than 60 were missing and more than 9200 were in treatment as a result of disaster. The tsunami was triggered by a 7.7 earthquake located 220 Km of Java Island. This tsunami caused several damages to infrastructure, land use and agricultural area including paddy field.

Based on the tsunami vulnerability map (Bakosurtanal 2006) and the experience of the last tsunami disaster in Pangandaran, it is therefore necessary to map and assess into more detail the potential impact due to the future tsunami. Parangtritis coastal segment, which located not so far from Pangandaran area, has potential risk due to tsunami. This paper is intended to study the potential impact of tsunami in Parangtritis. The goals of this work were to: (1) map the agricultural land (paddy field) within the coastal area of Bantul; (2) generate the tsunami hazard map for the Parangtritis-Bantul, southern coastal area of Central Java; and (3) assess the potential loss estimation of agricultural production under the scenario of tsunami inundation.

METHODS

The inundation zone due to tsunami would be determined using the predicted water depth scenario. This study intends to identify the inundation zone of the hypothetical water depth scenario and quantify the impact of the inundation to agricultural land. Unfortunately, we exclude the physical mechanisms or hydrodynamic characteristics of tsunami during generation, propagation, or inundation. Moreover, we do not consider factor such as tsunami source region and coastal configuration during inundation. Due to the lack of data and information pertaining to the detailed scale of the bathymetry on the study area, and take consideration that obtaining such data could be time consuming and very expensive, this study also ignored the bathymetry of the seabed for identification of the inundation zone. This method is therefore considered as a simple method. However, this would make the methodology attractive for local authorities and coastal manager to use.

Potential risk assessment has been done for agricultural land use, especially for paddy production. Spatial analysis and table calculation of inundation model and paddy field map were applied in order to obtain the land use affected by inundation. However, for indirect losses as well as intangible damage, such as reduction in land quality for agricultural production, and disturbance of ecosystems were completely neglected.

RESULT AND DISCUSSION

For the impact assessment of the agricultural land use, a spatial distribution of the agricultural and non-agricultural land use is needed. Agricultural land use, especially paddy field, has been delineated by visual interpretation of landsat satellite images. We divided the map units into two units, namely paddy field and non paddy field. Figure 4 revealed the paddy field unit on the coastal area of Bantul.

Effort to analysis of the impact of the tsunami inundation to agricultural land use requires data on surface elevations (Titus and Richman 2001), therefore the elevation data is considered as the main input for the generating of the inundation model. The elevation data was generated from contour map in the ILWIS software using interpolation method. Based on the water depth scenario and elevation data, the inundation area can be determined. The inundation model has been generated using different possible scenarios of water depth to present a range of possible outcomes. Other environmental conditions such as the direction of the wave, the coastal micro geomorphology, existing barrier vegetation along the coast etc also affect the spreading of the inundation. However, to incorporate such factors would be overly complex for modeling. Therefore, the simplification has been made on this model by using water depth scenario. Other environmental factors are not taken into consideration in this model generation. Two different scenarios of water depth have been selected; there are 10 m and 20 m depth of water for the low and high scenarios respectively. The inundation models are shown in Figure 5 and Figure 6 for scenario of 10 m and 20 m of water depths respectively.

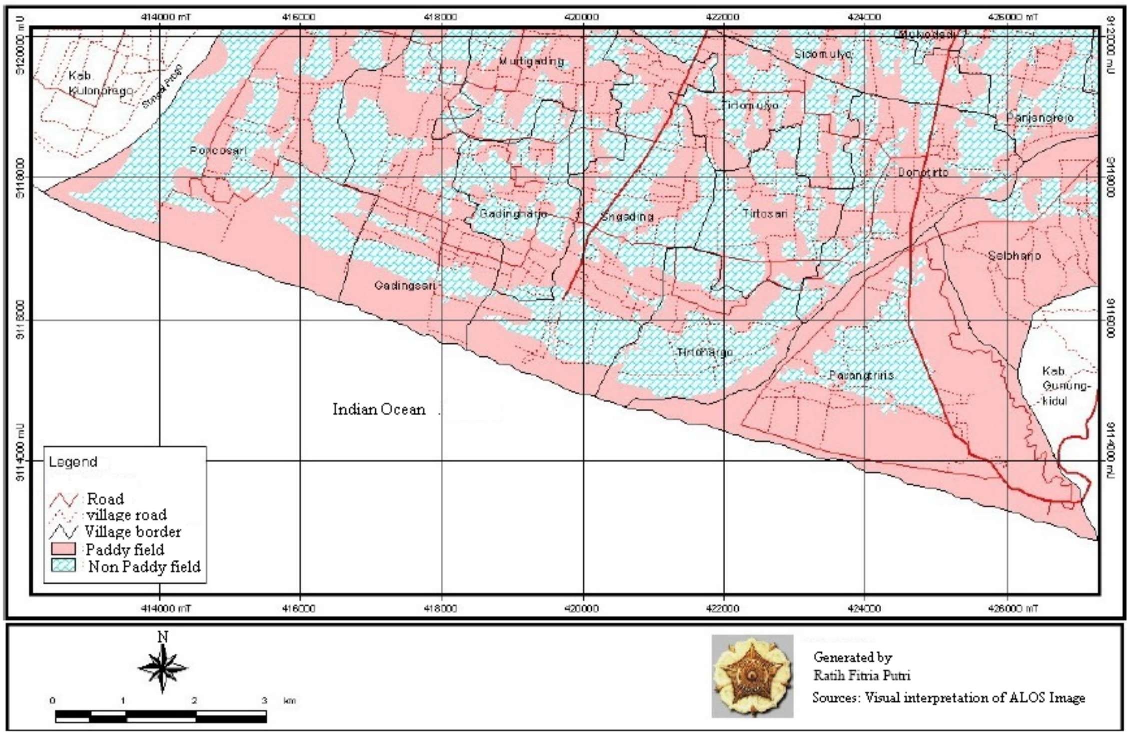

Figure 4. Map of agricultural land use (paddy field) on the coastal area

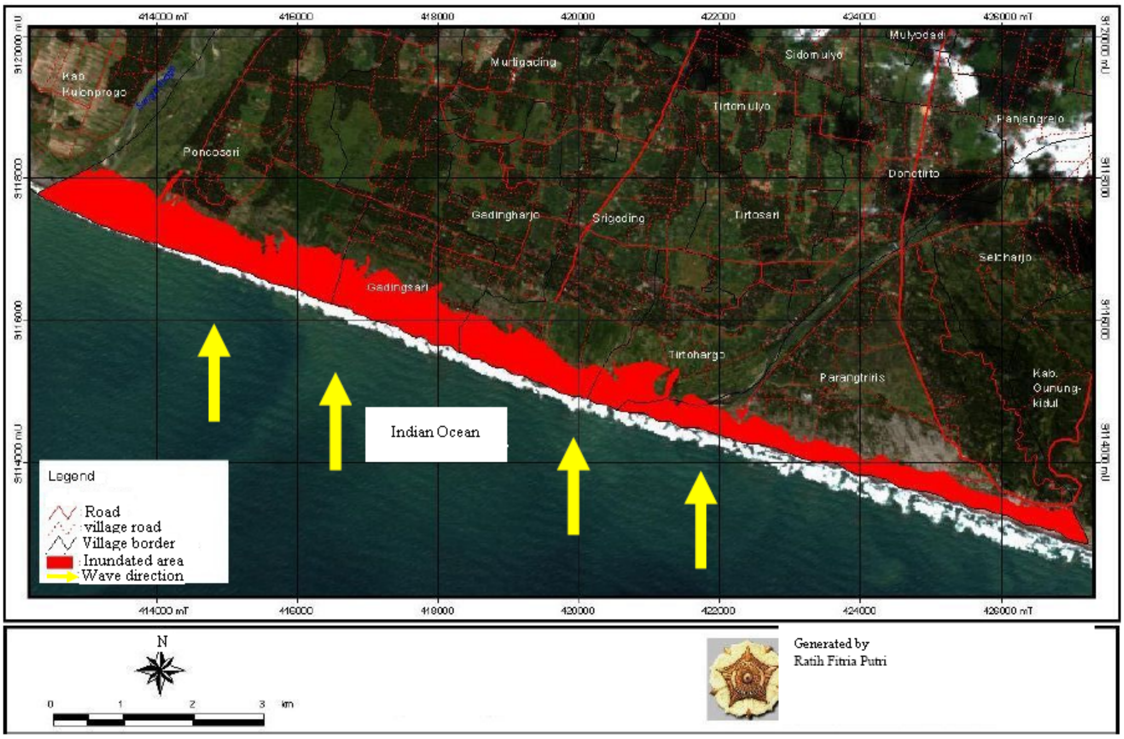

Figure 5 Tsunami inundation with scenario of 10 m water depth

Overlaying the inundated areas and agricultural land-use map permitted an assessment of the impact of the inundation. Total paddy field affected by inundation is shown in Table 1. Table 1 reveals that the area affected due to 10 m inundation is about 104 Ha and 638 Ha for agricultural land use and non-agricultural land use respectively. Meanwhile, for 20m inundation the area affected is about 366 Ha and 948 Ha for agricultural land use and non-agricultural land use respectively. The inundation would also give impact to the paddy production and disturbance on the ecosystem of water environment.

The agriculture productivity on the study area is relatively high. The paddy's productivity is about 4 ton / Ha / Year. Based on this value, the estimation loss of the productivity can be calculated. Table 2 revealed the loss estimation per water depth inundation. The 10 m inundation will cause loss of the productivity about 416 ton and for 20 m inundation will cause loss of the productivity about 1864 ton.

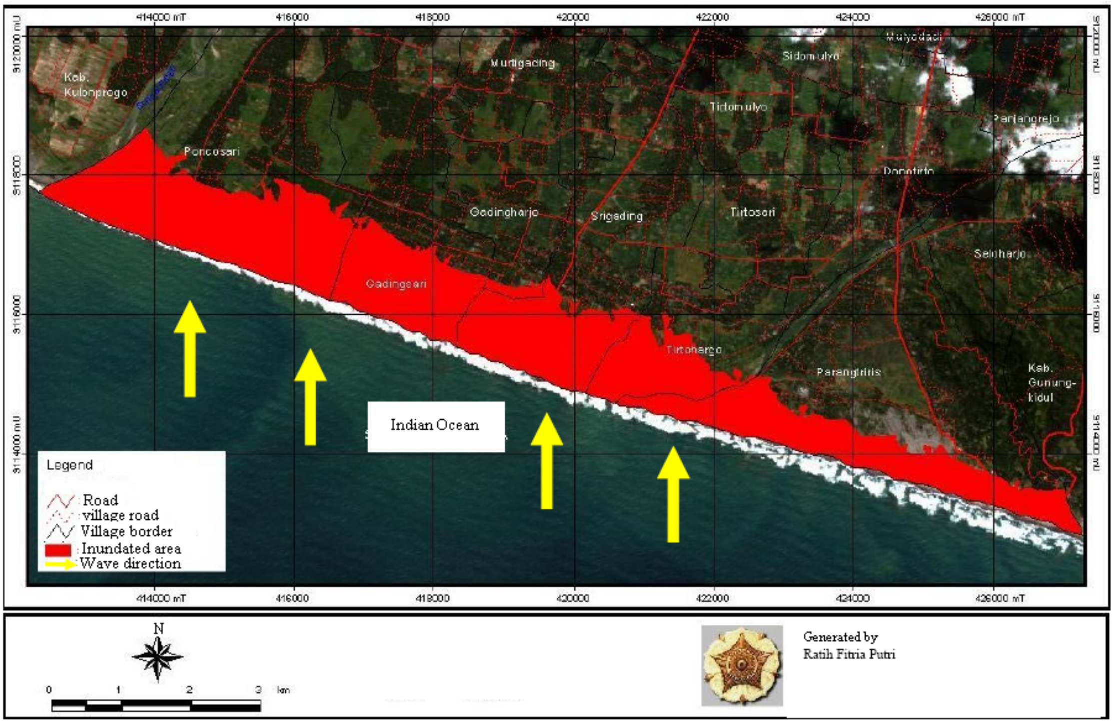

Figure 6 Tsunami inundation with scenario of 20 m water depth

Table 1. Inundation area on agricultural land and non-agricultural land

Water depth (m)	Inundated agricultural land (Ha)	Inundated non-agricultural land (Ha)	Total (Ha)
20 m	466	948	1414
10 m	104	638	742

Table 2. Risk calculation due to tsunami inundation

Water depth (m)	Risk calculation in one year (ton)
20	1864
10	416

CONCLUSION

Southern coastal area of Central Java is frequently affected by tsunami. We undertake a preliminary tsunami vulnerability assessment in a part of the coastal segment in southern coastal area of Central Java as a support for the disaster management system. The result of our study may have important implications for many different stakeholders. In addition, it would seem appropriate that those agencies tasked with coastal zone management ought to consider focusing their resources in the area of Bantul coastal area. In particular, agricultural land appears to be at significant risk to the impact of a future tsunami event. Finally, recommendations include (1) further research that considers the occurrence of tsunami, run up model, coastal characteristics, hydrodynamic and detail coastal geomorphology; (2) detailed land use mapping in order to identify the impact of the tsunami inundation and to calculate the detail potential loss in comprehensive approach. Furthermore, the result also suggests that integration of GIS and satellite image is a suitable method for detecting damage caused by tsunami inundation.

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The Banda Aceh Tsunami Drill: First Exercise of Vertical Evacuation in Indonesia (November 2nd, 2008)

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ABSTRACT

In November 2nd, 2008 at 8.30AM, 2 meters height of tsunami swept out the Meuraxa district, City of Banda Aceh, Nangroe Aceh Darussalam Province, Indonesia. The tsunami was triggered by shallow earthquake at the NW Banda Aceh with magnitude 8 at 8.00AM. The peoples run to the closer escape building after they heard a siren warn. This is a scenario of the first exercise for vertical evacuation of the Meuraxa peoples to the escape building. The Meuraxa sub-district is one of a flat and swampy area whereas four escape buildings had constructed by JICA.

The objective of Banda Aceh tsunami drill 2008 were to drill all tsunami warning system infrastructures which recently installed at City of Banda Aceh and to exercise vertical evacuation for people who live around dangerous areas and also escape buildings management. The tsunami warning system includes crisis center buildings, equipments, communication networks and command, risk maps, evacuation routes and signs. The most important aspects in tsunami drill 2008 in City of Banda Aceh is to raise public awareness of tsunami hazards.

The tsunami drill scenarios and preparations have been prepared for more than 5 months by City of Banda Aceh government in collaboration with Tsunami and Disaster Mitigation Research Center/TDMRC – University of Syiah Kuala and supported by Rehabilitation and Reconstruction Agency of Aceh and Nias and National Tsunami Drill Commission (Ristek, LIPI, BMKG, Ministry of Interior, ITB and other 11 institutions).

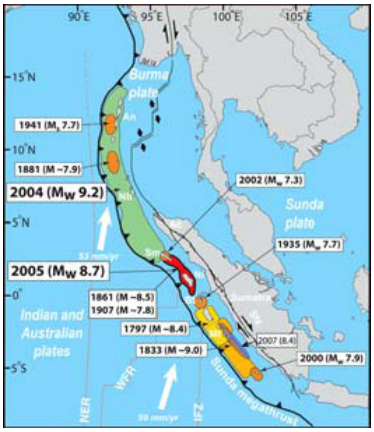
The tsunami drill participants spread out in six different locations and they evacuate to four different escape buildings. First escape building is TDMRC building in Meuraxa. The seconds is escape building in Lambung village, the third is escape building of Deah Glumpang village and the last is escape building of Deah Teungoh village. A time arrival of the evacuation for each escape building is about 5 to 10 minutes.

Although a tsunami tragedy is still vivid in the memories of the people in Banda Aceh, more than 4000 peoples participate in 2008's tsunami drill. Also, many peoples came from other district and present in each escape building during evacuation processes.

INTRODUCTION

The basic idea of new government regulation number 24, year 2007 is change of paradigm on natural hazard mitigation. In this new regulation, the society or community is also share the responsibility of hazard mitigation together with government and local government. It means that, the community should be ready to handle them selves when the disaster happens at any time without any support from government in limited time. In this case, the community and government must have an effective strategy on mitigation and disaster risk reduction. A disaster is free from administrative border, ethnic, or age when it hits, so comprehensive partnership amongst individuals, families, institutions and related stakeholders are very important to mitigate disasters. This new paradigm require periodical and continuity community capacity building on preparedness, response and awareness on earthquake and tsunami hazards.

The November 2nd, 2008 is known as the first experiences for the Banda Aceh people and local government in End to End tsunami drill and the first exercise for vertical evacuation drill in Indonesia. The tsunami drill was conducted at Meuraxa sub-district, NW of Banda Aceh City. This area has totally disappeared by 2004's tsunami disaster. The Meuraxa sub-district is one of flat and swampy area of the Banda Aceh City, where four escape buildings have been built and funded by JICA.



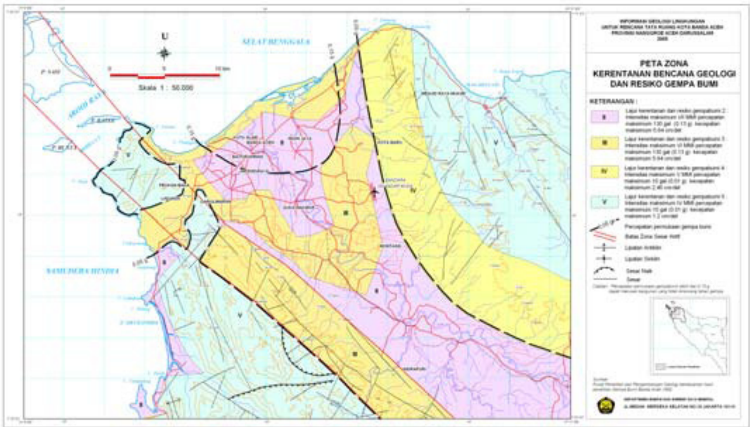


Figure 1. (Left). Historical earthquake data recorded along Simeulue-Andaman segment of Sunda Megathrust (after Briggs et al., 2006).
Figure 2 (right). The map of geological hazard vulnerability zone and earthquake risk of Banda Aceh City (ESDM, 2005).

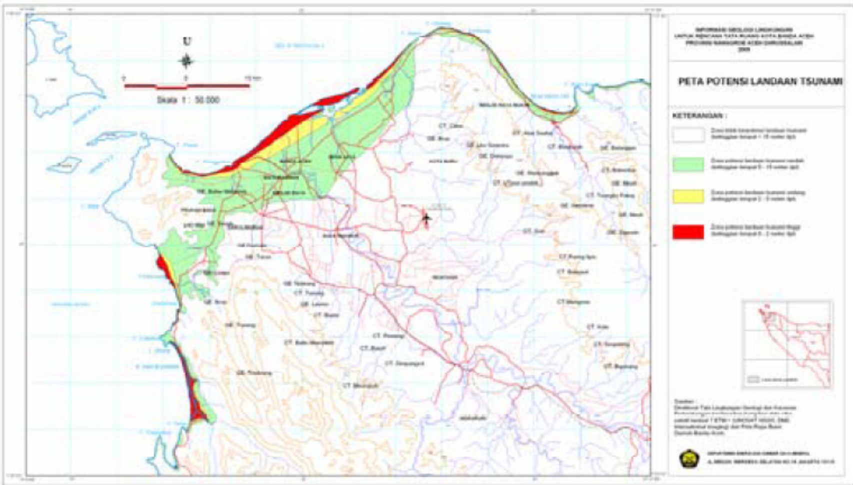


Figure 3. The map of potential tsunami flooding (ESDM, 2005).

The Banda Aceh City locates 200-250 km eastern of the Simeulue-Andaman segment as part of Sunda Megathrust. This segment more than 1000 km long has recorded important seismic activities since 18 century (Briggs et al, 2006) as shown in Figure 1. The Banda Aceh City itself tectonically situates in branches of northern off Sumatran Great Fault, one of active fault in the world. It's the reason why the Banda Aceh City was fall into 2nd and 3rd level of geological hazard vulnerability (Geological Hazard Vulnerability Zone and Earthquake Risk Map, ESDM, 2005, Figure 2).

A potential tsunami flooding Map, which published on 2005 (Figure 3, Energy and Mineral Resources Ministry) shows that northeastern part of Banda Aceh is vulnerable of tsunami hazard. Based on data above, it is clear that Banda Aceh City is situates in dangerous area, both earthquake and tsunami hazards. The natural condition pushes the local government to take an initiative in increasing capability and knowledge of natural hazard. This initiative is become important movement in Banda Aceh and hope also elsewhere in Indonesia.

OBJECTIVE

After 2004's tsunami catastrophic attacked Banda Aceh and Nias, the Indonesia Government together with International society came to help and support the Aceh people. The Indonesian government develops the Rehabilitation and Reconstruction Agency for Aceh and Nias to implement all effort regarding rehabilitation and reconstruction in Aceh and Nias. Not only infrastructure work, but also in education and training , trauma healing and many other activities for more then 3 years.

Recently, Banda Aceh City has finished on constructing, installing and completing all disaster risk reduction infrastructure of Tsunami Warning System such as Crisis Center, siren system, SOP of hazard mitigation draft, Risk Map, Evacuation route map and signboard, tide gauge and vertical evacuation building. The Crisis Center includes RANET (Radio Internet), tsunami modeling (hardware and software), communication networking and command. The TWS system directly connects with BMKG, Jakarta. The crisis center of Banda Aceh is one of four crisis centers in Indonesia. Other Crisis Center were developed in Padang, Denpasar and Jakarta. Figure 4 illustrates tsunami warning system consist of earthquake measurements, information sharing to a crisis center, tsunami siren warning dissemination and evacuation command. The NAD Province becomes a mini regional in hazard observation, monitoring, and data updating using available local human resources. In the future, optimistically, NAD Province will become reference, leader and center of exellence in TWS development for cities in Indonesia.

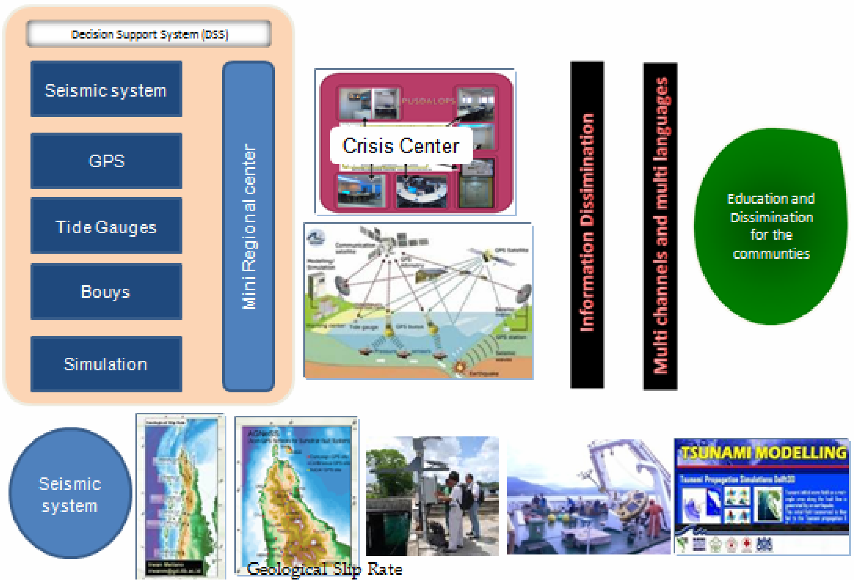


Figure 4. A complete tsunami warning system has been developing in Banda Aceh.

In Meuraxa sub-district, 4 escape buildings have constructed, such as TDMRC building (Figure 5), Lambung, Deah Glumpang and Deah Teungoh escape building. The escape building dedicated for capacity building training and public education in disaster reduction. The escape buildings that already constructed have 3 floors. The first floor was designed as open space, 4 meters high to avoid a previous tsunami flooding; the 2nd and 3rd floor as public room, office and library and the upper floor was completed by helipad for helicopter landing. All the escape buildings were positioned relative vertical to coastline to avoid sea water collision.

The government of Banda Aceh City aim to adopt a spirit of Hyogo framework action in order to reduce lost of lives, social, economy and environment assets caused a disaster. A tsunami drill is one of ways to exercise a public preparedness and awareness due to tsunami hazard in term a disaster risk reduction. The objective of Banda Aceh tsunami drill 2008 are to exercise all tsunami warning system infrastructures which had been installed in City of Banda Aceh, to evaluate people or community, building management and government officer in receiving and responding to disaster information and experience vertical evacuation for peoples who lived in dangerous areas. The goals of tsunami drill are:

a). To increase capacity, knowledge, awareness, and preparedness of community and government in anticipating a future earthquake and tsunami.
b). To exercise a tsunami warning system infrastructure, mechanism and disaster information dissemination.
c). To reduce a disaster victim as in Simeulue Island (Great Sumatra Earthquake and Tsunami 2004) and part of lesson learnt to community in NAD Province, Indonesia and abroad
d). To avoid siren alarm error as happened at June 6, 2007. The alarm error as causes a trauma, accident and victim of the Aceh people.
e). A natural hazard preparedness and awareness is positive way in tourism promotion

Figure 5. One of Escape Building in Meuraxa sub district (TDMRC building).

TSUNAMI DRILL PREPARATION

The City of Banda Aceh government has prepared tsunami drill scenario and preparation for more than 5 months in collaboration with Tsunami and Disaster Mitigation Research Center/TDMRC-University of Syiah Kuala and support by Rehabilitation and Reconstruction Agency of Aceh and Nias, the Sea Defense Consultant, ManGeoNad, Indonesian Red Cross (PMI), SAR and National Tsunami Drill Team (Ristek, LIPI, BMKG, Ministry of Interior, ITB and other 11 institutions and Jakarta Tsunami Information Center-Unesco).

It's really a long way and hard work to prepare and implements the tsunami drill in Banda Aceh. Various activities as structural and non structural have done. A structural activity as describe above is focused on infrastructure and hardware preparation. While a non structural activity focused on public education and training, research and development, technological alternative investigation, local wisdom identification, mitigation plan draft, draft of SOP development, disaster response training, logistics preparation, and coordination. The Socialization and dissemination to the people of Banda Aceh about drill and scenario plan to absorb a people aspiration about tsunami drill.

A massive and structured activity of community preparedness simulation against tsunami disaster called a tsunami drill. Including the drill is earthquake observation and measuring (magnitude, position and depth), by Indonesian Meteorological, Climatology and Geophysics (BMKG), and tide gauge data that operated by Bakosurtanal. The warning information spread out to crisis center or Pusdalops, police, military, local government and related stakeholder by handy talky, hand phone, facsimile, Ranet and siren and also traditional siren or kentongan or other technology. The activity flow describe above called end-to-end tsunami drill. The End-To-End Tsunami Drill activity in Banda Aceh City is large scale tsunami evacuation drill and its event has done by local government in collaboration with community and Ina TWS. This kind of drill has done in Padang

(2005), Bali (2006) and Banten (2007). The end-to-end tsunami drill and vertical evacuation in Banda Aceh hopefully become a lesson learnt, especially for Indonesian and also for Indian Ocean country.

To exercise a drill preparation, a table top simulation has done at October 17-18, 2008, two weeks before tsunami drill. The result of table top is very unsatisfied. Only few coordinator and represented participant understands about the drill scenario, the job and who is doing what still unclear. This condition is very crucial concerning limited time toward D-Day. Deputy Major of Banda Aceh as responsible of tsunami drill takes an initiative to evaluate and determine the problem arises: misunderstanding about tsunami drill, role of community, job description of coordinator and participant. A similar problem observed in elementary school 7th and 48th community. A teacher did not know what was their role in tsunami drill and the students understand they must run to the escape building when they feel a quake with or without any tsunami warn. A strategic step to resolve the problem is to re-formulation the tsunami drill scenario and takes pro-active and intensive dissemination and socialization to the community and Meuraxa inhabitant via radio, television and newspaper media and also banner and billboard. Other important recommendation under responsibility ManGeoNAD and LIPI is an intensive public education and training in school community.

A first rehearsal was planned at October 30, 2009, starting from Blang Padang public ground field with the goal is examining all drill preparation. The first rehearsal was canceled because bad weather just after general explanation about tsunami drill. The situation is relatively chaotic and less confident among the tsunami drill team. The day after, the first rehearsal repeat under lean weather at each point gathering. The activity focuses on the new drill scenario socialization, explanation what must to do during a quake, and what must to do when siren warn, without any mass movement to the escape building. A problem identified during the first rehearsal, just 3 days toward D-day was confusing the participants among earthquakes sign, siren warns and ambulances or fire brigades sirens. When they hear the sirens, even did not evacuation warn based on scenarios, all participants automatically run to evacuation sites. As we know, not all submarine earthquakes could be triggered a tsunami. A crucial problem also recognize is a role and job of Crisis center officer, communication among the officer and field coordinator is still disorganized, as well less signboard and banner was observed along evacuation route.

In the period a final rehearsal preparation and to avoid all weakness came up during the first rehearsal, the RAPIORARI organization (public radio communication society) was involved to help communication problem of Crisis Center during drill. As well, TDMRC and LIPI have done to explain a detail rundown, drill scenario, quake sign and function of siren warn to re-enforce participant and field coordinator capacity. The final rehearsal, just one day before D-day, success to demonstrate a participant knowledge and skill concerning a quake sign happened such as duck, hold and cover even a siren warn sound up from fire brigade car or ambulance. In 7 to 15 minutes after tsunami warning, all participants reached up the escape building. In the final rehearsal, PMI, SAR and military shows and exercise a skill and equipment to live rescue and evacuation.

The tsunami drill of Banda Aceh City is starting with the sound of low explosive dynamite as a quakes sign at 9.00, November 2, 2009. The drill participants at each point gathering have demonstrated a self rescuing from earthquakes disaster. Unfortunately, a siren sound of fire brigade car as a quakes sign disturbed a drill scenario practice because the sounds of siren known as evacuation warn. In consequence, the evacuation processes from all point gathering earlier than a command and communication among crisis center officer, vice-governor, satlak-satkorlak and incident commander. Evacuation process at every lane is going well in 5 to 10 minutes, even some obstacles caused the public traffic cannot be stopped. During tsunami drill, some troubles in communications is still observed as well the evacuation practice also disturbed by the present important attended of the Meuraxa inhabitant and also people come from another sub-district in the escape building. Almost of them are standing along the evacuation line in the building.

TSUNAMI SCENARIO AND RUNDOWN

The shallow earthquake at the NW Banda Aceh with magnitude Mw8 was happened at 8.00AM. Thirty minutes later, at 8.30AM, a tsunami wave, 2 meters height flooded the Meuraxa sub-district, City of Banda Aceh, Nangroe Aceh Darussalam Province, Indonesia. In 5 minutes, BMKG could detects and measure a position, depth, and magnitude of earthquake. The quake information will disseminate to the crisis center and other stakeholder in 7 to 10 minutes. If the earthquake will trigger a tsunami then tsunami warning will sound in 10 minutes. The peoples who lives or present in this area only have 10 to 20 minutes run to the closer escape building.

The tsunami drill participant composes a Meuraxa inhabitant and surrounding area, government officer, Sea Defense, school community (student and teacher), military and police component and its family, NGO, PMI, SAR, and RAPI-Orari. The international observer represented by French Red Cross, Unesco, BGR, GTZ, Nagoya University, and University of New Zealand.

The drill participant distribute in 6 different locations are 1) Ulheuleu port, 2) fish port and Cermin beach, 3) Blang Oi and Lambung community and school community, 4) Deah Glumpang village, 5) Deah Teungoh village and 6) school community as shown in Figure 6. After earthquake happened and siren warn, drill participant evacuates to four escape buildings (EB) that are TDMRC EB-1, Meuraxa EB-2, Deah Glumpang EB-3 and Deah Teungoh EB-4 (Figure 6).

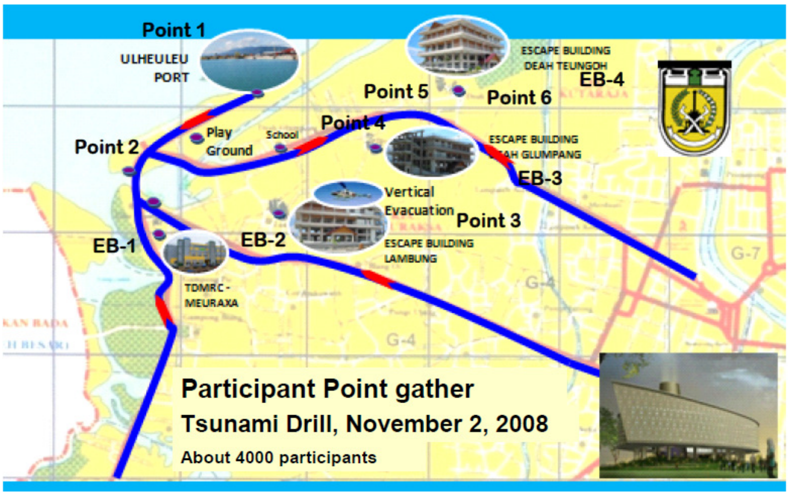


Figure 6. Map of meeting point participant and escape building

The TDMRC EB-1 is dedicated for VIP invited and visitor, incident commander center and ceremonial activities. This EB is evacuate location of the people around Gampong Pie village, people of fishery port, ferry port, play ground and Baiturrahim mosque of Ulhelue.

Lambung village EB-2 has designed a field hospital whereas the disaster victim and injured evacuates to this EB. The Lambung EB-2 has function also as evacuation building of Lambung village inhabitant and Blang Oi mosque people as well serious victim which rescuing by helicopter

The Deah Glumpang EB-3 is functioned as logistic public services and evacuation site of Deah Glumpang people, fisherman, and elementary student, while the Deah Teungoh EB-4 was functioned as disaster victim and injured information center. All evacuates personal data and condition registered here. As other escape building, the Deah Teungoh EB functioned as evacuation site of the people from Deah Teungoh village, meunasah and student from elementary school of SD 7 and SD 48.

The evacuation processes generally success but shelter management not really significant in function. Contrary, a complete search and rescue of tsunami victim have demonstrated during the tsunami drill, both on land and along the coastal as well by helicopter. In this case Health Department, PMI, SAR, Police and Military had shown best practice and skill.

THE PEOPLE RESPONSES

The tsunami drill program did not agree by Aceh people at the beginning because of trauma, hurt or budget loosed. A week before drill, the negative opinion due tsunami drill came up through newspaper or radio that tsunami drill is not important. Although a tsunami traumatic is still vivid in the memories of the people of Banda Aceh, more than 4000 peoples participate in 2008’s tsunami drill, both active and just present during tsunami drill at November 2, 2009 at four escape buildings. Also, many peoples came from other district to attend tsunami drill in each escape building during evacuation processes. It's necessary to the government to conserve a good momentum due tsunami drill through periodically tsunami drill to increase knowledge, capacity and skill against earthquake and tsunami.

The national media as well international media play a role in public opinion. Various radios interactive activity and regional television had been created due to tsunami drill socialization. So, involving the media since the planning and as active partner is very important. For Banda Aceh, the religion community and mosque are effective socialization media.

RECOMMENDATION

The evaluation and review meeting of Tsunami drill carry out some recommendations that need a follow up in raison to reduce the victim in the future disaster, as describe below.

1. The ferry port of Ulhelue situated in flat, isolated area and uncovered by siren warning. To necessaries reconstruct a new bridge to connect the port with a nearest escape building or to construct a new escape building at the port include siren warning system.
2. It's important to disseminates and familiarize a sound of siren as warn and local agreement on sign or sound of evacuation warning as well as a loudspeaker of mosque as tool of warning dissemination.
3. Routine exercise of siren sound is important as effort to socialize or pre-conditions of community. Depends on agreement with the community, a sound test could be in certain date each month.
4. To avoid viability disaster management, it's important for local government to take initiatives to develop various standard operation procedure of public port, escape building management, community and school community. All kind of SOP is part of SOP against disaster of Banda Aceh City.

ACKNOWLEGMENT

Special thank address to Banda Aceh City government, TDMRC and BRR, also National Team of Tsunami Drill 2008 who gave permits to publish a tsunami drill in Meuraxa district at November 2, 2008. Success story of tsunami drill in Banda Aceh is impossible without support all components in Banda Aceh.

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The Aceh Besar Community Preparedness in Anticipating Earthquakes and Tsunamis

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LESSONS LEARNT FROM THE GIANT TSUNAMI

The Aceh Besar District, geographically and geologically, is prone to natural disasters, including earthquakes, tsunamis, cyclones, volcanic eruptions, landslides, floods, droughts and fires. About 7 sub districts, including Pulo Aceh, Lhoknga, Leupung, Lhoong, Peukan Bada, Baitussalam and Mesjid Raya were hit by an earthquake and tsunami on 26 December 2004 (Government of Aceh Besar 2007). These areas were extremely vulnerable, due to their close proximity to the epicentre of the earthquake followed by the tsunami wave. This was related to the movement of the Indian Ocean plate and the Asian plate in the west (Indian Ocean) coming together and the movement of the Sumatran active faults in the Aceh area in the vicinity of Banda Aceh. The topography of these regions varies between relatively flat with a slope angle of $0 – 5^o$ and steep hills formed by limestone. These limestone hills are very steep with inclinations ranging from $60 – 80^o$, which is an obstacle for community members when trying to save themselves (LIPI - UNESCO/ISDR 2006).

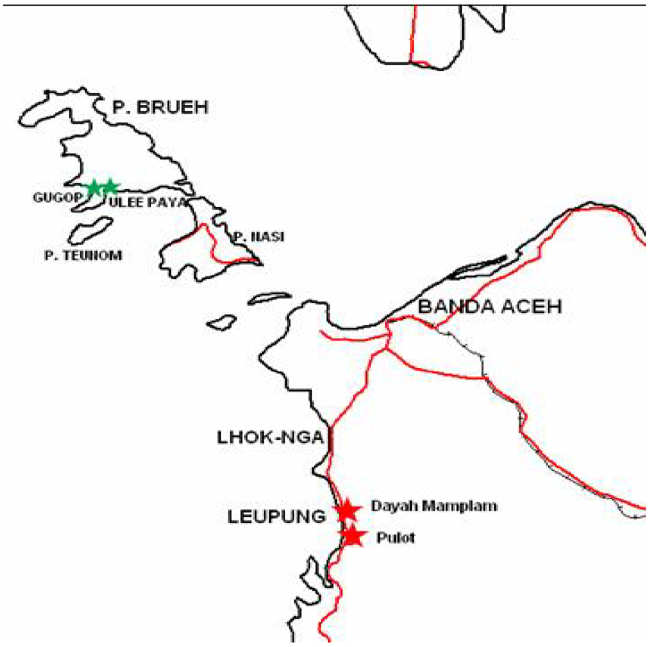
These regions have since become more vulnerable. The tsunami waves in 2004 caused soil erosion and abrasion that led to a reduction in the land area in some locations. The former highway and several coconut trees, previously on the coastal lands, are now covered by sea water. Inundation of water formed marshes in the coastal district which is now open, without a tree barrier, increasing the vulnerability of these locations.

The enormous disaster caused a huge number of lives to be lost, leading to demographic changes in the tsunami affected areas. More than 40,000 people lost their lives (1,460 were government staff), 2,800 are missing, 44,232 displaced and 182 disabled (Government of Aceh Besar 2007). The number of people has decreased substantially, by about 70 per cent in the Leupung sub district and 28 per cent in Pulo Aceh between 2003 and 2006. The tsunami killed most of the people in Dayah Mamplam village in Leupung, with only about 12 per cent of the people there still alive. Most of the victims were from the vulnerable group; women. The disaster has increased the gender ratio from 96 to 131 in Leupung and from 101 to 120 in Pulo Aceh. Indeed, the population density has declined significantly from 104 to 34 people per km^2 in Leupung and from 25 to 18 people per km^2 in Pulo Aceh (LIPI – UNESCO/ISDR 2006).

The large number of lives lost and the demographic changes indicate that the disaster preparedness of the community in the District of Aceh Besar was very low. This was mainly related to the lack of knowledge and awareness about earthquakes and tsunamis and lack of skills to reduce the disaster risks. Realizing the high degree of its vulnerability, the community has no other choice but to prepare in anticipation of such disasters.

This paper aims to analyze the community preparedness in the District of Aceh Besar based on the study conducted by LIPI – UNESCO/ISDR in 2006 and LIPI in 2007. The assessment, using a combination of quantitative (survey) and qualitative methods, was carried out in the sub district of Leupung, particularly in the villages of Dayah Mamplam and Pulot, and the Pulo Aceh sub district in the villages of Gugop and Ulee Paya located on Breuh Island. The survey involved 205 households, 60 school communities and 20 government staff.

The level of community preparedness was measured based on a framework developed by LIPI in collaboration with UNESCO/ISDR. This framework consists of five parameters, namely, 1) Knowledge about natural hazards and disaster preparedness; 2) Policy statement; 3) Emergency planning; 4) Warning system; and 5) Resource mobilization capacity. These parameters then were translated into variables that could be scored and indexed. This study classifies the preparedness according to five levels: 1) very prepared: with index value 80-100; 2) prepared: 65-79; 3) almost prepared: 55-64; 4) not enough prepared: 40-54; and 5) not prepared: less than 40. The study also identified seven stakeholders that are closely related to the community preparedness i.e. households, government, school communities, community institutions, non government organizations, professionals and the private sector. Three of them: households, government and school communities, are considered to be the main stakeholders, while the others are called supporting stakeholders in the preparedness for disaster. The unification of the main stakeholders' preparedness is seen as the community preparedness.



Map 1. The Study Locations in the District of Aceh Besar
Source: LIPI – UNESCO/ISDR, 2006

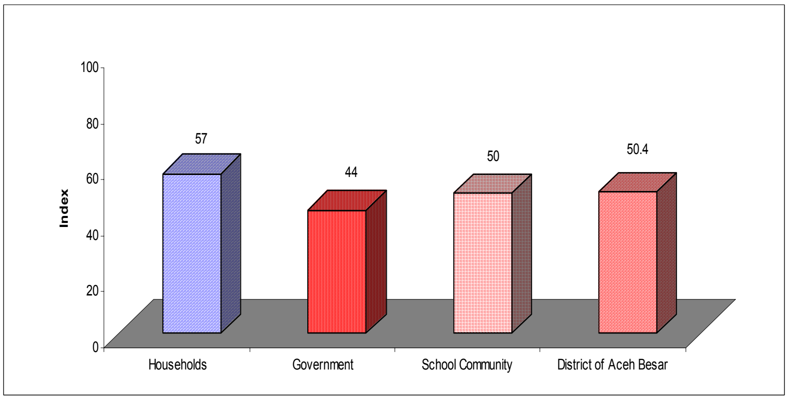


Chart 1. The Value Index of Community Preparedness in the District of Aceh Besar
Source: LIPI – UNESCO/ISDR 2006 and LIPI 2007

THE COMMUNITY PREPAREDNESS

Despite the extraordinary experience of the tsunami, the community in **the District of Aceh Besar was still not enough prepared by the end of 2007**. This is indicated by the index value that reached the figure of 50 from the maximum figure of 100 (Chart 1.). This lack of preparation appears among all main stakeholders, especially government institutions and school communities. The Aceh Besar government which is supposed to have a higher level of preparedness, actually has the lowest index;

in the category of not prepared. In contrast, the highest index is in the households, classified as almost prepared. Meanwhile, the index value of the school community is in the category of not enough prepared: between the households and the government.

The lack of community preparedness is due to a low index of all preparedness parameters, except knowledge. The study results explain that knowledge of the three main stakeholders has the highest index value, classified as prepared. However, the index value of other parameters (policy, emergency plan, warning system and resource mobilization capacity) is still low, in the categories of not prepared and not enough prepared.

The Household Preparedness

This study illustrates that **households have been classified as 'almost prepared'**, the highest level among the three main stakeholders. The 2004 experience has forced them to increase preparedness. This category is nominated by basic knowledge about earthquakes and tsunamis (Chart 2), even though an observation result indicates that community knowledge is still relatively low. The household knowledge is mainly related to their experience in the previous giant disaster and extensive information from television and radio about earthquake and tsunami disasters in other areas.

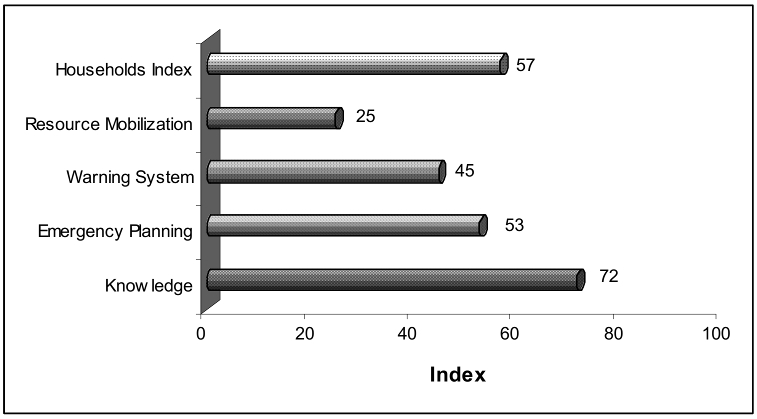


Chart 2. Index Value of Household Preparedness Based on Parameters in the District of Aceh Besar

Source: LIPI – UNESCO/ISDR, 2006 and LIPI, 2007

Most respondent households know that natural phenomena may lead to disasters, such as earthquakes and tsunamis. About 70 per cent mention that volcanic eruptions cause earthquakes and 57 per cent name the movement of tectonic plates. Most respondents understand the characteristics of earthquakes. They say that a strong earthquake is indicated by strong shaking, a long period of vibration and cracked/collapsed infrastructure and buildings. Most respondents know that earthquakes are unpredictable. Some respondents also claim that earthquakes lead to dizziness.

Before 26 December 2004 most respondent households were not familiar with tsunamis but since then, it has become a very important concern. They identified earthquakes beneath the sea and tectonic plate movements and eruptions as the causes of tsunamis. Half the respondents knew that erosion beneath the sea is another cause of tsunamis. When the respondents were asked about tsunami characteristics, most of them knew the right answer which included seawater seen to be receding, strong earthquakes and loud sounds like a bomb going off. Only a small number of respondents realized that massive clouds in the sky are another characteristic of tsunamis.

The respondent households had limited knowledge of the criteria for safe building construction for earthquakes. Less than half knew that 'a symmetrical building construction' and 'light building materials' are two of the criteria. Most of the respondents identified other criteria, such as 'parts of the building construction should be strongly attached to each other (67%) and 'deeply buried foundations' (81%).

The limited knowledge of the households can also be seen in the possible actions to be taken for reducing disaster risks, such as, what to do if an earthquake occurs. More than 90 per cent of respondents answered: ‘run to open areas’ and ‘stay away from hanging things, windows/walls, glass and bridges’. However, the proportion of respondents who answered concerning other activities was much lower, such as, ‘leave the room after the earthquake’ (49%), ‘cover the head for protection’ (56%), and ‘stay close to the wall which is free from hanging things (32%).

The household knowledge on possible activities, if a tsunami occurs, also varies. More than 90 per cent of respondents answered: ‘calm yourself down/do not panic’, ‘help children, pregnant women, elderly and disabled people to get out of their homes to a temporary safe place/building’, ‘stay away from the beach and run to a high place/building’ and ‘run to an evacuation place/refugee camp’. However, the number of respondents who named other activities was much less, such as ‘take emergency kit’ (67%), ’lock doors before leaving the house’ (39%), and ’turn off electricity, wood or gas cooker at home’ (36%).

As Chart 2 shows, the basic knowledge of the household members is not followed by the action needed to anticipate earthquakes and tsunamis. The households are still, not enough prepared for emergency planning. Less than half of the households have prepared an emergency kit, evacuation map and routes or attended simulations of evacuation. However, most households have increased their knowledge and skills and agreed on family evacuation places.

In addition, the households are still not prepared for accessing information about early warning or for responding to the warning. This condition is mainly due to limited knowledge and information about tsunami warnings. Most respondent households (82 %) stated that they did not know about the availability of a tsunami warning system in their location, either from the government or the local comminity. The government has developed a Tsunami Warning System or TWS, but it was not fully operational by the end of 2007. Therefore, dissemination regarding this system to the local community was still limited. Only less than 20 per cent of households knew about tsunami warnings based on their experience in 2004. Most of them also did not know the ’Smong’ story which is based on the 1907 earthquake and tsunami (smong) in Simeuleu Aceh that killed thousands of people, and advises: when a strong earthquake accompanied by receding seawater occurs, the local people have to immediately seek a safe area, although the story has been passed from generation to generation, from a father/mother to sons/daughters, among neighbours and newcomers.

The households are also still not prepared for increasing resource mobilization capacity, including information and skills to save lives and reduce the disaster risks. About 79 per cent of respondents have never participated in formal or informal meetings, training or seminars relevant to disaster preparedness. Only a few respondents in the Ulee Paya and Pulot villages, especially informal leaders, received relevant training but as the materials were still limited, they have not distributed the information to the local community.

The Government Preparedness

Preparedness of the government is crucially and urgently needed. As the principal stakeholder, the government should play a key role in developing community based disaster preparedness. In this study the government has been identified as a composite of three components, i.e. government institutions at district level (G1); government staff (G2); and government institutions at sub district level (G3). The G1 consists of institutions in charge of disaster management, including the United Nations and the Community Protection Bureau (Kesbang Linmas), the District Planning Board (Bappeda), the District Health Office (Dinas Kesehatan), the Government Secretary’s Office (Sekda), the Education Department, the Centre for Information and Communication (Kominfo), Public Works (PU), Transportation (Perhubungan), the Fire Brigade Office (Kebakaran), the Meteorological and Geophysical Bureau (BMG), PDAM, PLN and the Army (Kodim 0101).

This study shows that the index value of **the government of the District of Aceh Besar** is low**, in the category of not enough prepared** in anticipating earthquakes and tsunamis. The lack of preparedness is especially contributed to by government institutions at district (G1) and sub district (G3) levels. The G1, which is supposed to have a higher level of preparedness, actually has the lowest index and is classified as not prepared. In contrast, the highest index is from the government staff (G2), in the category of already prepared. Meanwhile, the index value of G3 is classified as not enough prepared, between G1 and G2 (Chart 1).

These figures indicate that disaster preparedness has not become a priority of the government in the District of Aceh Besar. The government has not significantly improved its preparedness, although this district has had horrible experiences in the earthquake and tsunami in 2004. The government awareness, of, especially, decision makers and those who have authority, of the importance of disaster preparedness is still limited. The government's focus is still on the rehabilitation and reconstruction of the disaster areas. Similar conditions also occur in the district parliament, particularly in the relevant Commission (Komisi A). The giant earthquake and tsunami in 2004 devastated almost the entire region. The district government collapsed in the early days of the disaster because the situation was absolutely chaotic. The recovery process has taken a long time and has relied heavily on the central government and foreign aid. Since the province had long been in conflict, the situation after the disaster has hampered the process of independence.

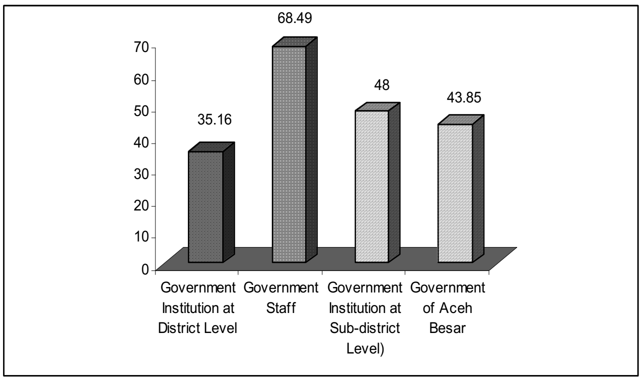


Chart 3. Index Value of Government Preparedness in the District of Aceh Besar
Source: LIPI 2007

Table 1. Index Value of Government Preparedness based on Parameters

Parameter	Government Institutions at District Level (G1)	Govern-ment Staff (G2)	Government Institutions at Sub District Level (G3)	Government of Aceh Besar District (G)
Knowledge (K)	-	68.4	-	68.4
Policy Statement (PS)	29.5	-	50.0	36.6
Emergency Planning (EP)	39.8	80.3	50.0	45.1
Warning System (WS)	35.7	76.6	50.0	45.3
Resource Mobilization Capacity (RMC)	34.4	62.4	0	28.1
Total Index	**35.2**	**68.5**	**48.0**	**43.9**

Source: LIPI 2007

The study result shows that the government preparedness varies among parameters and the government components (Table 1). The highest index is in the knowledge of the government staff. The basic knowledge about earthquakes and tsunamis and disaster impact mainly comes from their experience in the 2004 disaster. The staff also receives information from the mass media, especially TV, radio and newspapers. After the huge disaster, there was intensive and massive information about natural disasters. In addition, there were also many workshops and meetings, especially related to post disaster rehabilitation and reconstruction management.

However, the high index value of knowledge is not followed by action for preparedness. This can be seen from the low index of other parameters. Resource mobilization capacity has the lowest value, followed by government policy that is in the category of not prepared.

The capacity of the government to mobilize resources varies among the government components, with, for example, the district government still having limited capacity to mobilize all resources in the Aceh Besar District. This can be seen from weak institutional arrangements and lack of coordination among the stakeholders. The government staff capacity is much higher than of the district government. Most government staff has participated in relevant meetings or training, seminars and workshops. As government officials, they have the obligation to increase community preparedness. The high respondent participation has not been followed by activities in practice, such as skills dissemination and drills.

When this study was carried out in December 2007, there was no comprehensive policy or program for disaster management in Aceh Besar. The government still focused on post disaster activities which relied heavily on foreign aid. The institution in charge of disaster management at district level, known as Satuan Pelaksana Penanggulangan Bencana (Satlak PB), was formed following the Bupati Decree (SK Bupati) No 34 in 2007, replacing the previous decree (SK Bupati No.04, 2005). The Satlak, chaired by the Head of the District (Bupati), consists of many agencies from the relevant government sectors and non government organizations. The Satlak, however, has not fully achieved its function, since it is a non permanent institution with a limited allocated budget. According to a key informant: 'it is only on paper'. The Aceh Besar District has to set up a Working Group or 'Pokja' which is the responsibility of the District Planning Board. This Pokja would focus on development of the disaster management action plans.

Emergency planning (EP) is a crucial activity in anticipating natural disasters, but it is still in the category of not enough prepared. The EP varies among the government components with the lowest level coming from the district government and the highest from the government staff. Although this district has had bitter experience of earthquake and tsunami, the district government has given little attention to evacuation plans. According to the government key informant in charge of disaster management, evacuation places and routes have not been identified in this district. The government has a copy of the disaster risk map that is not informative, since it is in English, therefore not understood even by the government staff. The Aceh Besar District has the benefit of experience from the previous tsunami, especially in relation to First Aid and Health facilities, including tools and ambulances. However, other facilities such as a fire brigade, clean water and electricity are still limited. This district is also dependent on the provincial government for providing tools, equipment and harbour and airport facilities.

By the end of 2007 the Aceh Besar government was still not enough prepared in the warning system. This is reflected by the index value that varies among the government components with the lowest value contributed by the district government and the highest by the government staff. The Aceh Besar government, especially the Meteorological and Geophysical Bureau (BMG) as the institution in charge, has been developing a Tsunami Warning System (TWS) in this district. The BMG has installed TWS tools and siren towers in three locations. However, as the TWS has not, so far, been fully operational and effective, dissemination of the TWS to the local community is still limited. The interface between the technological warning and the local area is still missing. Networking among relevant stakeholders is crucially needed, particularly for a dissemination mechanism, but is still lacking.

The School Community Preparedness

The school community[1] is one of the three main stakeholders supposed to have an important role in developing community disaster preparedness. This community has been considered an agent of change and a key player in distributing knowledge on earthquakes and tsunamis and skills to reduce these disasters.

However, Table 2 shows that the index value of **the school community** has only reached 50, meaning **not enough prepared** in anticipating disaster. An astonishing result is the lack of preparedness mainly contributed by the school institutions which have the lowest index, classified as not prepared. In contrast, students and teachers have a higher level of preparedness, both in the category of prepared.

The low level of school community preparedness occurs in all parameters, except knowledge. The lowest index value is in the policy which is classified as not prepared. This indicates that almost no relevant policy has been made and implemented in the schools. The major cause was due to the schools' high dependency on policy from the District Education Office (Dinas Pendidikan Nasional) and the Department of National Education. Disaster

[1] The school community has been identified as a composite of three components, i.e. school institution (S1), teachers (S2) and students (S3).

preparedness have not become the main priority in school policies because they are more concentrated on the rehabilitation of schools after the tsunami.

Table 2. Index Value of School Community Preparedness Based on Components and Parameters

Parameter Index	School Institutions	Teachers	Students	Total
Knowledge	-	65	72	68
Policy Statement	10	-	-	10
Emergency Planning	18	76	62	39
Warning System	27	72	60	44
Resource Mobilization Capacity	19	57	48	33
Total Index	17	67	69	50

Source: LIPI – UNESCO/ISDR, 2006

The table illustrates that the school community has low capacity in mobilizing its resources, the second lowest index in the category of not prepared. This condition is again mainly contributed by the school institutions. Although teachers and students have higher index values, these school components are not capable of increasing the resource mobilization capacity of the school community. Teachers have more access to enhancing their capacity through participation in relevant meetings, training and community gatherings.

The school community is also not prepared in emergency planning. The level of preparedness varies among the school components from not prepared (school institutions), almost prepared (students) to prepared (teachers). The lowest level of the school institutions is reflected by little attention to evacuation plans and drills. In contrast, the highest level of teacher preparedness indicates a positive sign because they should play an important role in enhancing emergency planning of other school components.

Unlike other parameters, knowledge has the highest index and is classified as prepared. Although the index value of students is higher than of teachers, both are in the same category. Their knowledge about earthquakes and tsunamis has improved significantly, especially of students. This condition is particularly related to their personal experience during and after the extraordinary tsunami in 2004, added to knowledge acquired from massive information distributed by the mass media. The students also receive disaster information from relevant subjects at school. However, the study illustrates that their knowledge on possible activities to reduce risk is still limited.

So far, the efforts to improve the school community preparedness have been carried out on the basis of concern and capacity of relevant institutions. The availability of NGOs (national and international) is supposed to play an important role in developing community knowledge. However, international NGOs are more concerned with reconstruction activities (Tanaka, S cited by Takahashi et al. 2008). When the survey was conducted in 2006, most efforts laid most emphasis on rehabilitation and the reconstruction of buildings.

CONCLUSION

This study results show that the Aceh Besar community is still not enough prepared in anticipating earthquakes and tsunamis. The horrible experience of the tsunami in 2004 has not significantly increased community preparedness. The awareness of decision makers and those who have relevant authority is still limited because they are still focused on post disaster activities which rely heavily on foreign aid. The government and school community which are supposed to have a higher level of preparedness actually lacks preparation. Although the basic knowledge of the main stakeholders, including households, government staff and school community, has substantially improved, it is not followed by preparedness actions. Efforts to improve public education and community preparedness have not been the main priority. Policies or programs for disaster management are still lacking. Emergency planning is also limited, indicated by main stakeholders' little attention to evacuation plans and drills, provision of basic needs and critical facilities. The tsunami warning system has not been fully operational and effective with limited dissemination about the warning and response to the warning. The capacity of the main stakeholders to mobilize resources is still low as reflected by a lack of participation of the community in relevant meetings or training and in practices, such as of skills and drills. The low capacity is also related to weak institutional arrangements and lack of coordination among the stakeholders.

The above illustration indicates the importance of enhancing community preparedness in the District of Aceh Besar. The improvement in awareness of the importance of preparedness and capability to anticipate a disaster for the household, government and school community is crucially and urgently needed. Various efforts should be carried out to reduce disaster risks, including preparation for warning and of emergency situations and improvement in the capacity of human resources. Another important effort should be to enhance the capacity of Satlak and the political will of the government, especially in the policy and program of disaster preparedness. International agencies, such as the International Federation of the Red Cross, the British Red Cross and the Non Government Institutions, such as PMI, have a high potential to facilitate and develop community preparedness as has public education as conducted by Compress LIPI in early 2007 and tsunami drill in 2008. If put into effect, this might change the level of community preparedness in this district.

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Coastal Zone Management Due to Abrasion along the Coastal Area of Tegal, Central Java Indonesia

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ABSTRACT

As an archipelago country, Indonesia has very large coastal areas. Some of the coastal areas are facing with the environmental degradation including erosion, abrasion, and coastal inundation. Brebes and Tegal Districts, which are located on the northern coastal area of Central Java, are suffering from the abrasion process leading to environmental and ecosystem problems. With the coastline of about 84.5 km, Brebes-Tegal coastal area is considered as the vulnerable area to abrasion process. In last 3 years the abrasion process are increasing until more than 10m/year. Several factors causing the abrasion process including absent of the mangrove forest along the coastal area, lack of the coastal management and inappropriate law enforcement.

This research aims at the mapping of the distribution of the abrasion along the coastal area of Brebes-Tegal, assessing the environmental damage due to the abrasion and formulating the action plan to reduce the impact of the abrasion to the coastal environment. The abrasion areas had been mapped using the image interpretation. Meanwhile the environmental damages had been identified by field observation and interview. The research revealed that several action plans might be proposed using engineering and non-engineering approaches. Several structural measurement including Jetty, groin, and structural revetment are also intended. Meanwhile several soft engineering including forest (mangrove) rehabilitation would also very useful to reduce the impact of the abrasion. The important key factors was formulated for institutional coastal management, which was emphasized on co-management, community based management, capacity building, and traditional knowledge development.

Keywords: coastal abrasion, coastal management, structural measurement, and soft engineering

INTRODUCTION

The coastal environment consists of the interface between land and sea (Dey 1999, Marfai et al. 2008). This area has many physical processes including coastal abrasion, waves, tidal process, sea level rise, erosion, land subsidence, and sedimentation. Those processes play an important rule for the coastal environmental management. The coastal environments are also modified by human intervention including urban growth development. The human activities along the coastal area triggered resource use conflicts spawn environmental degradation (Dey et al. 2002, Marfai et al. 2008). In addition, Bird and Ongkosongo (1980) has mentioned that the building of sea walls and breakwaters, the advancement of the shoreline artificially by land reclamation, and the removal of beach material from the coastline, as the human actions, effect directly to the coastal dynamic and shoreline change.

Coastal abrasion as one of the coastal problem occurs frequently on the many coastal areas in Indonesia (Sunarto 2004). Several processes play an important role in coastal abrasion including wave action caused by winds, high tides due to astronomical tidal activity, tidal surges created by weather systems, and accelerated sea level rise due to global warming.

Abrasion is also influenced by natural processes such as cross-shore and long-shore sediment movement and due to dynamic water levels at the coastal area, such as waves, tides, storm, sea level rise, etc. Additionally, the landuse changes and population growth on the low-lying area and near the coastal zone give impact to the shoreline dynamic and creating the more vulnerable area. It has become important to map the abrasion as an input data for the risk assessment (e.g. Azab and Noor 2003). Information about the location of the abrasion as well as impact of the abrasion is also vital for coastal zone management (e.g. Morton et al. 1993).

Monitoring abrasion on the long-term period is important task for the coastal hazard vulnerability assessment. Shoreline data can be used to help the determination and calculation of the hazard and vulnerable area along the coastline. Residential area, industrial state, and agriculture area along the shoreline are susceptible for the shoreline change, e.g. due to the erosion processes.

In Central Java Province, emphasis in Tegal coastal area, abrasion is the major coastal hazards that threat to land use, coastal ecology, property and infrastructure in coastal area (Sunarto et al. 2001, Yudono 2008). Numerous infrastructures and agricultural land use behind the coastline are subject to abrasion. Governmental report from the Board of the Environmental impact monitoring (Bapedalda Jawa Tengah) (2002) revealed that the abrasion along the northern coastline of the Central Java Province was 2,910 Hectare in last five years. Agricultural land use including fishpond area and paddy field were the most vulnerable unit due to abrasion. Coastal protection measures have been constructed in a number of vulnerable areas, including the groin and dyke systems. However, the risk to coastal communities from coastal abrasion continues to present major challenges to coastal managers. Therefore, in an effort to limit future abrasion, improvement of coastal zone management is required. This paper reported the coastal abrasion and its mapping in Tegal, Central Java by using the satellite image interpretation, revealed the investigation of the impact of the abrasion, and formulated the action plan for coastal zone management. Due to the lack of series data, the abrasion process has been mapped crudely from the Year 1944 to the Year 2005 based on two time series images and topographic maps. However, in the near future this work would be extended with other time series data to have a detail result of assessment.

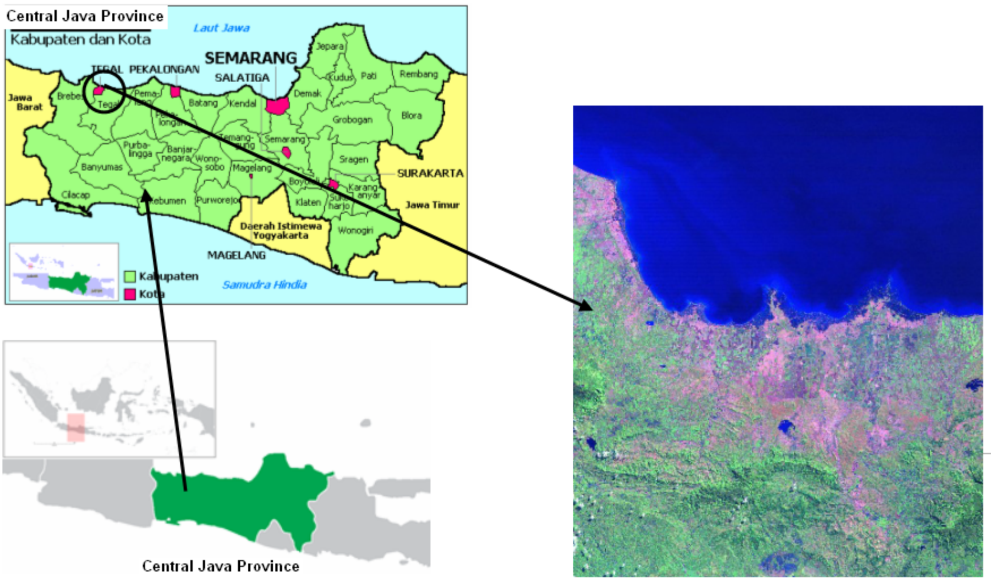

Figure 1. Tegal coastal area, Central Java Province, Indonesia (Yudono 2008)

TEGAL CITY AND ITS SURROUNDING AREA

Tegal is a coastal urban area situated on Java Island Indonesia. Geographically, it is located at the northern coast of Java and about 330 km east of Jakarta (Figure 1).The city consists of vary land use including fishery, residential, industrial, public and commercial, forest, bare land and others. Some infrastructures, such as roads, harbor and transport facilities, have been prepared to support the future development. Physical characteristic of Tegal coastal area features by sandy and muddy beaches. Sandy beach has larger in grain size and heavier compare to muddy materials. However, sand is less cohesive and therefore relatively easier to erode lead to abrasion. From the topographical point of view, Tegal has large of lowland areas and limited hilly area on the southern part. The surface elevation of the Tegal City is range from 0 m above sea level up to 925 m (Yudono 2008). In general, the shoreline slope is steep which allow waves to break closer to the coast and thus, enhancing abrasion. Coastal and low-lying area is very dynamic area with multi-uses purposes. The major economic and agricultural activities of Tegal City are situated on the low-lying and coastal areas cause over exploitation of environmental resources. In addition, coastal area of Tegal has complex geomorphological processes including erosion-sedimentation processes. Long period of intensive erosion-sedimentation processes and damage of the mangrove forest causes shoreline change dynamic.

METHODOLOGY

Abrasion along the coastal area can be monitored using the classical and conventionally method, where shoreline is manually identified and traced based on the time series aerial photograph, topographic map or satellite images (e.g. Elkoushy and Tolba 2004). The technology of the Geographic information system (GIS) can be applied as an essential tool for the delineation process of the satellite images and topographic map. The images and other spatial data can be translated into the digital form through scanning followed by geocoding and referencing. Then the visual delineation using screen digitizing based on the images on GIS technology can be done without difficulty. The conventional method and their integration with the GIS technology provide reliable results on digital form. Abrasion studies and shoreline change monitoring using such kind of the conventional methods have been done by various researches, for example Elkoushy and Tolba (2004), Marfai (2003), Mazlan et al. (1989), and Raj (1982). Our research was intended to map the abrasion using time series data along the coastal area of Tegal and surrounding area using the visual interpretation.

Although there has been detail coastal geomorphological research on several parts of the Indonesian coastline, the coastal features of Tegal-Central Java have not yet been well documented. Limited time series data was available, e.i., Topographic Maps Year 1944, 1965, Landsat ETM year 1991, 2001 and 2005. In this study, visual interpretation and delineation has been done using vector operation on GIS software. Image enhancement of the Landsat images including image processing, geo-referencing and filtering have been done prior to visual interpretation. Image enhancement has been done using linear stretching in order to obtain the better visualization. Linear stretching is a stretch method by which all values in an input map are converted into new values in an output map by using one formula. Once the image enhancement is finished, the shoreline delineation can be created using the classical interpretation. GIS superimpose method has been used for maps overlay operation in order to identify the shoreline dynamic as well as detection of the abrasion of the surface area. For this purposes all the dataset has the same georeferenced.

ABRASION ALONG THE COASTAL AREA OF TEGAL

Visual interpretation and delineation technique of the Landsat images has been applied to detect the abrasion along the coastal area. The suspended sediment along the coast may causes inaccuracies during the visual interpretation. To minimize the inaccuracies, image enhancement and filtering have been applied for Landsat ETM prior to visual interpretation. Figure 2 revealed an example of the visual delineation of the shoreline on the study area. Once the delineation is finished, the result then converted into segment map. Superimposed techniques have been carried out following the delineation. In general, with the crude data sources, the result revealed that during the period 1944 to 2005, the shoreline changed and moved to the land leading to the loss of coastal land areas. The map in Figure 3 revealed the significant abrasion occurred along the coast qualitatively. However, it is important on the next project to measure the abrasion and change of the shoreline quantitatively and enhancing the shoreline map by putting more time series data.

IMPACT OF ABRASION ON COASTAL ENVIRONMENT

According to Yudono (2008), on the local context in Tegal Coastal area, recently the abrasion occurs for about 250 m of the shoreline within this Coastal City and in some parts, the coastline moved up to 180 m to the land. The increasing of the abrasion process on the coastal area threats the coastal community leading loss of coastal land and damage to the coastal settlement. Figure 4 exposed the impact of the abrasion along the Tegal Coastal area.

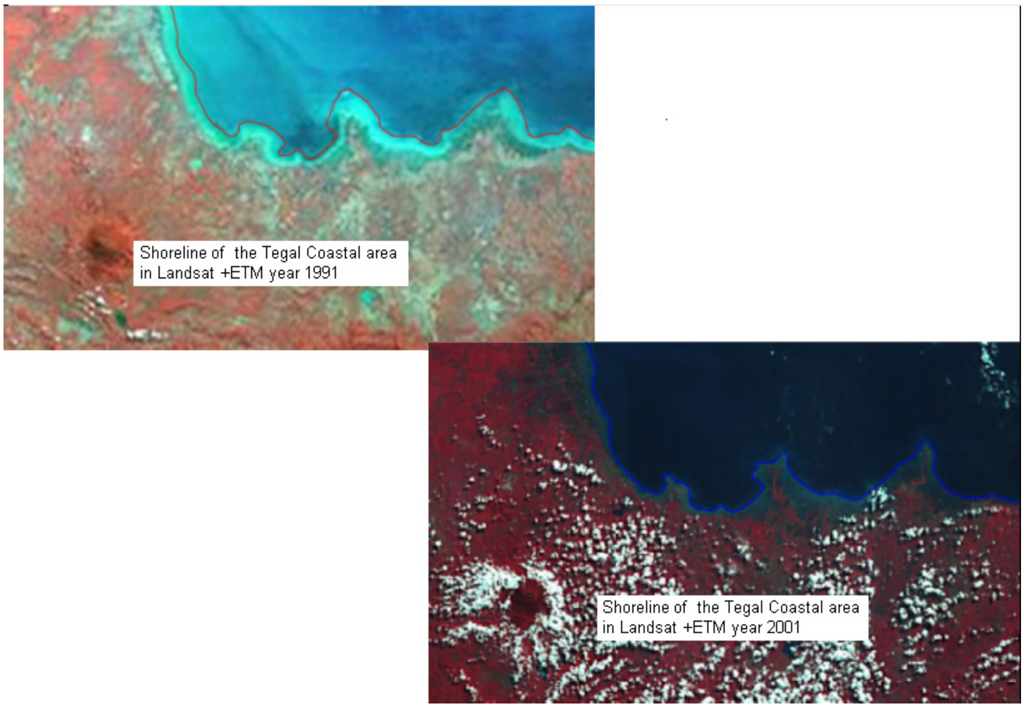

Figure 2. The delineation of the landsat data Year 1991 and 2001 (Yudono 2008)

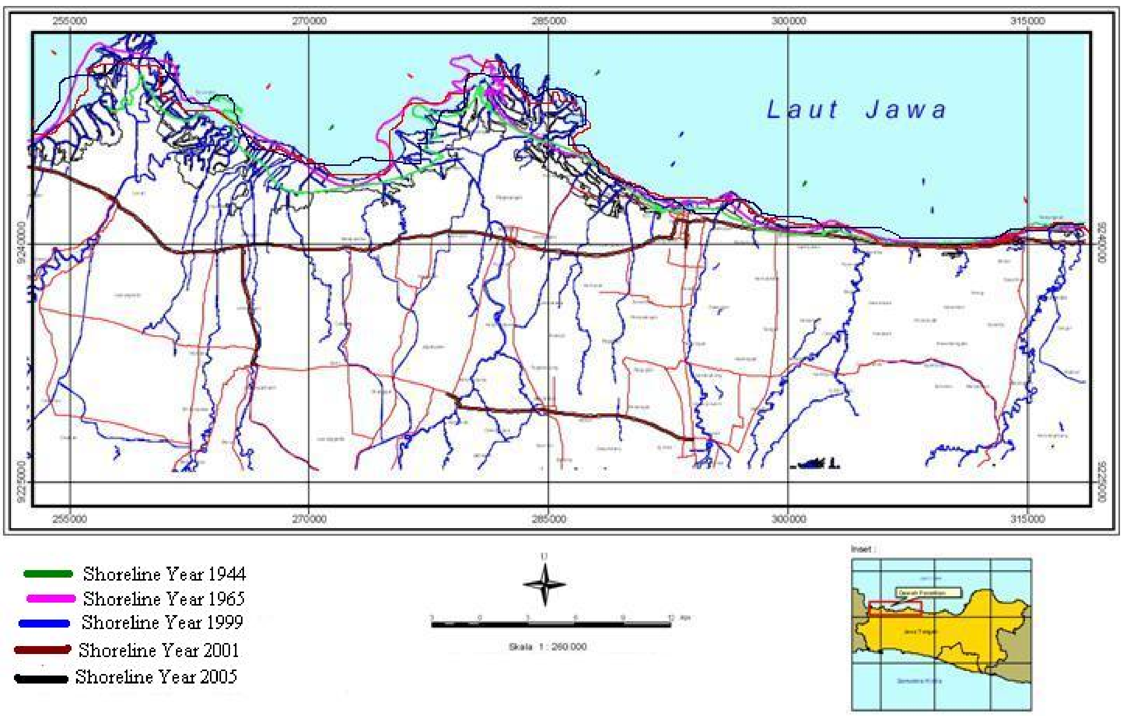

Figure 3. The shoreline change during the Year 1994 to 2005 indicates the abrasion process along the coastal area (Sunarto et al. 2001, Yudono 2008)

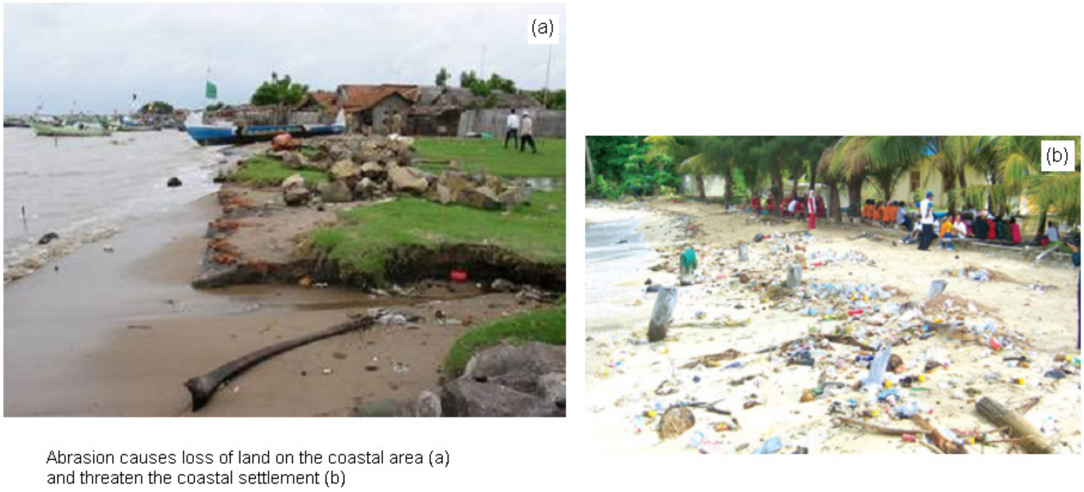

Figure 4. Abrasion causes loss of land on the coastal area (a) and threatens the coastal settlement (b) (Yudono 2008)

As mentioned earlier, that the abrasion is one of the important issues in coastal management in Central Java Province. Several cities are facing with the erosion and abrasion due to the absent of the coastal protection measures including mangrove forest. Mangroves are natural coastal features, which serve as buffers against the erosion energy of waves. Decreasing the mangrove density on the coastal areas contributes to the erosion and abrasion along the coastal area. Thus, the presence of mangrove forests lessens a coastal segment's vulnerability to erosion. The abrasion and the damage of the mangrove forests in several cities in Central Java Province are figured in Table 1.

Table 1. The Abrasion and the damage of the mangrove forests in several cities in Central Java Province Indonesia

No.	City/Regency	Abrasion/Ha	Level of mangrove damage (Ha)		
			Minor	Medium	Major
1	Kab. Brebes	818.0	21.0	205.0	9.0
2	Kota Tegal	37.1	770.5	4.215.0	3.3
3	Pemalang	1,549.0	54.9	41,487.5	12.0
4	Kab. Pekalongan	30.0	-	-	-
5	Kota Pekalongan	6.10	-	-	-
-6	Batang	2.50	-	20.0	1.2
7	Kendal	217.0	2.9	668.6	124.1
8	Demak	145.5	7.7	37.0	4.1
9	Jepara	86.0	8.5	-	-
10	Pati	3.1	5.0	6.5	4.5
11	Rembang	15.8	491.3	33.8	103.7
Total		2,910,1	1,344.7	45,702.5	249.9

Sumber : Bapedalda Jawa Tengah (2002), (Yudono 2008)

RESPONSE TO COASTAL ABRASION

As a community, the people in the coastal area responded to the prevalent abrasion by mangrove re-forestation, building structural measures such as ripraps, or sandbags. In addition, the local government supported the conservation by constructing seawall, jetty or groin. According to the locals, the ripraps and sandbags were not effective in preventing abrasion and maintaining them became costly in the long run. However, the structural measures using groin were pointed as an effective way to reduce the abrasion, as it is shown in Figure 5. In addition, increasing the application of the soft engineering including forest (mangrove) rehabilitation would also very useful to reduce the impact of the abrasion. The root system of mangroves is capable of reducing erosive forces of waves, tidal currents and consolidating sediment. In addition, as an ecosystem mangroves are capable of performing certain environmental services. Mangrove plants produce organic matter through photosynthesis and this produces the food for most of the fish and shellfish in the coastal waters. Therefore, from ecological point of view, coastal forests also form a natural barrier and protecting against natural disasters. Figure 6 revealed an example of the model of the mangrove re-forestation on the coastal area and Figure 7 shown the positive impact of the mangrove conservation. Moreover, in brief, we proposed several measures to be taken to minimize the abrasion and to solve the environmental problem related coastal dynamic process, i.e., hard engineering, soft engineering and social engineering (See Table 2)

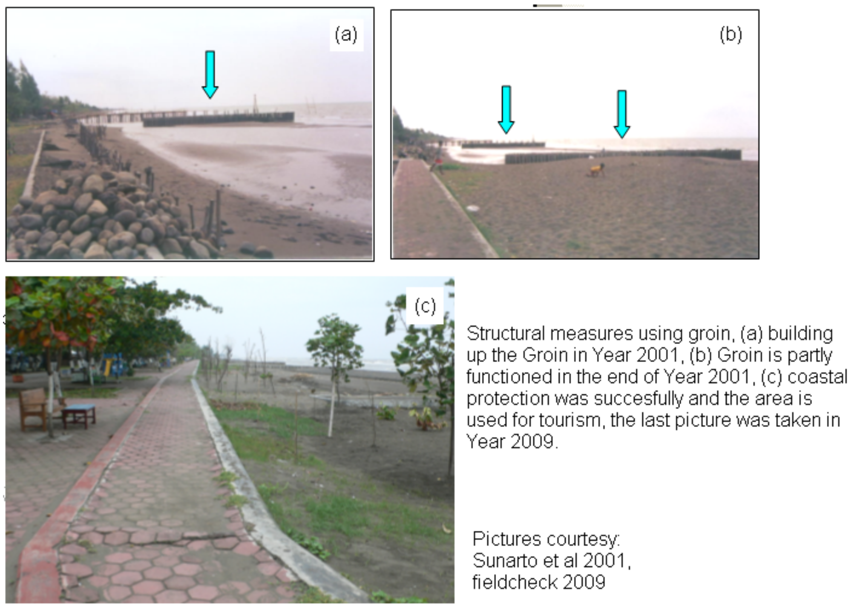

Figure 5. Structural measures using groin and its progress (a) building up the groin in Year 2001, (b) Groin is partly functioned in the end of Year 2001, (c) coastal protection was successfully and the area is used for tourism, the last picture was taken in Year 2009

CONCLUSION

In term of the coastal hazard management, long term monitoring of abrasion is one of the most valuable data. Historical shoreline change provides valuable data on erosion and sedimentation trends and permit limited forecasting of shoreline movement. Integration of the GIS technology and various spatial data (topographic maps and satellite images) can be considered as a promising method regarding lack of homogeneous data sources in the long period of time. However, further issues remain, as it is mentioned by Mills et al. (2005) that in monitoring of the shoreline dynamic in long period time, the results should be examined carefully. It should be noted that the good accuracy is influenced not only by the visual delineation method, but also by the geo-referencing accuracy of the sources images. Although the result on this project was satisfactory, some further enhancements related geo-processing and consideration of the hydrodynamic factor as well as micro-landform should be done for a future version.

Rates and causes of abrasion may vary along the coastal segment, and the mitigation measures may also differ accordingly. Unfortunately, our study has not identified into detail the causes of abrasion. Based on the field observation it can be said that the groin measure was an advantage measure and it already shows the good conservation result along the coastal area of Tegal. In addition, the mangrove forestation can be considered as a valuable vegetative measure. However to minimize the abrasion, some measures might be proposed including hard and soft engineering as well as social engineering.

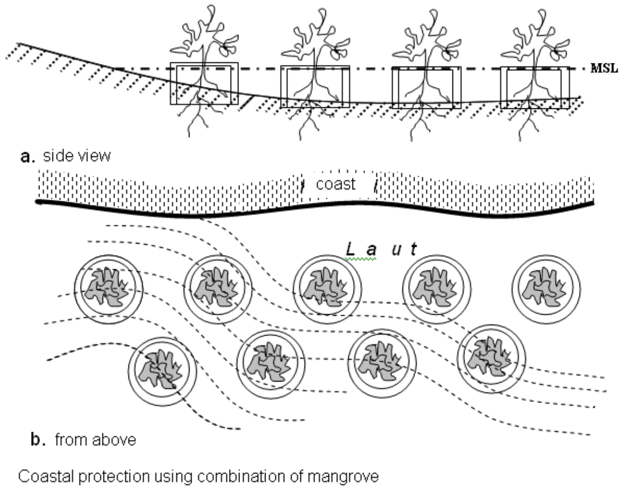

Figure 6. Coastal protection using combination of mangrove re-forestation program (Sunarto et al. 2001)

Figure 7. Example of the re-forestation (young mangrove) on the coastal area of Tegal

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Table 2. Proposed model for coastal zone management against abrasion

Nu	Approach	Function	Structure	Type	Shape
1	Hard engineering	Breaking waves and reduce the waves energy	Revetment	Permeable revetment: 1. Rip-rap (open filter material) 2. Stone pitching 3. Concrete block 4. Impermeable revetment: 5. Aspalt revetment 6. Bitumen grouted stone	
			Seawall	1. Vertical wall structure	
			Breakwater	1. Overtopping 2. Non-overtopping	
		Reduce erosion and suspend the sediment	Jetty	Mono Multi	
			Groin	1. Permeable (over passing) 2. Impermeable (end passing)	
2	Soft engineering	Coastal stabilization		1. Reforestation	1. Mangrove
3	Social engineering	Community development		Community based management and Capacity building	1. Enhancing knowledge of the coastal community 2. Stakeholders coordination and consultation 3. Community participation 4. Empowerment of the local groups, etc

Community-based Restoration of Mangrove Forest Land and Livelihood Security, Baan Thong Lhang, Phang Nga

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ABSTRACT

This paper illustrates the potential of community-based natural resource management (CBNRM) to secure community livelihood in a mangrove community in a Tsunami-affected area on the coast of Thailand. It demonstrates how community-based mangrove forest management is one means for increasing community solidarity and mitigating conflict among multi-stakeholders. Lessons learned can be applied on a broader scale to empower local communities to successfully manage the forest and improve their livelihoods.

Key words: Community-based mangrove restoration, deforestation, community-based mangrove forest management, natural resource access, gender roles, livelihood security

Baan Thong Lhang is a Tsunami-affected coastal community in Phang Nga province in southern Thailand. From their experience, they strongly believe that the mangrove forest plays an integral role to community wellbeing—in providing for livelihoods, particularly food and income security, as well as in mitigating the effects of natural disasters.

SOCIO-ECONOMIC BACKGROUND OF BAAN THONG LHANG

Baan Thong Lhang was established in its present location 66 years ago, in a coastal plain between the mountains and the Andaman Sea. It currently numbers 151 households, most of whom are engaged in rubber plantations and fisheries for their livelihoods. Many villagers and youth also work in the local tourism industry, as employees at golf resorts and tour agencies.

The community is dependent on a variety of local natural resources. Many collect honey and edible wild plants from the mountain, and depend on the upland area as a watershed source for their rubber plantations and fruit orchards. Locals catch freshwater fish and shrimp from the cannel that runs through the village. From the coastal mangroves residents catch crabs, fish and many varieties of clams and mussels, which from the primary basis of the village food supply. They also harvest wood and honey from the mangrove forest. Some residents also fish out at sea. Ten households are entirely dependent on mangrove forest products for livelihoods and income generation.

MANGROVE DEFORESTATION

Deforestation of local mangrove forest land began with the legal granting of forest concessions in 1964. In 1982, a charcoal plant was established locally, and logging for charcoal increased dramatically. In 1986 the government promoted shrimp farming, companies and some wealth locals to converted rice fields and mangrove areas into shrimp farms. During this period, large areas of mangrove were deforested—the mangrove area shrunk from 534 hectares in 1964 to 178 hectares in 1989—and the wildlife population in the canal had dwindled significantly. Shrimp farming continued expansion into mangrove forest land until 2005, with conflict increasing between shrimp farm owners and local forest user groups who collected mangrove products for subsistence and livelihood purposes. Community leaders and other stakeholders came together to discuss possible strategies to resolve these problems, and in 2005, the community leaders appealed to the governor to investigate. By 2006, in the wake of Tsunami, the community formed a committee to negotiate with the owners of the shrimp farms and reclaim mangrove land to rehabilitate.

REHABILITATION ACTIVITIES

The community decided to restore and expand their mangrove area through a community forestry initiative introduced by a local NGO. The community mangrove forest management plan was devised and area demarcation and resource mapping carried out with the full participation of community members. Rehabilitation activities have been implemented twice-yearly to help raise community awareness, and also include:

- replanting mangrove areas, which had been cut and destroyed through organizing local institutions (school, NGOs, local government and private sector) in planting events coinciding with the King and the Queen's birthdays
- establishing roles and responsibilities of committee member to monitor the forest area
- re-introducing wild orchid species indigenous the area that had disappeared due to the land conversion
- starting up community income-generation projects, such as beekeeping, in the mangrove forest area.
- creating a mangrove network with another local community to coordinate and monitor continuing mangrove rehabilitation efforts.

OUTCOMES OF REHABILITATION ACTIVITIES

Since the inception of community forest activities, the local mangrove forest area has expanded, with noticeable increases in numbers of diverse plants, trees, non-timber products and marine animals. The improved health of the forest has meant that villagers also have easier access to local forest products, better securing their livelihood. Incidences of conflict have also been reduced significantly, and women have had key roles in mangrove forest management and conflict transformation.

Outcomes of note include:

- The relationship between local government and residents has improved, and government authorities now consider Baan Thong Lhang as a good model of community-base forest restoration.

- Forest cover and wildlife population increased significantly in the mangrove area.
- Food supply of fish, crabs, clams and mussels, shrimp greatly increased. As a result, the time spent in product collection decreased, and income earned from this activity increased.
- Community confidence for their welfare and property in the event of another natural disaster, such as another tsunami, has increased, due to villagers' greater sense of ownership in mangrove management and appreciation of local natural resources in mitigating the effects of natural disasters.
- Women have greater roles in community social development in activities such as income generation, the community savings group, and natural resource management.
- Conflict has decreased dramatically between shrimp farmers and residents regarding shrimp farm expansion and wastewater management.

CONCLUSION AND KEY LESSONS LEARNED

Baan Thong Lhang continues their activities today and is an example of the potential in community-based mangrove and coastal resource management for improving livelihoods. Due to their strengthened community mangrove forest organization, Baan Thong Lhang community received public acclaim in the form of several awards and certificates from governmental offices and private sectors in national and international level.

Key lessons learned include:

- Community involvement and ownership in the mangrove rehabilitation process was integral to Baan Thong Lhang's success because the local government had limited resources. The community, due to its proximity and dependence on mangrove resources, became key partners and stakeholders in the process.

- The rehabilitation process itself is an ecological process but can be beneficial to processes of conflict resolution by bringing different stakeholders together to cooperate in the resolution of common problems.
- The cooperation and participation of the most dependent user groups was essential to the rehabilitation process, because these are people who use the forest everyday and are best placed for rehabilitation activities.
- Networking between all local stakeholders greatly improves the efficiency of forest rehabilitation and monitoring.

Tsunami Hazard Management in Thailand

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ABSTRACT

On 26 December 2004, the world's most catastrophic tsunami generated by an undersea earthquake off the western coast of northern Sumatra, Indonesia, devastated the Andaman coast of southern Thailand without warning between 9.40–10.30 a.m. local time. A series of destructive waves ranging from 1.50 to 12.30 meters above mean sea level and inland penetration of up to 2,000 meters wrought massive destruction along six coastal provinces, leaving 5,395 lives lost, 8,457 injured and 2,817 missing. The highly destructive waves destroyed infrastructure and productive capacity, interrupting economic activity, and creating irreversible change in the natural resource base. The suffering and losses beyond description due to this adverse natural phenomenon reduce the pace of sustained social and economic development of the country.

While the occurrence of the earthquakes and ensuing tsunami cannot be prevented, the magnitude of their impacts can be limited through effective disaster management. Prior to the 2004 catastrophic event, the disaster-related government agencies in Thailand were focused primary attention on the delivery of post calamity relief and reconstruction. In the aftermath of the 2004 tsunami's destruction, the Royal Thai Government has undergone a paradigm shift in their approach to disaster management. The new approach places relatively more emphasis on pre-disaster aspects of mitigation and preparedness to ensure that the country's development gains are not lost through natural calamities. An array of hazard mitigation and preparedness strategies developed and implemented in order to enhance the country's tsunami disaster resilience include the establishment of an early warning system, the enhancement of public awareness regarding tsunamis, the development of a tsunami hazard map, the protection of healthy coastal ecosystems and the incorporation of tsunami-related topics into university curricula.

Key words: tsunami hazard, tsunami impacts, disaster management, mitigation and preparedness measures

INTRODUCTION

The kingdom of Thailand is located in the middle of the Indochinese Peninsula, between latitudes 5^0 $40^/$ and 20^0 $30^/$ N, and longitudes 97^0 $20^/$ and 105^0 $45^/$ E. The kingdom's total area is 513,115 square kilometers. Geographically, Thailand is divided into four regions; the North, the Central, the Northeast and the South or the Southern Peninsula. The mountain ranges form the backbone of the Peninsular South, with the eastern coastline facing the Gulf of Thailand and the western shoreline facing the Andaman Sea. More coastal plains and stretches of long beaches are found on the east coast, whereas the west coast appears to be a submerged coast, with a very irregular shoreline and many estuaries. The "golden axe" shape of the peninsula provides over 2,705 kilometers of shoreline and thus affords the region excellent access to the sea, with 23 of its 76 provinces touching the coast (Arbhabhirama *et al*., 1988). The country's tourism and aquaculture potentials are therefore considerable.

Due to its geographical location, geophysical situation on the steep upland slope, fragile coastal ecosystems, and the strong influence of monsoons and typhoons, Thailand is highly susceptible to a wide range of natural hazards. The northern region terrain is mountainous which render this area to be prone to water-related disasters such as flashflood, landslide and associated debris flow. The northeastern region, which is on a semi-arid plateau, characterized by undulating surface, frequently suffers severe drought and cold spell during summer and cool season, respectively. The central region, the vast fertile land on alluvial plain, often encounters the repeated riverine flood and urban inundation during the rainy season. The southern region terrain, which is hilly on the west coast and the coastal plain on the east, has frequented flashflood, landslide and associated flooding and debris flow, and coastal storms (DDPM, 2006).

VULNERABILITY TO COASTAL HAZARDS

In response to the phenomenal growth of the tourism and aquaculture industries, beach resorts, tourism facilities, and aquaculture infrastructure have replaced much of the mangrove and beach forests along the coastal shores. During the period from 1961-1996, erstwhile mangrove forests drastically decreased by 56.0 percent, contributing to a 32.7 percent increase in shrimp farming area (Aksornkoae and Tokrisna, 2004). Moreover, many of the coastal sand dunes that act as natural barriers against extreme natural events have been removed to make way for the construction of tourism facilities and to create better views from tourist hotels and resorts overlooking the sea. As a consequence of the destruction of coastal ecosystem structure, the coastal areas of southern Thailand have become extremely vulnerable to the occurrence of coastal hazards, particularly tsunamis. These natural hazards, and their potential for disaster, pose a significant threat to coastal communities in the southern part of the country.

TSUNAMI EVENT OF 2004 AND ITS IMPACTS

In 2004, for the first time in the country's recorded history, Thailand experienced the devastating effects of a giant tsunami, caused by the second largest earthquake ever instrumentally recorded, with a moment magnitude of 9.3. The undersea quake occurred some 150 kilometers off the west coast of northern Sumatra, Indonesia at 00:58:53 (GMT) on December 26, 2004. This adverse natural phenomenon triggered disastrous tsunamis that propagated throughout the Indian Ocean, causing massive casualties, extreme inundation, and destruction along the Andaman coast of southern Thailand between 9.40 – 10.30 a.m. local time (UNEP, 2005). A series of destructive waves ranging from 1.50 to 12.30 meters above mean sea level and inland penetration of up to 2,000 meters wreaked vast damage along the coastlines of six coastal provinces, namely: Ranong, Phang Nga, Phuket, Krabi, Trang and Satun (Tables 1 and Figure 1). The tourism, coastal fisheries and aquaculture, and agriculture industries sustained the largest losses, with beachfront hotels and bungalows, fishing boats and gear, aquaculture hatcheries and shrimp ponds, and agricultural land severely damaged (Tanavud, 2004). The force of the waves caused significant geomorphologic changes along the coastal shore such as enlargement of water channels, widening of lagoon mounts, and erosion of sand beaches (Umitsu *et al.*, 2007). The large inflow of sea water and silt load caused deterioration of the quality of coastal soil and water resources. The huge surges of water also produced considerable damage to coral reefs, beach and mangrove forests, and washed away crops such as coconut, cashew nut and oil palm (Figure 2). The suffering and losses beyond description due to this catastrophic event reduced the pace of sustained social and economic development of the country.

As can be seen in Table 2, the Royal Thai Government casualty estimates were reported at 5,395 dead, 8,457 injured, and 2,817 missing (Thai Government, 2005). The total estimate of damages and losses from this adverse natural phenomenon in southern Thailand was US $ 2.09 billion, with the largest proportions of the damages concentrated in tourism, fisheries and aquaculture industries (UN, 2005). The financial impact has lowered the country's GDP by 0.4% (UNDP, 2005). Of the affected areas, the worst-hit province was Phang Nga, in particular Takua Pa District, and to a lesser extent, Phuket and Krabi Provinces (Thai Government, 2005). The hardest hit coastal inhabitants along the coast included fisher folks, tourist resort workers and migrant laborers. The majority of the tsunami surviving victims 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. Many survivors 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. These critical issues led to a decline in the quality of life of the affected communities. According to NGI (2006), a recurrence of a quake-triggered tsunami originated from the same tectonically active region can be expected in southern Thailand within the next 50-100 years.

Losses caused by perpetual events of the tsunami disaster retard social, economic and environmental development, and lead to diversion of scarce resources from development to relief and rehabilitation. It was calculated that losses due to this natural phenomenon were on such a scale as to cancel out the aid provided for Thailand by developed countries. The damaging and destructive tsunami of 2004 highlighted the extreme vulnerability of coastal communities to natural hazards. Continued removal of shoreline protection functions provided by coastal ecosystems, expansion of economic and development activities into coastal area, and unplanned human settlements within a narrow fringe of coastal land, inevitably resulted in further increase in tsunami vulnerability to coastal inhabitants. It is therefore imperative that disaster management capacity of the country' relevant departments/agencies should be improved and strengthened to lessen the negative impacts of the tsunami hazards and bring about development sustainability.

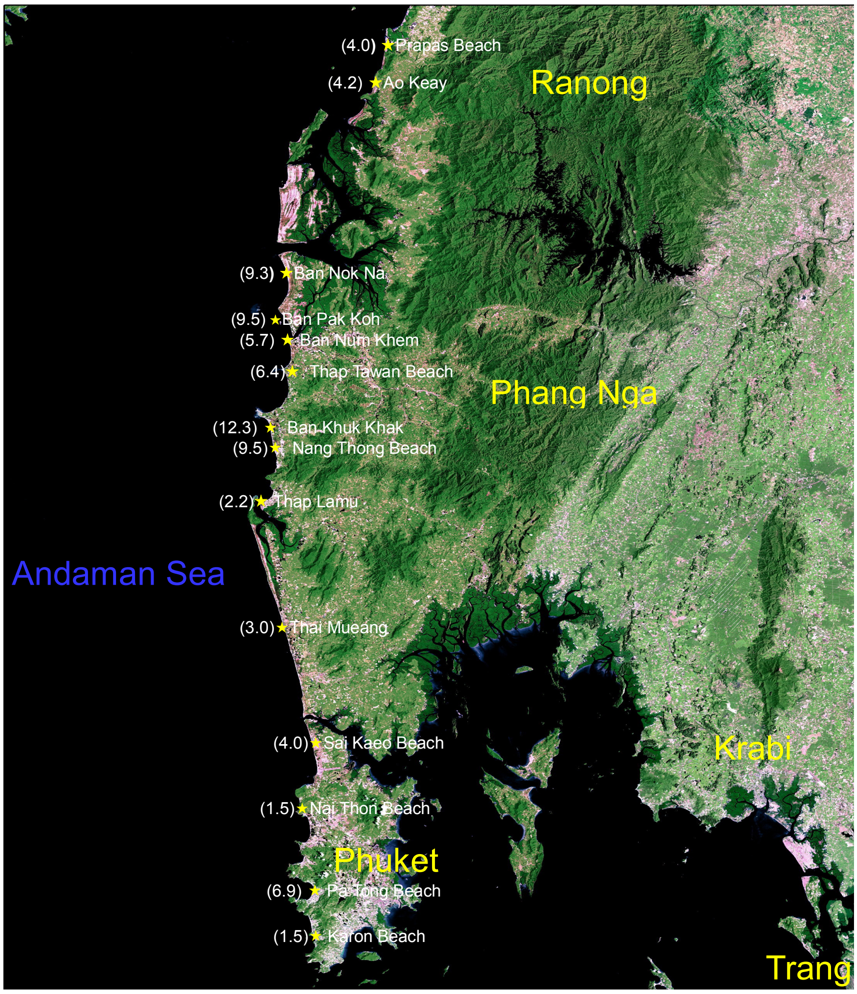

Figure 1 The Andaman coast of southern Thailand and the distribution of tsunami inundation heights (m).

TSUNAMI HAZARD MANAGEMENT

Disaster management, which is widely seen as embracing four elements: mitigation, preparedness, response, and recovery, seeks to ensure safety of life and reduction of damage to property. In Thailand, however, disaster management focused primarily on the emergency period response and post-impact recovery. Historically, Thailand has been a disaster-free country, suffering only minor losses from natural hazards through the years (Shook, 1997). The suddenness and the scale of impacts of the 2004 tsunami indicated that harmful consequences that this extreme natural event created exceeded the country's capacity to manage such a natural calamity. In light of concerns about the recurrences of a quake-triggered tsunamis originated from the same tectonically active region (NGI, 2006), a holistic and pro-active approach towards mitigation and preparedness should be adopted and implemented to reduce tsunami hazards.

Table 1 Tsunami inundation heights in Ranong, Phangnga and Phuket provinces.

Location	District	Province	Coordinates	Heights (m) above mean sea level
Prapas Beach	Khura Buri	Ranong	0433791 E 1036079 N	4.00
Ao Keay	Khura Buri	Ranong	0432065 E 1030105 N	4.21
Ban Nok Na	Takua Pa	Phang Nga	0417880 E 0995169 N	9.30
Ban Pak Koh	Takua Pa	Phang Nga	0418551 E 0983660 N	9.50
Ban Nam Khem	Takua Pa	Phang Nga	0419974 E 0979683 N	5.70
Thap Tawan Beach	Takua Pa	Phang Nga	0417995 E 0973742 N	6.40
Bang Sak Beach	Takua Pa	Phang Nga	0418886 E 0971908 N	7.80
Pakarang Cape	Takua Pa	Phang Nga	0414471 E 0965720 N	5.00
Ban Khuk Khak	Takua Pa	Phang Nga	0416527 E 0960937 N	12.30
Nang Thong Beach	Takua Pa	Phang Nga	0416904 E 0957918 N	9.50
Khlong Rian Bay	Takua Pa	Phang Nga	0416219 E 0952054 N	7.90
Thap Lamu	Thai Mueang	Phang Nga	0414641 E 0947445 N	2.20
Ban Na Tei	Thai Mueang	Phang Nga	0419626 E 0918778 N	3.60
Thai Mueang Beach	Thai Mueang	Phang Nga	0417174 E 0928455 N	3.0
Sai Kaeo Beach	Thalang	Phuket	0421648 E 0904828 N	4.00
Siri Nart National Park	Thalang	Phuket	0422648 E 0894218 N	2.60
Nai Thon Beach	Thalang	Phuket	0420519 E 0890636 N	1.50
Kamala Beach	Kathu	Phuket	0420553 E 0878837 N	7.0
Pa Tong Beach	Kathu	Phuket	0422748 E 0873949 N	6.95
Karon Beach	Kathu	Phuket	0422118 E 0867602 N	1.50
Ao Chalong	Kathu	Phuket	0427744 E 0864479 N	7.20

Table 2 Death toll and injuries in the six affected provinces.

Provinces	Dead	Injured	Missing
Krabi	721	1,376	544
Phang Nga	4,225	5,597	1,655
Phuket	279	1,111	608
Ranong	159	246	9
Satun	6	15	-
Trang	5	112	1
Total	**5,395**	**8,457**	**2,817**

Five months after the 2004 tsunami, the National Disaster Warning Center (NDWC) was established to function as a centralized unit receiving, monitoring, processing and relaying critical information on impending natural disasters and issuing public warning in such an event (UN, 2005). In addition, 79 warning towers equipped with signal receivers have been installed on populated beaches along the Andaman coast. Further, a DART (Deep-Ocean Assessing and Reporting of Tsunamis), has been deployed off the west coast of southern Thailand to detect any sudden increase in the ocean-bottom's pressure and sea level. For warnings of imminent disasters, the NDWC receives seismological information from various agencies in the country including the

Meteorological Department, the Department of Mineral Resources and the Royal Thai Navy as well as from global seismic networks such as the Pacific Tsunami Warning Center and Japan Meteorological Agency. Upon receiving the tsunami-related information, particularly seismic activities and sea level, the NDWC analyze the data, before decision can be made to issue a tsunami warning alert.

Figure 2 The effects of the tsunami on coastal resources, human settlements and natural environment.

Even if a tsunami early warning system had existed in Thailand prior to the 2004 tsunami disaster, the warnings and accompanying instructions would have done little to save lives of coastal inhabitants due to a general lack of public awareness of the tsunami threat and how to respond appropriately in order to minimize losses. A community tsunami awareness programme must therefore be developed to increase awareness and understanding of the tsunami hazard through public education and provision of tsunami information materials. An education programme, designed at appropriate levels for coastal populations at risk from tsunamis, should impart basic knowledge about the nature, processes, impacts and consequences of a tsunami, the signs of an impending tsunami, and how to respond to tsunami warnings and when to evacuate. Indigenous knowledge – for instance, the "Moken" (Sea Gypsy of southern Thailand) have a saying known to everyone that "the suddenly receding tide from the coast exposing the sea floor is a sign of danger", which forewarned them of the approaching tsunami (Arunotai, 2006), could prove extremely valuable in mitigating future threats from tsunamis. It is known to many rural people that "the silence of some insects (USAID, 2005)," and "when many animals especially elephants move from the coasts to further inland (Waltham, 2005)," are the signs of an impending tsunami. Efforts should also be made to educate all those who are at risk from a tsunami in modern scientific research such as "coastal areas on gentle beach slope with elevation close to mean sea level are extremely vulnerable to tsunami (UNESCO, 2006)". The tsunami information and educational materials should be dissemination through newspapers, radio and television, signage on roads and beaches, and posters and pamphlets. Vital information about areas at risk and safety, evacuation routes and sites, and effective response activities, should be made available to coastal inhabitants and visitors. To ensure a reduction of tsunami effects on lives, detailed evacuation plan should be formulated and evacuation drills should be conducted regularly at schools, hospitals and populated beaches in high-hazard areas to ensure the communities' readiness for potential tsunami disasters.

It is generally accepted that a hazard map is the fundamental basis of local hazard reduction planning. The hazard map has been created for the vulnerable areas along the Andaman coast of southern Thailand (Tanavud *et al*., 2008). Based on coastal features which are directly or indirectly correlated with the magnitude of tsunami waves including nearshore slope, elevation above mean sea level, inland distance from the shoreline, and the presence/absence of natural barrier such as beach and mangrove forests, coral reefs and sand dunes, tsunami hazard areas were delineated through the use of GIS. Resettlement of the tsunami-impacted communities and reconstruction of damaged or destroyed houses, buildings and infrastructure are prohibited in the areas designated as high tsunami hazards. Existing villages and tourism infrastructure located in hazard prone areas are moved to low-hazard areas further inland. Single storey family houses in high hazard areas are retrofitted to better withstand the wave force in the event of tsunami disaster. Tsunami signs have been installed in high hazard area as defined by the hazard map. The hazard map also facilitates identification of safer places and evacuation routes for rapid evacuation of vulnerable populations in an emergency (Tanavud *et al*., 2007). The map has been disseminated to disaster-related government agencies, the general public and vulnerable coastal communities.

To ensure reduction in tsunami losses, structural mitigation measures should be undertaken in conjunction with non-structural mitigation efforts. However, provision of structural mitigation works may encourage a false sense of security because they are designed to withstand extreme natural events of specific magnitudes, and may cause impacts on the coastal environment. Construction of artificial walls and dikes of reinforced concrete along the coastline to protect against tsunami hazards needs to be considered in the light of investment costs, tourism potential, impact on coastal ecosystems such as a decline of sea turtle nesting sites, and adverse effect on the livelihoods of fisher folks who rely almost entirely on the sea for their daily living. The significance of structural works in averting future tsunami catastrophes, particularly in developing countries like Thailand, therefore, remains an open question.

As a result of the recent catastrophic tsunami, the remaining coastal resources along the Andaman coast were further damaged, leaving the coastline more vulnerable to possible future disasters. To reduce the impact of future tsunamis, these natural defensive ecosystems need to be reconstructed. In this regard, casuarinas and mangroves have been replanted in suitable areas along the coastlines as they can absorb considerable amounts of wave energy and protect the coast beyond. Sand dunes stabilized by vegetation, and artificial coral reefs, have also been re-established to act as a natural defense against incoming destructive waves to reduce the impact of any future tsunami.

In the aftermath of the 2004 tsunami, much has been achieved in the area of disaster education, especially in higher education. Prince of Songkla University has pioneered the incorporation of disaster risk reduction as part of the university curriculum. A disaster management subject has been offered to both undergraduate and postgraduate students at the Faculty of Natural Resource. This subject, which includes sustainable development concepts, focuses on all aspects of disaster risk management, namely mitigation, preparedness, response and recovery. The subject covers topics such as hazard identification and assessment, disaster cycles, vulnerability and risk analyses, disaster and environment, community based approaches to disaster risk management, application of remotely sensed data and GIS for developing and implementing hazard mitigation strategies and emergency response plans, and disaster and sustainable development (Tanavud, 2007). This disaster education is recognised as a long-term strategy for increasing and maintaining public awareness of the natural hazards, and creating a safer future for the country.

It is also encouraging that the 2004 tsunami tragedy has offered the opportunity for southern Thailand to revitalize and/or strictly enforce the concepts of Integrated Coastal Management – ICM

(Masselink and Hughes, 2003) to effectively address the vulnerabilities that the coastal communities face by reversing current trends of resources exploitation for economic and development activities. It is anticipated that successful implementation of the array of strategies which embrace both preparedness activities and mitigation actions as proposed in this study will bring about an enhancement in disaster resilience which is so crucial to the stability and sustainable development along the coastal shore of southern Thailand.

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Challenges to Cyclone Disaster Management in Bangladesh: Lesson from Super Cyclone SIDR

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ABSTRACT

Bangladesh is one of the most disaster prone countries of the world. Except volcanic eruption and snow falls, the country experiences nearly all other major disasters, and among those the cyclonic storm-surge ranks the top. After the catastrophic storm-surge of 1991, witnessing a death toll of more than 143000 people, there has been a remarkable improvement in cyclone disaster management of Bangladesh, both structurally as well as at policy level. Despite criticisms on spatial distribution and structural design of cyclone centers, and functional characteristics, particularly deep rooted social behavior of rural people, the construction of more than 1800 cyclone centers along the coastal belt has already given a successful result to reduce the casualties. The same is true for the policy guidelines, and formation and functions of disaster management committees from national to grass-root levels. The wide network of 33,000 Red Crescent Volunteers under CPP (cyclone preparedness program) along coastal belt and their immediate response to cyclonic events at grass-root level (disseminating signals, evacuation and rescue) is a remarkable step forward to cyclone management. Moreover, the adaptation of SOD (standing order on disaster) by the Government, with specific responsibilities of individual and institution is a very powerful document to ensure immediate response to concern persons at the time of cyclonic event. During the last two decades, the achievement of Bangladesh to cyclone disaster management is widely known. Bangladesh is now considered to be the model country to successful management of cyclone disaster.

However, after the catastrophic event of super cyclone SIRD of 15 November, 2007, with a death of 3447 people and about 55300 injuries, the whole issue of cyclone disaster management of Bangladesh becomes questionable. The aim of this study is thus to assess further challenges to effective disaster management, with particular attention to reduce the loss of human-lives and resources. Due to high population density, over exploitation of resources and massive unplanned development measures, the coastal belt of Bangladesh is already ecologically fragile and environmentally vulnerable. On the other hand, there is no doubt that the coastal belt is being frequently hit by cyclone at an accelerate rate due to rapid global warming and enhance climatic change scenarios. The cyclone disaster management issue becomes questionable not only because of fewer number cyclone shelter centers, inadequate space inside, poor accessibility, and ineffective response to CPP volunteers, but also some other new challenges emerge. Based on extensive fieldwork at Sarankhula upazila (a badly affected area), immediately after the SIDR, the study shows that the major cause of casualties and injuries is due to ineffective warning system and poor issue of news bulletin. There was at-least two hours time lag between the projected surge-time and the real hit. Besides, the rural people have a very poor trust on such warning; only two months earlier the tsunami warning along the costal belt did not work. The study also shows that the indigenous knowledge and rural social bonds as decision making tool to life saving measures and copping strategies is very important. A noticeable finding is the massive destruction of mangrove plants due to SIRD. Moreover, there is no second or third generation coastal afforestation program, and as consequence in near future the coastal belt would be more open and vulnerable to tropical cyclone after the natural falling of the existing mangrove belt . Mangrove plantation and regeneration along coastal belt requires immediate attention to sustainable management of cyclone disaster in Bangladesh.

Key words: Cyclone Centers, Warning System, Indigenous Knowledge, Mangrove

1. INTRODUCTION

Bangladesh is a small South Asian country (147570 sq. km), with a population density of 855 sq/km and per capita in come of only $ 386 per annum. It is probably the most disaster prone country in the world and is affected by nearly all major natural hazards, except volcanic eruption. Bangladesh frequently gets international attention when it is been hit by some major natural hazard; the image of country to international communities is mostly as a disaster prone nation.

2. MAJOR DISASTERS IN BANGLADESH

From historical time Bangladesh has been suffering from a number of natural disasters. Among those some common natural disasters are floods, riverbanks erosion, seasonal draught, arsenic contamination, earthquake, and sea-level rise.

2.1. Floods

Flood is a regular annual phenomena in Bangladesh. During the monsoon period about 30 % the country, mostly the floodplain areas along the major rivers, become under normal inundation and the people of this areas are prepared to live with such annual flood. However, the extent of such annual flood when cross the vertical and horizontal limits of sustainability, it become catastrophic in nature; such flood causes human suffering, and loss of lives and properties. For example floods of 1987, 1988 and 1998 were catastrophic in nature and caused enormous loss of standing crops, infrastructures, lives and resources.

2.2. Riverbank Erosion:

Bangladesh is criss-crossed by a network of 230 rivers, many of which are either the tributaries or distributaries of the Ganges-Brahmaputra-Meghna (GMB) river system. More than 25,000 families are displaced annually from their homesteads due to severe riverbanks erosion (Banglapedia, 2006). Such people are forced to move to cities for jobs and shelter. Riverbank erosion is a major push factor for rural-urban migration and is responsible for unplanned urbanization in Bangladesh.

2.3. Seasonal Draught:

The northwester part of Bangladesh suffers for severe seasonal draught, affecting 20 districts, which led to shortfall of rich production and famine. It has been found that during the last 50 years, at least 20 times draught condition prevailed in this part of the country (Elahi, 2001). The main cause of such draught is due to global warming and upstream withdrawal of Ganges water at Farakka point.

2.4. Arsenic Contamination:

Arsenic Contamination of groundwater is a serious problem in Bangladesh. About 75 million people of 59 districts are at risk and out of 4 million tube-wells 50% exceed safe limit (0.05 mg/l) (Khuda, 2001). . South-central part of the country is the worst suffering region due to severe arsenic contamination.

2.5. Earthquake

Till now Bangladesh has not very severely been affected by an earthquake. However, in recent years as series of earthquake tremors have been recorded of which some important earthquakes are Hamjarbag EQ (5.6 magnitudes on 21 November, 1997, 23 deaths), Moheskhali EQ (5.2. magnitude, repeated shocks between 22 July and 2 August, 1999, 2 deaths) and Barkol EQ (5.1. magnitude 0n 27 July, 2003, 1 death). Due to poor infrastructure and old buildings, their is a risk of high casualties in the major cities, particularly in Dhaka and Chittagong after an earthquake of 6^+ magnitude.

2.6. Sea-Level Rise:

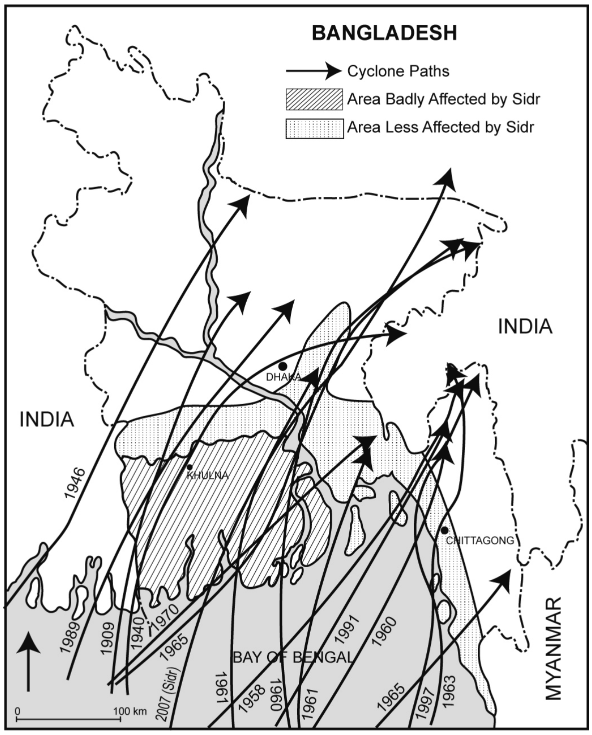
According the IPCC (2007) assessment due to sea-level rise among many other low-lying deltaic countries Bangladesh would be the worst victims. The coastal belt, which occupies about one-third of national territories, would be inundated, and more than 40 million coastal people would be displaced from the homesteads and would become climate refugee. The world largest mangrove forest, the Sundarbans would disappear due to accelerated sea-level rise.

3. CYCLONIC EVENTS IN BANGLADESH

Bay of Bengal is the breeding place of tropical cyclones. In the Bay, cyclones are usually formed in between 5°N and 5°S latitudes (ITCZ region), during the early or late when temperature remain 26-27°C. Each cyclone is associated with abrupt surge of water known as storm surge. Height of surges is linked to wind speed and tidal limit. It has found that along Bangladesh coasts, surge limits can go up to 6m, 8m and 10m at 150 km, 175km and 200km wind speed, respectively (Chaudhur *et al*, 1997). Till now 45 severe cyclones associated with surges have attacked the coastal belt of Bangladesh with a total death toll of more than 7 million people. Some catastrophic cyclones are shown in table-1, of which cyclone1970 and 1991 were unprecedented and had to count millions of death bodies.

Table-1: Some Major Cyclones Along Bangladesh Coast During Last Four Decades

Date	Maximum Wind Speed (km/hour)	Storm Surge Height (m)	Badly Affected Area	Death Tolls
12 November, 1970	222	10.6	Bhola, Chittagong, Barguna, Patuakhali	500,000
25 May, 1985	154	3-4.6	Chittagong, Cox's Bazar, Noakhali, Coastal Islands	11,069
29 November, 1988	162	4.5	Khulna, Barisal, Jessor	5708
29 April, 1991	225	5-8	Chittagong, Cox's Bazar,	143,000
02 May, 1994	200	??	Cox's Bazar, Coastal Islands	
19 May, 1997	225	5	Chittagong, Cox's Bazar, Noakhali, Bhola	126
November 15, 2007	210	6-8	Barguna, Pirojpur, Bagerhat, Patuakahli	3447

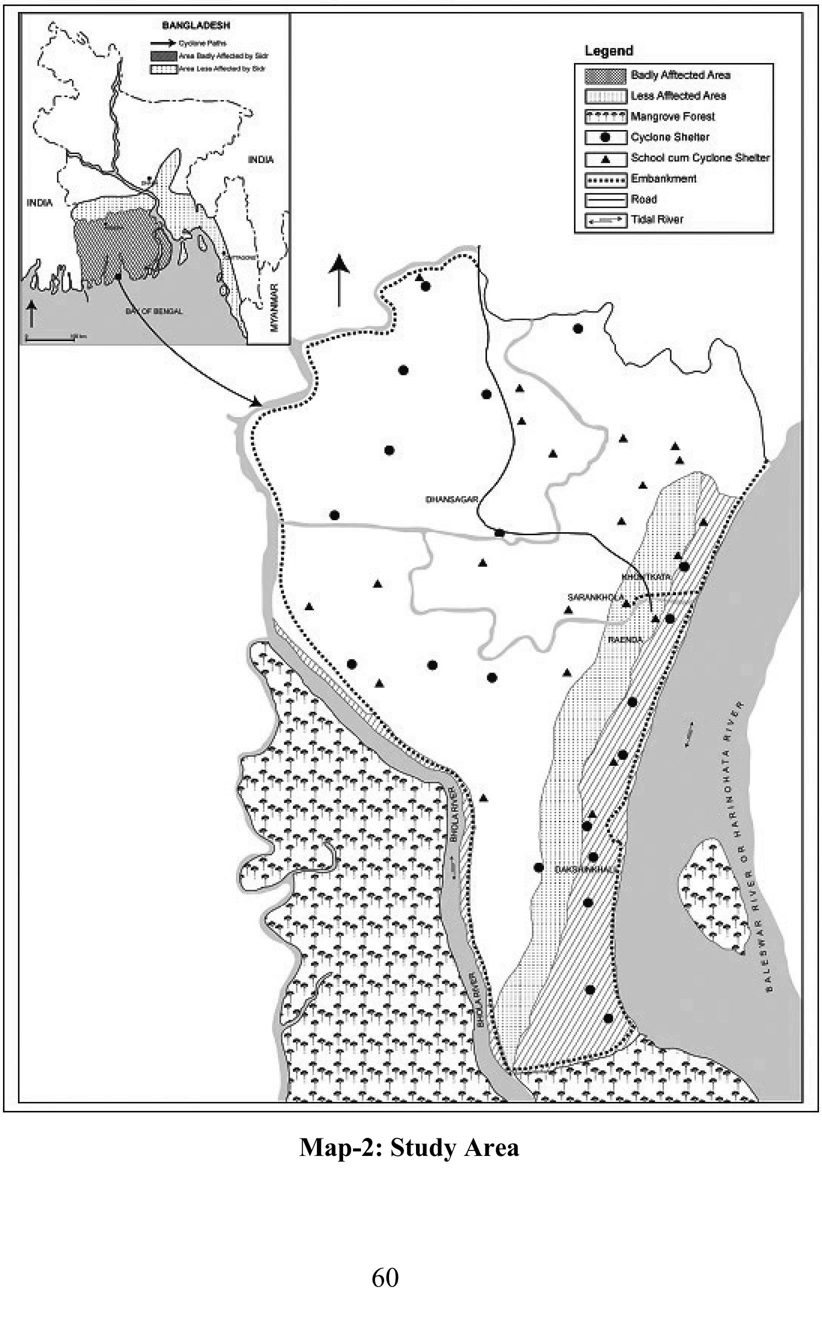


Map-1: Cyclone Paths and Area Affected by Sidr

Each cyclone after its formation in the Bay of Bengal gradually moves towards north. However, due to the funnel shape of the Bay, most of the cyclones find their paths from south-west to north-east direction, which finally cross the coastal belt of Bangladesh. Pramanik (1983) classified the coastal belt of Bangladesh in to three major zones: south-western stable, south central dynamic and south-eastern unbroken zone. Majority of the previous cyclone hit the south-central and south-eastern coastal zones (Map-1). The apex of the funned, particularly Bhola, Hatia, Swandip and Noakhali area highly vulnerable to cyclone. This part of the coast can be termed as the death-trap; each person living in this area gets new life once in every 20 years (!) of cycle after been survival from a major storm surge.

4. OBJECTIVES

Super cyclone Sidr hit Bangladesh on 15 November, 2007 at around 8 pm local time at a wind speed of 210 km/hour and loss of 3447 lives (GoB, 2008). Such as huge death toll as compare to cyclone of 19 May, 1997 (only 126 deaths) makes the whole issue of early disaster preparedness of the government questionable. The aim of this study is to examine the effectiveness of the disaster management steps of the government and to find out the causes of failure to save lives and properties in the light of super cyclone Sidr.



Map-2: Study Area

5. METHODOLOGY

Immediately after the Sidr event a fieldwork was conducted in the Sidr affected area to collect field-level information. A total of 15 FGD (Focus Group Discussion) were made to share the experiences with local people. Twenty five case studies were recorded to know how each individual person responded to the Sidr event. Moreover, policy documents, published articles, reports and maps on cyclone disaster management have been reviewed.

6. STUDY AREA:

The fieldwork was conducted at Sarankhola upazila of Bagerhat district. The study area is bounded by Baleswar-Haringhata river in the east, Morrelganj upazila in the north, Mongla upazila in the west, and Bhola river in the south and south-west (Map-2). It is a tide dominated area and is only less than one meter above the sea level. To protect the area an earthen embankment has been contracted along the Baleswar-Haringhata and Bhola river side in the east, west and south. In this upazila there 20 cyclone shelters and 21 school-cum cyclone shelters are located. The area is protected by the Sundarbans mangrove forest in the south-west; it was one of the worst affected areas by Sidr

7. SUPER CYCLONE SIDR

'Sidr' is a Sinhali world which means 'eye'. But the Sidr that hit Bangladesh was not the lovely eye of the beloved person, it was the horror eye of the nature. On November 9, 2007, a weather disruption was reported in the south-east of Andaman islands. Tropical cyclone formation alert was issued by the Metrology Department of Bangladesh on 11 November, which intensified as Cyclonic storm Sidr on 12 November. On the morning of 15 November the cyclone intensified as Category-5 and peak of wind speed was of 210 km/h. Sidr made landfall in the study area at about 8 pm associated with a surge of 5m height from the nearby Baleswar-Haringhata river. The cyclone became weak quickly after landfall and finally disappeared on 16 November, 2007.

The size of the cyclone was double the size of Bangladesh, affecting 30 districts, of which 8 were very badly affected and 4 were worst affected districts. The worst affected districts are Bagerhat, Barguna, Patuakhali and Pirojpur. Officially 3447 people were killed, but Red Crescent Society reported that the number of deaths could be up to 10,000 (IFRC, 2007). The damage at a glance is shown in table-2. Figure-1 shows district wise number of people affected and number of houses damaged.

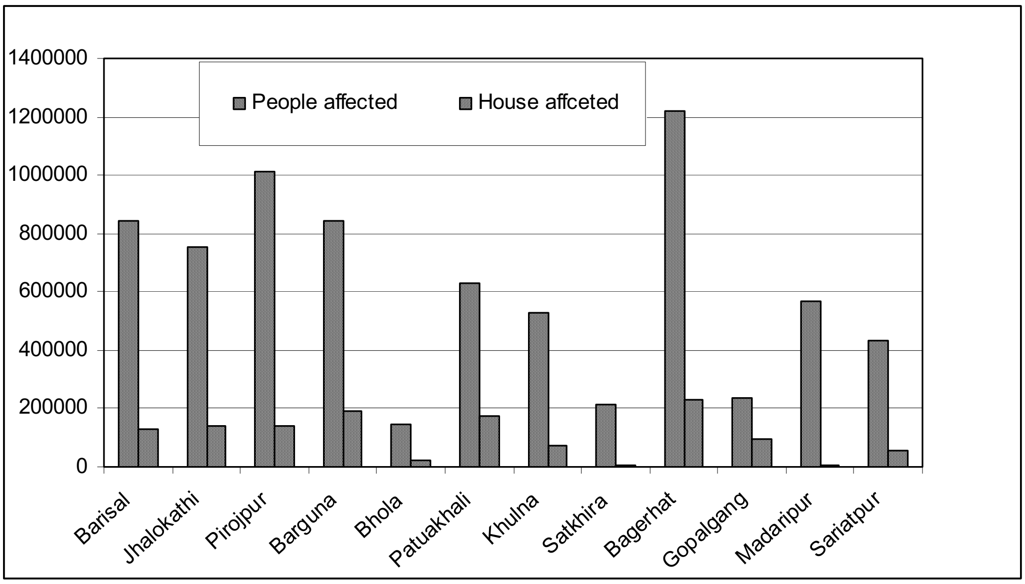


Figure-1: Total Number of People Affected and Hoses Damaged by Districts

8. LESSONS FROM SIDR

8.1. CPP Volunteers

After devastating cyclone of 1970, the government of Bangladesh launched the Cyclone Preparedness Program (CPP) in 1973. The goal of CPP is to minimize loss of lives and properties in cyclone disaster by strengthening the capacity in disaster management of the coastal people. Under CPP a strong network of 143 wireless stations (largest network in Asia) and about 6000 teams of 33,000 CPP volunteers in 2043 wards of coastal areas has been formed. The CPP volunteers disseminate cyclone warning signals issued by the Metrology Department to the local communities, assist local people to evacuate and move to cyclone shelters, and rescue distressed people affected by cyclone. In 1997 when a massive cyclone stuck Bangladesh, the CPP network and volunteers functioned very effectively, thousand of people were saved and only 126 were killed. This strong CPP network did not work well during the Sidr period. It has been found that many CPP volunteers were either out of their stations, did not response promptly and effectively or were busy to evacuate themselves without giving proper attention to evacuate the communities; in many cases the megaphone and searchlight were not working properly.

Table-2: Damage and Loss Due to Cyclone Sidr.

Serial No	Item	Quantity
01	Districts Affected	30 districts
02	Most Affected Districts	12 districts
03	Affected People	8.9 million
04	Crop Damaged (ha)	10,01473
05	Fully Damaged (ha)	3,00,000
06	House Damaged	15,22077
07	Fully Damaged	5,64967
08	Death Tolls	3,447
09	Injured	55,282
10	Missing	1,001
11	Death of Poultry & Livestock	18,73694
12	Educational Institute Damaged	16,954
13	Fully Damaged	4,232
14	Road Damaged (km)	8,075
15	Fully Damaged	1,714
16	Bridge/Culverts Damaged (no)	1,850
17	Tree Damaged (no)	40,65316

8.2. Warning System

Bangladesh Metrological Department (BMD) issues the cyclone warning signals and disseminates the news through electronic media, print media and CPP volunteers. The radio and TV channels regularly issue weather bulletins at regular interval to inform the communities. However, there is a time lag between the collection of weather information, (information either from satellite or radar station), processing of data and their dissemination. During the Sidr period, it was found that there was at least 2 hours time lag between the real position of the eye and the projected time of landfall. Due to electricity cut-off, the electronic media did not work in the remote areas. The dissemination of warning signals and news bulleting in Bangladesh is not user friendly. The warning signals are issued mainly for ports areas and in a formal language, which is not easily understandable to local people; they need news bulletins in local dialects, which is mostly done by CPP volunteers.

During the Sidr period there were missing links between the signals issued, news dissemination, move to nearest cyclone shelters and the real struck of the surge.

Past records show that cyclone frequently visit the south-central and south-eastern parts of the country. People of those areas suffer frequently and are thus well motivated to move to cyclone shelters when signals are issued. Unlike those areas, the people in the south-western part of the country were found less motivated to move to cyclone shelter, leaving behind their belongings and household articles. Moreover, one major cause not to leave the house was the mistrust of the warning signals, due to failure of Tsunami warning signal issued for coastal districts only two months ago. On 13 September, 2007 tsunami alert was issued for coastal districts of Bangladesh when an earthquake hit Sumatra and killed 10 people; thousand people ran to or were evacuated to safer places, but nothing had happened.

8.3. Cyclone Shelters

After devastating cyclone of 1972, a program was undertaken to construct cyclone along the coastal belt. However, the program again accelerated after the 1991 cyclone and till now about 1800 such shelters have been constructed to support about 2 million people (Paul and Islam, 2005).. The buildings constructed as cyclone centers are used for multi-purposes, especially as schools, community centers, government offices, and union council offices. Most of the cyclone centers are not located in suitable locations and are being built ignoring local opinions and also without proper planning. However, despite all these limitations cyclone shelter plays a significant role to minimize the suffering and death tolls of coastal people from cyclone and storm surge.

In this study it has been found that cyclone shelters played an important rote to save lives. It has been mentioned earlier that there was a missing link between the news dissemination, its trust and read struck. However, local people when realized that the cyclone hit was confirmed they ran to find shelter to nearby cyclone shelters. Many of them could reach the shelters and saved lives, but many were killed on their way to shelters. Among the exiting numbers, cyclone shelters are mostly located in the south-east and south-central part of the coastal belt. Paul and Islam (2005) studied the location of cyclone shelters of Kutubdia island and found that the average distance between shelters is about 0.5 km. In the southwester part these are more sparsely distributed. During Sidr more people could have been saved if more cyclone shelters were built in this part of the coast.

8.4. Mangrove Forest

Sundarbans is the largest single mangrove forest of the world, covering an area of 6000 sq. km. in the south-western part of Bangladesh and about 2000 sq. km in India (Blasco, 1977). It is a reserve forest and is enriched with about 70 tree species, many of which are commercially important; Sundri (*Heritiera fomes*) and Gewa (*Ecoecara agallocha*) are the dominant tree species. The height of the forest varies from 5m to 20m and as regards density, about 50% of the area have more then 70% canopy closure (Banglapedia, 2006). It is the home of the world famous Royal Bengal Tiger (*Panthera tigris tigris*) and beautiful spotted deer (*Cervus axis*). The forest was very badly affected by Sidr; 40 species of mammals, 400 species of birds and 200 species of fish were dead and 4 million trees were up rotted, 4-5% of the forest was severely damaged and 15% was partially damaged. Despite, the forest acted as a natural defense to Sidr and save many lives. It is worried that the casualties would have been many folds higher if the mangrove forest was not there.

8.5. Indigenous Knowledge

The existing cyclone disaster management initiatives of the government mostly address the institutional and organizational capacity, without any proper attention to local knowledge and individual skill. It has been mentioned earlier that 25 cases were examined and each case was unique to safe their lives. Three example cases are illustrated below:

Case-1: My name is Alam (not real name) and I am thirty two years old. I have a son of three months old. During the cyclone when water was rising-up I climbed a coconut tree and hold it tightly with my two arms. Same time I hold the shirt of my son very tightly under my teeth and my son remained hanging in such way for more than two hours.He is now safe. (What an intelligent case!, see picture-1).

Case-2: My name is Layla (not real name). I am seven years old. When the wave entered, my house was damaged in a moment. I swam and hold a nut tree in the yard, but the tree was swinging very fast. My father shouted and told me to swim and hold a coconut tree. I started to swim in the strong wave for five minutes and found a coconut tree. I kept it holding for two hours and saved my life (What a courageous case!, see picture-2)

Case-3: My name is Mrs Farida (not real name). I am forty five years old. When the water started to rise-up with my five family members I climbed on the coconut tree just behind my house. We all hold the tree strongly; see my arms and the scar. We are rich family in the village, but my organized family of 25 years was totally ruined in two hours, now we are beggars (What a tragic case, see picture-3).



Picture-1 **Picture-2** **Picture-3**

9. DISASTER MANAGEMENT IN BANGLADESH:

Disaster management is a special type of response to any natural calamities, which includes measures related to disaster prevention, mitigation, preparedness, emergency response and recovery. As a disaster prone country the people of Bangladesh have developed their own management strategies based on their local knowledge. However, the catastrophic effects of 1970 and 1991 cyclones, and million of dead bodies stimulated the government to take various disaster management initiatives. During the last four decided many structural, such as construction of coastal embankment and building cyclone centers; and non-structural, such as coastal afforestation and devising the Standing Order on Disaster, measures have been undertaken to cyclone disaster management.

The standing Order on Disaster (SOD) is a powerful tool of the government to emergency response to any disaster. The SOD laid down the guidelines for actions at various stages of the disaster by all concerned government agencies. The SOD specifies the roles and responsibilities of various Disaster Management Committees and their constituent member agencies, in the fulfillment of their disaster management mandate.

However, the disaster management issue is laid upon a number of committees of the government, which are as follows:

9.1. National Disaster Management Council (NDMC)

National Disaster Management Council is the supreme body of the government to disaster management. The council is headed by the Prime Minister; concern Ministers/Secretaries is the members of the council and the cabinate secretary is the member secretary. The council is responsible to formulate policy, guidelines, examine recommendations of other bodies, issue directive measures, approves SOD, and consider all other issues related to disaster.

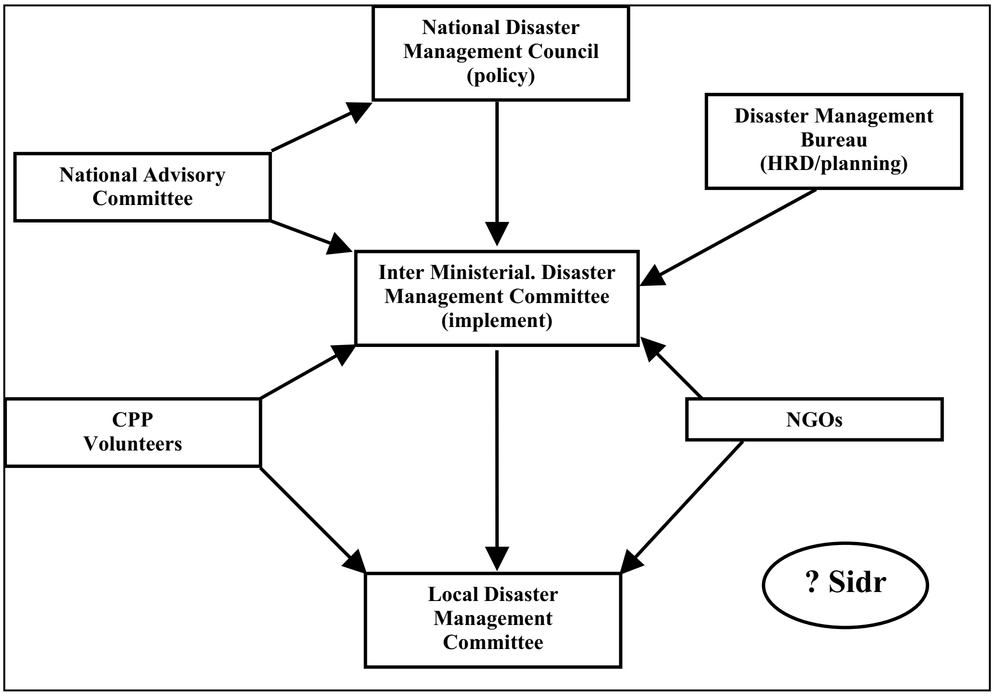


Figure-2: The Flow Char Shows the Organizational Arrangement of Disaster Management System in Bangladesh

9.2. Inter Ministerial Disaster Management Coordination Committee (IMDMCC)

Inter Ministerial Disaster Management Coordination Committee is the implementing body for all disaster related activities. It is headed by the Minister of Disaster Management and Relief; the Secretaries of concern Ministries are the members. The committee is responsible to implement the decisions of the NDMC, coordinates and review the activities of different agencies, coordinate post disaster relief operation, and take actions for disaster prevention, mitigation, preparedness and warning system.

9.3. National Disaster Management Advisory Committee (NDMAC)

This advisory committee is a technical committee and includes the expert persons on Disaster management from the Universities, Government organizations NGOs and also Parliament members. An expert person nominated by the Prime Minister acts as the Chairperson of this committee. The expert committee advices the NDMC, IMDMCC and DMB on technical aspects of disaster management; prevention, mitigation, preparedness and emergency-responses.

9.4. Disaster Management Bureau (DMB)

Disaster Management Bureau (DMB) is the focal point of the government to foster all disaster preparedness matters. It is the house of dynamic professional units at national level to perform specialized functions for disaster management. DMB was established in 1993 under Ministry of Disaster Management and Relief. DMB is responsible to reduce the loss of lives and properties from any disaster, to design disaster preparedness program at grass root level, to conduct training programs to increase awareness, to collect disaster related and data-base, and to technically coordinate disaster related activities. Director General is the head of the DMB and s/he is assisted by technical staffs of the Bureau, foreign and local consultants, and NGOs.

9.5. Field Level Disaster Management Committee

As per SOD there are a number of disaster management committees at filed level, such as district committee, upazila committee and union committee; each committee is headed by the concern office head. Local committees play the key role to emergency response, such as disseminate warning news, rescue people, and post disaster relief and rehabilitation activities.

9.6. NGOs

NGOs are playing an important role to awareness development and in the rescue, relief and rehabilitation activities. To ensure NGOs participation in the disaster management initiatives of the government, they are included in all major committees and activities. It helps to ensure coordination and avoid duplication of activities between government and the NGOs.

From the above discussion it is found that the institutional settings and the pre-disaster preparation of the government is quite good. The management of 1997 cyclone was a successful story, whereas the initiatives taken to manage Sidr appears to be non-effective and questionable (see figure-2; flow chart). The casualties could have been more if the mangrove defense was not there, and if it was then a high tide time. It is not the efficient management measures, rather it is the nature (mangrove and low tide) itself saved many lives. The 1997 cyclone echoed the horror memories of 1991 catastrophic cyclone and as consequence all concerned bodies responded promptly and very effectively. From 1997 to 2007; a time gap of ten years and may be by this time the emotion and commitment to emergency response and effective initiatives by various committees and persons disappeared. As consequence the nation had to count 3447 dead bodies.

10. FURTHER CHALLENGES AND LOOK FORWARD:

Bangladesh is considered to be the model nation in cyclone disaster management. After 1991 cyclone there has been a remarkable improvement in all major sectors of cyclone disaster management. Management of 1997 cyclone was an example of success. However, the super cyclone Sidr reflects a different story. Despite adequate pre-disaster preparedness, the huge death tolls can not be accepted without question. Is Bangladesh really a successful country to manage cyclone disaster? Off-course a great success if compared to 1991 cyclone or cyclone Nargis that hit Myanmar on 2 May, 2008; but off-course not success if compared to 1997 cyclone.

During this study it has been found that Bangladesh has the preparation, both structural and non-structural.; but during the Sidr period the functional and non-structural setting did not work well. It is thus necessary to take actions to strengthen the existing system as further challenges to address cyclone disaster management.

CPP Volunteers: They play the key role during and after the disaster. More effective and sincere CPP volunteers are thus needed. These volunteers should get proper training with supporting equipment and exercise drill once a year,

Cyclone Centers: Cyclone centers are found to play an important role to provide shelter to affected people during the disaster, but their number is very inadequate in the south-western coastal belt. More cyclone shelters need to be constructed in the region

Coastal Afforestation: Coastal Afforestation is a successful plantation program along the coastal belt of Bangladesh. During the last four decades nearly 148000 hectors of new mangrove forest has been created (Islam, 2006). Mangroves act as a natural defense against storm surge: during Sidr event Sundarbans acted as a barrier and saved many lives. All the planted trees are now in their mature stage and would naturally fall-down in next few years. It is thus necessary to initiate second generation mangrove plantation.

Improvement of Signals: The present signal system is erroneous and not in real time. It is necessary to simplify the signals and dissemination of news bulletin. A real time warning system needs to be introduced.

Indigenous Knowledge: In this study it has been found that local knowledge is very important in life saving of local people. It is necessary to acknowledge this local knowledge in disaster management, its policy guidelines and actions.

Political Stability: The ultimate success of any disaster management measure depends on the political stability of the government. During the Sidr event there was a 'State of Emergencie' throughout the country and all political activities were banded. There was very little involvement of the political parties in rescue and relief operations. For sustainable cyclone disaster management political stability is prerequisite.

More Research: More academic and applied researches are necessary to update our understanding the natural and human forces to effective disaster management. Universities and professional research organizations can play effective role to conduct such research activities, and government should extend all necessary supports.

11. CONCLUSION

The goal of disaster management is to safe lives and properties, and reduces human sufferings. The people of Bangladesh have been fighting and living with disasters, such as flood, cyclone, tornados etc for centuries, and find their own way to survive. These people are courageous and each time they are struck, they fight back and survived. However, the initiatives of the government and effective disaster management can reduce the sufferings of those innocent people many folds. The top-bottom approach is no more effective, and it is now the time to bottom-up consideration of disaster management policy and guidelines. The success of fighting against all disasters depends on government, NGOs and community partnership. Sidr- the deadly super cyclone that hit Bangladesh on 15 November, 2007 gave us the same lesson.

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Coastal Vulnerabilities and its Integrated Management along Bangladesh Coast

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ABSTRACT

The coastal zone of Bangladesh that covers about one-third of country's total land area facing or having proximity to the Bay of Bengal and the exclusive economic zone (EEZ). The zone is generally perceived as a zone of multiple vulnerabilities. Moreover, it contains several important and critical ecosystems. However, the opportunities and potentialities of the zone have not yet received adequate attention. By harnessing and exploiting its opportunities, the Coastal Zone can make a substantial contribution in achieving the national goals of accelerated poverty reduction and millennium development goals. Bangladesh has one of the largest mangrove ecosystems in the world which is called Sundarbans mangrove ecosystem – the world heritage. The economic activity of the country which is mainly revolved by her agricultural activity might face a subversive action due to sea level rise. It has been seen that 84% of Sundarbans area will be inundated with 32cm sea level rise in 2050 and almost whole area of Sundarbans will be inundated with 88cm sea level rise in 2100. Flood and cyclonic storms frequently affect the coastal area of Bangladesh and cause huge loss of lives and damages to properties. The Bangladesh coast has been hit by 15 major cyclones over the last 38 years causing large scale loss of human life, livestock and severe damage to crops, properties and physical infrastructures. In April 1991 Bangladesh was hit by a catastrophic cyclone that led to the loss of 138,882 lives. Management of Bangladesh coastal zone has been started since 1960 with Coastal Embankment Project (CEP) by constructing embankment and sluices in the coastal areas to protect loss of life and crops from tidal surges, cyclone and saline intrusions. Since then Bangladesh government has taken many initiatives for the management of its coastal zone. Finally Integrated Coastal Zone Management Plan (ICZMP) has been prepared in 2005. Now the Bangladesh government is taking initiatives to implement the ICZMP for better management of its coastal zone. This paper describes all the above issues in detail.

1.0. GENERAL DESCRIPTION ABOUT THE BANGLADESH COAST

About 710 km long coast of Bangladesh comprising the complex delta of the Ganges-Brahmaputra-Meghna river system has immense resources for development. Bangladesh has an area of about 144,000 square kilometres and a population of more than 140 million, of which 23% of the total population lives in the coastal region. It is situated in the north-eastern part of the South Asian subcontinent and has a vast sea area to the south in the Bay of Bengal (a northern, extended arm of Indian Ocean, covering about 510,000 square kilometres). Most of the country is drained by the Ganges, Brahmaputra and Meghna rivers, which constitute one of the largest river systems in the world. This system has its origin in the Himalayas and the Khasi-Jaintia Hills in the north of the country. While flowing through Bangladesh on its way to the Bay of Bengal, the system carries an estimated annual sediment load of 2.4 billion tons (Holeman, 1968). These sediments are subjected to coastal dynamic processes generated mainly by river flow and tidal and wind actions, leading to accretion and erosion in the coastal area of Bangladesh. The landward boundary of the coastal zone of Bangladesh has been established based on the tidal water movement, salinity intrusion, cyclone and storm surges (Fig. 1). It covers a land area of 47,201 square kilometres within 19 administrative Districts (Islam, 2004). Poverty record on coastal population shows that 52% population are absolute poor and 24% are extreme poor.

The coastal morphology of Bangladesh is characterized by a complex network of rivers, an enormous discharge of river water heavily laden with sediments, a large number of islands in between the channels, strong tidal and wind actions and tropical cyclones and their associated storm surges. The peak cyclone risk times are April (pre-monsoon) and September/October (post-monsoon). The tidal range varies greatly across the coastal region of Bangladesh, with extremes of 7m at Sandwip, 3m on the west side of Hatia, 2.5m at Hiron point and the lowest range 0.75m. Maximum salinity varies along the coastal belt from 15-20 ppt.

Wave heights have not been recorded during severe storms until now. Wave model indicates that under the prevailing S-SE winds with an average wind speed of 8 m/s, the average significant wave height varies between 0.6-1.5m in the nearshore zone. In the dray season waves are generally lower than 0.6m and during monsoon wave heights exceed 2m.

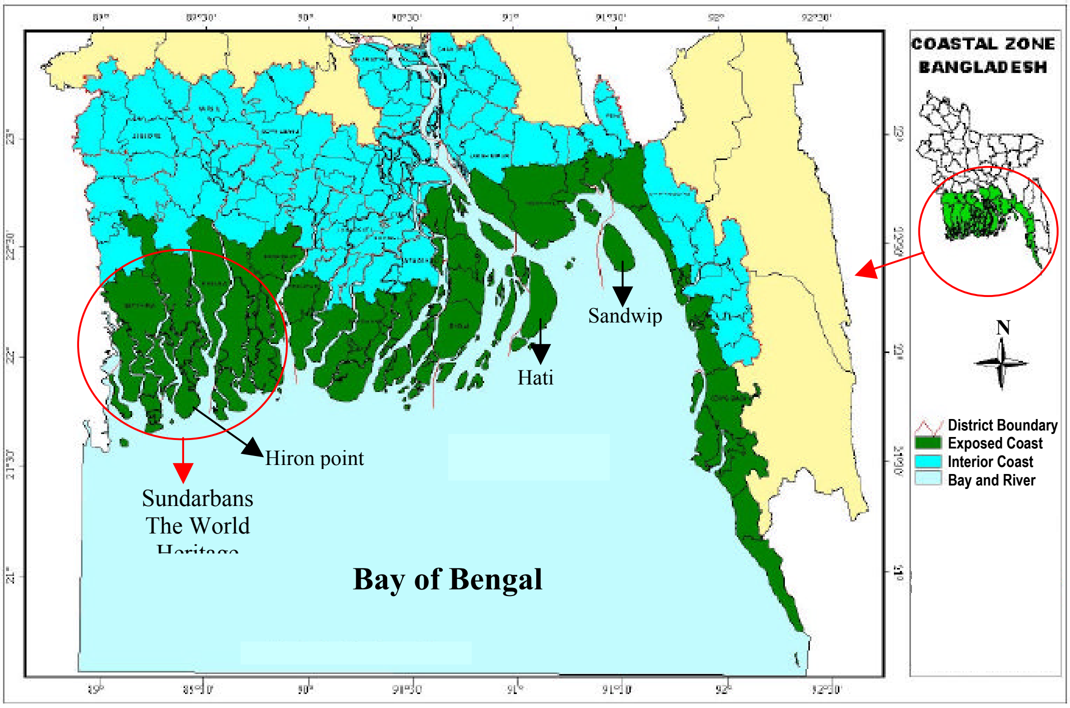

Fig. 1: Map of the Coastal Zone of Bangladesh

The Sundarbans Reserve Forest (SRF) is an ecologically sensitive area comprising the largest diversified mangrove forest of the world and also the World Heritage. It is highly productive as well as profoundly important in terms of biodiversity. Waterways in Sundarbans are important for capture fisheries and for growth of prawn. Sundarbans forms an effective natural barrier against cyclone induced storm surges.

Bangladesh is endowed with vast offshore marine water having high fisheries potential. This area is considered to be one of the most productive zones in the world because of the presence of the Sundarbans mangrove forest. It is rich in fish, shellfish and other aquatic resources. The Bangladesh Government has conducted several surveys and identified three major fishing grounds in the Bay of Bengal. It is identified and recorded more than 475 species of fish belonging to 133 families, about 10 species of marine shrimps of commercial importance, about 108 species of shellfish, molluscs and crabs and 2 species of lobsters from the Bay of Bengal. There are also 334 plant species and 425 species of wildlife – 49 mammals, 315 birds, 53 reptiles, 8 amphibians in Sundarbans Mangrove forest.

2.0. COASTAL VULNERABILITIES

The coast of Bangladesh is vulnerable to different types of coastal hazards. The principal elements of coastal hazards include cyclones and storm surges, river floods, erosion and accretion, drainage congestion, human interventions, climate change and sea level rise. These elements are continuously deteriorating the coastal environment with the results of the various effects as increase of risk of life and wealth, reduction of wildlife habitat and marine population, increase in pollution and contamination and increase in exposure to coastal hazards.

The three basic natural system processes and events that govern vulnerabilities of the coastal zone of Bangladesh are: tidal fluctuations; salinities (soil, surface water or groundwater) and cyclone and storm surge. One of the problems in Sundarbans is increasing of salinity due to reduction of upstream freshwater flows. It is suffering from increasing pollution. Loss of biodiversity, declining of fish stocks, reduced forest products will have a substantial adverse impact on the incomes of those peoples who are dependent on the Sundarbans for their livelihood.

The Bay of Bengal is one of the favourable areas for the generation of tropical cyclones. About one-tenth of the global total cyclones forming in different regions of the tropics occur in the Bay of Bengal. Not all of the tropical cyclones formed in the Bay of Bengal move towards the coast of Bangladesh. About one-sixth of tropical storms generated in the Bay of Bengal usually hit the Bangladesh coast. Meteorologically, the Bay of Bengal is located in the North Indian Basin together with the Arabian Sea, The Andaman Sea and the Golf of Thailand. In this region cyclones occur in the pre- and post monsoon seasons. With respect to cyclone surges and their damage, the Bangladeshi coast is one of the most exposed in the world. There are two main reasons for this. The first is that the continental shelf is long and shallow, and that the shape of the coast tends to concentrate and amplify the surge in the northern part of the Bay. The second reason is that the combination of relatively rare occurrences of cyclones and the need for every bit of land to accommodate the large population, results in people living also in areas, which are potentially very exposed to cyclone surges.

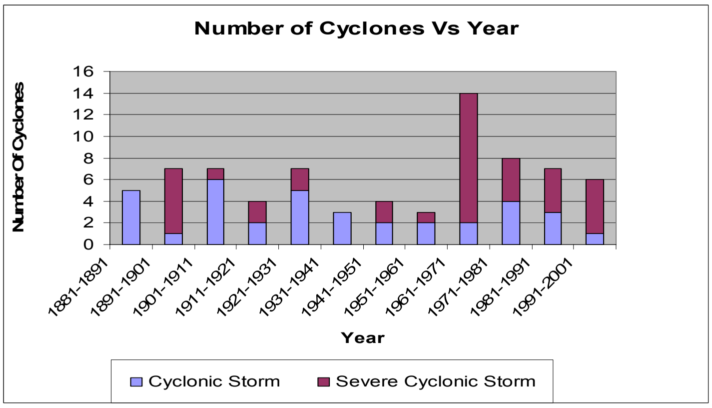

Fig.2: Number of cyclones hit to the coastal areas of Bangladesh

Flood and cyclonic storms frequently affect the coastal area of Bangladesh and cause huge loss of lives and damages to properties. The Bangladesh coast has been hit by 15 major cyclones over the last 38 years causing large scale loss of human life, livestock and severe damage to crops, properties and physical infrastructures. Catastrophic cyclones hit coastal area in November 1970, May 1985, November 1988, April 1991, May 1995, May 1997, November 2007 and these cyclones caused massive damage to life and properties. Records of the last 200 years show that at least 70 major cyclones have hit the coastal belt of which 37% hit during the month of May-June and 44% hit during October-November. The most severe and devastating ones affect the whole coastline from south-eastern tip of

Cox's Bazar district to the Sundarbans forest in the southwest. The records of cyclones that have hit to Bangladesh coast is shown in Fig.2.

Two different types of cyclones form in the Bay. One is tropical cyclone, which forms during the pre- and post-monsoon season and the other is the monsoonal depression which develops during monsoon, Tropical cyclones are the most destructive which are associated with usually low atmospheric pressure that can produce winds of 240 km/hr, in extreme cases storm surges of 6 to 7m (and even 9m) and intense rainfall. Table 1 shows the records of severe cyclones in last few decades:

Table 1: Records of severe cyclones in last few decades (Source: SWMC, 2001)

Period of cyclone	Cyclone speed (km/hr)	Surge height (m)	Number of death	Property damage
12 November, 1970	222	10	> 300,000	• Created havoc in the coastal districts
24-25 May, 1985	153	3-4	4,624	• Extensive damage of property • Damages of 3000 ha mangrove plantation • Severe impairment was caused to coastal embankment infrastructure
29 April, 1991	225	6-7	138,882	• About 500,000 heads of cattle, goats and sheeps were lost • 1.75 million houses and 6,500 schools were damaged • Standing crops covering 278,600 acres land were destroyed • 470 km of coastal embankment were seriously damaged
15 November 2007 (Cyclone Sidr)	240	5-6	3,406	• A super cyclone named Sidr, is a category 4 storm as defined on the Saffir-Simpson hurricane scale, wrought havoc to the south-western coastal areas and central plains of Bangladesh. • 55,000 people suffered physical injuries • 2.3 million households affected • 367km embankment were broken and 2105 km were partially damaged due to overflow caused by storm surge • overall economic growth in the country was affected by around 0.5 percent during FY08 • Total losses and damages caused by Sidr had been estimated to be Taka 115.6 billion (US$ 1.7 billion) and as such effects of it are calculated to be equivalent to 2.8% of Bangladesh's GDP.

Most of the cyclones hit the coasts of Bangladesh with north-eastward approaching angle. Surge wave generated at the deeper sea is driven towards the coast by the wind and propagates over land being amplified near the coast. The tracks of the cyclone storms happened in Bangladesh coastal zone in last century has been shown in Fig.3. One of the coastal embankments damaged by cyclone Sidr happened in 2007 is shown in Fig. 4.

A thorough study on erosion and accretion processes in the study area between 1972 and 1991 was carried out during Multipurpose Cyclone Shelter Programme (MCSP). The study found that slight erosion is taking place all along the coast in the West Zone, while in the Central Zone major erosion/accretion is going on. In the East Zone, small amount of accretion has taken place along the Cox's Bazar coast while some erosion has taken place in other parts of the zone.

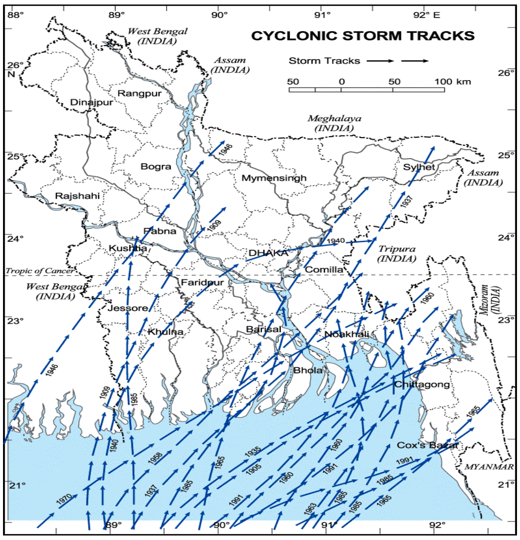

Fig. 3: Tracks of cyclone storms happened Bangladesh Coastal zone

Fig. 4: Photo of damaged embankment by cyclone in Sidr in 2007

The natural processes of the coastal processes have been being interrupted by human interventions like, construction of dams, polders, embankments etc. The human interventions have interacted with the delicately balanced natural processes, and have drastically hastened the raising of river bed levels unless specific actions have been taken to prevent it.

Any rise of the sea level propagates upstream into the river system. In Bangladesh this backwater effect is more pronounced because of the morphologically dynamic rivers, which adapt their bed levels relatively in a short time period. This whole process leads to decreased river gradient, increased flood risks and increased drainage congestion. Drainage congestion may become an even more serious threat than flood risks. Due to the siltation and the poor maintenance of the drainage channel network in many parts of the coastal zone, drainage congestion is already a grave problem and the problem is expected to increase considerably.

The low lying delta of Bangladesh possesses great danger due to global warming specially sea level rise. The economic activity of the country which is mainly revolved by her agricultural activity might face a subversive action due to sea level rise. Recent sea level rise trends due to climate change in years of 2030, 2050 and 2100 are 14cm, 32cm and 88cm respectively which is based on the third assessment report of the IPCC (Intergovernmental Panel on Climate Change) and NAPA (National Adaptation Programme of Action). A study carried out by IWM (Institute of Water Modelling) shows that by the year 2100, 88cm sea level rise will inundate 4107 square km area which is about 11% area of 16 coastal districts. It has been seen that 84% of Sundarbans area will be inundated with 32cm sea level rise in 2050 and almost whole area of Sundarbans will be inundated with 88cm sea level rise in 2100.

3.0. SOME MANAGEMENT ACTIVITIES

Mangrove ecosystem

Bangladesh has one of the largest mangrove ecosystems in the world which is called Sundarbans mangrove ecosystem (Fig. 5). This ecosystem serves multiple functions. Such as food source for offshore fisheries, coastal protection, economic and commercial forest resources, recreational resort and essential element for onshore shrimp cultivation. Erosion or accretion is another important factor controlling the extension and the functioning of the mangrove ecosystem. They control not only the characteristics of the bottom sediment, but also the local mean water level, and the watercourses themselves. Consequent influences on nutrient distribution, water regime and salt balance determine mangrove productivity as a whole.

In Bangladesh the great rivers (the Ganges, Brahmaputra, Meghna and Karnaphuli) empty into the large estuary at the apex of the Bay of Bengal. This freshwater run-off carries large quantities of nutrients. The nutrients mix with organic and inorganic elements derived from litter-fall decomposition of the mangrove forests of the coast. The fresh water bearing these nutrients mixes with the saline water of the bay where sedimentation and flocculation occur together with absorption to convert them into digestible smaller components. This is why the Bay Bengal is one of the most fertile grounds of the world.

Bangladesh is prone to cyclones. The mangroves are essential to protecting the country from the worst effects - the trees acting as a barrier to any associated tidal waves. They also absorb the energy of tidal surges. If the Sundarbans forest disappears, it will leave the rest of the country much more vulnerable to the predicted dramatic weather events associated with climate change.

Fig. 5: Photos of Sundarbans mangrove ecosystem

Coastal embankment project

Beginning in the early 1960s, the former East Pakistan Water and Power Development Authority (EPWAPDA) started the construction of embankments with standardized planning and design. Embankment crest elevations were set at a height equal to the normal maximum recorded water level plus the selected free-board to protect against cyclonic surges and tidal waves.

Embankment alignment was tentatively selected using available maps and aerial photographs. Final alignment was selected in the field. Villages and developed areas were included within the area protected by embankments wherever practicable. Channel closures were required whenever the embankment crossed a river or khal. Drainage sluices were planned and designed to drain excess rain water from polders into adjacent channels. Drainage is accomplished during times of low tide when the water level inside the polder is higher than the water level on the river or sea side. Flap gates on the river side of the sluices close automatically when the river water level rises above the country side level and prevents flow into the polder. Empolderization has mostly been done in the coastal region below the salinity line of 1,000 micromhos (aprox. 6.76 ppt). At least 123 polders have been created through construction of 5107 km earthen embankment providing protection of 1.5 Mha of coastal land.

The construction of large numbers of polders required the closure of many tidal channels. As a result, these channels are in the process of readjustment of channel section in order to cope with the tidal flows. This has caused ecological changes especially affecting the fish of the area. It is also creating problems for drainage from polders during the rainy season and for communication as traditional navigation channels have become blocked from siltation.

Afforestation

Forests are always considered to be low-cost and natural protection to the lands subjected to attack of current and storm surges. A hydraulic model study has been done at the southern part of Hatia island on afforestation under 2nd CERP (Coastal Embankment Rehabilitation Project) in order to assess the effect of afforestation on the storm surge height and to develop a basis for having the necessary engineering judgement in designing the minimum width of forest cover to reduce the height of the embankment system. The southern part of Hatia island is always exposed to the Bay of Bengal and most of the time hit by cyclonic surges. In investigation, mangrove forest was laid along the southern shoreline of Hatia by defining the equivalent Manning number for the *Rizophora* species of mangrove forest and 1970 cyclone was considered for equivalent surge condition. The study was based on the two-dimensional numerical model of Bay of Bengal. The study shows that the mangrove forest with width of 600m decreases the surge height of 0.45m around the southern tip of Hatia island. The first 133m width of forest absorb the thrust of the storm surge reducing it by 0.18m. No appreciable positive impact of afforestation was found at other locations at the south-eastern side and south-western side of the polder. The findings of this study can help the planners and designers to compute the formation level of the polder with the consideration of afforestation.

Realizing the importance of coastal afforestation for the consolidation of newly accreted land, the Bangladesh Forestry Department has undertaken extensive afforestation projects in the coastal districts of Bangladesh (particularly in the central region). By 1976, an area of about 11,000 ha had been planted. By 1980, about 40,000 ha of plantation had been completed, as reported by the Forestry Department. A massive afforestation programme by plantation of about 40,500 ha in the coastal area was targeted for the period 1981-1985. Up to June 1985, about 37,000 ha had been planted as estimated by remote sensing techniques. Till 2004 over 140,000 ha of newly formed mud flats have been planted with various mangrove species of which *Sonneratia apetala* is the most common one (Forest Department data of 2005).

Unfortunately, forest areas in Bangladesh are under relentless pressure from river erosion, timber merchants, fuel wood collectors, grazing animals and land clearance for rice or shrimp culture. Thus, the coastal afforestation projects are only a small beginning towards improving the nation's wood supply and forest cover.

Land reclamation

Cross-dam techniques have been applied in Bangladesh and successful results have been achieved. A major branch of the Meghna used to flow between the Noakhali mainland and Ramgati Island but gradually it silted up over a period of 20-30 years prior to 1957. Meghna Cross-Dam No. 1, a 12-km-long embankment, was constructed in the shallow bed of the Meghna in 1957 connecting Ramgati Island with the mainland and the flow was diverted to the west in Shahbazpur Channel. Cross-Dam No. 2, between Char Jabbar and the main-land, was constructed in 1964. These two cross-dams have added a substantial landmass area to Bangladesh. The gross protected area totals about 900 sq km from old river beds and the bay. Gradually, the process of sedimentation around this reclaimed landmass is increasing every year.

The Bangladesh Water Development Board (BWDB) through its land reclamation project is planning to construct a cross-dam between Sandwip and Noakhali (Urir Char). Various model studies have been under-taken with Netherlands experts after analysing historical developments in the area. The possible orientation and alignment of the dam is being further examined by BWDB.

Newly emerged land in the coastal area will have to be developed thought both-short-range and long-range programmes. The overall strategy for the development of these areas depends on the consolidation and stabilization of the newly formed land and the retardation of the erosion of stable land. The basic strategy for the development of the newly accreted land into stable and productive land is to put such lands into afforestation immediately so as to keep the soils relatively undisturbed for at least 10 years. This will increase natural vegetation also. After the land has stabilized, trees may gradually be cut from the central part of the forest for timber and fuel-wood, while the outer-fringe trees are kept to protect the land against erosion, tidal action and storm surges. The central part cleared of trees may be used for cultivation and habitation. Thus, the land gained and stablized by afforestation and saved from erosion will provide for an increase in cultivable land and agricultural production.

Cyclone Preparedness Programme (CPP)

The Cyclone Preparedness Programme (CPP) is a collaborative effort of the Ministry of Food and Disaster Management and the Bangladesh Red Crescent Society. It is one of the most successful initiatives in early warning in the South-East Asian region, internationally recognized as a “standard of excellence” with a dedicated team of community volunteers living in coastal and offshore island villages. The CPP covers 11 districts in the coastal areas. Volunteers have been trained to play a crucial role in the dissemination of cyclone warnings, evacuation, rescue, first aid, emergency relief and in the usage of radio communication equipment. CPP’s 27,600 male and 5,520 female volunteers are the first line of an early warning system to the members of their communities. As an operational wing of the government’s disaster management bureau, the CPP provides scheduled daily weather reports via an extensive high frequency (HF) radio transmitting system operated by volunteers throughout the coastal region of Bangladesh. In addition, government has constructed about 2,400 cyclone and flood shelters along its coastal belt. There is still a requirement to construct a further 1,500 shelters to serve 3.56 million people residing in the high risk coasts. Government has also initiated a complimentary disaster preparedness programme to promote community participation in the construction and maintenance of cyclone shelters. Presently, Bangladesh is working on developing a Tsunami Preparedness Programme as an extension to the Cyclone Preparedness Programme.

4.0. EVOLUTION OF COASTAL ZONE MANAGEMENT IN BANGLADESH

4.1. Policy development

The Coastal Embankment Project (CEP) started its efforts to build embankment and sluices in the coastal areas to protect loss of life and crops from tidal surges, cyclone and saline intrusions. The CEP was the single most dominant programme in the coastal zone until the late1970s. In 1978 the GoB, with technical assistance from the Government of the Netherlands, embarked on a programme of erosion control and development of newly accreted land in the estuary through the Land Reclamation Project (LRP). The project went for several pilot tests with some positive results. The overall conclusion of the LRP was that the new khas land takes many years to produce reasonable agricultural yields and enable farmers to make a suitable living.

In the late 1980s, the Economic and Social Commission for Asia and Pacific (ESCAP) took the first initiative to formulate a coastal management policy in Bangladesh. In 1988 a report titled “Coastal Environmental Management Plan for Bangladesh” was produced (ESCAP, 1988) that addressed the most obvious problems of the coastal zone. One of the unique aspects of this study was the integration of socio-economic considerations into the environmental issues. It was a brave attempt at an integrated approach to coastal zone management but was not formulated at a level of specific plans and proposals for implementation. In 1986, in a process operating in parallel, the GoB, finally completed Phase I of the National Water Plan.

In 1989 the European Communities reached an agreement with GoB to finance the Cyclone Protection Project II (CPP II) comprising feasibility and design studies of protection measures against cyclonic flooding. The study was undertaken under the Flood Action Plan (FAP, Component 7). The study recommended “an integrated master plan study for protection measures against cyclones covering all aspects including coastal embankments, warning system, cyclone shelters, means of evacuation, emergency planning etc." (FAP 7, 1992).

In April 1991 Bangladesh was hit by a catastrophic cyclone that led to the loss of 138,882 lives. Immediately after that the Planning Commission, Government of Bangladesh initiated a study titled "Multi-purpose Cyclone Shelter Programme" (MCSP) with financial assistance from the United Nations Development Programme (UNDP) and World Bank. This was jointly conducted by the Bangladesh University of Engineering and Technology (BUET) and Bangladesh Institute of Development Studies (BIDS) during early 1992. The core objective of the study was to prepare a "Master Plan for Multipurpose Cyclone Shelters" for storm surge prone areas of the coastal belt of Bangladesh" (BUET-BIDS, 1993).

In its analysis the study based on a number of factors delineated the cyclone prone areas of Bangladesh as falling within the "risk zone (RZ)" and the "high risk area (HRA)." Based on the factors mentioned, the study delineated an area of 12,046 km^2 (8.4 percent of Bangladesh), comprising 49 thanas in the 13 coastal districts as being cyclone prone and falling within a "risk zone". A plan was formulated to serve as a "framework for establishment of a Cyclone Shelter Network in the coastal areas which will define the basic concept, strategy and location pattern to be followed in all future construction".

Based on the review of the findings of MCSP, a follow-up project named "Cyclone Shelter Preparatory Study (Cyclone Risk Area Development Plan)" was launched in 1995 with financial support from the European Union. The objectives of the project were to "provide life-saving protection for the population at high risk from cyclones, in a manner that can be maintained on a sustainable basis; upgrade disaster preparedness and management systems in the high risk areas; maximize the utility of the life-saving infrastructure during non-cyclone periods, through the use of facilities as schools or for other community purposes; to the extent economically justified, provide life-saving protection for livestock in the high risk area" (Sener Ingenieria Y Sistemas SA et al., 1998).

In 1999, the World Bank (WB) involved the Netherlands Government and the World Food Programme in a mission to identify specific concepts, goals, objectives and policy formulations to move forward the process of the integrated management of coastal zones that had been under discussion for Bangladesh for nearly a decade (Soussan et al., 1999).

Basing the analysis on earlier works in Bangladesh, and specific assessments in Asia and further afield, it aimed at a truly integrated approach. This has attempted to identify the whole range of stakeholders, encourage a wider appreciation of the implications of their activities and foster an attitude of adaptation and response to the zone's special challenges. Thus, it has become usual to speak of Integrated Coastal Zone Management or ICZM.

In February 1999 the GoB sent a high level delegation to South-east Asia to study ICZM. The team consisted of four Secretaries of key Ministries, along with the Chief Conservator of Forests and the Chairman of the BWDB. This delegation's work subsequently culminated in drafting the first GoB Policy Paper on ICZM in September 1999. This paper represents the present accepted policy framework for coastal development in Bangladesh and provides a context within which coastal policy-livelihoods relationships need to be analyzed. This paper built on the analysis of the donor mission discussed above (Soussan et al., 1999) to identify the issue of interdepartmental co-ordination as a major challenge in coastal areas: "development problems to not occur departmentally; they appear in a complex web of interrelationships needing concerted efforts by more than one agency" (GoB. 1999).

Later in the year the WB developed a proposal to use the Coastal Embankment Rehabilitation Project (CERP) and other projects (Char Development and Settlement Project - CDSP, Meghna Estuary Study - MES, Supporting Environmental Management Programme - SEMP, Fourth Fisheries Project –FFP, Fisheries Resource Management Programme - FRMP etc.) as building blocks of an ICZM Plan. The GoB has accepted the proposal and, with the aid of assistance from the Netherlands Embassy, commenced its ICZM programme preparation.

4.2. Integrated Coastal Zone Management Plan

ICZM Plan project is started on 01 February 2002 and was ended in 31 December 2005. The six major outputs of this project are Coastal Zone Policy, Coastal Development Strategy, Priority Investment Program, Community capacities to enhance livelihoods, Enabling institutional environment and Integrated knowledge base.

a) Coastal Zone Policy (CZPo)

The main purpose of Coastal Zone Policy was to agree on a process of harmonization of sectoral policies and planning activities and to establish a process of ICZM to facilitate the improvement of community livelihoods, enhance the benefits of development efforts and facilitate formulation of a policy document for adoption by the Government.

b) Coastal Development Strategy

The coastal development strategy (CDS) document is the main output of the ICZM project. The CDS links the CZPo with concrete development programs and intervention. The objectives of the CDS are to select strategic priorities and actions in implementation of the CZPo with emphasis on the creation of the institutional environment that will enable GoB to embark on a continuous and structured process of prioritization, development.

c) Priority Investment Program

The Priority Investment Program (PIP) is the operational arm of the Coastal Development Strategy (CDS) and the linking mechanism to streamline the coastal development into national planning process. PIP is considered as a vehicle to implement the process of identification, preparation, implementation and monitoring of priority interventions. Issues can be identified in different ways and are elaborated through participatory approaches. Concept notes for investment projects were developed through multi-agency participation. The CDS preparation proposes structured steps in identification of (priority) interventions through identification of strategic thrusts, types of interventions and finally specific interventions/actions.

d) Community capacities to enhance livelihoods

The focus of this output is on development of models of good practice to enhance the capacity of communities to improve their livelihoods. Guided by the Sustainable Livelihood Framework (SLF), the Project undertook activities to develop and quantify the concept of community vulnerability.

e) Enabling institutional environment

The enabling institutional environment aims to create the conditions that would support local communities in improving their livelihoods. In general terms, the objectives of this output are: to assess the existing procedures of harmonization of different policies and sectoral plans; to assess the existing procedures of co-ordination between institutional actors; and to design ‘partnership’ procedures outlining the ‘best practices’ of institutional and legal arrangements at different levels of operation.

f) Integrated knowledge base

The purpose of the activities aiming at an integrated knowledge base is to have better information and a better understanding of coastal conditions and processes in support of ICZM. The approach was to first facilitate collection, collation of readily available information at district and project levels. Then a library was established containing books, reports and CDs relevant to planning and management of the coastal zone. Relevant information was analyzed and synthesized and working papers were prepared for wider dissemination.

5.0. CONCLUSION

Based on the present trend of population growth, the estimated population in the coastal area is 41.8 million by the year 2015. The main challenges for coastal managers are to ensure the basic needs of the increasing population. By reducing the vulnerabilities and developing definite strategies for sustainable coastal development and to use natural resources wisely in an equitable manner to promote and support a dynamic and sustainable coastal economy. In addition to that threats from global warming are inundation of coastal areas, change in precipitation pattern, and increase of land erosion, floods and deterioration of biodiversity. The Government of Bangladesh has done many activities for manage its coastal zone by reducing coastal vulnerabilities. Integrated Coastal Zone Management Plan (ICZMP) has been prepared in 2005. Now the Government of Bangladesh has started the institutionalization and operationalization of ICZMP.

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Coastal Landform Variations of the Mekong River Delta, Vietnam in Relation to Monsoon Activities

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ABSTRACT

This study emphasizes on coastal landform variations of the Mekong River Delta (MRD) in relation to monsoonal activity at the active delta in the eastern part and delta margin in the southern part progradated for the last 3 ka. Two depositional patterns and their distinct landforms could be recognized in the following: (1) The active delta plain shows tide- and wave-dominated delta and characterized by sandy beach-ridge systems well distributed on the subaerial delta plain. Almost sand and sandy silt deposited at the active delta to form delta front and pro-delta facies and fine sediments transport southwest-wards owing to longshore currents generated by northeast monsoon. (2) Tide- dominated delta progradation occurred in the Ca Mau deltaic margin. It is characterized by well-developed mangrove marsh on the subaerial delta plain. There is not any sandy beach-ridge to be found in the subaerial delta plain, and subaqueous delta shows pro-delta and shelf mud facies.

Total shoreline of the MRD is about 740 km long including over 400 km long on the East Sea and the remainder located on the West Sea. The erosion and accumulation processes that permanently occur both at the shore areas and the river mouths. The MR transports a great amount of suspended and bottom sediments. These sediments, under various hydrodynamic processes such as long-shore and tidal currents and wave, dominantly affect the active geo-morphological evolution of the coastal zone. The coastlines of Ben Tre, Tra Vinh and Soc Trang regions are affected by mixed process of erosion and deposition in different places. Data from the last 40 years show that accretion coastlines are usually located around the present river mouths with its rate of 15-20 m/y. At the same time, depending on the morpho-hydrodynamical processes, coastal erosion occurs at some places and its rate is 10-15 m/y. During the last 100 years, especially at the Ganh Hao area, coastal erosion is more severe with its average rate of 30-50 m/y. Beside coastal erosion the Ca Mau cap is well-known as rapid accreation coastline. Its rate is approximately 50-80 m/y, some places are up to 100 m/y. This phenomenon is evidently driven by deposition of material discharged by the MR system as well as by material derived from coastal erosion of above mentioned areas. Moreover, present tidal sand flat is found at the Ca Mau cape, meanwhile, there is not any evidence of sand flat and beach ridges in Ca Mau deltaic margin. Above-mentioned data indicate that the change in coastal landforms of MRD seems to be effected more strongly by monsoonal activity in the recent years.

INTRODUCTION

The Mekong River Delta (MRD), one of the largest deltas in the Asia, is mainly located in the southern Vietnam has been formed by the Mekong River system. This is a tide dominated delta in the humid tropical climate and monsoon. During the highstand and regressions of relative sea-level over the last 5500 yr.BP., delta progradation has formed a great delta plain of 62,500 sq. km of which the total shoreline is about 740 km long [1]. Shoreline of the Southern China Sea, over 400 km long, is characterized by semi-diurnal tides with an average amplitude of 3- 4 m, meanwhile the Gulf of Thailand about 340 km long, characterized by diurnal tides with small amplitude of 0.5- 1.0 m. The tidal regimes surrounding the MRD together with monsoon and wave activities, have appreciable contributions to coastal landform variations.

Coastal MRD is a broad coastal plain composing of two different morpho-sedimentary areas: Eastern Coastal Area and Ca Mau Peninsula. Eastern Coastal Area is located in the active delta among the present distributaries. Morphology of the Eastern Coastal Area is strongly dissected by many different sets of the beach ridges. The former sets are seemed to be in northeast - southwest direction with lower elevation of 3.0 to 4.0 m a.s.l., the younger ones are single or braided arc patterns with complicated directions and the present sand dunes are parallel to coastline with elevation of 5 to 6 m a.s.l., some of them reach 8 to 10 m a.s.l. This area is characterized by tide- and wave- dominated delta progradation for the last 3 ka. Ca Mau Peninsula is located on the southwestern part of the MRD. Main area, with elevation of 2.0 m a.s.l., is occupied by coastal plain deposits in which marshy deposits are scattered in the lower lands of 1.0 m a.s.l. The lowest lands of mangrove marshy deposits mainly occupy the southern part of the Ca Mau Peninsula in which present mangrove forests expand over 90 km long and 25 km wide. Ca Mau peninsular is typical for tide dominated delta progradation [1,3].

This study emphasizes on coastal landform variations of the MRD in relation to monsoonal activity at the active delta in the Eastern Coastal Area and Ca Mau delta margin in the southern part progradated for the last 3 ka.

METHODS

Coastal landform variation is comparison of topography maps which published in the different intervals of 1881-1896, 1952 by France; 1963-1965 by American; and 1977, 1980,1985, 1998 by Vietnamese. Aerial photographs and satellite images including LANDSAT, SPOT and NASDA in the interval of 1973-1992, Terra-Aster 03, 1987 (MSS), 1989,1996 (TM), 2001 (ETM), 2004 (ETM) are also useful. Field survey were carried out at the some typical coasts in Ben Tre, Tra Vinh and Ca Mau.

RESULTS AND DISCUSSION

1. Depositional patterns and landforms

Two depositional patterns and their distinct landforms in this study areas could be recognized in the following:

1.1. The active delta plain of Ben Tre and Tra Vinh area located at the eastern part of MRD shows tide- and wave-dominated delta and characterized by sandy beach-ridge systems well distributed on the subaerial delta plain. Sediments are characterized by a coarsening-upward delta front facies covered by a fining-upward subtidal to intertidal facies, followed by a coarsening-upward fore shore/dune facies. The tide- and wave-dominated delta is characterized by a beach-ridge system on the subaerial delta plain, longshore sediment dispersal, and steep delta-front topography in the proximal delta [3]. Almost sand and sandy silt deposited at the active delta to form delta front and pro-delta facies and fine sediments transport southwest-wards owing to longshore currents generated by northeast monsoon.

1.2. Tide- dominated delta progradation occurred in the Ca Mau deltaic margin located in the southernmost part of the Mekong River Delta. Based on the changes of morpho- sedimentary map and detailed investigations of deltaic facies in the boring cores, the Ca Mau deltaic margin has been formed since the last 3.000 years. Sediments are characterized by the thick prodelta/shelf mud facies overlie on late Pleistocene followed by delta front mud facies, sub-to intertidal mud flat and marsh. The tide-dominated deltaic margin is characterized by well-developed mangrove marsh on the subaerial delta plain. There is not any sandy beach-ridge to be found in the subaerial delta plain. Ca Mau peninsula is subjected under tidal and monsoonal regimes in the East and West seas. Semi-diurnal tide is in the East sea with an average amplitude of 3-4 m, and diurnal tides is characterized in the West sea with small amplitude of 0.5-1.0 m. Both the tidal and monsoonal regimes play important role to coastal evolution in the Ca Mau deltaic margin. Under northeast monsoon activity, almost fine grained sediments such as silt and clay transported southwestwards by longshore current from the distributaries of Mekong River system and deposit in Ca Mau area. Ca

Mau cap is located at the border of the semi-diurnal and diurnal tides of East and West seas and characterized by high rate of coastal deposition.

2. Change of coastal landform in the active delta plain (Ben Tre and Tra Vinh coastal areas)

The erosion and accumulation processes that permanently occur both at the shore areas and the river mouths. The MR transports a great amount of suspended and bottom sediments. These sediments, under various hydrodynamic processes such as long-shore and tidal currents and wave, dominantly affect the active geo-morphological evolution of the coastal zone. The coastlines of Ben Tre, Tra Vinh areas are affected by mixed process of erosion and deposition in different places. Data from the last 40 years show that accretion coastlines are usually located around the present river mouths with its rate of 15-20 m/y. At the same time, depending on the morpho-hydrodynamical processes, coastal erosion occurs at some places and its rate is 10-15 m/y.

Deposition and erosion area at BenTre coast (ha)

Period	Erosion area	Deposition area	Total area	Average
1972 - 1987	-524	+2,913	+2,389	159
1987- 1996	-670	+1,281	+611	68
1996 - 2004	-367	+1,203	+836	104
1972 - 2004	**-1,561**	**+5,397**	**+3,336**	**105**

3. Change of coastal landform in the Ca Mau delta margin

In comparing topographic maps, satellite images and field measurements data showed that coastline has changed considerably by both erosion and accretion processes at the Ca Mau coastline. The Bo De coastline is well- known as erosive coast with its rate of 30-50 m/y from 1885 to 1985, then particularly at the south side of Bo De mouth, it has been increasing up to 50-90 m/y since 1985 [2]. Beside that at Ca Mau cap, the coastline is well-known as rapidly depositional coast, its rate is approximately of 50-80 m/y and some places are up to 100 m/y from. This phenomenon is evidently driven by deposition of material discharged by the MR system as well as by material derived from coastal erosion of above mentioned areas. But a new data show that some places has been eroded considerably with its average rate of 40- 60m/y since 1998. It seems to be effected by typhoons in the recent years.

During the last 100 years, especially at the Ganh Hao area, coastal erosion is more severe with its average rate of 30-50 m/y. Beside coastal erosion the Ca Mau cap is well-known as rapid accreation coastline. Its rate is approximately 50-80 m/y, some places are up to 100 m/y. This phenomenon is evidently driven by deposition of material discharged by the MR system as well as by material derived from coastal erosion of above mentioned areas. Moreover, present tidal sand flat is found at the Ca Mau cape, meanwhile, there is not any evidence of sand flat and beach ridges in Ca Mau deltaic margin. Above-mentioned data indicate that the change in coastal landforms of MRD seems to be effected more strongly by monsoonal activity in the recent years.

CONCLUSION

Coastal landform variations of the MRD in relation to monsoonal activity at the active delta in the Eastern Coastal Area and Ca Mau delta were clarified by investigating Ben Tre, Tra Vinh and Ca Mau coasts.

The erosion and accumulation processes that permanently occur both at the shore areas and the river mouths. The MR transports a great amount of suspended and bottom sediments. These sediments, under various hydrodynamic processes such as long-shore and tidal currents and wave, dominantly affect the active geo-morphological evolution of the coastal areas. The monsoon effect in the wet season leads to the supply of fine sediments and mud deposition under the low-tide line. In contrast, in the dry season, sediment supply is limited and mud is brought away.

The change in coastal landforms of MRD seems to be effected more strongly by monsoonal activity in the recent years as a consequence of global warming and climate change.

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Holocene Coastal Delta Development Patterns and Sediment Discharge of the Mekong River in Vietnam

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ABSTRACT

The Mekong River Delta (MRD) located at the mouth of Mekong River, Southern Vietnam is a typical mixed-tide and wave energy delta and with a wide delta plain of 62,520-93,781 km^2 it is one of the largest deltas in the world. The river has its headwaters in the Tibetan mountains, and it flows down the Indochina Peninsula through several countries – China, Laos, Myanmar, Thailand, and Cambodia – before emptying into the South China Sea in southern Vietnam with sediment discharge is 160 million t y^{-1}.

Coastal delta development patterns and sediment discharge of the Mekong river during the Holocene are presented based on detailed analyses of samples from boreholes on the delta plain. The deltaic sediments are composed of early Holocene aggradational sediments and progradational sediments of middle to late Holocene age. Holocene sea-level change controlled this evolution of the Mekong river delta.

The Holocene progradational delta has evolved from a tide-dominated delta to the present mixed wave- and tide-dominated delta during the last 3 ky. The tide-dominated delta was characterized by a well-developed mangrove forest on the subaerial delta plain, cross-shore sediment dispersal, and tide-influenced sedimentary facies. The tide- and wave-dominated delta exhibits a beach ridge system in the subaerial delta plain, longshore sediment dispersal, and a steep delta-front topography, in which the sediments of the proximal river-mouth area are coarse-grained and those more distal are fine-grained. This evolution indicates that as river-mouth coastal systems evolve from estuaries to deltas in response to sea-level changes, the tide-dominated delta was formed in the early phase of the highstand systems tract and has changed to more wave- dominated delta in the subsequent regression.

Based on sediment-volume analysis, estimated sediment discharge of the Mekong River for the last 3 ky was 144 ± 36 million t y^{-1} on average, or almost the same as the present level. The constant rate of delta front migration and stable sediment discharge during the last 3 ky indicate that a dramatic increase in sediment discharge owing to human activities, as has been suggested for the Yellow River watershed, did not occur. However, in centennial and decadal scales, sediment discharge of the Mekong river may be changed due to human activities therefore it needs to study more detailed.

INTRODUCTION

The Mekong River Delta (MRD) located at the mouth of Mekong River, Southern Vietnam is a typical mixed-tide and wave energy delta and with a wide delta plain of 62,520-93,781 km^2 it is one of the largest deltas in the world. The river has its headwaters in the Tibetan mountains, and it flows down the Indochina Peninsula through several countries – China, Laos, Myanmar, Thailand, and Cambodia – before emptying into the South China Sea in southern Vietnam with sediment discharge is 160 million t y^{-1} [1].

The MRD has prograded more than 200 km from the Cambodian border to the present coastline in southern Vietnam over the last 5-6 ky [2]. The detailed topography of the subaerial delta plain show two parts: an upper (inner) delta plain dominated by fluvial processes, and a lower (outer) delta plain characterized by a well-developed beach-ridge system and mainly influenced by marine processes. The modern, active subaerial delta environment is composed mainly of beach ridges (including the foreshore) and tidal flats. Ca Mau Peninsula is located on the southwestern part of the MRD and characterized by the lowest lands of mangrover marsh.

Coastal delta development patterns and sediment discharge of the Mekong river during the Holocene are presented based on detailed analyses of samples from boreholes on the lower delta plain.

METHODS

Surface characteristics are analysed on the basis of morpho-sedimentary map interpreted by aerial photographs and satellite images.

Subsurface characteristics are studied mainly on the basis of samples from 15 boring cores, over 50 auge-holes and soil-pits on the delta plain. The cores were split, described and photographed. X-radiographs were taken throughout all split cores. Primary sedimentary structures in fine-grained sediments are well preserved. Characteristic of depositional environments are also based upon fossil investigation (diatom, foraminifer). ^{14}C ages are measured on plant fragments and molluscan shell fragments by the Accelerator Mass Spectrometry (AMS) method.

RESULTS AND DISCUSSION

1. Sedimentary facies

On the basis of sedimentary characteristics, granulometry, sedimentary structure, microfossil and ^{14}C age dating, sedimentary facies of MRD are divided as follows:

1.1 Late Pleistocene undifferentiated sediments are recovered at the lowest parts of all most sites and consisted of stiff, slightly oxidized yellowish-grey silty sand and fine-medium sand bearing scattered quartz pebbles. It is +5 m Late Pleistocene terrace to the north part of the MRD, and lowered to about -2 to -4 m in the Plain of Reeds and the west part of Long Xuyen Quadrangle [2], then commonly -10 to -35 m around the present coast of the South China Sea and -10 to -15 m in the Ca Mau peninsula excepting some incised valleys reaching over -70 m as the case of a core in Ben Tre [3]. These sediments were dated ca. 43.4 and 50.4 cal ky BP and were overlaid unconformably by Holocene marine sediments [4, 5].

1.2 The transgressive incised-valley fill sediments have been investigated in more detail at the core in Ben Tre site. The sedimentary succession showing incised-valley infilling ranges from estuarine channel/tidal river sandy silt, muddy tidal flat/salt marsh, to estuarine marine sand and finally open bay muddy facies in ascending order. These facies present a fining-upward succession indicating the Holocene transgressive sediments. The soft honogenous greenish-grey mud and discontinuous - parallel laminated mud, 10 to 13 m thick, are characterized by abundant marine planktonic diatoms and open bay foraminifers [3]. The sedimentary succession is only found in and around the incised-valleys in Ben Tre, Vinh Long and Dong Thap provinces and indicates that a maximum transgression occurred at ca. 6.0 - 5.5 ky BP [5].

1.3. Delta progradation sediments are composed of deltaic sediments from prodelta, delta front, sub- to intertidal flat, foreshore, beach ridge/marsh silt facies in ascending order. There are some differences in sedimentary facies somewhat between the boring sites located around present coast and the boring sites located in the hinterland around 50-120 km from the present coast, with respect to grain size and sedimentary structures. The grain size of sediments of the sites around the present coast is coarser than that of another in the hinterland. The sediments of the sites in the hinterland display a fining-upward succession with parallel lamination and lenticular bedding, and an overlying subaerial delta plain facies. These characters are also found at the sites around present coast;

however, they display a wide variation in sedimentary structures including wavy bedding, flaser bedding, and cross-lamination, in addition to parallel lamination and lenticular bedding, and they are covered by coarse sediments of the subaerial delta plain facies. These features of this facies are tide-influenced, and it is interpreted as a subtidal to intertidal flat facies. However, the facies at the sites located around present coast were influenced not only by tides but also in part by waves [4, 5]. In the southwest marginal delta of MRD, the characteristic of deposition process is different from the active delta. Sediments are characterized by the thick prodelta/shelf mud facies overlie on late Pleistocene followed by delta front mud facies, sub-to intertidal mud flat and marsh.

2. Holocene delta development patterns

Delta progradation over the last 5 - 6 ky was not constant. The topography and sediment facies show that the upper delta plain formed in a tide-influenced environment before 3 ky, during the last 3 ky the lower delta plain formed in a more wave-influenced environment and the Ca Mau margin delta formed in a tide-influenced environment [5]. Holocene delta progradation can be divided into three development patterns in three different localities and periods as follows:

2.1. Tide dominated progradation occurried in the upper delta plain in the Plain of Reeds and Long Xuyen Quadrangle around 6-4.5 ky BP. It is characterized by 2-5 m thick intertidal flat and mangrove swamp mud facies and overlain the Late Pleistocene basement strata. The progradation rate is estimated about 40 to 45 m/y based on the mangrove swamp sediments well occupied behind a system of the relict beach ridge dated 4,5 ky BP.

2.2. Deltaic progradation around the distributary channel during the last 6- 5 ky

Since the last 6- 5 ky, the deltaic sediments have well prograded around the present distributary channels of the Mekong River where deltaic sandbody is found. This is a typical deltaic succession, 15 to 25 m thick, consisting of prodelta mud facies, delta front sandy silt facies, sub- to intertidal flat sandy silt facies and subaerial delta plain facies in ascending order. The pro-delta mud facies, 4 to 12 m thick, shows a coarsening-upward succession and consists of dark grey silt and sandy silt. Delta front sandy silt facies, a 6- to 9-m-thick coarsening-upward succession, consists of intercalated greenish gray sandy silt and fine sand. Sub- to intertidal flat sandy silt facies, 6 to 8 m thick, consists of laminated dark grey sandy silt and fine sand. Subaerial delta plain facies (marsh and beach ridge) is 4 to 5 m thick, and consists of dark silt and sandy silt with rich organic matter, rootlets, and mica flakes. Based on the changes of morpho- sedimentary map and detailed investigations of deltaic facies in the boring cores, it was suggested that there are two types of deltaic succession. A tide dominated delta in the upper delta plain changed to present mixed tide- and wave- dominated delta during the last 3 ky. The progradation rates are also changed from 30-40 m/y to 10-20 m/y in the tide dominated delta to mixed tide- and wave- dominated delta respectively [4].

Related these changes, progradation rates of the deltaic system also decreased from the inner to outer delta. This decrease may be related to the increase in wave influence resulting in sediment dispersal southwestward. Most waves are related to the monsoon climate and approach the Mekong River Delta region from the northeast. The headland east of Ho Chi Minh City sheltered the river mouth from these waves before 3 ky BP. However, as the delta prograded seaward and projected past the headland during the last 3 ky, the environment became more wave influenced, and the sediment facies and topography began to resemble those of the present delta.

3.3. Tide dominated progradation during the last 5- 4 ky in the southwest part of Mekong delta (Ca Mau deltaic margin)

The deltaic margin in Ca Mau peninsula is characterized by 15 to 20 m thick deltaic mud facies unconformably covered the Late Pleistocene basement strata. The deltaic succession consists of the pro-delta/shelf mud facies, delta front mud facies, sub- to intertidal flat and mangrove marsh mud facies. The pro-delta/shelt mud facies is about 5 to 10 m thick common shell fragments and dated 4.3 ky BP at the core in Ca Mau. The delta front mud facies is 10 to 15 m thick, parralell laminated silty clay are common and found at the all boring cores. The sediment of delta front was dated 4 ky BP. Sub- to intertidal flat mud facies is about 3 to 5 m thick and dated 1.5 ky BP. Marsh and mangrove marsh mud facies well occupied in the subaerial delta plain. The morpho-sedimentary map and data from boring cores suggest that a tide dominated progradation has occupied the deltaic margin in Ca Mau peninsula. The progradation rate is estimated about 35- 38 m/y during the last 4 ky. It seems to be sediments transport southwestwards and longshore currents generated by winter monsoons play important role in formation and development of Ca Mau deltaic margin.

3. Millennial-scale sediment discharge

The volume of sediment deposited over the last 3 ky can be roughly estimated using the present topography and bathymetry, the palaeo-offshore break line at 3 ka, and sediment thickness. The calculated sediment volume deposited during the last 3 ky is $360 \pm 90 \times 10^9$ m^3 (20 ± 5 m in thickness, 18×10^3 km^2 in area), which is equivalent to 144 ± 36 million t y^{-1} using a bulk density of 1.2 ± 0.1 g cm^{-3}. Estimated sediment discharge of the Mekong River for the last 3 ky was 144 ± 36 million t y^{-1} on average, or almost the same as the present level. The constant rate of delta front migration and stable sediment discharge during the last 3 ky indicate that a dramatic increase in sediment discharge owing to human activities, as has been suggested for the Yellow River watershed, did not occur. However, in centennial and decadal scales, sediment discharge of the Mekong river may be changed due to human activities such as constructing dams in the upstream, or tropical storm, typhoon increase caused more erosion in the coastal areas of MRD. Therefore further research on sediment discharge in centennial and decadal scales should be done more detailed to estimate environment impacts due to increasing human activities or natural conditions and predict the coastal erosion/deposition processes more effectly.

CONCLUSION

Coastal delta development patterns and sediment discharge of the Mekong river during the Holocene are presented based on detailed analyses of morpho-sedimentary map and samples from boreholes on the delta plain. The typical sediments are early Holocene transgressive incised-valley fill sediments and regressive progradational sediments of middle to late Holocene age.

During the sea-level highstand and the subsequent period of slightly falling in the last 6-5 ky, delta progradation was divided into tide predominance and tide –and wave predominance as follows:

(1) A typical delta succession occupied around the present distributary channels during the last 6-5 ky. It is characterized by 15-25 m thickness consisting of prodelta mud facies, delta front sandy silt facies, sub- to intertidal flat sandy silt facies. A tide dominated delta in the upper delta plain has been changed to present mixed tide- and wave- dominated delta during the last 3 ky. The progradation rates are also changed from 30-40 m/y to 10-20 m/y in the tide dominated delta to mixed tide- and wave- dominated delta respectively.

(2) Tidal predominated progradation occurried the upper delta plain around 6-4.5 ky BP. It is characterized by 2-5 m thick intertidal mud facies and overlain the Late Pleistocene sediments. Since the last 3 ky fluvial process has become predominant and flood plain sediments have caped the intertidal mud facies.

(3) Tidal predominated progradation has occurred a deltaic margin at southern part of the MRD during the last 4 ky BP., and characterized by 15-20 m thick delta/shelf mud facies overlain the Late Pleistocene sediments. The progradation rate is estimated about 35- 38 m/y during the last 4 ky

Based on sediment-volume analysis, estimated sediment discharge of the Mekong River for the last 3 ky was 144 ± 36 million t y^{-1} on average, or almost the same as the present level. However, it needs to research on sediment discharge in centennial and decadal scales to estimate more exactly.

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Protection and Management of Karstic Geosites of Ha Tien – Kien Luong Coastline, Viet Nam

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ABSTRACT

The Ha Tien – Kien Luong coastal zone is a typical site where a number of karstic geosites are valuable to scientific research and natural resources. Significantly, the geosites provide considerable resources for interdisciplinary studies e.g. angular unconformity of the oldest strata in Nambo Southern Vietnam which is between the Chua Hang formation aged late Devonian-early Caboniferous (D_3-C_1*ch*) and the Ha Tien formation aged Pecmian (P*ht*); the geomorphological landscapes of karstic vestiges in various forms such as conical, tower-liked, pyramid-liked at 30-200 meters (m) height above sea level (h.a.s.l). In addition, several caves at 2-3m, 15-20m, 40-60m h.a.s.l, for example, Mo So, Cay Ot, Tien, and Thach Dong are historical and cultural representations. There are a number of rare mammals, birds, and reptiles investigated in several limestone hills within the Hon Chong, Kien Luong, Ha Tien in recent years. Due to the spectacular karstic surface as well as the splendid caves, Ha Tien-Kien Luong becomes an attractive site to tourists. Furthermore, the exciting sites are attracted to students from different universities to visit and to study yearly.

However, under natural processes and anthropogenic impacts, several geosites are seriously being degraded. The natural reason is mainly fall-in phenomenon, where typical example is the collapse of Hon Phu, a National-credited landscape in Hon Chong, Binh An commune, Kien Luong district (Kien Giang province). The combined Hon Phu-Tu is a symbol of Kien Giang province, thus the collapse of Hon Phu leads to a number of negative impacts such as tourist declination. Over-explorations, natural resource destructions of karstic environment due to human activities are increasingly happening in the areas, especially limestone exploitation for cement production, uncontrolled forest shattering, unsustainable tourist development.

Karstic structure is very brittle, easy-broken. In addition, it is impossible to restore after broken. Therefore, karstic sites are very sensitive to anthropogenic impacts. The exploitation, unplanned/unplanned use, will even destroy the sources that seriously affect to the current and future generation. Consequently, responsibility from the government as well as resident duty for protection and close control must be required. In this talk, a number of solutions for protection, management of the geosites in the Ha Tien-Kien Luong coastal zone are proposed as follows: 1) Investigation of valuable characteristics of each geosite; 2) Mapping geosites on which different levels of valuableness; 3) Setting up a raising awareness program to local people about the karstic degradation and solutions to reduce impacts; 4) Development of tourist economic 5) Protection and management of the karstic geosites based on cooperation among different management levels and different branches.

INTRODUCTION

Karstic geosites along the Ha Tien – Kien coastal zone are beautiful and precious landscapes in the South Westen Vietnam. Some of these become famous and attract many tourists to visit annually. However, scientific, economical, and social values of each geosite have not been fully taken into consideration leading to unreasonably use and exploit. As the results, a number of geosites have being degraded even disapeared due to natural and anthropogenic impacts. This paper briefly presents about current status and values of several typical geosites; consequently, proposes solutions for protection and management toward efficiency and sustainability.

STUDY AREA

The study area is the coastal zone which belongs to Ha Tien town, Kien Luong district, Kien Giang province, elongating about 60 km from the border of Cambodia to Hon Chong cape (Figure 1). At this coastal zone, appearing rocks are as follows [1, 2]:

- Chua Hang Formation aged late Devonian-early Caboniferous (D_3-C_1*ch*): siltstone, silt-sandstone intecalated with black, thin limestone layers.
- Ha Tien Formation aged Pecmian (P*ht*): white – grey limestone, in many places feebly recrystallized, thick – bedded; limestone intercalated with dark – grey marls.
- Nui Cop Formation aged middle Triassic (T_2a*nc*): tuff boulderstone, rhyolite, fensite and their tuffs.
- Sediment rocks aged Holocene (Q_{IV}): marine deposits are largely distributed, they consist of clay, silt, sand, in some places, plant humus or shell remains.

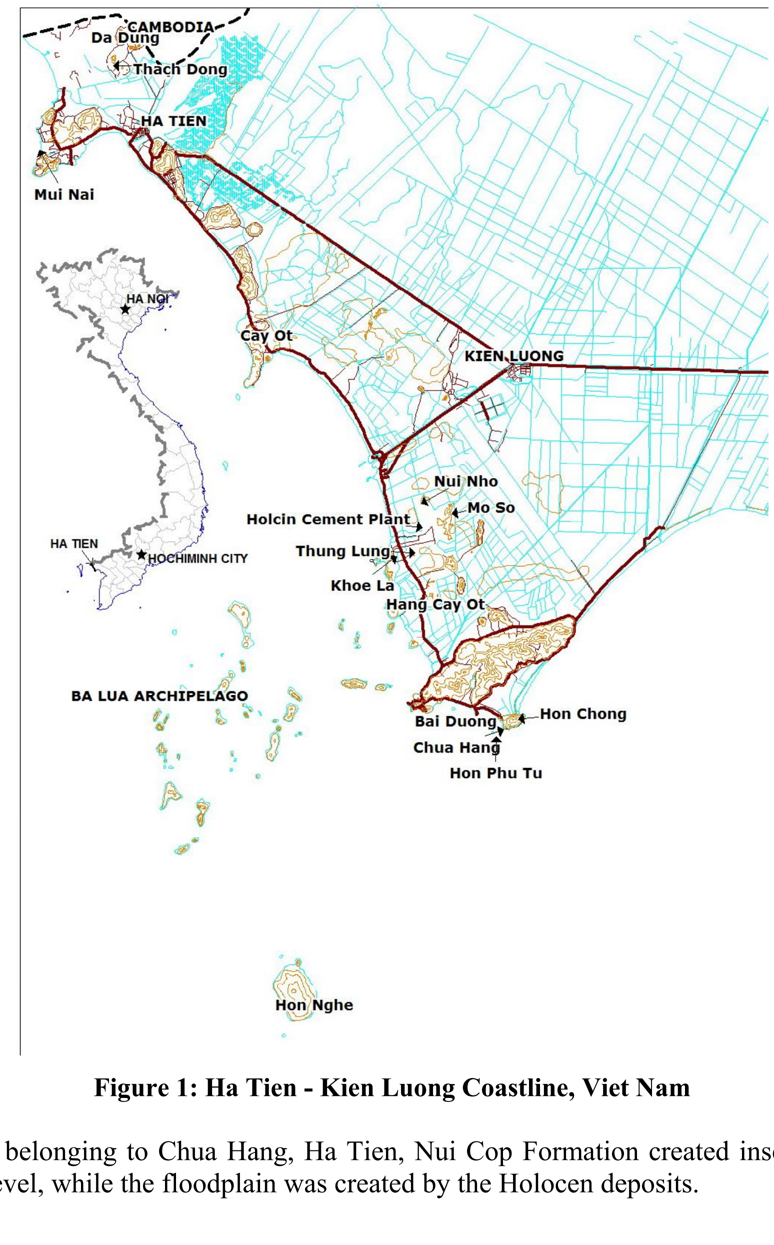

Figure 1: Ha Tien - Kien Luong Coastline, Viet Nam

The rocks belonging to Chua Hang, Ha Tien, Nui Cop Formation created inselbergs which is above the sea level, while the floodplain was created by the Holocen deposits.

The karstic geosites was mainly generated by Permian limestones of the Ha Tien Formation (P*ht*). The limestones are scatteredly exposed on Ha Tien coast, from Da Dung mountain, near the border with Cambodia, to Chua Hang with the famous Hon Phu Tu, but concentratedly located at the area between Bai Ot and Hon Chong. They unconformably cover Chua Hang Formation (D_3-C_1*ch*) at Chua Hang.

SOME TYPICAL KARSTIC GEOSITES

1) Thach Dong mountain

Thach Dong is a column of rock with 80m height, which looks like a *feather – cap of the English* cavalry and called "Bonnet à poil" in French (Figure 2). At the Thach Dong mountain, Thach Dong cave is wide and beautiful, and inside the cave is the Tien Son pagoda made of wood in 1790.

Thach Dong cave is one of the most beautiful landscapes in Ha Tien which also relates to some traditional legends (e.g Thach Sanh saved Quynh Nga princess). The cave's bottom is about 20m height covers about 50 m^2; whereas the cave's ceiling is 6-7m higher than the bottom. The main entrance to the cave is in North-East direction; other entrances are in South-West, West, and North direction. There are quite a number of distinct stalactites which is twinkling when having light in the cave walls.

At the West entrance, tourist can see green rice fields, Khmer pagodas, Mui Nai beach, islands in Thai Lan Gulf which are very splendid (Figure 3). At the North-East entrance, one can see palmyra forest in Cambodia.

2. Da Dung Mountain

Da Dung Mountain is balanced-trapezium-shaped, 98m height, distributing in the South – Westernmost area of Vietnam (Figure 4). The mountain includes a 14 cave system with diverse ways inside; many entrances appear in the mountain wall at differently high levels.

The way coming to this 14 cave system is about 3.149m. Each cave has their own beauty which relates to a number of mysterious legends especially due to the different figures of stalactites, for example, wine gourd-shaped (Doi cave); turtle-shaped (Than Kim Qui cave) (Figure 5); bitter melon-shaped (Kho Qua cave); in the Trong Nguc cave, when flapping on one's chest, some noises as drumming appear.

During the American war, the cave system is a base for the South Liberation Army. Some remains of the war can still be seen in some caves as the results of cartridge, bombs.

3. Mo So Mountain

The Mo So Mountain ("Mo So" is white rock in Khmer language) is about 30 m height, elongating in the north direction. The mountain has a system of more than 20 large and small caves. In the south of the mountain, haft of it, have being exploited for cement production.

Figure 2: Thach Dong Mountain

Figure 3: Landscape in the West of Thach Mountain

The cave's bottom is 1.0-1.5 m height which is as high as the current plain (Figure 6). The caves are inter-connected by underground rivers; in some places in the caves are spacious. Stalactites in the caves have distinct shapes. On the cave's wall is attached by shell remains. Inside the mountain is a valley with round-shaped, flat bottom, 1000 m^2. Impacts of sea level changings at 1.5 – 2.0 m, 2.5 m-3.0 m created trace of waves around the Mo So mountain (Figure 7).

The Mo So mountain is also a base for the South Liberation Army during American war. The commanding office, hospital, post office … of the Liberation Army were located here.

Figure 4: Da Dung Mountain

Figure 5: Than Kim Qui Cave

Figure 6: The main entrance to Mo So Cave

Figure 7: Traces of waves

4. Hon Chong

Hon Chong is a gathered landscape including Hon Chong Mountain, Chua Hang, Hon Phu Tu, and Bai Duong. Some people compare Hon Chong landscapes as " Ha Long Bay in the South".

Hon Chong Mountain

Hon Chong Mountain is 221 m high with a number of sharp rocks looked as spike table (Spike means "Chong" in Vietnamese) (Figure 8). In the south of the mountain, it is covered by forest, mainly Keo plant (*Acacia auriculiformis), Dau plant (Dipterocarrpus_alatus)*. In this area, a diversity system of animal is also reported abundantly, especially the existing of rare birds such as Giang sen (*Mycteria leucocephala)*, Khoang Co (*Nettapus__coromandelianus*), Bo Nong (*Pelecaniformes*), Quam (*Ciconiiformes)* green wing, typically Seu red head (*Gruiformes*) (Figure 9). A scarce Vooc Bac community (*Trachypithecus villosus)* is also found in some limestone peaks in Hon Chong.

Chua Hang

Chua Hang has an original name "Hai Son Pagoda" (Figure 10) [4] built by the King Nguyen Anh in order to remember his sister who died here. The main of this pagoda located within the mountain of a karstic cave. Two entrance lead to North-East and South-West direction, more than 50m length, the back gate looks to the sea. Annually, from 8 to 15 April (Lunar calendar), a festival is organized here solemnly (Figure 11) [4].

Figure 8: sharp rocks looked as spike table in Hon Chong mountain

Figure 9: Seu red head (*Gruiformes*)

Figure 10: Entrance to Chua Hang

Figure 11: Buddhist festival in Chua Hang

Figure 12: Hon Phu Tu - the symbol of Kien Giang province

Figure 13: Hon Phu Tu after collapse

Hon Phu Tu

Few years ago, the Hon Phu Tu (as a symbol of Kien Giang) is 2 high rock columns and tilted in the same direction. This looks like a father and son toward the sea (in Vietnamese, "Phu" means father, "Tu" means son). The big one is 33.6m height assumed as "Father", and the small one is 32.9 m height assumed as "Son". These two rock columns are connected by a rock platform as 5 m higher than sea level. The collapsing of the big one in 9 August 2006 affected this famous landscape in the South.

Bai Duong

Bai Duong beach is about 2 km length; haft of the beach is covered by Duong plant (*Casuarina equisetifolia)* and haft is covered by Dau plant (*Dipterocarpus alatus*). In front of Bai Duong is Kien Vang island which is 500 m far from the shore. Bai Duong is a beautiful beach, tiny sand, secretive beach behind the Duong plant lines and miscellaneous forest as a blind separated from roads.

DESTRUCTION BY NATURE

The appearance of dense cracking systems have split the limestone layers into separated blocks or disconnected columns. The weathering, dissolving, abrading processes by water, waves, winds are the main factors causing these fragile geosites degraded. The collapse of Hon Phu is typically represented for the natural effects on the karstic geosites (Figure 12, 13) [3].

DESTRUCTION BY HUMAN

Some activities such as limestone exploitation for construction materials, uncontrolled forest shattering, unsustainable tourist developing have destroyed the karstic resources even more than the natural factors.

Exploitation for construction materials

To serve for the current benefits, limestone exploitation is happening extensively in the Kien Luong region, for example: Khoe La (Figure 14), Mo So, Tuc Khoi, Cay Ot cave, Thung Lung (Figure 15), Nho mountain … These exploitations is extending whereas the beautiful limestone landscapes are disappearing. Some of the limestone mountain is flattened or exploited underground even -90m (in planned). These limestone exploitation has also severely affected habitat areas of rare species in Kien Luong region (Figure 16, 17) [5].

Figure 14: Limestone exploitation in Khoe La mine

Figure 15: Deep exploitation in Thung Lung mine

Unsustainable tourist developing

Some caves have been decorated, lighted that change the natural conditions, as well as degraded the stalactites. Constructing new entrances (Figure 18) or closing some caves will negatively affect on birds, bats etc. Illegally, superstitious activities, temporal house construction (Figure 19), unconscious tourist are threatening species especially those live in the lower areas of the mountains.

Forest exploitation

Hon Chong forest is a rarely specialized forest on limestone in Kien Giang. The forest is characterized by diversity of plants as boi loi (*Litsea glutinosa)* hậu phát, huynh (*Tarrietia parvifolia),* sen (*Madhuca pasquieri*), dau rai (*Dipterocarrpus alatus),* sao (*Hopea Hainanensis*). This forest is currently illegally exploited for burnt-over land, wood, medical purposes …

Figure 16: Seu red head (*Gruiformes*)

Figure 17: Air pollution by blasting

Figure 18: New entrances to Loc Ky cave (Da Dung Mountain)

Figure 19: Temporal house construction in valley (Mo So Mountain)

SOLUTIONS FOR PROTECTION AND MANAGEMENT

Proposed solutions for protection and management of the karstic geosites in the Ha Tien – Kien Giang coastal zones are as follows:

- Investigation of valuable characteristics of each geosite in term of scientific, cultural/historical, social/economic aspects.
- Mapping geosites on which different levels of valuableness, the important sites need to be strictly protected are presented. In addition, attached to each site is a diagram describing characteristics of geology, cultures, and environmental resources.
- Setting up a raising awareness program to local people about the possible karstic degradation and solutions to reduce environmental impact in the karstic landscapes.
- Development of tourist economic based on the unique characteristics of landscapes, ecology, cultural tradition instead of, for example, constructing material exploitation.
- Protection and management of the karstic geosites based on cooperation among different management levels and different branches.

CONCLUSION

Karstic structure is very brittle, easy-broken. In addition, it is impossible to restore after broken. Therefore, karstic sites are very sensitive to anthropogenic impacts. The exploitation, unreasonable/unplanned use, will even destroy the sources that seriously affect to the current and future generation. Consequently, responsibility from the government as well as resident duty for protection and tight control must be required.

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Mangrove Flora Biodiversity in Con Dao National Park, Baria - Vung Tau Province, Vietnam

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ABSTRACT

There are 31 ha of mangrove in Con Dao National Park distributing in 04 main areas, in which 7 ha is on the Southern East, 11 ha is on Southern West and 8 ha and 5 ha is on Northern West and Northern East respectively. The mangrove is virgin forest that remains in Vietnam.

There are 15 species of mangrove tree in 9 families, of which 14 species are true mangrove, 1 associated mangrove species with the abundance of 2,833 individuals per ha in Bo Dap – Bai Duong. In Dam Quoc – Dam The, 18 species belongs to 10 families, of which 17 species is true mangrove , 01 associated mangrove species and the abundance of 1,998 individual per ha. Identically, in Dam Trau – Ong Cau there are 15 species in 10 families, of that are 14 true mangrove species, 01 associated mangrove species with the abundance of 2,013 individuals per ha. It is found that 13 species belongs to 9 families, 11 species is true mangrove, 02 associated mangrove species with the population of 1,550 individuals per ha in Dam Tre.

There are 45 mangrove species in Con Dao National Park, of which is 35 tree species, shrub and climber are 5 species for each. There are 26 true mangrove species belonging to 11 families; 19 associated mangrove species in 15 families. The 45 mangrove species are identified and listed, 3 species is in the Vietnamese Red Book are Duoc doi (*Rhizophora apiculata* Blume), Coc do (*Lumnitzera littorea* (Jack) Voigt) and Quao nuoc (*Dolichandrone spathacea* (L.) K.Sch); 2 new species that have been identified in Vietnam are Vet hainessi (*Bruguiera hainessi*) and Xu rumphii (*Xylocarpus rumphii*). Rhizophoraceae is dominant family having 9 species, Combretaceae has 3 species, and Leguminosaceae has 3 species, 1 – 2 species for the rest families. The average of abundance is 2,099 tree per ha. Five dominant species are Su do (*Aegiceras floridum* Roem & Schult) occupied 25.02% of total species, Vet du (*Bruguiera gymnorrhiza* (L.) Lamk) is 11.39%, Da voi (*Ceriops tagal (*Perr*)* C. B. Rob) is 10.85%, Dung (*Rhizophora mucronata* Lamk) is 9.47%, Duoc doi (*Rhizophora apiculata* Blume) is 7.74%. The Important Value Index (IVI%) of these 5 species is 63%, 19 remaining species is 37%. Average community diversity index is: S = 4 ± 1.07, Magalef (d) = 0.96 ± 0.38, Pielou (J') = 0.71 ± 0.18, Simpson (D) = 0.49 ± 0.18, Shannon (H'_e) = 0.94 ± 0.34.

1. INTRODUCTION

Mangrove plays important roles in coastal protection, erosion control, raw material providing, herbal, tourist and study place… but in recent decades, mangrove in Viet Nam was decreased by many reasons in which mainly is economic development purpose. The Con Dao mangrove ecosystem on the East Sea coastline of Viet Nam is unique place that has primary forest remaining in the country.

The diversity of mangrove plants in the Con Dao studied aiming at to increase awareness of the true value of mangrove ecosystems. The diversity and abundance may reflect the status and functioning of mangrove forest ecosystems and serve as potential biological/ecological indicators of habitat change in both natural and managed mangroves. Biodiversity is widely regarded to be important in maintaining genetic richness, ecological functioning and the resilience of the ecosystem (Heywood, 1995).

The objective of this study was to understand natural mangrove of Con Dao in different areas, species composition, tree communities and management. This type of information is valuable for monitoring the ecological development and conservation of mangrove in Viet Nam.

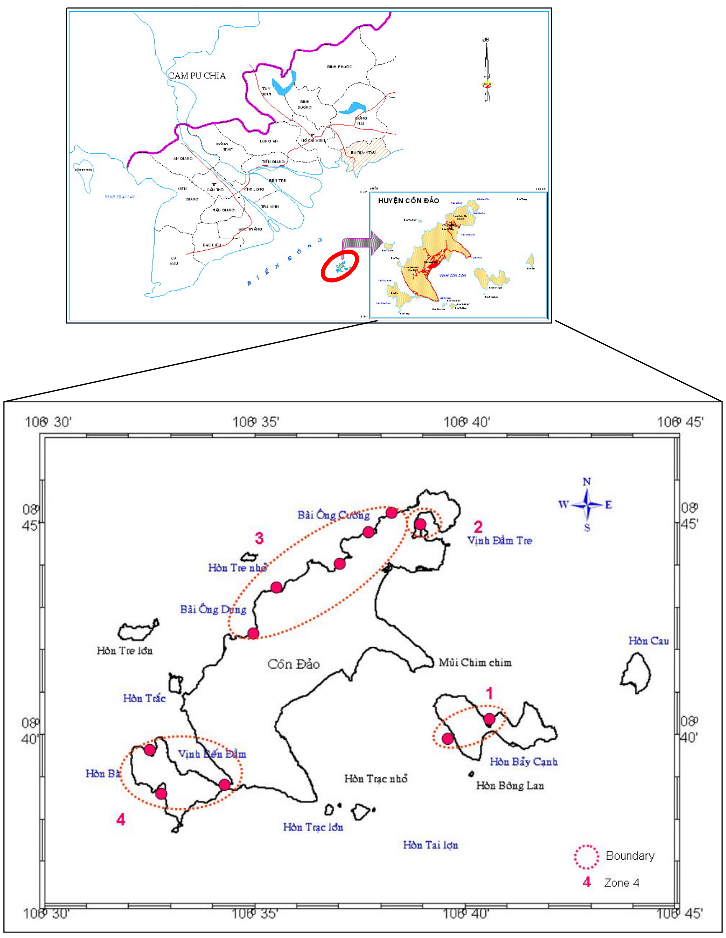

Figure 1: Mangrove forest distribution in Con Dao National Park, the position of the study zones (1 to 4). The locations are: (1) Bo Dap – Bai Duong; (2) Dam Tre; (3) Dam Trau – Ong Cau; and (4) Quoc – Dam The.

2. MATERIALS AND METHODS

2.1. Study sites

The study was conducted in the Con Dao National Park, Con Dao island is South East of Ho Chi Minh city about 150 km which lies between $48^0 37^,$ - $48^0 48^,$ latitude; $106^0 32^,$ – $106^0 45^,$ longitude. The study area covers in Con Dao districts, Ba Ria – Vung Tau Province of Viet Nam. The total area of Con Dao National Park is about 20,000 ha in which has 14 islands (6,000 ha) and 14,000 ha of water body. The functions and duties of Con Dao National park are as followings:

- To protect, rehabilitate the ecosystem of flora, fauna on islands and sea.
- Forest conservation and landscape together with historical, cultural areas.
- To carry out scientific researches, education and tourism services.

2.2. Data collection

The study was based on the data collection directly from the field. The study area was selected by using the help of forest map and satellite images of Con dao National Park and the 64 plots determined for four zones. Each zone is 16 plots. Sampling plot of 10 m × 10 m = 100 m^2 size was taken in each area (English, S., 1997). Standard procedure were followed to measure density, frequency abundance, Relative density (R.D.), Relative Frequency (R.F.), Relative Abundance (R.A.) and Important Value Index (IVI) of the species. Diversity index, the Shannon-Winner index for diversity and Species Richness index were also measured.

2.3. Data analysis

For each major location, four measures of local diversity of true species were calculated. These were: total number of species (S); total abundance of individuals; Shannon-Weiner diversity $H = \sum (P_i * \text{Log}_e(P_i))$ (where P_i is the number of individuals of the ith species as a proportion of the total number of all *i*th species); and Pielou's evenness $J = H/\text{Log}_e S$, Beta diversity $H\beta' = S/m$ (Anne E. Maguran, 2004) where S = species number (all samples), m = average number of species per sample. To evaluate the biodiversity of rare species, we calculated the rarity index (IR)=1- (n/N)*100, where n is the number of squares in which the species was found and N the total number of squares surveyed. The index ranges from 0 to 100. A species is rare when the index is greater than or equal to 78.08 and lower than 95; very rare, when the value is between 95 and 97; extremely rare, when it is greater than 97 (Guarino C, Napolitano F, 2006).

Further patterns in community composition were assessed using PRIMER (Plymouth Routines in Multivariate Ecological Research) (Clarke & Warwick, 1994). Community (species abundance) data were square root-transformed to reduce the influence of dominant and rare species. The Bray-Curtis similarity measure was then calculated between every permutation of sample pairs (Clarke & Warwick 1994). The relationship between samples and species was displayed in PCA (Figure 6).

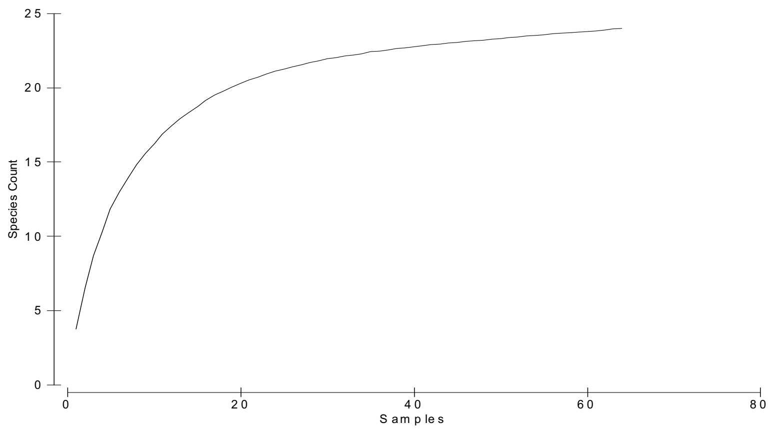

Figure 2: Species Accumulation Curve of Mangrove trees in Con Dao

3. RESULTS AND DISCUSSION

There are 45 mangrove species in Con Dao National Park, of which is 35 tree species, shrub and climber are 5 species for each. There are 26 true mangrove species and 19 associate mangrove species. The 45 mangrove species in which 3 species is in the Vietnamese Red Book are Duoc doi (*Rhizophora apiculata* Blume), Coc do (*Lumnitzera littorea* (Jack) Voigt) and Quao nuoc (*Dolichandrone spathacea* (L.) K.Sch); 2 new species that have been identified in Vietnam are Vet hainessi (*Bruguiera hainessi*) and Xu rumphii (*Xylocarpus rumphii*). The average of abundance is 2,099 tree per ha.

There are 26 true mangrove species belonging to 11 families; 19 associated mangrove species in 15 families. Rhiphoraceae is dominant family with 9 species occupies 55.09% of total individual (Fig 4), Myrsinaceae is 22.54%. Combretaceae has 3 species (22.54%), Leguminosaceae has 3 species (0.41%) and the remain families have 1 – 2 species. Apocymnaceae is lowest (0.23%).

At the Bo Dap - Bai Duong the trees were about 28 per 100 m^2. Tree density was lowest at Dam Tre because relatively fewer seedlings distribution there due to Dam Tre is bay. Four mangrove tree species were recorded in Dam Quoc – Dam The.

There were *Rhizophora* trees in the mixed *Aegiceras floridum/Ceriops tagal* stand with dominant *Ceriops tagal* in Bo Dap - Bai Duong, where seedlings of *Ceriops tagal* can grow in the rocky area. A few *Avicennia alba a*nd *Avicennia marina*, *Sonneratia alba* trees were also recorded in Dam Trau - Ong Cau, showing that these mangrove species had distributed from Mekong Delta.

The species compositions are also reflected in the diversity indices. Margalef's richness and

Shannon diversity were greatest in Dam Trau - Ong Cau. The diversity analyses (Table 1) show Dam Quoc - Dam The to be the most diverse location with the highest species richness and Dam Tre is lowest. However, it also has the lower evenness value since dominance value is high (0.49). Using Beta diversity value to compare diversity between zones reveal that Dam Quoc - Dam The is highest diversity and lowest is Dam Trau - Ong Cau.

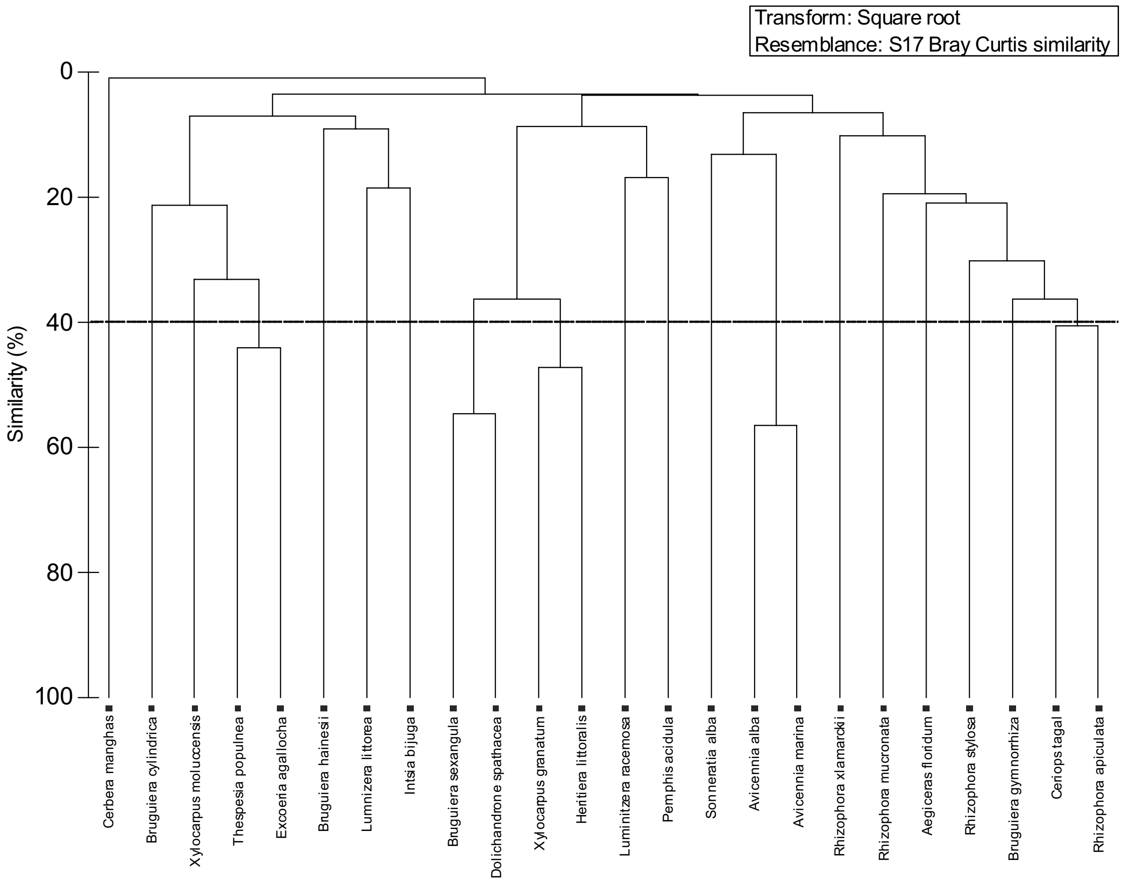

Figure 3: Dendrogram of mangrove species composition at Con Dao calculated using group-average linking of Bray-Curtis similarities

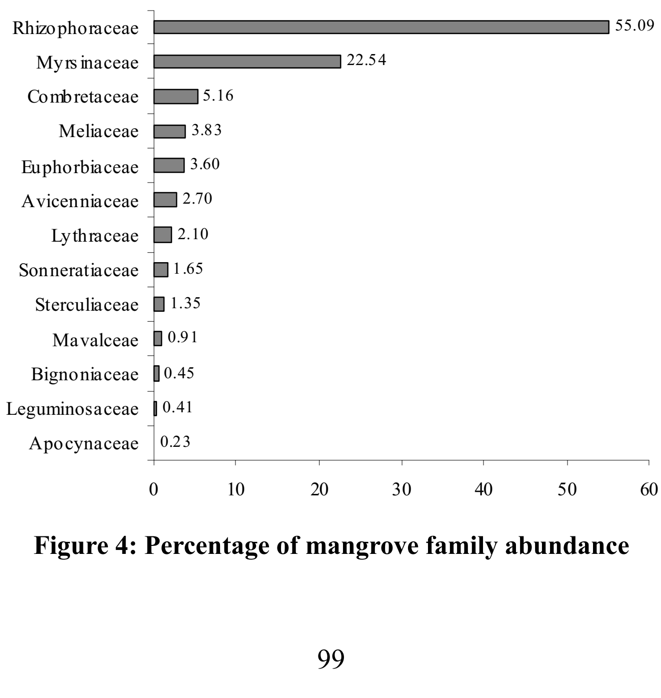

Figure 4: Percentage of mangrove family abundance

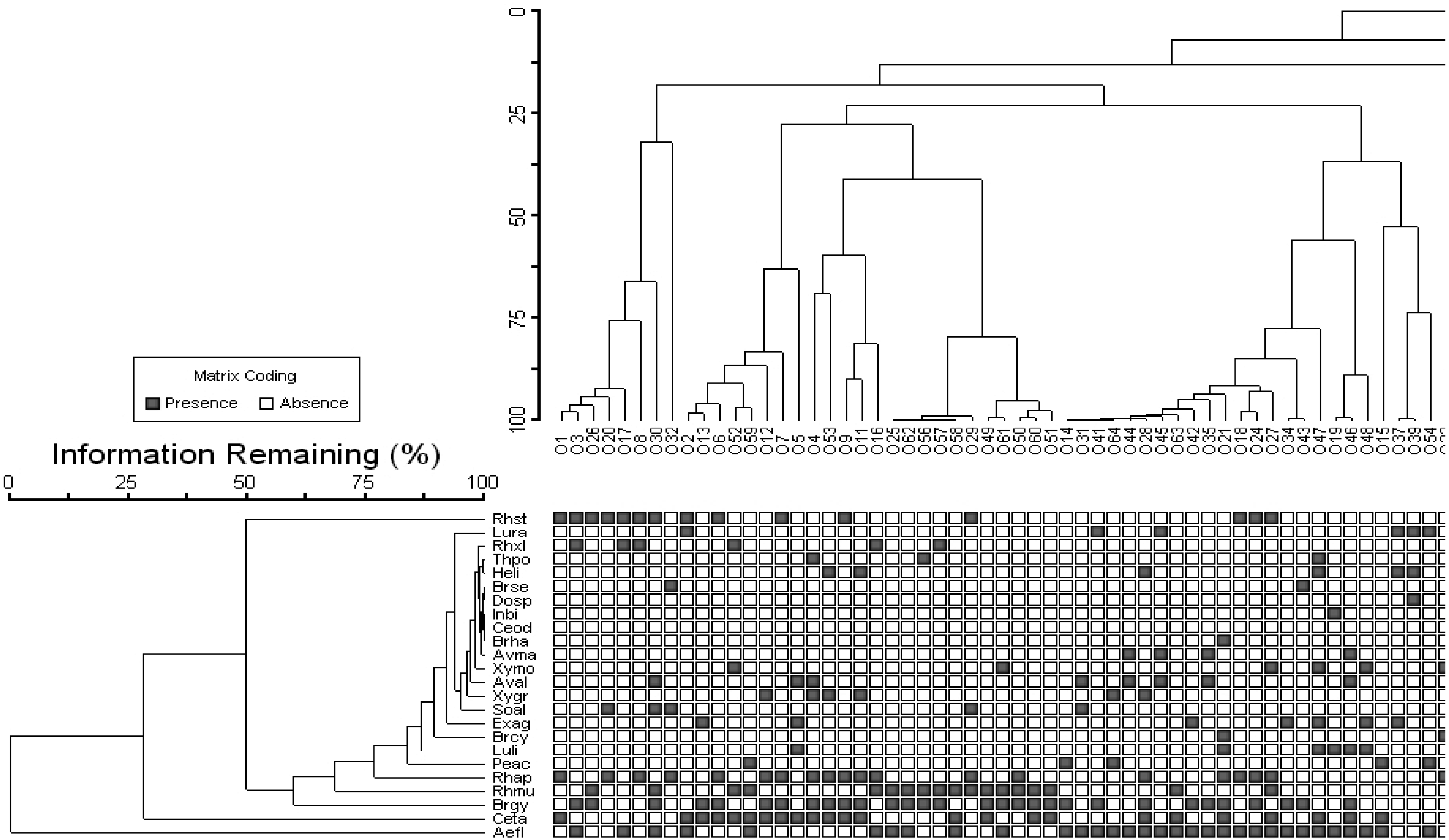

Figure 5: Two-way clustering of species and study plots

Table 1: Univariate measurements for mangrove tree in the Con Dao study sites

Zone	Location	S	N/100m^2	Margalef (d)	Piloue (J')	H' (loge)	Dominance (D)	Beta (ß)
1	Bo Dap - Bai Duong	3.81 ± 0.44	28.31 ± 1.59	0.94 ± 0.21	0.72 ± 0.11	0.96 ± 0.18	0.48 ± 0.10	3.934
2	Dam Tre	3.31 ± 0.32	15.50 ± 1.81	0.85 ± 0.11	0.68 ± 0.10	0.82 ± 0.15	0.54 ± 0.09	3.925
3	Dam Trau - Ong Cau	3.94 ± 0.60	19.94 ± 5.34	1.05 ± 0.21	0.75 ± 0.09	1.03 ± 0.19	0.45 ± 0.09	3.810
4	Dam Quoc - Dam The	4.00 ± 0.75	19.88 ± 2.56	1.02 ± 0.26	0.70 ± 0.09	0.96 ± 0.20	0.49 ± 0.09	4.500
	Con Dao	4.00 ± 1.07	20.90 ± 0.52	0.96 ± 0.38	0.71 ± 0.18	0.94 ± 0.34	0.49 ± 0.18	

S = Number of species, R = Margalef's richness, H' = Shannon diversity, J' = Pielou evenness, D = Simpson's dominance and. Means show ± confidence.

Table 2: Quantitative structure of mangrove tree of the Con Dao area

Specie's name	N/ha	RD(%)	RF(%)	RG(%)	IVI%	Rank
Aegiceras floridum Roem. & Schult	472	22.68	13.64	38.75	25.02	1
Bruguiera gymnorrhiza (L.) Lamk	236	11.34	12.40	10.46	11.40	2
Ceriops tagal (Perr.) C.B. Rob.	264	12.69	9.92	9.94	10.85	3
Rhizophora mucronata Lamk	214	10.29	7.44	10.68	9.47	4
Rhizophora apiculata Blume	161	7.73	8.26	7.22	7.74	5
Rhizophora stylosa Griff	189	9.09	6.20	5.73	7.01	6
Excoecaria agallocha L.	75	3.60	4.13	3.24	3.66	7
Xylocarpus moluccensis (Lam.) M. Roem	42	2.03	3.72	2.98	2.91	8
Lumnitzera littorea (Jack) Voigt	61	2.93	2.48	2.42	2.61	9
Xylocarpus granatum Koening	38	1.80	3.72	1.43	2.32	10
Heritiera littoralis Dryand	28	1.35	4.55	0.91	2.27	11
Sonneratia alba J. Sm.	34	1.65	*2.07*	2.78	2.16	12
Avicennia alba Blume	41	1.95	3.31	0.43	1.90	13
Lumnitzera racemosa Willd	34	1.65	2.89	0.60	1.72	14
Pemphis acidula J. R. Forst.& G. Forst	44	2.10	2.07	0.94	1.70	15
Bruguiera cylindrica (L.) Blume	48	2.33	1.24	0.83	1.46	16
Rhizophora x lamarckii Giff	25	1.20	2.48	0.21	1.30	17
Thespesia populnea (L) Soland ex Lorrea	19	0.90	2.48	0.26	1.21	18
Bruguiera sexangula (Lour.) Poir	13	0.60	2.07	0.03	0.90	19
Avicennia marina (Forssk) Vierk	16	0.75	1.65	0.03	0.81	20
Dolichandrone spathacea (L.) K.Sch.	9	0.45	1.24	0.04	0.58	21
Intsia bijuga (Colebr) O. Ktze	8	0.38	1.24	0.02	0.54	22
Cerbera manghas L.	5	0.23	0.41	0.03	0.22	23
Bruguiera hainesii C.G. Rogers	5	0.23	0.41	0.03	0.22	24
Total	2,081	100	100	100	100	

Following table (2) is illustrating highest density of mangrove trees: *Aegiceras floridum* (472 plants) and the lowest density *Bruguiera hainesii* (5 plants). Moreover, the highest relative density was found in *Aegiceras floridum* (22.68%) and the lowest was shown by *Bruguiera hainesii* (0.23%). On the other hand, the highest frequency was found in *Aegiceras floridum* (13.64%) and the lowest were found in *Bruguiera hainesii* and *Cerbera manghas* (0,41%). Furthermore, the highest abundance was measured in *Aegiceras floridum* (38.75%) followed by *Bruguiera gymnorrhiza* (10.46%) and the lowest abundance was shown by *Bruguiera hainesii, Cerbera manghas, Intsia bijuga*, *Thespesia populnea,Bruguiera sexangula, Avicennia marina*

The highest IVI was calculated in *Aegiceras floridum* (25.02) and the lowest IVI was shown by *Bruguiera hainesii* (0.22) in Table 2. There are 6 species having IVI higher 5% such as *Aegiceras floridum, Bruguiera gymnorrhiza, Ceriops tagal, Rhizophora mucronata, Rhizophora apiculata, Rhizophora stylosa* in which 5 species belongs to Rhizophoraceae. .

Ordination by PCA (Figure 6) of the data shows that species belong to Rhizophoracea is separated from the other sites of the plot. The first three components explain 64.02% of the variation in the data. Principal component 1 (x-axis) reveals 32.22% of the variation. Principal component 2 (y-axis) reveals 22.86% of the variation.

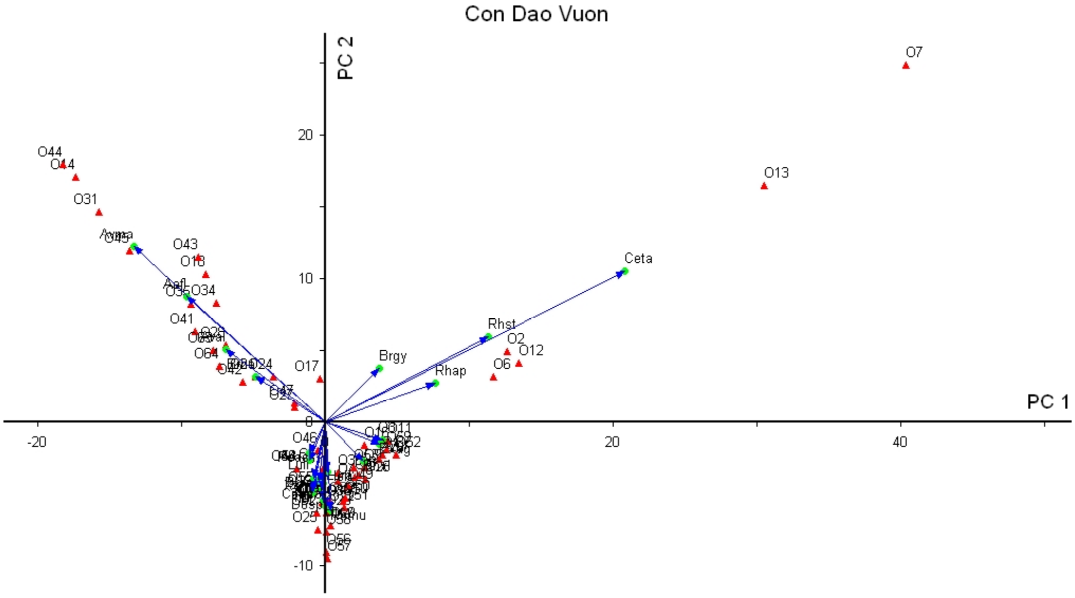

Figure 6: PCA ordination of species data for the study sites.

Table 3: Rare mangrove species of Con dao National Park

No	Species	Rare Index	Value Rarity
1	*Intsia bijuga* (Colebr) O. Ktze	98,44	RR
2	*Cerbera manghas* L.	98,44	RR
3	*Bruguiera hainesii* C.G. Rogers	98,44	RR
4	*Bruguiera cylindrica* (L.) Blume	95,31	MR
5	*Avicennia marina* (Forsk) Vierk	93,75	R
6	*Dolichandrone spathacea* (L.) K.Sch.	93,75	R
7	*Pemphis acidula* J. R. Forst & G. Forst	92,19	R
8	*Bruguiera sexangula* (Lour) Poir	92,19	R
9	*Sonneratia alba* J. Sm.	92,19	R
10	*Rhizophora x lamarckii* Giff	90,63	R
11	*Thespesia populnea* (L) Soland ex Lorrea	90,63	R
12	*Lumnitzera littorea* .JackVoigt	90,63	R
13	*Lumnitzera racemosa* Willd	89,06	R
14	*Avicennia alba* Blume	87,50	R
15	*Xylocarpus granatum* Koening	85,94	R
16	*Xylocarpus moluccensis* (Lam) M. Roem	85,94	R
17	*Excoecaria agallocha* L.	84,38	R
18	*Heritiera littoralis* Dryand	82,81	R

Note: R: rare species; MR: very rare species; RR: extremely rare species.

4. CONCLUSION

The study site on the island is bounded by sea. The study found 45 species in which 26 true mangrove species belonging to 11 families; 19 associated mangrove species in 15 families

Dominant family (Rhizophoraceae) is in consistent with the study. The highest IVI of *Aegiceras floridum* (25.02) and the lowest IVI was *Bruguiera hainesii* (0.22).

Diversity index varied with different groups as well as different zones of study. In the study areas the average species richness index is 4 and Shannon-Winner Index is 0.94. The range of species richness index for shrubs is 0 - 4 and the range of Shannon-Winner Index is 0.70 - 1.03.

With 3 mangrove species indicated as extremely rare species, *Intsia bijuga*, *Cerbera manghas* and *Bruguiera hainesii.* These species should be reintroduced in the Con Dao National Park to re-constitute by insitu and exsitu conservation.

Existing mangrove forests may act as a catalyst for successful natural forest succession of mangrove tree using the microclimatic, environmental conditions and water currents . Hence, may be creating a more favorable environment for the establishment of native mangrove forest and facilitate to attract fauna.

Ultimately, may be leading to conserving biological diversity. The study eventually concludes that a proper protection from human interferences and scientific research of the study area may lead a biodiversity rich site in the Con Dao National Park as well as in Viet Nam.

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APPENDIX

Two new mangrove species recognized in Con Dao National Park in Vietnam by Vien Ngoc Nam and et al, 2007

Figure 1: ***Bruguiera hainesii*** **C.G. Rogers**

Figure 2: ***Xylocarpus rumphii*** **(Kostel) Mabb**

Carbon Sequestration of *Ceriops Decandra* (Griff.) Ding Hou in Can Gio Mangrove Biosphere Reserve, Ho Chi Minh City, Vietnam

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SUMMARY

The study on carbon sequestration of *Ceriops decandra* on above ground is based on the methods of forest biomass. Research results indicated that the ability of carbon accumulation of natural *Ceriops decandra* populations in Can Gio Mangrove Biosphere Reserve.

The average density is 13,489 tree/ha, the average diameter at breast height (DBH) is 2.78 ± 0.18 cm, average height is 4.28 ± 0.26 m, the average carbon accumulation is 19,22 ± 3.36 tones C/ha. In which the rate of carbon accumulation of stem is the highest 10.51 ± 1.79 tones C/ha (55.05 ± 0.39%) range from 51.36 - 57.04%; carbon accumulation in branches is 4.88 ± 1.01 tones C/ha (24.42 ± 1.06%) and fluctuation is about 20.21 to 37.76% compared with the total volume of populations. Carbon accumulates in leaves at lowest rate comparing with the total volume of carbon in populations, the average is 3.84 ± 0.62 tones C/ha (20.53 ± 0.69 %) and the variation is from 10.88 – 22.78%.

1. INTRODUCTION

Mangrove is ecosystems especially the coastal areas of tropical and subtropical, it is important for the life of people in coastal areas as protection against the storm, create good conditions for alluvium deposition, alleviate the impact of natural disasters and floods, provide food, wood, non-timber forest products... Besides, mangroves also act as the research and tourist places, travel, rest, entertainment for everybody.

Can Gio Mangrove Biosphere Reserve is situated adjacent to the southeast of Ho Chi Minh City – Vietnam, an area of 71,361 hectares covering the many tree species as *Rhizophora apiculata*, *Rhizophora mucronata, Lumnitzera sp, Ceriops sp*, ... but *Rhizophora apiculata* is mainly dominant. Can Gio mangrove is "kidney" which filtrate waste water from upper stream and flow down before to the sea. During the period of 1965-1970, approximately 57% of mangrove area was destroyed by herbicide spraying (Ross, P. 1975), environmental changes, the land is harder, aquatic resource reduced drastically. From 1978 to present, Ho Chi Minh city have rehabilitated the mangrove ecosystems in Can Gio, forests grow and develop very well, the seafood increases, wild animal come back to the mangrove. Obvious values of Can Gio mangrove is needed to improve the ecological environment, creating landscapes for Ho Chi Minh City, is a factory which absorbs CO_2, supply of oxygen to the city.

Mangroves are not only great value for scientific, economic with people, the value used for the living of organism but also plays a vital role in the biological conversion of ecosystems, which is the process of cancellation, the accumulation of material on the forest floor, contributing to reduce the effects greenhouse. Effect greenhouse is issue that the scientists and many people are especially interested. There are many causes as climate change leads to the increase of air quality effects greenhouse, in which has CO_2. Forests can absorbs CO_2, so research capabilities for accumulating carbon by forest calculated by the CO_2 absorpbility of the forest is very necessary. Quantitative, assessment capabilities of carbon accumulation by forest trees is an important information for managers, forest business as well as for policy makers that is interested in the mechanism of clean development (CDM).

The objective of this study is conducted to collect information, scientific data about the natural *Ceriops decandra* as a based for calculation ability carbon accumulation and CO_2 absorpbility for payment of environment service, contributing economic and social development, environmental protection in Can Gio mangroves.

2. Materials and Methods

2.1. Study sites

Can Gio Mangrove Biosphere Reserve locate in the southern of Ho Chi Minh city about 45 km, the total area of 71,361 hectares in Can Gio district, Ho Chi Minh City, Vietnam, with geographical coordinate is as following:

+ 106^{0}16'12" - 107^{0}00'50"
+ 10^{0}22'14" - 10^{0}37'39"

The study areas are Forestry Compartment 10, 11, 12, 13, 17, 21 of Can Gio Mangrove Biosphere Reserve, Can Gio district, Ho Chi Minh City.

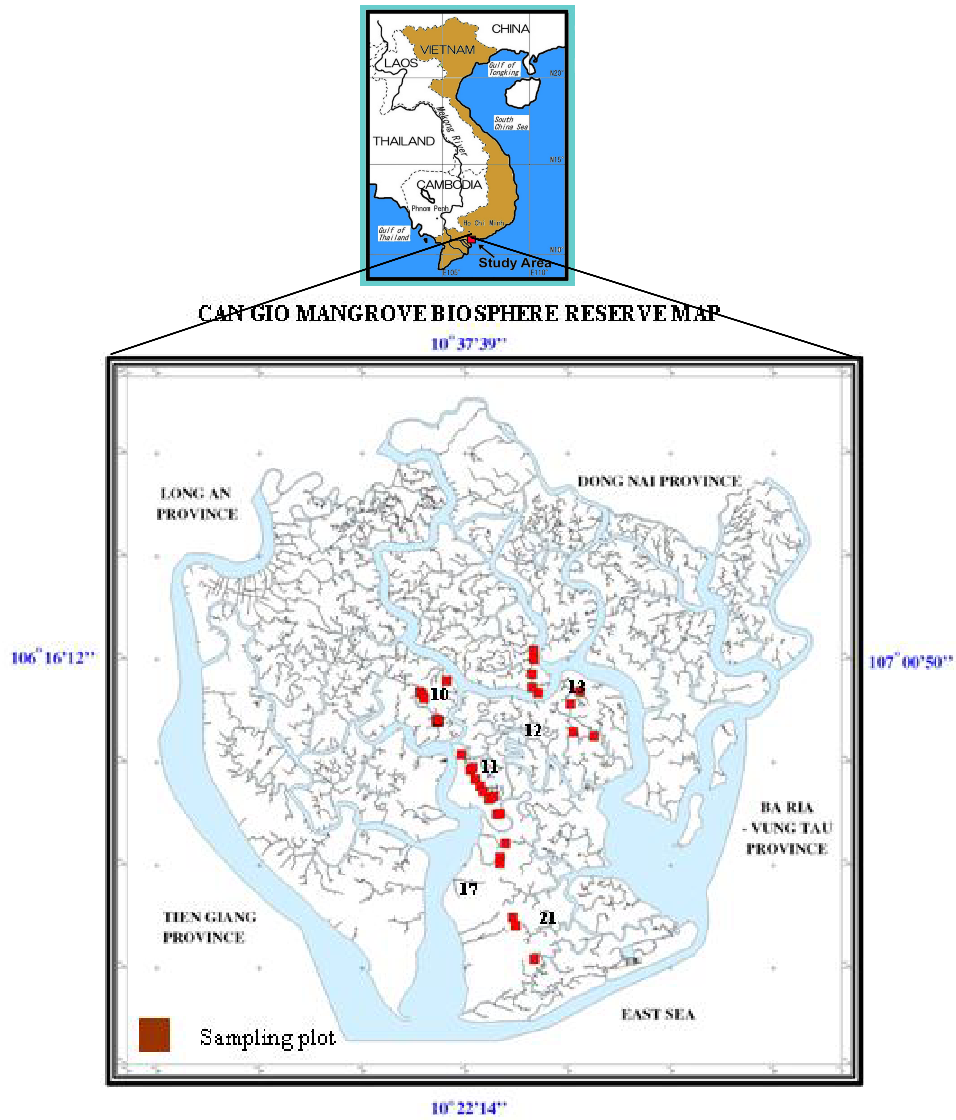

Figure 1: Location of study sites in Can Gio Mangrove Biosphere Research

- Sampling plots are determined on the forest map and satellite images of Can Gio district, then check in the field: the 35 plots determined in six Forestry Compartments.
- The size of plot is 10 m x 10 m = 100 m^2 (English, S., 1997). In each plot measures diameter at 1.3 m (DBH), total height and density.
- Select about 35 trees randomly to represent the full range of diameter (DHB) classes existing from minimum to maximum. Some part of the tree such as stem, branches, leaves weighted immediately in the field to obtain fresh weight.
- Felled trees for measurement (not disease, straight bole, steady canopy) are divided into the length of 1 m to determine D_1 (first position of tree), D_2 (second position), ... D_n; H_n (n position of the tree). Then volume trees were calculated in study area.
- The length of tree stem is divided in to 5 equal parts, each part gets 1 kg of wood and tie in nylon bags to the laboratory and dried at 105^0C until the weight does not change; to take 1 kg of leaves to laboratory and dried at 80^0C until the weight does not change. Then, the dried samples were calculated the amount of carbon.

2.3. Data analysis

- Determining the amount of carbon accumulated: Volume of carbon in dry biomass defined through coefficient conversion of parts as stem, branches, leaves with coefficient are 0.4535; 0:48; 0.5025 respectively. Carbon accumulation is calculated by multiplication the dried biomass of parts with the coefficient. Total carbon accumulation of trees is the total carbon accumulation of the parts: stem, branches, leaves. From carbon accumulation, the absorpbility of CO_2 by forests calculated by the method of NIRI (Institute Nissho Iwai-Japan): the CO_2 absorbed = Carbon accumulation * 44/12 or 1 tones carbon is equal to 3.67 tones of CO_2.

3. RESULTS AND DISCUSSIONS

3.1. Correlations between fresh biomass of parts of individual tree with $D_{1,3}$

The relationship of biomass is closely with diameter (DBH), height (H). The relationship between biomass and diameter are common use by measuring diameter directly and exactly and more accurate than height. Therefore, we use the relationship of the biomass with diameter ($D_{1,3}$) to determine biomass of individual trees.

Table 1: The equation of fresh biomass of parts of individual tree with $D_{1,3}$

Fresh Biomass	The equation of the fitted model	Correlation Coefficient (R)	Standard Error of Est. (SE)	F-Ratio
Total tree	$\ln(W_{total}) = -0.957098 + 2.36598*\ln(D_{1,3})$	0.9845	0.1845	1037.5
Stem	$\ln(W_{stem}) = -1.4971 + 2.30043*\ln(D_{1,3})$	0.9764	0.2227	673.65
Branches	$\ln(W_{branch}) = -2.88373 + 2.74036*\ln(D_{1,3})$	0.9707	0.2965	539.23
Leaves	$\ln(W_{leave}) = -2,15425 + 2,08752*\ln(D_{1,3})$	0.9580	0.2732	368.38

All the equations have high Correlation Coefficient (R) with R (0.9580 to 0.9845), standard error of Est. (SE) is small, and the F - Ratio value is higher than the F table at 95%, therefore the equation applied to calculate fresh biomass of *Ceriops decandra* in Can Gio.

Table 2: The equation between dry biomass of individual tree parts with $D_{1,3}$

Dry Biomass	The equation of the fitted model	Correlation Coefficient (R)	Standard Error of Est. (SE)	F-Ratio
Total tree	$\ln(W_{total}) = -1.5706 + 2.40729*\ln(D_{1,3})$	0.9829	0.1974	938.93
Stem	$\ln(W_{stem}) = -2.05418 + 2.34016*\ln(D_{1,3})$	0.9708	0.2530	539.92
Branches	$\ln(W_{branch}) = -3.40991 + 2.74679*\ln(D_{1,3})$	0.9708	0.2967	540.91
Leaves	$\ln(W_{leave}) = -2.95058 + 2.10343*\ln(D_{1,3})$	0.9576	0.2767	364.69

3.2. Relationship between dry biomass of individual tree parts with $D_{1,3}$

The correlation coefficient (R) is high with R = (0.9567 to 0.9829), standard error of Est. (SE) is small, and the F - Ratio value is larger than the F table at 95%, therefore we use the equation to calculate dry biomass of *Ceriops decandra* in Can Gio.

3.3. Correlations between total dry biomass and fresh biomass of *Ceriops decandra*

$$\ln(W_{total\ dry}) = -0.599 + 1.018*\ln(W_{total\ fresh})$$

$$R = 0.9996 \qquad SE = 0.0298$$

- Identifying dry biomass through fresh biomass is easy and accurate, the selected equation has high Correlation Coefficient (R) and standard error of Est. (SE) is small.
- So, relationship between total dry weight with the total fresh weight of tree can be applied in practical purpose, the total fresh weight of tree can measure in the field, the we use the equation to calculate the total dry weight of tree or stands.

3.4. Relationship between carbon accumulated in parts with $D_{1,3}$ of *Ceriops decandra*

The equations have high Correlation Coefficient (R = 0.9574 to 0.9821), standard error of Est. (SE) is small and the F - Ratio value is larger than the F table at 95%. Therefore, we use the equations to calculate the amount of carbon for *Ceriops decandra* in Can Gio.

Table 3: The equation between carbon accumulated in individual tree parts with $D_{1,3}$

Carbon accumulation	The equation of the fitted model	Correlation Coefficient (R)	Standard Error of Est. (SE)	F-Ratio
Total tree	$\ln(C_{total}) = -2.28073 + 2.37351*\ln(D_{1,3})$	0.9821	0.1579	899.56
Stem	$\ln(C_{stem}) = -2.77767 + 2.29021*\ln(D_{1,3})$	0.9686	0.2038	501.34
Branches	$\ln(C_{branch}) = -4.20606 + 2.78629*\ln(D_{1,3})$	0.9706	0.2204	536.70
Leaves	$\ln(C_{leave}) = -3.61105 + 2.0861*\ln(D_{1,3})$	0.9574	0.2071	362.69

3.5. Carbon accumulation and CO_2 absorbed by stand of *Ceriops decandra*

- Table 4 shows the average density of the *Ceriops decandra* populations is 13,489 ± 1,464 tree/ha, the highest density populations in the 4^{th} stand with 25,700 tree/ha, the lowest in populations in the 9^{th} stand with 2,600 trees/ha. The average diameter at breast height of stand is 2.78 ± 0.18 cm; the highest is in 31^{st} stand (4.14 cm) and the lowest is in 24^{th} stand (1.85 cm). The average height is 4.28 ± 0.26 m; the highest is 32^{nd} stand (5.79 m), the lowest is in 2^{nd} stand (2.91 m).
- Forest stand 4 and 17 have $D_{1.3}$ and Hvn low but high density, therefore the ability of carbon accumulate is high, the density factor affects to the ability of carbon accumulation of forest.
- In table 4 indicates that the rate of carbon accumulated mainly in parts such as stem biomass, the average is: 10.51 ± 1.79 tones C/ha, occupied 55.0 ± 0:39 %. The rate of carbon accumulation in the leaves is lowest; the average is 3.84 ± 0.62 tones C/ha occupied 20.53 ± 0.69%.

3.6. Absorptivity of CO_2 of *Ceriops decandra* populations

- The average ability of absorbed CO_2 of *Ceriops decandra* populations in Can Gio Mangrove Biosphere Reserve is 70.54 ± 12.34 tones C/ha with the average density is 13,489 ± 1,464 trees/ha, the average diameter is 2.78 ± 0.18 cm, average height is 4.28 ± 0.26m.
- Average density of the populations *Ceriops decadal* at plot 31 is 15,000 trees/ha, average diameter is 4.14 cm, average height is 5.66 m and the ability of accumulate carbon is highest in stand 35^{th}: 47.02 tones C/ha equivalent to the ability to absorbs CO_2 is 172.55 tones/ha. Similarly the average density of the populations *Ceriops decandra* at sampling plot 05 is 8,400 trees/ha, average diameter in the 1.3 m is 1.96 cm, average height is 3.35, the ability of accumulate carbon is lowest at 4.98 tones C/ha equivalent to the ability to CO_2 absorbs is 18.29 tones/ha. This factor structure of the forest reserves such as the diameter, height and density of forest trees are affected to the ability of carbon accumulated by forests.

Table 4: Carbon sequestration of *Ceriops decandra* stand in Can Gio

Stand	N/ha (Trees/ha)	$D_{1.3}$ (cm)	H (m)	C_{stem} (tone/ha)	$C_{branches}$ (tone/ha)	C_{leaves} (tone/ha)	C_{total} (tone/ha)	Total absorbs CO_2 esq. (tone/ha)
1	7,800	2.12	3.73	2.94	1.08	1.17	5.19	19.05
2	8,200	2.24	2.91	3.82	1.54	1.47	6.83	25.08
3	13,100	2.26	3.21	6.04	2.38	2.35	10.77	39.52
4	25,700	2.86	5.08	19.93	8.73	7.54	36.20	132.86
5	8,400	1.96	3.35	2.82	1.04	1.12	4.98	18.29
6	12,000	2.01	3.45	3.95	1.40	1.58	6.93	25.42
7	12,200	2.13	3.56	5.13	2.07	1.97	9.18	33.68
8	13,500	2.96	4.10	13.19	6.56	4.67	24.42	89.61
9	14,500	2.84	4.11	11.40	5.09	4.27	20.75	76.16
10	9,500	3.30	4.27	12.14	6.30	4.23	22.67	83.22
11	11,500	3.16	4.26	11.75	5.51	4.33	21.58	79.21
12	13,900	2.80	4.06	10.88	4.86	4.08	19.82	72.73
13	11,600	2.96	4.15	10.44	4.92	3.81	19.16	70.33
14	9,100	3.16	4.26	9.37	4.48	3.41	17.25	63.32
15	13,400	2.51	3.85	7.75	3.17	3.00	13.92	51.08
16	18,400	2.25	3.72	8.03	3.07	3.16	14.26	52.33
17	21,000	2.87	4.15	16.97	7.63	6.34	30.94	113.56
18	18,900	3.07	4.24	17.99	8.37	6.64	33.00	121.11
19	2,600	3.76	4.70	3.91	1.98	1.39	7.28	26.71
20	12,000	2.60	3.86	8.06	3.51	3.05	14.62	53.66
21	12,100	3.08	4.31	11.02	4.96	4.13	20.12	73.83
22	18,400	2.34	3.77	9.21	3.70	3.57	16.48	60.50
23	13,400	2.26	3.72	6.11	2.41	2.38	10.90	40.00
24	15,700	1.85	3.26	4.57	1.62	1.82	8.01	29.38
25	10,500	2.49	3.83	6.24	2.66	2.37	11.27	41.35
26	10,200	3.35	5.42	12.24	6.19	4.30	22.73	83.42
27	16,600	2.84	5.05	13.00	5.75	4.90	23.65	86.80
28	13,500	3.47	5.16	15.66	7.32	5.80	28.78	105.62
29	10,600	3.51	5.23	12.44	5.80	4.61	22.85	83.87
30	17,900	2.64	4.32	18.56	13.64	3.93	36.13	132.59
31	15,000	4.14	5.66	25.29	12.67	9.06	47.02	172.55
32	14,400	3.00	5.79	11.87	5.13	4.53	21.52	78.98
33	15,700	2.64	4.79	9.98	4.14	3.85	17.97	65.95
34	15,500	2.86	4.88	11.79	5.09	4.49	21.37	78.43
35	15,300	3.03	5.60	13.26	5.88	5.00	24.14	88.59
Average	**13,489 ± 1,464**	**2.78 ± 0.18**	**4.28 ± 0.26**	**10.51 ± 1.79**	**4.88 ± 1.01**	**3.84 ± 0.62**	**19.22 ± 3.36**	**70.54 ± 12.34**
Min	**2,600**	**1.85**	**2.91**	**2.82**	**1.04**	**1.12**	**4.98**	**18.29**
Max	**25,700**	**4.14**	**5.79**	**25.29**	**13.64**	**9.06**	**47.02**	**172.55**

3.6. Absorptivity of CO_2 of *Ceriops decandra* populations

- The average ability of absorbed CO_2 of *Ceriops decandra* populations in Can Gio Mangrove Biosphere Reserve is 70.54 ± 12.34 tones C/ha with the average density is 13,489 ± 1,464 trees/ha, the average diameter is 2.78 ± 0.18 cm, average height is 4.28 ± 0.26m.

- Average density of the populations *Ceriops decadal* at plot 31 is 15,000 trees/ha, average diameter is 4.14 cm, average height is 5.66 m and the ability of accumulate carbon is highest in stand 35th: 47.02 tones C/ha equivalent to the ability to absorbs CO_2 is 172.55 tones/ha. Similarly the average density of the populations *Ceriops decandra* at sampling plot 05 is 8,400 trees/ha, average diameter in the 1.3 m is 1.96 cm, average height is 3.35, the ability of accumulate carbon is lowest at 4.98 tones C/ha equivalent to the ability to CO_2 absorbs is 18.29 tones/ha. This factor structure of the forest reserves such as the diameter, height and density of forest trees are affected to the ability of carbon accumulated by forests.

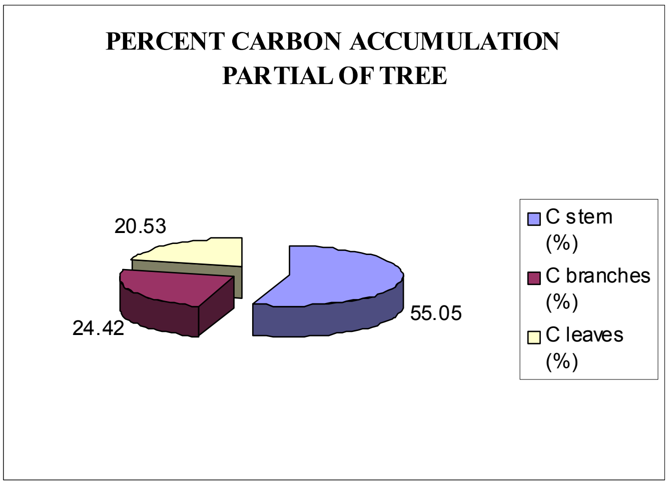

Figure 2: Percentage of carbone accumulation in tree parts

- Graph in Figure 2 showing the percentage of carbon accumulated mainly in the stem (average is 10.51 ± 1.79 tones C/ha occupied 55.05 ± 0.39%. The rate of carbon accumulation in the leaves is lowest (3.84 ± 0.62 tones C/ha, occupied 20.53 ± 0.69%.

3.7. The estimation of economic value of absorbed CO_2

The result in table 5 indicates that the value of commercial of CO_2 Esq. of *Ceriops decandra* forest areas in Can Gio Mangrove Biosphere Reserve. The capacity of forest stands absorbed CO_2 is 70.54 tones/ha, the value revenue from CO_2 is about 775.94 USD/ha. This can be used to calculate the potential for payment of environment service and determine the beneficial sources of income, which is useful and meaningful for forest management and conservation in Can Gio.

Table 5: The predicted economic value of the amount of CO_2 absorbed to the *Ceriops decandra* stand in Can Gio

The amount of absorbed CO_2 esq. (tone/ha)	Price (USD/tone CO_2)	Value (USD/ha)
70.54	11	775.94

4. CONCLUSION

- The average density of *Ceriops decandra* is 13,489 trees/ha, the average diameter at breast height (DBH) is 2.78 ± 0.18 cm, average height is 4.28 ± 0.26 m, the average carbon accumulation is 19,22 ± 3.36 tones C/ha. In which the rate of carbon accumulation in stem is the highest (10.51 ± 1.79 tones C/ha) occupied (55.05 ± 0.39%). Carbon accumulation in branches is 4.88 ± 1.01 tones C/ha (24.42 ± 1.06%) and fluctuation is about 20.21 to 37.76% compared with the total volume of populations. Carbon accumulated in leaves is lowest rate compared with the total volume of carbon in populations, the average is 3.84 ± 0.62 tones/ha (20.53 ± 0.69 %) and the variation is 10.88 – 22.78%.

- The structure of the forest such as the diameter, height and density of forest trees are affected to the ability of carbon accumulate.
- The capacity of average absorbed CO_2 esq. of *Ceriops decandra* forest in Can Gio Mangrove Biosphere Reserve is 70.54 tones/ha, the value in revenue from CO_2 is about 775.94 USD/ha.
- Application of research results to other mangrove species at large scale in Can Gio as well as in Vietnam

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Assessing Potential Impacts of Sea Level Rise on Coastal Areas in Songkla Lake Basin Using GIS and Remotely Sensed Data

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ABSTRACT

Due to its long coastline and relatively low elevation, Songkla Lake Basin's coast is particularly vulnerable to catastrophic inundation as a result of sea level rise. Such an extreme event presents a threat to the basin's development strategies by damaging coastal infrastructure and productive capacity, interrupting economic activity, and degrading the coastal environment. This study presents an assessment of the potential impacts of sea level rise on the basin's coastal sub-districts. Static 0.5, 1.0 and 3.0 m rises in the current sea level were simulated using a DEM constructed from elevation datasets in a GIS environment. The results showed that, after a simulated static 0.5 m rise in sea level, approximately 13,942 ha or 41.9% of the study area would be inundated. With the 0.5 m sea level rise scenario, a total of 3,133 ha of shrimp farm land, 8,958 ha of agricultural land, and 1,056 ha of urban areas would be susceptible to inundation. With the second scenario, approximately 16,875 ha or 50.7% of the study area would become inundated under a 1 m sea level rise condition, with adverse impacts on 4,066 ha of shrimp farm area, 10,251 ha of agricultural land, and 1,432 ha of urban areas. With the worst case scenario of a 3.0 m sea level rise, approximately 23,878 ha or 71.7% of the study area would become completely inundated, with a total of 5,973 ha of shrimp farm land, 13,877 ha of agricultural land, and 2,488 ha of urban areas threatened by inundation. It is interesting to note that, after the modeled 3 m rise in sea level, all of the mangrove forests in the study area would be lost through inundation. Such inundation information under sea level rise scenarios simulated in this study is vital for the adoption and implementation of adaptation measures to address the potential impacts of sea level rise in the future.

Keywords: Sea level rise, coastal areas, adaptation measures, remotely sensed data, GIS

INTRODUCTION

Coastal zones are among the most dynamic and productive areas and, as such, have attracted considerable human settlements, tourism facilities and infrastructure, and economic development activity. Many of these coastal areas are particularly vulnerable to inundation from sea level rise caused by both oceanic thermal expansion and the melting of Artic and Antarctic glaciers as consequence of global warming. A sea level rise of 0-1 m has been estimated as possible during the 21^{st} century (IPCC, 2001; IPCC 2007). Continued growth of greenhouse gas emissions and associated global warming could promote sea level rise of 1–3 m in this century, and unexpectedly rapid breakup of the Greenland and west Antarctic ice sheets might produce a 5 m sea level rise (Dasgupta et al., 2007). The projected rise in sea level is likely to pose a significant threat to low-lying coastal areas and river deltas, which are already under pressure from a combination of natural processes and anthropogenic activities. Direct implications of this coastal hazard include increased risk of inundation, exacerbation of coastal erosion, saltwater intrusion into lakes, rivers and streams, contamination of coastal property and infrastructure, and loss of wetland (Nicholls, 1995; Mimura, 1999). While sea level rise will only directly impact the coastal area, such changes raise significant concern due to high concentrations of coastal population and natural and socio-economic values located along the coastal zone. In addition to inundating low-lying coastal areas, rising sea level increases the vulnerability of coastal regions to flooding caused by storm surges and tsunamis. As the sea level rises, storms of a given magnitude may reach higher elevations and produce more extensive areas of inundation (FitzGerald et al., 2008).

Songkla Lake Basin is located on the eastern coast of the southern Thai Peninsula, between latitudes N $6^{o}\,27^{'}$ and $8^{o}\,12^{'}$ and longitudes E $99^{o}\,44^{'}$ and $100^{o}\,41^{'}$. The basin stretches 150 km from Nakhon Sri Thammarat Province to the State of Kedah in Malaysia, and varies in width from 50 to 65 km in the east-west direction. The lake basin covers an approximate area of 8,463 km^2, of which 1,043 km^2 or 12.3% is open water in the form of three interconnected lakes: Thale Noi, Thale Luang and Thale Sap Songkla (Figure 1). The basin's coastal sub-districts are sparsely populated communities with about 230,412 people inhabiting 33,299 km^2. The basin's coastal area, extends 99.5 km along the Gulf of Thailand, is crowded with residential, industrial and tourism-related development. Development along the coast varies from heavily urbanized centers, such as Mueang District, Songkla Province, which lies to the south of the basin, to rural areas in Ranot and Sathing Phra Districts to the north of the basin. With its long coastline and its relatively low elevation, Songkla Lake Basin's coast is considered to be vulnerable to the impacts of global climate change such as accelerated sea level rise, which will exacerbate the stress on coastal areas. In response to the phenomenal growth of the aquaculture industry, cultured ponds have replaced much of the mangrove forests along the coastal shores of the basin. As a result, the basin's coastal area is becoming increasingly vulnerable to catastrophic inundation as a result of sea level rise. Rising sea level and consequent coastal inundation result in economic repercussions in relation to coastal agriculture, aquaculture, and tourism industries – on which coastal communities heavily depend. Over the next century, the rate of sea level rise will increase with global warming (IPCC 2007), and hence the impact of this hazard on the low-gradient coastal areas is expected to be catastrophic. There is therefore a compelling need to model the estimated impact of significant sea level rise.

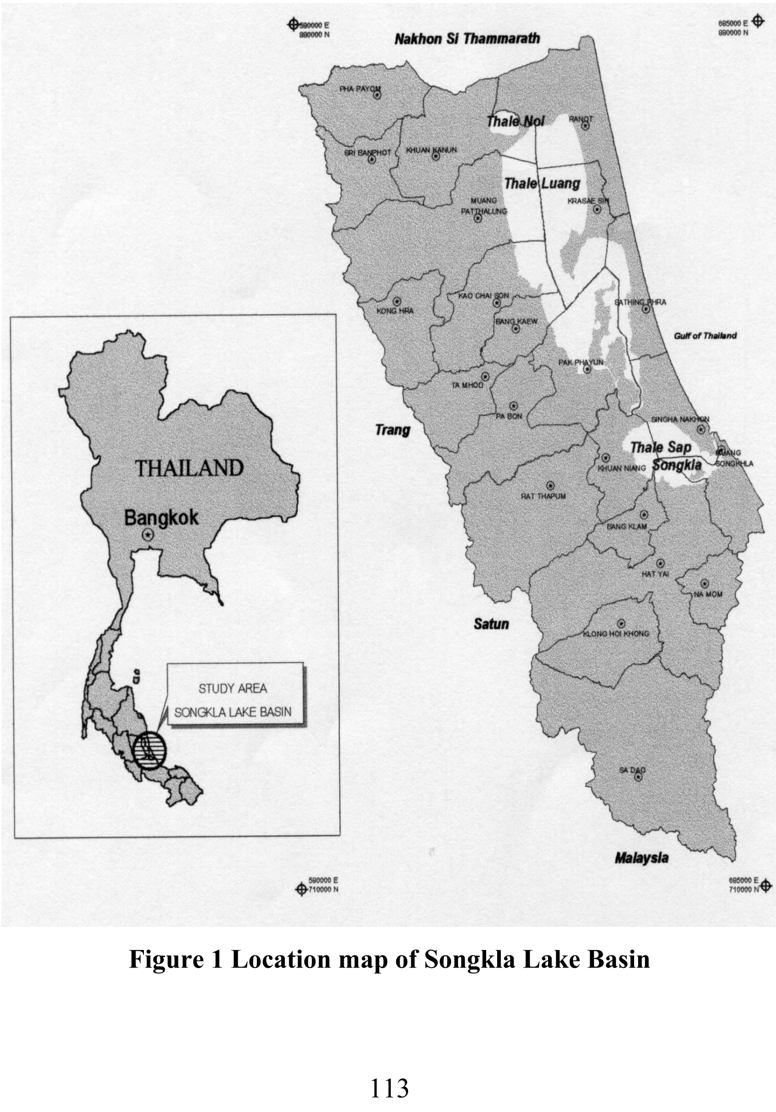

Figure 1 Location map of Songkla Lake Basin

The objective of this study was to identify and quantify the potential impacts of rising sea level through inundation in the coastal sub-districts of Songkla Lake Basin using remotely sensed data and Geographic Information Systems (GIS). In this study, the coastal areas that are most likely to be inundated as a result of sea level rise projections of 0.5 m, 1.0 m and 3.0 m are delineated. The 0.5 m and 1.0 m scenarios correspond to the most commonly predicted extent of sea level rise over the next century (Church et al., 2001). The projected sea level rise of 3.0 m represents the worst case scenario of a rising sea. Considering the profound impacts sea level rise can have on coastal settlements, development and ecosystems, appropriate and adequate adaptation measures to address the potential impacts of sea level rise are also discussed in this study.

MATERIALS AND METHODS

1. Materials

1) Topographic maps on a 1:50,000 scale in L7018 series, pertaining to the coastal sub-district in Songkla Lake Basin, published by the Royal Thai Survey Department.

2) Landsat-5 TM Satellite Images of 2006 on a 1:50,000 scale, pertaining to the area of concern, produced by the Geo-Informatics and Space Technology Development Agency (GISTDA).

3) Digital elevation data derived from aerial photographs at a 1:4,000 scale, pertaining to the basin's coastal area, produced by the Department of Public Works and Town and Country Planning.

4) Tide Tables for 2006, published by the Hydrographic Department, the Royal Thai Navy.

2. Methods

ArcGIS 9.2 software was employed for analysis and coverage overlays in this study. Shoreline data layers were derived from the Landsat-5 TM imageries of 2006 which were already in digital format. The shoreline was delineated as to where the water meets the surface topography of the land (Boak and Turner, 2005). Digitization of the basin's shoreline from geo-referenced images was carried out on the computer screen. Corrections for tide were calculated from the tide tables.

Elevation data derived from the 1:4,000 aerial photographs were used to develop a Digital Elevation Model (DEM) of the coastal sub-district areas of Songkla Lake Basin. Field surveys were also conducted using survey instruments including a theodolite and a global positioning system (GPS) to aid in the construction of the DEM. Coastal land use types, such as agricultural land, aquaculture areas and urban areas were extracted from a land use map, digitized on a computer screen from 1:50,000 Landsat TM images acquired in 2006. Ground truthing was also performed to check the accuracy of image interpretation and record the local tidal datum. Future sea level rise projections of 0.5, 1.0 and 3.0 m were applied to the DEM to illustrate the extent to which coastal areas are likely to be inundated from sea level rise. The map of inundation area projected for each sea level rise scenario was overlaid upon the coastal land use maps in ArcGIS environment to identify critical impacted areas that would be inundated.

RESULTS AND DISCUSSIONS

A rise in sea level has major implications for coastal areas in terms of inundation. Table 1 summarizes the inundated areas under each sea level rise scenario and its corresponding percentage of the basin's coastal area. Assuming no adaptive response and neglecting erosion, it was estimated that 13,942 ha or 41.9% of the coastal area would regularly be lost through inundation by the ocean or is at risk of periodic inundation due to storm events in a scenario of a 0.5 m rise in the current sea level (Figure 2). Increases of 1.0 and 3.0 m in sea level would probably cause land loses of 16,875 ha and 23,878 ha, respectively, or 50.7% and 71.7% of the total coastal area of the basin (Figure 3 and 4).

Table 1 Inundation area under each sea level rise scenario.

Sea level rise scenario	Inundated area (ha)	% of total coastal area
0.5 m	13,942	41.9
1.0 m	16,875	50.7
3.0 m	23,878	71.7

Assuming that land use types in the future would remain the same as the current pattern and there is no structural works to protect against inundation, a scenario of a 0.5 m rise in the current sea level would subject 8,958 ha or 41.9% of agricultural land to inundation, a 1.0 m increase would inundate 10,251 ha or 48.0% of its total area, and a 3.0 m increase in sea level rise would flood 13,877 ha or 65.0% of its total area (Table 2). Concerning shrimp farm area, a sea level rise of 0.5 m would impact 3,133 ha or 48.7% of its total area and a 1.0 rise in sea level is predicted to affect 4,066 ha or 63.2% of its total area, and a 3.0 m increase in sea level rise would impact 5,973 ha or 92.8% of its total area. As for the urban areas, a total of 1,056 ha or 34.2% of its total area are predicted to become inundated by a 0.5-meter sea level rise. This would increase to 1,432 ha or 46.4% of its total area in a 1.0 m sea level rise scenario, and to 2,488 ha or 80.6% of its total area in a 3.0 m sea level rise scenario. Regarding mangrove forests, a total of 45 ha or 75.0% of its total area would be inundated by a 0.5-meter rise of sea level. The inundated mangrove area would increase to 51 ha or 85.0% of its total area in a 1.0 m sea level rise scenario, and to 60 ha or 100.0% of its total area in a 3.0 m sea level rise scenario (Table 2).

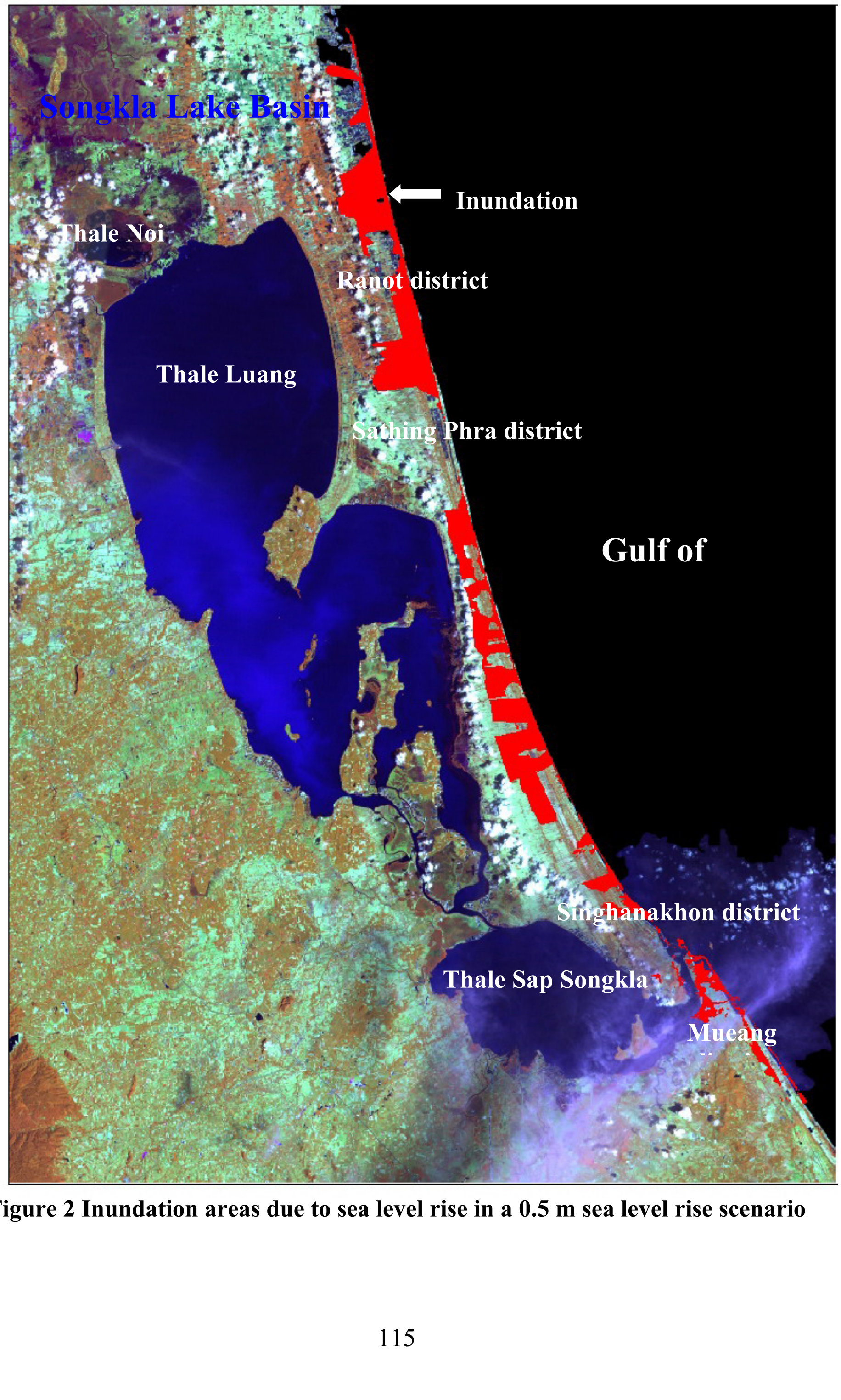

Figure 2 Inundation areas due to sea level rise in a 0.5 m sea level rise scenario

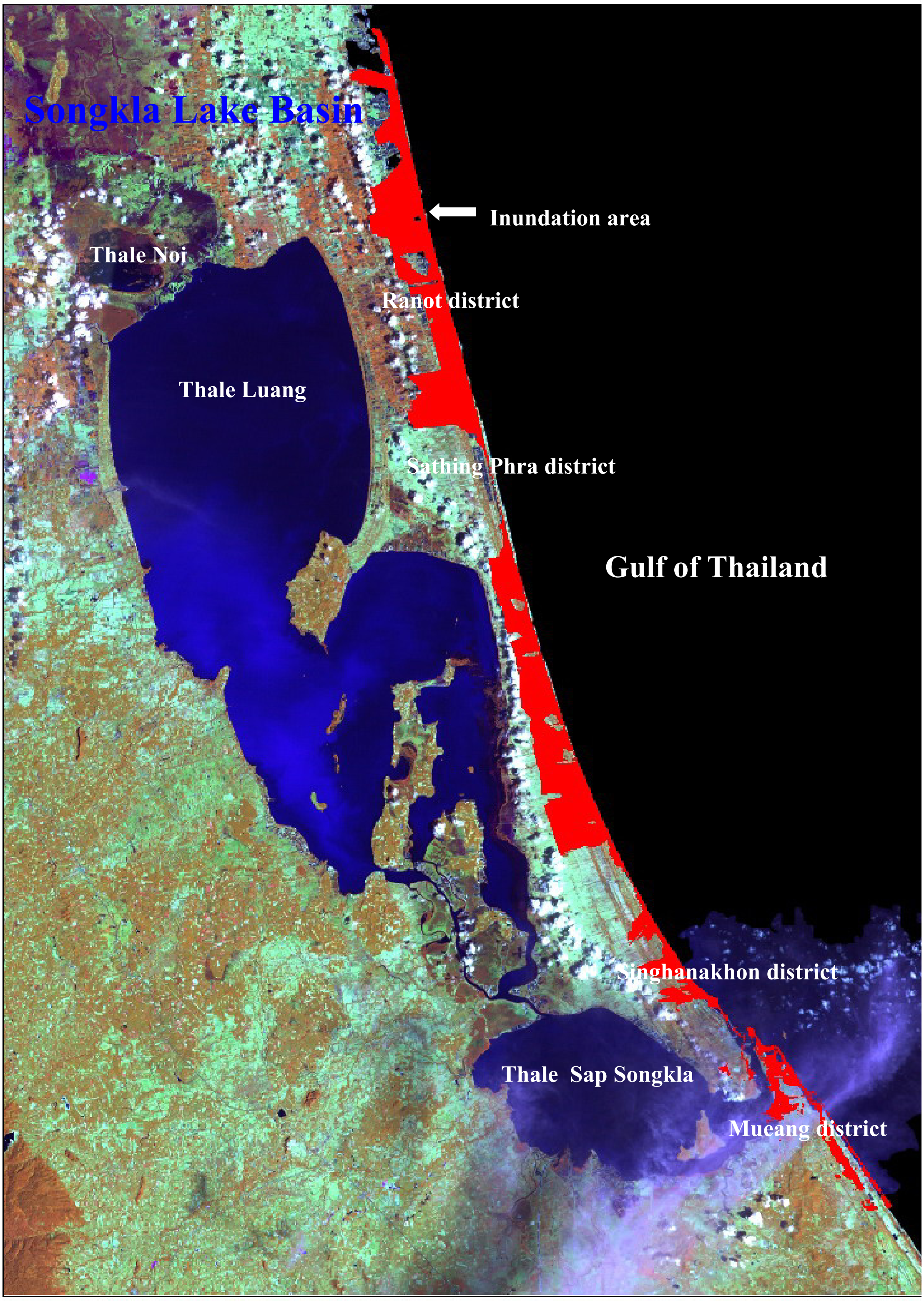

Figure 3 Inundation areas due to sea level rise in a 1.0 m sea level rise scenario.

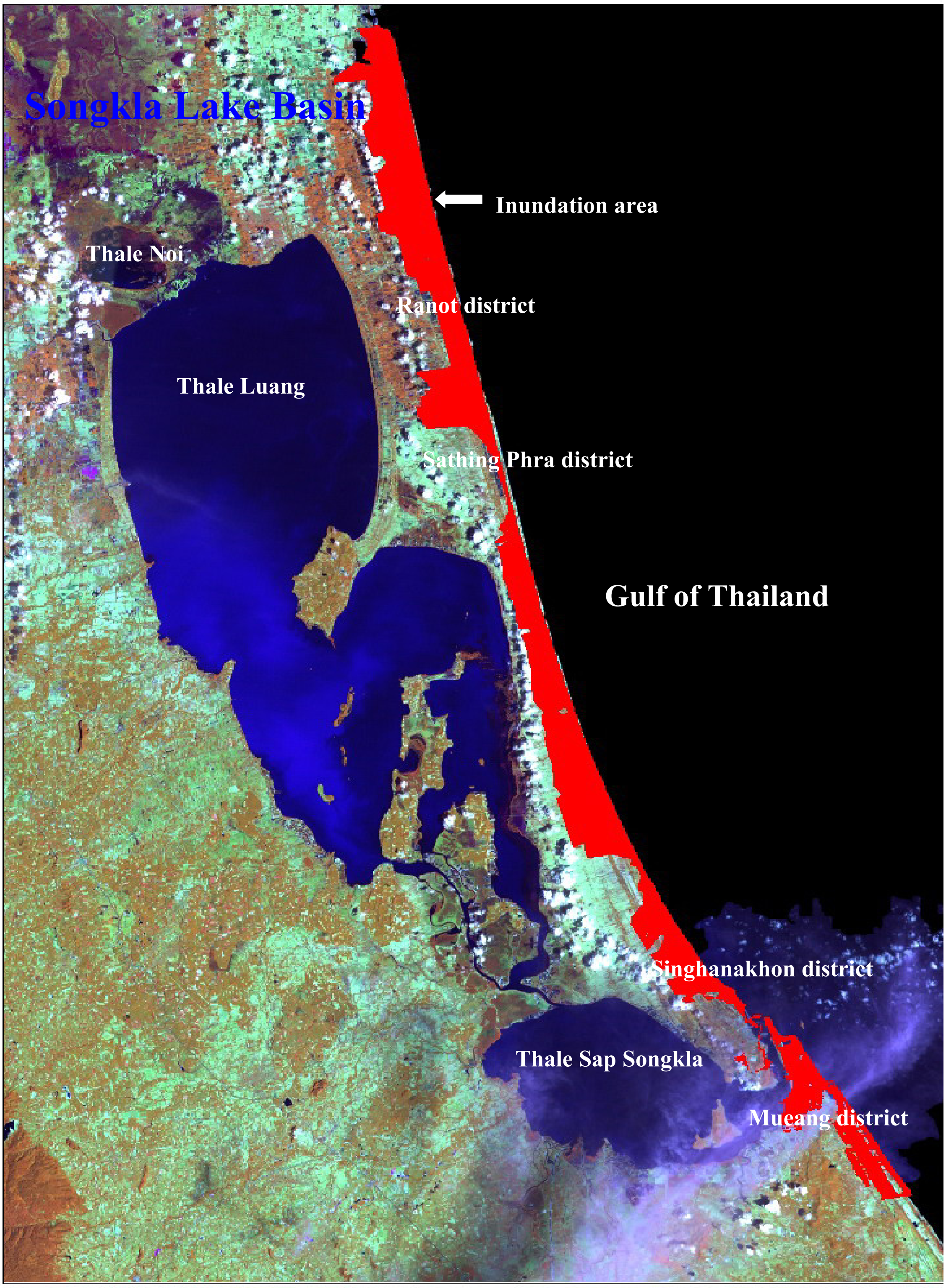

Figure 4 Inundation areas due to sea level rise in a 3.0 m sea level rise scenario.

Table 2 Impacts of sea level rise on coastal land use under different sea level rise scenarios.

Land use type	Existing area		0.5 m sea level rise scenario		1.0 m sea level rise scenario		3.0 m sea level rise scenario	
	ha	% of total area (ha)	Impacted area (ha)	% of its area	Impacted area (ha)	% of its area	Impacted area (ha)	% of its area
Forest	368	1.1	18	4.9	20	5.4	26	7.1
Agricultural land	21,361	64.2	8,958	41.9	10,251	48.0	13,877	65.0
Shrimp farm	6,434	19.3	3,133	48.7	4,066	63.2	5,973	92.8
Mangroves	60	0.2	45	75.0	51	85.0	60	100.0
Fresh water swamp	176	0.5	1	0.6	30	17.0	49	27.8
Open water	104	0.3	19	18.3	36	34.6	72	69.2
Urban	3,088	9.3	1,056	34.2	1,432	46.4	2,488	80.6
Miscellaneous	1,708	5.1	712	41.7	989	57.9	1,333	78.0
Total	33,299	100.00	13,942		16,875		23,878	

Given a 0.5 m rise in the current sea level and no coastal defences, mangrove forests would be the most severely impacted with a loss of over 45.0 ha or 75.0% of their total area, followed by shrimp farm areas with a loss of 3,133 ha or 48.7% of the total area, and agricultural land with a loss of 8,958 ha or 41.9% of their total area. It is of interest to note that, without coastal protection practices, all of the mangrove forests could be lost due to sea level rise, followed by shrimp cultivation areas (a loss of 92.8% of their total area), and urban area (a loss of about 80.6% of the total area) for a 3.0 m sea level rise. The removal of protective coastal feature particularly mangroves contributes to the degradation of ecological functions of coastal ecosystems, which, in turn, leads to increased flood risk. Another feature of interest is that forested areas are projected to be the least impacted of the land use types, losing only 20 ha or 5.4% of their total area under the median sea level rise scenario of 1.0 m, and losing only 26 ha or 7.1% of their total area even under the maximum rise scenario of 3.0 m (Table 2). This is because they are located on relatively higher elevation away from the coast and thus are immune to the effect of a rising sea.

It should be stressed that the potential impacts of sea level rise due to climate change will vary from place-to-place because of the difference in the locality's oceanographic response to sea level rise and the uplift of subsidence of the land surface (Klein and Nicholls, 1998). Further, geologic setting, coastal morphology, wave action, and storm frequency play an important role in the magnitude and impacts of sea level rise (Gornitz, 1991). The ultimate impact to coastal development and population due to inundation as a result of sea level rise depends on coastal processes and future adaptations.

The impacts of sea level rise in the basin are potentially catastrophic for coastal population, their livelihoods, infrastructure and ecosystems. Thousands of the basin's coastal inhabitants are likely to be displaced by sea level rise and accompanying economic damage will be severe for many. Buildings, households, communities, business establishments, tourism facilities and infrastructure located on a narrow strip along the shorelines will be significantly impacted. Productive coastal land and coastal livelihoods will be lost. Saltwater incursion may alter fresh water swamps and mangrove estuaries, deteriorate coastal water and soil qualities, and spread diseases such as malaria (FitzGerald et al., 2008). The rising sea may also cause saltwater intrusion into the freshwater lake system, affecting its life supporting functions and the ecosystem's ability to sustain human activity. Furthermore, inundations of coastal wetlands alter plant composition and modify fish and wildlife populations resulting in far reaching ecological consequences. Thus, without human adaptation, by 2100 Songkla Lake Basin would experience substantial loss and alteration of the coastal areas due to inundation, causing widespread impacts on coastal settlements, developments and ecosystems. Since a sea level rise in the range of 1-3 m is regarded as realistic (Dasgupta et al., 2007) and adaptive responses require time to accomplished, there is a need to start strategic planning for timely and appropriate responses to meet the challenges of this coastal hazard in the future.

ADAPTING TO SEA LEVEL RISE

It is widely recognized that the adaptation strategies to managing coastal inundation risks under conditions of sea level rise consists of various options that fall under 3 broad approaches; namely, retreat, accommodation and protection (Klein et al., 2001). Examples of the retreat option include the abandonment of lands and structures in coastal areas at risk of flooding and the relocation of threatened assets, tourist facilities or infrastructure away from the coasts to avoid or eliminate a direct impact of sea level rise. For Ranot and Sathing Phra Districts in Songkla Lake Basin, which are mostly rural in nature with many small villages, it may not be feasible to undertake large-scale coastal defences to protect vulnerable areas simply because the immediate costs of construction are often more than offset by the value of coastal land and infrastructure that would otherwise be lost to inundation (Brooks et al., 2006). In this case, the option of retreat may be the only viable response (Gravelle and Mimura, 2008). The accommodation option allows occupancy in the areas at risk of inundation to continue with reinforced structures and stronger building codes to minimize impacts. Under this option, setback lines are created and strictly enforced to restrict new human settlements and future development activities within a prescribed distance from the shoreline to diminish losses to life and property from sea level rise. The accommodation option may also involve efforts to enhance coastal resilience through the restoration and preservation of natural barriers to the impacts of sea level rise such as coral reefs and mangroves. For Mueang District, which is the basin's extensively developed and populated area with a high degree of infrastructure and sea port, the option for retreat is limited so protection option remains the only viable future solution. The protection action offers benefits in protecting against inundation through the installation of hard engineering structures such as seawalls, dikes, levees and revetments, and/or the deployment of soft engineering schemes including beach nourishment and elevating land surfaces with fill. Such endeavors, however, can be extremely costly and may not be in the best interest of the coastal environment. In practice, there is no single option which is best or most effective in addressing the impacts of sea level rise in isolation. Appropriate adaptation strategies may incorporate multiple approaches, including retreat, accommodation and protection strategies, depending on economic, social and ecological considerations. To be most effective, the development and implementation of strategies for adapting to a rising sea will require an active involvement of all stakeholders such as government departments, private sectors, and the local communities that are directly affected. The strategies are also most effective when they are incorporated into the country's Economic and Social Development Plan (Mimura, 1999). For mitigation, governments at all levels should take initiatives to stop deforestation and control the use of fossil fuel to reduce greenhouse gas emissions in order to minimize future impacts of global warming and hence sea level rise.

In summary, this study has demonstrated that remotely sensed data and GIS are valuable tools for assessing potential impacts of sea level rise under future climate change. The results obtained make it possible to plan for the protection of existing buildings and infrastructure and to discourage the construction of buildings or other infrastructure in areas that are likely to be impacted by sea level rise. Identification of the areas at risk of flooding from the predicted rise in sea level is necessary for the comprehensive sea level rise adaptation planning and management strategies. It is important to recognize that the models used in the present study can not represent the effects of future shoreline changes arising from erosion, accretion and land subsidence. Moreover, the models do not take account of adaptation in the form of coastal protection structures such as seawalls and dikes. Such protection may result in a considerable reduction in land lost, thus affecting the accuracy of this study's results. Inundation area as a result of a rising sea delineated in this study must therefore be interpreted with recognition of such limitations.

ACKNOWLEDGEMENTS

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Relationships between Acid Sulfate Soils and Landforms in Nakhon Si Thammarat, Thailand

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ABSTRACT

Characteristics of acid sulfate soil and landforms of its distribution in Nakhon Si Thammarat Thailand was studied. Landforms of areas are classified as hill and mountain, low relief alluvial fan, depression, former backswamp, mudflat and sand barrier, old beach ridge and recent tidal flat. The geologic surface are classified from bottom to surface as marine clay, tidal sediment, fluvial sediment and organic rich topsoil, respectively. Radio carbon dating results show age of fossils in sediment is 5000-7000 cal. yr BP. Acid sulfate soil mostly occupies in the area of former backswamp which enclosing old beach ridges. It is difference of elevation between lowland and upland in area, lowland including acid sulfate soil area is lower than 5 m whereas upland is higher than 10 m. The six soil samples were studies in the area, they are grouped as acid sulfate soil and non acid sulfate soil. Characteristics of acid sulfate soils are dark gray to dark brown silt to silty clay with plant fragments topsoil, it has pH 4.5-6.0. This horizon overlay gray silt with orange, red and yellow mottles and plant fragments, some profiles have blackly to dark brown peat, pH value is 4.0-5.0 and 4.0 at horizon contains yellow mottles. The lower part of two profiles is gray silt to silty clay with plant fragments, peat, dark brown, and black organic, it has high pH value 5.5-8.0. The bottom of is brownish gray to dark gray silty clay without molltle, pH 7.0 has found at the bottom of profile in only one site. However, the lower of profile of anothor one has bluish gray silty clay with a few plant fragments, thin sand layers and shell fragments, it has pH 8.0. Non acid sulfate soils, they have gray with brown and yellow mottles, silt to silty clay top soil. Subsoil is gray silt with small brown and orange mottles, and containing thin very fine sand layers and plant fragments. The bottom is gray and bluish silt with brown and orange mottles, thin sand layers, shell and a few plant fragments. They have high pH value thoughout profiles, 6.0-7.0 at upper part and 8.0 at lower part. To compare characteristics of the soils, acid sulfate soil has massive peat and plant fragment containing, very low pH value as 4.0 and yellow mottles in actual acid sulfate soil and high pH in potential acid sulfate soil which containing sulfidic material. The results could be considered that sulfidic material in the acid sulfate soil was formed in the period of Holocene sea transgression as former backswamp which covering with mangrove forest. Then the sea regression, environment changed from marine to fresh water conditions, sulfidic material is covered with alluvium and still under reducing condition. Acidification has been developed after oxidation until the present.

Keywords: acid sulfate soil, landforms, Nakhon Si Thammarat

INTRODUCTION

Acid sulfate soil is one of the serious problem soils. Since the soil contains iron sulfides which produce sulfuric acid when exposed to air. It is especially formed in the estuaries, mangrove swamps, and tidal plains. In a board sense acid sulfate soils were mostly formed after the last major sea level rose, within the past 10,000 years or the Holocene Epoch (Department of Natural Resources and Water, 2007). This soil occupies in Thailand around 8,810 km^2 (Land Development Department, 2006), the largest area of the soil is the Lower Central Plain and the second is in Nakhon Si Thammarat, southern Thailand (Fig. 1). The occurrence of acid sulfate soil probably related with the sea transgression in the area. The purpose of this paper is to study characteristics of acid sulfate soils, correlation of its distribution and landforms and development of the coastal plain.

REGINAL SETTING

The study area is Pak Phanang Watershed, it is located in the Peninsular Thailand at 7°45'N 99°41'E and 8°30'N 100°30'E. The main part of the water shade is Changwat Nakhon Si Thammarat and small part in Pattalung and Songkhla (Office of the Royal Development Projects Board, 1999), total area is about 3,000 km^2 (Royal Forest Department of Thailand, 1999) and Pak Phanang River is the main river in the watershed, water moves south to north direction and flows to the Gulf of Thailand at Pak Phanang Bay, the river channel is about 147 km (Pramojanee and Changprai, 1999). Overview distinct geomorphological units of area and surroundings, it has a mountain and hills, a wide alluvial lowland studded with hills of shale, sandstone and conglomerate, and some limestone, a coastal plain including lakes and swamps, seperate from the sea by a sandy barrier (Jarupongsakul and Paphavasit, 1993). There is 292,636 rai or 468.22 km^2 of acid sulfate soil area (Land Development Department, 1997) which is mostly used for paddy field (Pramojanee and Changprai, 1999).

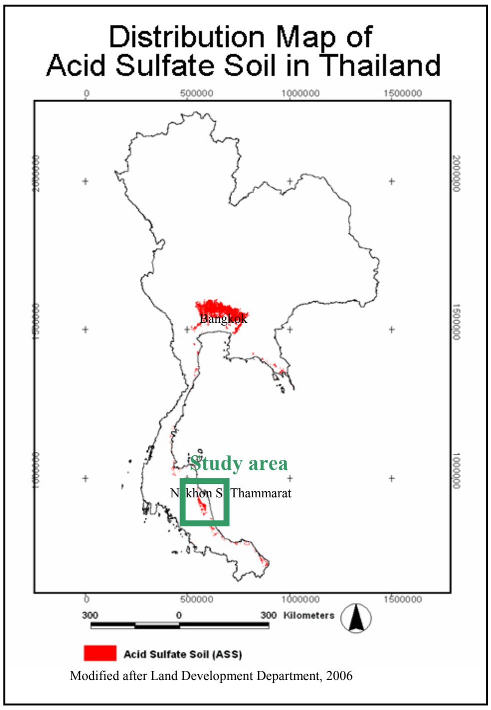

Fig. 1 Distribution map of acid sulfate soil in Thailand

METHODS

Landform classification was interpretd by consider satellite image, topographic map, SRTM-dem data to make 3D-diagram (Fig. 2). Geologic surface were studied based on depositional environments and radiocarbon dating of peats and shell fragments in sediments has been conducted in order to date age and explain evolution of the land. Moreover, soil were drilled to determine morphology, soil reaction (field pH value) and material accumulation of the soils.

RESULTS AND DISCUSSIONS

Landforms of areas are classified as hill and mountain, alluvial fan, low relief area, former backswamp, mudflat and sand ridge, beach ridge, river channel and recent tidal flat (Fig. 3). Acid sulfate soil mostly occupies in the area of former backswamp which enclosing old beach ridges. It is difference of elevation between lowland and upland in area, lowland including acid sulfate soil area is lower than 5 m, sand ridges and slightly higher area attain a height of 5-10 m whereas upland is intervening higher than 10 m.

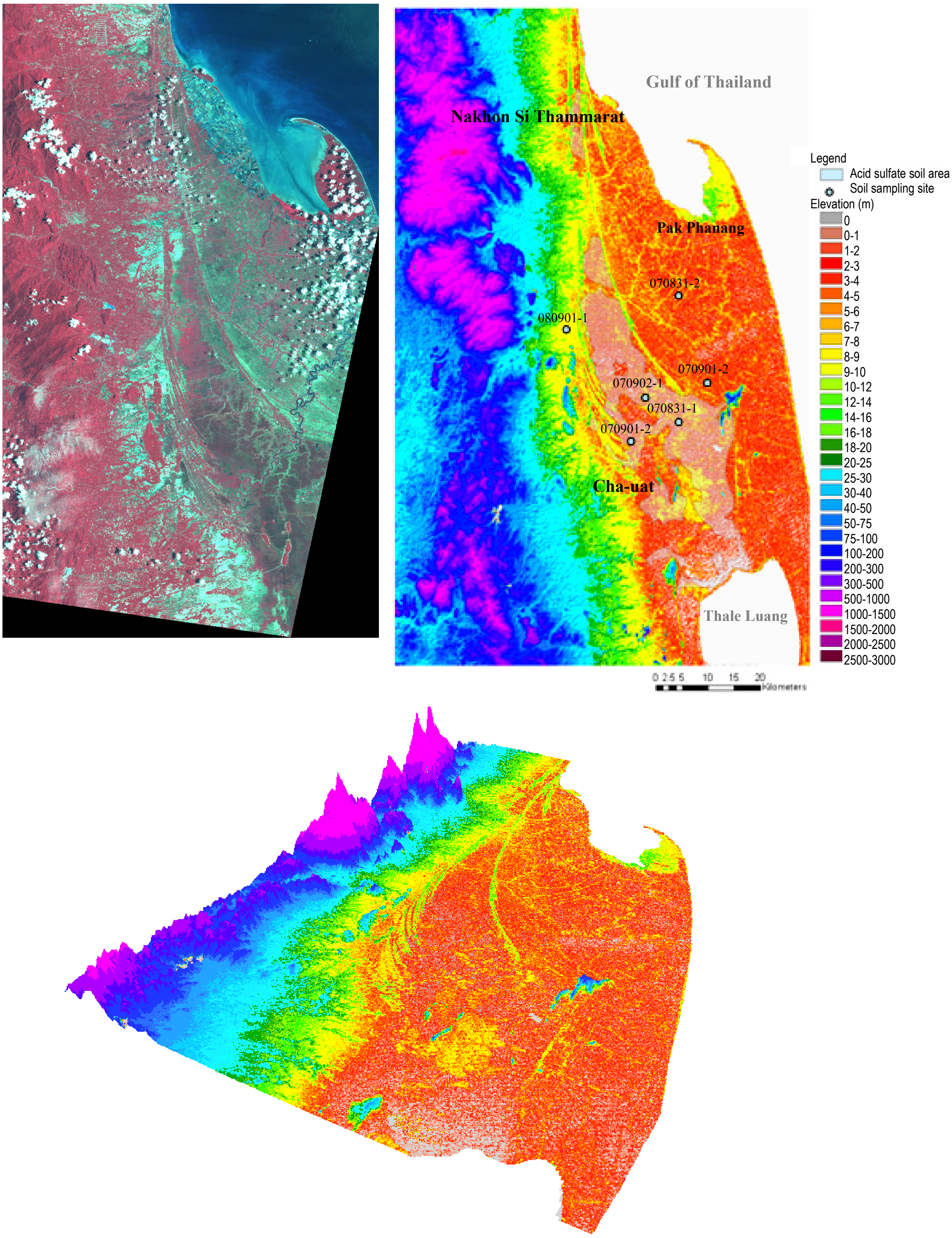

Fig 2. Landsat ETM RGB 432 (up left) , elevation classification from SRTM-dem, acid sulfate area and soil sampling sites (up right) and 3D diagram of area (low)

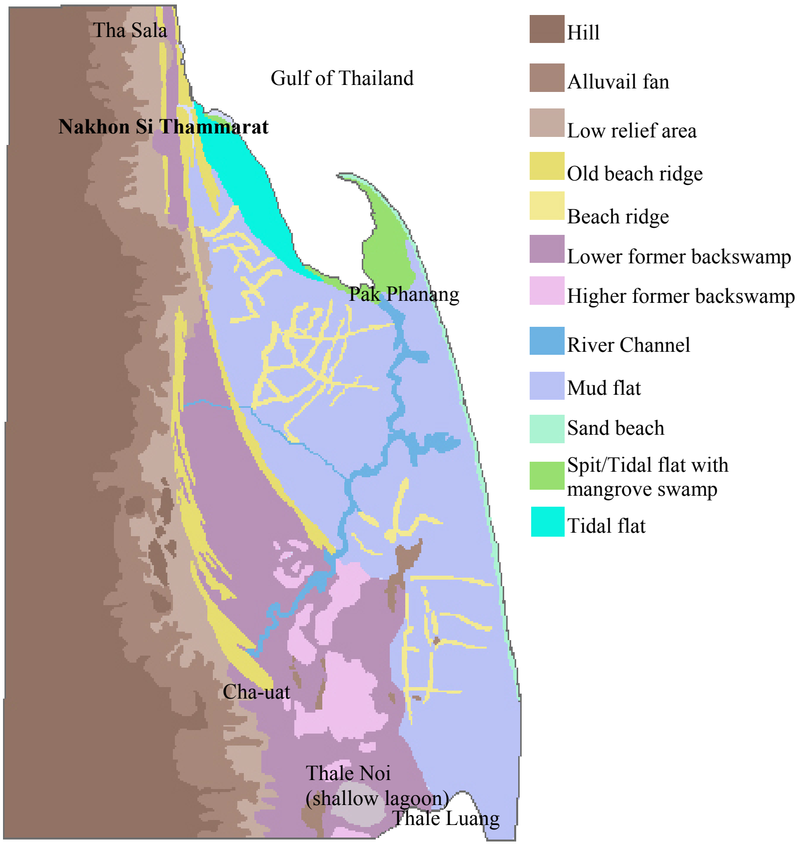

Fig. 3 Landform classification map

The geologic surface are classified from bottom to surface as marine clay, tidal sediment, fluvial sediment and organic rich soil, respectively. In acid sulfate soil area, it could observed thick organic soil or peat horizons in profiles whereas non acid sulfate soil area could not. Radio carbon dating results show age of fossils in horizon of former backswamp which is acid sulfate soil area, it is 5000-7000 cal. yr. BP. Whereas fossils of coastal plain which is non acid sulfate soil area has only 1000-3000 cal. yr. BP. This indicates acid sulfte soil area has developed around the Holocene Epoch, then the coastal plain has developed later.

The six soil samples were studies in the area, they are grouped as acid sulfate soil and non acid sulfate soil (Fig. 4). Characteristics of acid sulfate soils are dark gray to dark brown silt to silty clay with plant fragments topsoil, it has pH 4.5-6.0. This horizon overlay gray silt with orange, red and yellow mottles and plant fragments, some profiles have blackly to dark brown peat, pH value is 4.0-5.0 and 4.0 at horizon contains yellow mottles. The lower part of two profiles is gray silt to silty clay with plant fragments, peat, dark brown, and black organic, it has high pH value 5.5-8.0. The bottom of is brownish gray to dark gray silty clay without molltle, pH 7.0 has found at the bottom of profile in only one site. However, the lower of profile of anothor one has bluish gray silty clay with a few plant fragments, thin sand layers and shell fragments, it has pH 8.0. Non acid sulfate soils, they have gray with brown and yellow mottles, silt to silty clay top soil. Subsoil is gray silt with small brown and orange mottles, and containing thin very fine sand layers and plant fragments The bottom is gray and bluish silt with brown and orange mottles, thin sand layers, shell and a few plant fragments. They have high pH value thoughout profiles, 6.0-7.0 at upper part and 8.0 at lower part. To compare characteristics of the soils, acid sulfate soil has massive peat and plant fragment containing, very low pH value as 4.0 and yellow mottles in actual acid sulfate soil and high pH in potential acid sulfate soil which containing sulfidic material.

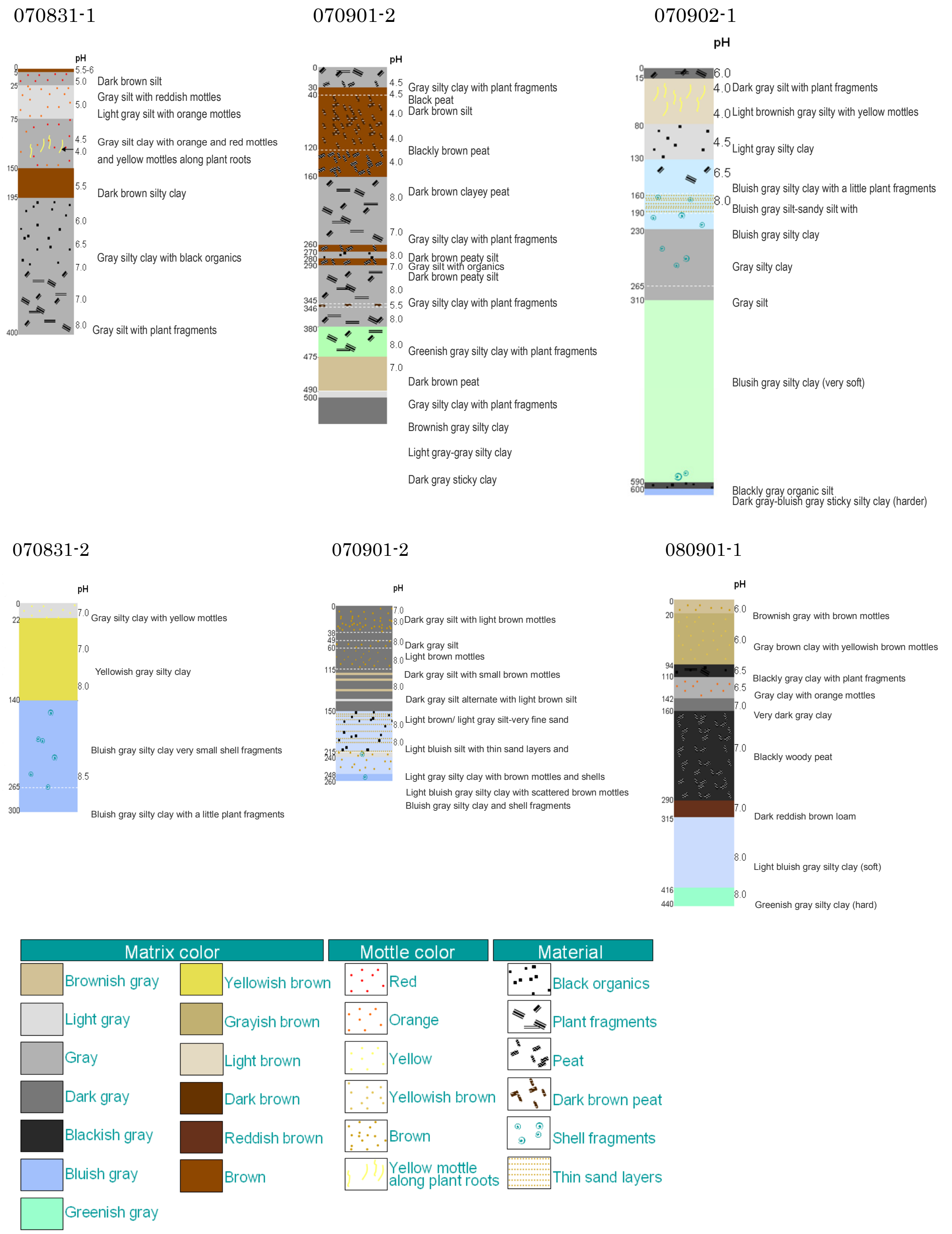

Fig. 4 The soil diagrams. Profiles of 070831-1, 070901-2 and 070902-1 are non-acid sulfate soils whereas 070831-2, 070901-2 and 080901-1are acid sulfate soils.

CONCLUSION

From the results, it is clear that acid sulfate soil occupies in the distinct area as bog which is enclosed with old beach ridges. The bog was former mangrove swamp in the period of Holocene sea level transgression by the first old beach ridge at the east side was already developed, and sulfidic material should accumulated in this time. After sea regression the younger beach ridge started to generate at the west side until it obstructed intrusion of sea water. This caused mangrove died and land covering changed to be secondary forest (such as salt grass and Melaleuca leucadendron) under reducing condition, thus, sediment of secondary forest deposited on sulfidic material. Consequently, environment of area change again by fresh water sediment deposited on rough surface as thin topsoil. Whereas area of non acid sulfate soil was shallow marine to marine in the period of sea level transgression and formed as land after sea level regression. However, it was improper environment for plants cultivating especially mangrove trees. The condition was unsuitable for sulfidic material formation, therefore acid sulfate soil is not developed in the area.

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Application of SRTM3 DEM and LANDSAT ETM Data to Generate Geomorphologic Map for the Purpose of Flood Risk Map in the Thu Bon alluvial plain and Hoi An, Vietnam

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ABSTRACT

Use of geomorphologic map for flood risk mapping is obviously necessary for a frequently flooded area. This paper aims to create a flood risk map of the Hoi An town and surrounding area based on the SRTM3 DEM and LANDSAT ETM data. Hoi An ancient town in the middle Vietnam, a town of the cultural World Heritage, has experienced floods almost every year.

Using conventional methods to make DEM (Digital Elevation Model) and geomorphologic classification map by aerial photos commonly takes time and money. Moreover, these kinds of data of Hoi An are insufficient and inconsistent. Therefore, utilizing remote sensing sharing data to conduct such kind of research is more feasible and convenient. The objective of this study is to generate geomorphologic map by using SRTM and LANDSAT.

SRTM (Shuttle Radar Topography Mission) launched in February 2000, especially 3 arc-second SRTM data (SRTM3) with 90 m resolution, has provided invaluable elevation data. Although application of SRTM still approaches some technical problems such as low resolution, systematic noises, and voids (spikes and wells), SRTM has served as functional topographic data for targeting the geomorphologic delineation. In this paper, voids have been filled by interpolation with free software 3DEM. In order to have a better understanding about the study area, this study uses LANDSAT ETM 30m spatial resolution. Panchromatic band of LANDSAT image proves the potential to detect in detail the concerning objects when merging with other bands. Land cover surface was extracted from LANDSAT ETM, then, visually compared with digital elevation model derived from SRTM in the same area. Consequently, we could clarify the landforms of Hoi An alluvial plain including natural levees, flood basin, sand dunes, sand bars, back marsh and terraces. The result of this study is expected to be an efficient method for flood risk mapping in low-land area. Accuracy of the result was validated by doing field survey.

Keywords: SRTM, LANDSAT ETM, geomorphologic map, alluvial plain, flood risk map

INTRODUCTION

Severe floods often occur in many places of the developing countries, and the consideration for the floods are very important in such places. In Vietnam, many places often experience severe floods and the areas need to mitigate the disasters.

The narrow alluvial plain in Central area of Vietnam suffers from severe flood annually. Especially, Hoi An ancient town, the cultural World Heritage town, has experienced flood almost every year. The town is located in the lower reaches of the alluvial plain of Thu Bon river and is one of the most density towns in Vietnam with 12,000 people/km^2. As the urbanization is occurring rapidly, the issue of the flooding is very important to consider.

Use of geomorphologic map for flood risk mapping is obviously necessary for such a frequently flooded area. Flood risk map is greatly necessary for disaster prevention, and the detail data is required for the risk map. For further research on the reason of flood risk at any area, geomorphologic map is basic and important module. However, factually in developing countries this kind of data are difficult to obtain or insufficient and inconsistent if available, particularly for alluvial plain with flat and low terrain. Therefore, taking advantage of satellite images to conduct such kind of research is more feasible and convenient.

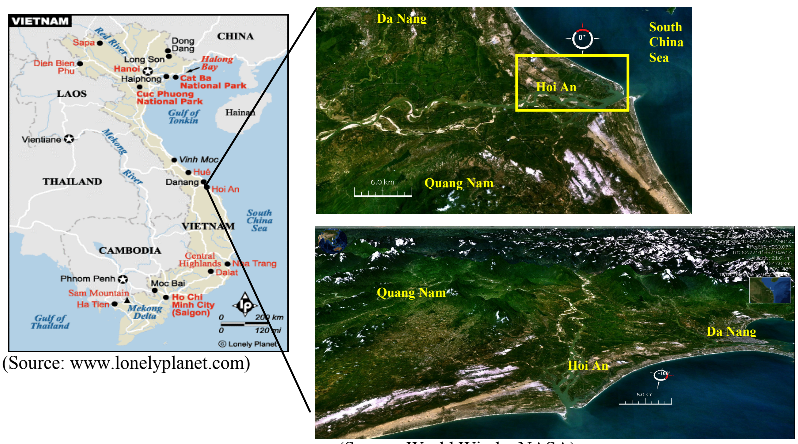
In the regions where the detail topographic data is not available, SRTM3 DEM and LANDSAT ETM data are very useful for the analysis. SRTM DEM, available from February 2000 with 80% landmass, has proved huge applications on geosciences, especially geomorphology and hydrology. It has served a particularly crucial role in developing countries where data resources commonly limit and are under the inadequate conditions comparing with those of the rest of the world. With SRTM 3 arc-second resolution, an open dataset for global scale, it can offer chances to overcome mentioned above obstacles. Although these data still remain several problems in results of extracted data, their achievements have been surprising.

SRTM DEM has employed in plenty of applications and combined with several other satellite image data dominated for terrain analysis. This source of data has really served as a very crucial role on any research needing earth ground data. However, with 90m horizontal resolution for global scale, its applications are particularly useful with large-scale study area. By applying SRTM data, topographic form can be detected, especially with high-relief and high-elevation terrain. For low-relief area, typically plain terrain that is generally flat, employment of SRTM data has been really come up with obstacles due to the vague relief and low resolution. In addition, SRTM did not generate "bare-earth" DEM but is identified as Digital Surface Model (DSM) if there is coverage of tree canopy and/or buildings (Kocak et al., 2004) known as noise or bias. Thus, it causes confused in determining whether certain areas are appeared inherent bare-ground elevation or not. There are several researchs to estimate, analyze and reduce the noise by collating with other dataset or by sampling ground truth. However, SRTM 90m resolution still limit for small-scale area and low land applications.

With effort to overcome mentioned above barriers and utilizing free data for developing country research, this paper aims to (1) employ 3 arc-second SRTM DEM version 2 as principle topographic data to delineate geomorphologic features prepared for flood risk map, (2) apply LANDSAT ETM with land cover extraction as module to verify reliability of elevation of areas covered with trees and construction affecting to accuracy of landform classification. A case study has carried out in Hoi An area around Thu Bon river mouth, Central Vietnam.

STUDY AREA

The alluvial plain of Thu Bon river, developing about 12 km from east to west and about 10 km from north to south, is located in the lower reaches of the river, and the broad coastal plain develops along the coast of the South China Sea. Topographic characteristics of the alluvial plain consist of flood plain with braided channels and a lot of former channel courses. Elevation of the plain is mostly lower than 10 meters and it is less than 2 meters in the lowest areas of the plain. Rows of sand dunes and sand bars aligned in parallel with the coastline developing in the coastal plain and the height of the sand dune are over 10 meters in some places.



(Source: www.lonelyplanet.com)

(Source: World Wind – NASA)

Fig 1: Study area – Thu Bon alluvial plain

The Hoi An ancient town is located in the northeastern part of the alluvial plain and is located in the left bank of the Thu Bon River. The town, known as the cultural World Heritage, is also located in the place about 7 km from South China Sea, and it has experienced flood almost every year. Urbanization is occurring rapidly without proper planning. Therefore, it needs to protect from disasters, and flood risk map is significantly crucial for this area.

METHODOLOGY

We generated 3D topographic diagram from SRTM3 DEM data and created landform classification map based on the 3D topographic map and the land cover maps based on the LANDSAT ETM data. Micro-landform of Thu Bon alluvial plain is delineated by relationship between uneven relief of terrain based on SRTM3 data and land cover. GRASS6 and ArcScene (ArcGIS) were used to generate topographic 3D diagrams and land cover maps. Field survey for the confirmation of landforms and the measurement of flood water level were also done in several times.

Data used and characteristics

-SRTM DEM: The Shuttle Radar Topography Mission (SRTM) successfully collected Interferometric Synthetic Aperture Radar (IFSAR) data over 80 percent of the landmass of the Earth between 60^0 N and 56^0 S latitudes using the America NASA/JPL C-band (5.6 cm, 5.3 GHz) and the German DLR X-band (3.1 cm, 9.6GHz) in February 2000. It's available 1 arc-second SRTM (SRTM1) of U.S and 3 arc-second SRTM (SRTM3) for the rest of the world.

SRTM3 used in this paper is 1 degree C-band SRTM downloaded freely from in ftp://e0srp01u.ecs.nasa.gov/srtm. It's version 2 data known as finished, or edited due to be processed such as defined water bodies and coastlines and filling voids (spikes and wells) despite there are still missing data left (JPL - NASA).

-LANDSAT ETM+ has been well-known in remote sensing application and can be accessed free at page: http://glcfapp.umiacs.umd.edu

Table 1: Technical characteristics of data

Data	Time	Resolution	Position	Characteristics
SRTM3	2000/02		N15E108	.hgt, filled – finished Version 4,
LANDSAT ETM	2001/03/23	30m	Path128/ row049	L1G
	2001/10/17	5m (pan)		Tiff

SRTM processing

File SRTM3 N15E108.hgt is filled remain voids of version 2 SRTM. There are several common techniques to fill missing data (Reuter et al., 2007) and performed by some free softwares (Trina Kuuskivi et al., 2005). We adopt 3DEM (Visualization Software LLC, 2004) derived from page www.visualizationsoftware.com/3dem.html to patching spikes and wells.

After filling missing data, SRTM DEM can show elevation with height interval 1m by combining between visual NVIZ function of GRASS6 and ArcScene (ArcGIS) to view SRTM 3D (Fig 3). And we can see terrain relief clearly. Depending on SRTM DEM, geomorphologic features of Hoi An alluvial plain can be briefly, including natural levees, deltaic lowland (1-3m), sand dunes, and backmarsh.

LANDSAT processing

Three of these images were rectified again to fit each other, then, merged with panchromatic band 8 to enhance image by achieving high resolution spectral image 15 m/pixel. Making composite images with false color set RGB = 542 can interpret geomorphologic features advantageously.

Comparison of SRTM and LANDSAT to get landform features and the results

- March is crop period and in October the paddy fields harvested, therefore comparing the difference between two images and interpretation can detect main land cover in alluvial plain with categories: residential areas, paddy field, channel network, sand dune (Fig 2).

Table 2: Temporal relationship of data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
					Dry season						*Rainy season*	
2000		*SRTM*										
2001			*LANDSAT (Mar.)*							*LANDSAT (Oct.)*		
			Crop time							*Crop harvested*		

Dry season
Rainy season
Flood season

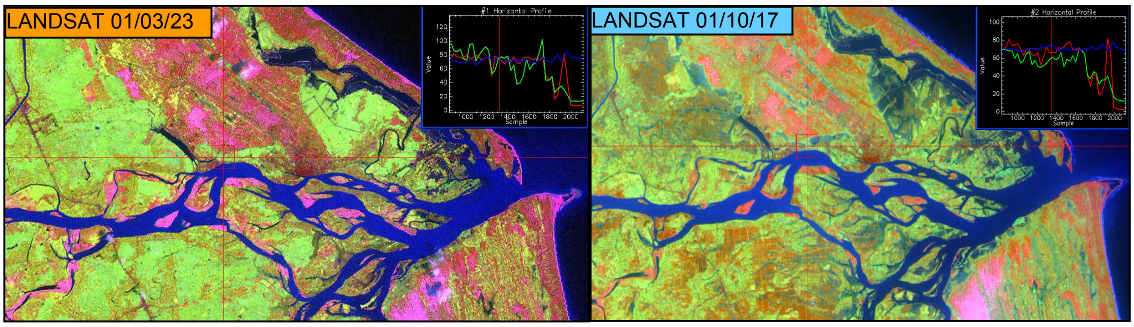
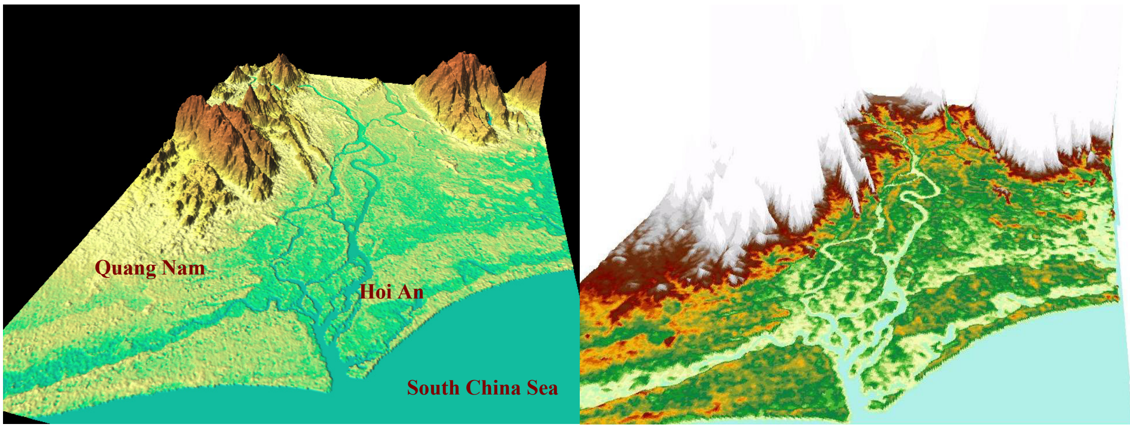


Fig 2: Comparison of two LANDSAT images could get land cover characteristic



SRTM 3D view by GRASS **SRTM elevation view by ArcGIS**

Fig 3: SRTM DEM shows high terrain relief

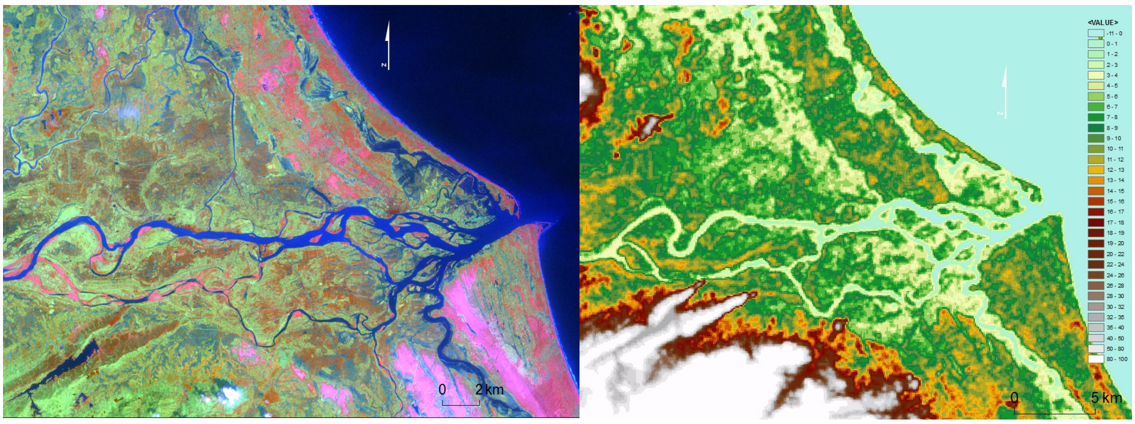


Fig 4: Combination of SRTM and LANDSAT interpretation to find out geomorphologic features

- With suspicious areas that they're affected by tree-and-house noises, they would be compared with LANDSAT image of October
- Natural levees are too small to be recognized by SRTM, it must be relied on LANDSAT to be classified.
- This comparison assists to verify SRTM systematic noises (Fig 4).

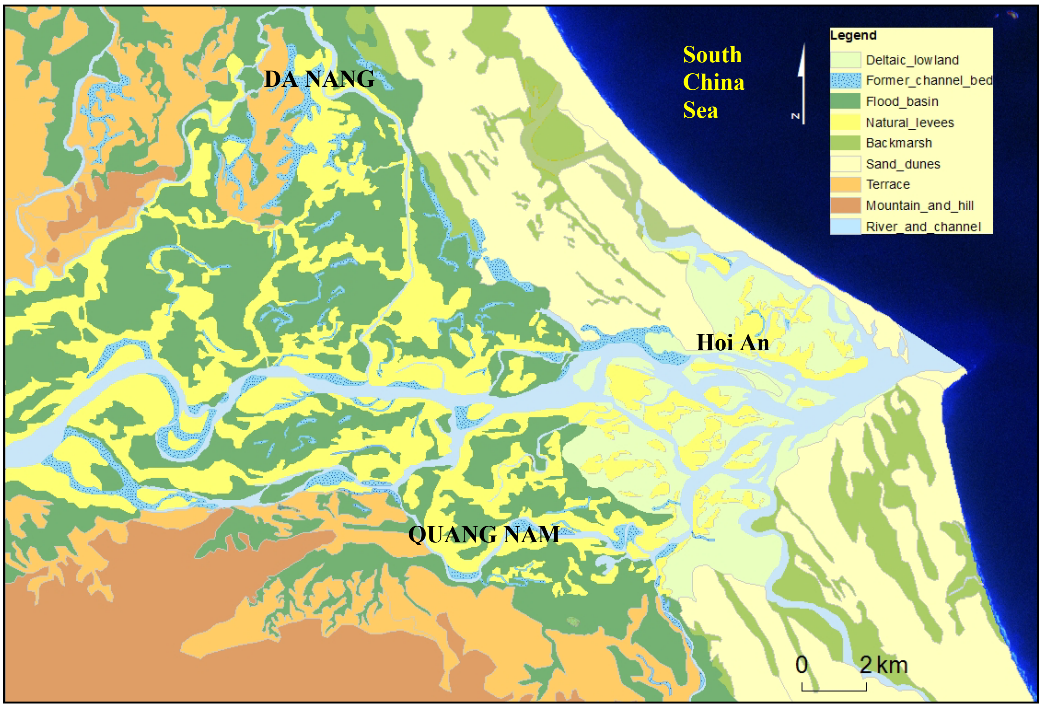


Fig 5: Geomorphologic map made from SRTM and LANDSAT

RESULT AND DISCUSSION

Based on this method, landforms of alluvial plain can be classified into categories: deltaic lowland, flood basin, natural levees, former channel bed, back marsh, sand dunes, terraces have been showed in Fig 5.

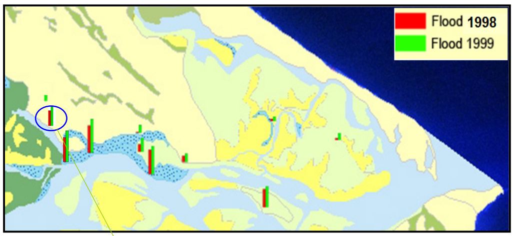
In general, back marsh and former river channel are subjected to the deep inundation, and natural levees are considered as the shallow flooding places with less risk. We can recognize the flooding condition from the map according to the characteristics of the flooding condition in relation to the micro landforms. The deltaic lowland is low and flat but the inundation depth is not deep in general. It is because that the floodwater can easily escape from the area to the sea. In the place of the study area, however, inundation depths may sometimes rise higher than the general deltaic area because the sand dunes near the mouth of the Thu Bon River affect to enclose the deltaic area and keep the flood water level higher. So the lowest reaches of the Thu Bon alluvial plain (Hoi An town) is also to be considered as a risky place in the time of severe flooding. Comparison of flood height record of Hoi An revealed good fit between flood condition and the result of landform classification based on SRTM and LANDSAT in this study.

However, with smaller area, however, it encounters some limitation because of low spatial resolution. At sites which any landform has large area (> 3 pixel of SRTM3), good result can be achieved because its pattern is quite clear and can be identified. For that reason, narrow areas are hard to be separated, especially at strait ranges along the river or channels (Fig 6).

CONCLUSION

Application of SRTM3 as topographic data for delineating landforms of Thu Bon alluvial plain has accomplished acceptable results that are examined by collating with real conditions. Despite several problems in use of this kind of elevation data, it can be utilized with combining with other satellite data like LANDSAT ETM. Moreover, SRTM3 is also enhanced by applying GRASS6, it can highlight relief of terrain that help isolate areas with different elevation. That geomorphologic map can be created by this method has facilitated flood risk mapping. Thus, future processing of flood risk map is high feasibility than that in previous with utility of free satellite images.

a)



b)

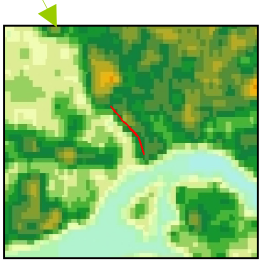


Fig 6: a) Flood record of Hoi An town demonstrate good fit between flood status and landform classification
b) Limitation of SRTM can not separate lower landform at narrow area of the edge of sand dune

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LANDSAT source: http://glcf.umiacs.umd.edu/data/

SRTM source: http://srtm.csi.cgiar.org/SRTMdataProcessingMethodology.asp

GRASS source: http://grass.itc.it/index.php

Community Base Approach in Mangrove Restoration and Management in Simeulue Island Province of NAD, Indonesia

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ABSTRACT

This study outlines the community base approach in activities of mangrove restoration and management in Simeulue Island, Province of NAD-Indonesia. Simeulue Island is located on Northern of the Sumatra mainland and was 30 km from the epicenter of the December 26th 2004 giant earthquake. Despite of its proximity to the epicenter, of Simeulue's population of 76,000 people, only 7 people died as the result of the tsunami. This was due largely to the local *smong* legend which recalls the deadly 1907 tsunami that hit the island. The residents knew what to do, and their quick evacuation from the lowlands following the earthquake undoubtedly saved many lives. Other factors influencing Simeulue's low death tool included propagation of the tsunami itself, and the ability of the mangrove swamps to buffer some of the water turbulences.

There are a number of organizations working on mangrove restoration in the island, and many have become interested in how to protect coastal inhabitants from future tsunamis. Mangrove conservation and rehabilitation is a potentially powerfull tool to tsunami mitigation. International and National organizations are dedicated to preserving and rehabilitating the wetland ecosystems including mangrove forests. There have been implemented several mangrove planting projects at the several villages in Teluk Sinabang bay which are exposed the open ocean with very little vegetative buffer. However, because most of the activities on mangrove restoration has been centered only on techniques for planting and growing mangrove trees, out from an ecosystem management perspective, most of the works are not yet to be succeed.

Keywords: Natural resources, Mangrove, Community, Management

I. INTRODUCTION

The community plays an important role in a more suitable management of natural resources. That is a reason why bottom-up approach, in which community becomes a key factor of management, has become a new trend recently. Well and Brandon (1993) said that it has become rare to find a forest or park management project proposal that does not talk about local participation in conservation. It means nowadays local peoples are an important factor and their involvement is required in every single activities related to natural resources management project. Campbell & Vainio-Mattila (2003) it will be difficult to find a rural conservation project, which does not define itself as community-based. Some scholars argued that bottom-up approach is better for both social justice and sustainability of natural resources (Alder, 2000; DENR, 2001). On the other hand, top-down approach, which is the domination of government roles in management natural resources, has already been failure in many cases along side the need of more democratic and equal in natural resources management.

This paper will define concept of community-based approach (CBA) and answer the question why it is important to implement in natural resources management. The second part will describe a short explanation about Indonesia, mangrove ecosystem, utilization and conversion, and the Indonesian government projects and policy related to the mangrove conservation and management. In the third, I will share our experiences in implementing community based mangrove management while give a short explanation of number of activities related to CBA in Simeulue Island, Indonesia.

At the end, I will analyze CBA based on our experiences organizing the fisher-folk organization, which I identified as the best result of CBA in our project, and how the role of the organization in mangrove management in particular and coastal resources management in general.

II. REVIEW ON COMMUNITY BASED APPROACH

Community-based Approach (CBA) has already been used by many conservationists, donors, governments, NGOs and corporations for a few decades in many developing countries. The CBA is believed as an approach to promote sustainable environment, social justice, and development efficiency. The fundamental assumption is that the domination of state-based management has been a failure in taking charge of natural resources management. The factors which contributed to the failure are the lack of communication between resource administrators and users, and resistance by local stakeholders in implementation of appropriate plans (Glaser, 2003). On the other hand, the peoples who live close to a resource and whose livelihoods directly depend upon it relatively have greater interests in sustainable use and management of natural resources than the governments or corporations. Local communities are more cognizant of the intricacies of local ecological processes and practices, and they are more likely to effectively manage those resources through local or traditional form of access. Combination of conservation objectives and improving the position of impoverished rural communities can be offered by the community base approach (Li, 2002; Brosius et al, 1998).

Community Base Resource Management (CBRM) initiative is not new. There are many examples of CBRM practiced by indigenous people all over the world with their own ways. In Para Island, Indonesia, coastal community has practiced the initiative for more than 400 years by involving the community to manage coastal and fishing grounds (Mantjoro, 1996). The identical initiatives can also be found in many ethnic groups in the other islands of Indonesia. Pomeroy (1995) reported that in India, since 1920s, a community development program was introduced throughout the region.

CBA in coastal and marine areas, rural development, and fisheries development were evolved during 1980s (Kay and Alder, 2000). In 1980, the World Conservation Strategy, a commission in the United Nations Environmental Program and World Wildlife Fund, focused their conference on issues related to political, cultural and economic (The WCS, 2004). In 1982, World Congress on National Park in Bali emphasized the linking of protected area management with local area economic activity (Wells and Brandon, 1992). This concept was developed to link conservation with sustainable development, and led the establishment of Integrated Conservation and Development Plan (ICDP) (Kay and Alder, 2000). Later, the concept was applied in a number of National Parks in the whole world funded by World Bank, ADB, UNEP, and the other funding agencies related to the environmental and sustainable natural resources management.

CBA is an integrated environmental and resource management activities into people's everyday lives, where community makes some resource management decisions (Kay & Alder, 1999 p.137). DENR et al, (2001) added that CBA is a process of involving local resources users and community members in active management and taking full responsibility for the process of coastal resource management planning, implementation, monitoring, and evaluation. Both explanations above emphasize that community is an integral part of management and as a key factor from the beginning to the end of managing natural resources process.

CBA becomes more suitable in natural resources management because of some reasons. Involving community in management resources provide a sense of ownership, responsibility, acceptability and stronger commitment on the part of resource users. Community will become more responsible if they feel that particular natural resources are owned by them. The most importantly, they will be more respect and will do everything if they know the particular natural resources can provide 'benefits' for them.

CBA is also more effective, equitable than centralized management. In terms of administration, monitoring and enforcement, it is more profitable from economic and social perspectives compared with classical management proposed by the government. People tend to be voluntarily protecting their own resources if we trust them. CBA is also flexible and adaptive to the specific and changing conditions because community has better understandings what they should do to solve a particular problem in a specific situation. In top down approach, for examples, usually decision making processes determined by the top level of bureaucracy which need more time and long process.

At last, the development of CBA meets with particular needs and conditions, and has a larger role for local indigenous knowledge and expertise. As we know, local peoples who have already live within their natural resources know better than the outsiders. They can determine what particular resources they need are and what are not. In many cases in Indonesia, government makes a wrong decision in determining the needs of particular village because they do not know well the village situation and what local people needs. For example, Indonesian government from top level in Jakarta determines that all of communities in the small islands are fishermen who suppose to be supported with the fishing tool or boat. In contras, some of indigenous people in many islands of Indonesia are farmers.

Kay and Alder (2000) identify some factors related to the characteristic of CBA. CBA is mostly initiated by local people, which have an informal organization such as family clan, tribe or any kind of relationships which are not include in 'formal' government management guidelines. Their type of leadership is usually mutual adjustment in which policy and decision making process are de-central and autonomy.

Even though many scholars argued that CBA is the best way to involve community in management, there are some critiques on CBA application. Many experiences found that CBA is not really a panacea for resources management (Kay and Alder, 2000). For the wider area, where multi-culture communities inhabited and more complex of natural resources, we cannot adjust by using a single management in this situation. It means we should combine CBA with the other approaches because not every community is suitable for CBA and not all elements of management authority can be allocated to the community. Russel and Harshbarger (2003) added that many donor institutions usually support a CBA initiatives financially, which is part of complex political process involving multiple constituencies, but sometimes they do not really understand for what they are donating towards. Mostly, the implementers' understanding are based on natural resources systems, as opposed to an understanding of existing relationships between users and their resource, and on the assumption that since no 'modern' system has existed, no system exists at all. Some NGOs also have traditionally been rooted in the natural sciences, bring with them associated professional norms, prioritize conservation, lack of social sciences, and attempt to implement community-based initiatives.

In reality, the 'marginalized' communities/indigenous people sometimes are not similar to the CBA's expectations. In my opinion, global market and interaction with outsiders have caused all of indigenous people change a little bit from their previous culture to follow 'the modern' one. They are also not always natural resources dependent communities. Lynch and Tallbott, (1995) said that they are strategic and rational actors rather than ecologically noble savage. They are also often heterogeneous and unequal. Sometimes they are mobile as they seek a better opportunities outside their place (Li, 2002).

III. MANGROVE COMPOSITION AND DIVERSITY IN INDONESIA

Indonesia has 5 major islands, Sumatera, Java, Kalimantan, Sulawesi, Papua (Irian Jaya), with the majority of the total population, & approximately 17,500 medium and small-size islands. It becomes place of more than 217,825,400 people (DKP, 2004), which consists of more than 400 hundred ethnic groups. Most of the ethnic group has their own language, so that at least 383 languages still exist in Indonesia today. Every ethnic group has their own culture, customs, language, and identity.

Indonesia is a country with the second longest coastline in the world behind Brazil. It has 81,000 kilometers coastline and 80% of population live within 100 kilometers of the coastal area. 75% of Indonesian territory is coastal and marine and fish consumption is 66% (DKP, 2004). As a tropical country and the largest archipelagic country, Indonesia identified as one of the biodiversity hotspot among 17 places in the world (Cox & More, 2000; DKP, 2004).

One of the coastal ecosystems which become characteristic of tropical region is mangrove. Mangrove, coral reef, estuarine wetlands, and sea grass bed plays an important role in global primary productivity (Vannuci, 2004). Mangrove ecosystem in Indonesia covered an area of 4,250,000 hectares in 1982. Unfortunately, due to various human-induced pressures, it decreased became 3,700,000 hectares in 1992 and in 2003 only 2,500,000 hectares remained (Soegiarto, 2004).

Mangrove ecosystem has highly diversity of species, which Indonesian mangrove is the highest degree of it (Soegiarto, 2004). Indonesia have recorded 189 species of plant, including 80 species of trees, 24 species of lianas, 41 species of ground-covering plants, 41 species of epiphytes, and 3 species of parasites (Kartawinata et al and Giesen in Soegiarto, 2004). Mangrove also becomes habitat for birds, insects, reptiles, crustaceans, and mammals. A number of endangered and endemic species of mammals in Indonesia reported remain in mangrove area such as Tarsius spectrum, Sulawesi monkey Macaca nigra, and endemic Sulawesi wild pigs Babirousa babirousa. Many others important and economic species of fish and mollusks are spawned in mangrove area. Mangrove also has many physical functions, such as prevention of erosion, coastal stabilization, and serve pollution trap.

Mangrove are used and conversed in many ways. For centuries, Indonesian people have utilized mangrove for fire wood, charcoal, tanning dyes, timber, and boat construction. Nypa, one of mangrove species, is used for roofs, baskets, cigarette papers, sugar, and palm wine (local: arak). Mangrove ecosystem is also conversed to become agriculture field such as rice field and coconut plantations. Housing complexes, industrial sites, recreational areas, harbor developments, warehouse compounds are also the other examples of conversion of mangrove ecosystem which are found in many parts of Indonesia.

One of the most destructive ways of mangrove conversion is fish and shrimp aquaculture. In Indonesia, aquaculture increase during 1970s along with the ‘blue revolution’ in many part of the world (Stonic, 2000), and it is identified as a main problem of lost of a half of Indonesian mangrove areas for two decades. Even though there are some problems related to management of shrimp aquaculture in Indonesia, it seems that this activity still increase recently.

Government of Indonesia has many programs related to mangrove conservation and management. They consist of replanting and restoration projects, policy making processes, establishing green belts, proposed and establish marine nature reserves and protected areas, built a mangrove center in Bali, and number of projects related to community development. However, Indonesia, which has a huge number of populations and a multi-culture country, needs a ‘specific’ cultural-based management approach to be applied in every ethnic group. Failure of Indonesian government’s management during Soeharto era was generalizing management of natural resources from the top of government in Jakarta and applied it similarly in the whole archipelago in provincial, district thorough village level. CBA is one of alternative approaches in Indonesian context with high degree of coastal biodiversity and high divers of social and culture.

IV. EFFORTS OF MANGROVE RESTORATION IN SIMEULUE ISLAND

Simeulue island is located just off the Sumatra mainland and was 30 km from epicenter of the December 26th earthquake. Despite its proximity to the epicenter, of Simeulue’s population of 76,000 people, only 7 people died as the result of the tsunami. This was due largely to the local smong legend which recalls the deadly 1907 tsunami that hit the island. The residents knew what to do, and their quick evacuation from the lowlands following the earthquake undoubtedly saved many lives. Other factors influencing Simeulues’s low death deat toll included propagation properties of the tsunami itself, and the ability of mangrove swamps to buffer some of the energy.

Mangrove forests play many important roles both environmentally and economically. They have an incredible rich and diverse flora and fauna association. By stabilizing coastal sediments, thus reducing erosion, they create habitats rich in organic matter making them important nurseries to shellfish, shrimp, spiny lobster, blue crabs, and baby fish, all which attract migratory birds. Environmental services include preventing excess nutrients from entering the ocean and protecting the coastline from wind, typhoons, monsoons and sea storm surges, which reduces the need for maintaining sea dikes (Hoang, 1998). Mangrove forest also provide wood resources and several studies support the idea that coastal fish communities can thrive in this estuarine environment, although controversy remains about the degree of dependence and importance (Baran, 1999).

Even though Simeulue Island has huge mangrove forests, there are some problems related to conservation the areas. Increasing of shrimp/fish aquaculture is the biggest problem there. As a result, almost a half of mangrove areas were conversed to shrimp or milkfish ponds. Intrusion of sea water face to the rice paddy agriculture and most of wells as main drinking-water sources for community have intruded by salty-water. In addition, most of the people also do not have alternative incomes unless fishing and 'small' farming. Few of them become labors in shrimp aquaculture. Meanwhile, in the dry season, people suffer the lack of food especially a need of carbohydrates sources . In this difficult situation, people tend to cut mangrove and sell them as timber or fire-wood or even performed illegal blast and poison fishing. Some of them go out looking for a job in the nearer cities.

Recovery time estimates for damaged forest in on the order 20-25 years, which presumable is about the amount of time needed for a successful forest to be grown. This means that there must be commitment for that time period to maintaining the site. Because rehabilitation projects must be managed a regular areal photos, cataloging of physical conditions and species composition, etc. Overlapping bureacracies and a lack of clear lines of accountability have led to neglect. This partially explains why the most successful project are community based and supported locally. Although ultimately the need and desires of the local population will determine the success and longevity of a mangrove ecosystem, political will and support at any level of government advances rehabilitation and conservation efforts.

After tsunami, during 2005 – 2007, government of Indonesia and some International NGOs was implemented mangrove restoration to reduce the problem of mangrove resources depletion. The project has some activities which related to mangrove conservation such as community development, awareness and restoration. Some models were applied including empang parit (shrimp pond surrounded by mangrove) and replanting mangroves in some villages.

Unfortunately, the mangroves replanting program did not really gain success. In some areas a few of mangrove grew well but most of the plots were unsuccessful. Fields observation showed that the project success as low as 15 - 40% because of less control after replanting, poor quality of seed, site unsuitable for species planted and lack of community involvement. The first three factors are not very serious because technical problems can be solved. However, the last factor is outside control of rehabilitation implementers. In this situation, involving community in the project is needed to gain a better result in replanting and management of mangrove conservation. But in replanting project, government paid a group of people to search mangrove seed, planting, and maintenance the mangrove seedling. The community who involved in this project were not really based on their awareness of mangrove conservation but relatively based on how much money they earn in each seed they plant. The conservation are not really based on what the community need. This failure becomes an important experience for the future in managing mangrove should not based on money payments but it should be started by encourages the awareness of the community.

V. CBA IMPLEMENTATION IN MANGROVE MANAGEMENT

A. Process with Involving Community

The main activities of CBA which implemented in Simeulue Island can be described as follows:

1. Preparation

Preparation with choosing community organizers (COs), who will work and stay within the community. Four COs were selected. Consider to the social and cultural condition in the bay, it was chosen 2 male and 2 female as COs. Training was provided to COs by giving them skills in community organizing, community mapping, participatory rural appraisal (PRA), program evaluation and any other skills related to the program. There was also set up branch offices one in the bay and one in capital of district. While doing preparation, secondary data and field observations was implemented, met with local governments, informal leaders, religious leaders, and some key actors in the bay, introduced staffs, and explained our plan to gain the project goal.

2. Participatory Rural Appraisal (PRA)

PRA is being used to describe a growing family of approaches and methods to enable local people to share, enhance and analyze their knowledge of life and conditions, to plan and to act (Chambers, 1994). Some scholars used the other term in this activity. DENR et al (2001) used term

Participatory Coastal Resource Assessment (PCRA) to the similar activity which they define it as 'a method of resource assessment wherein local communities actively participate in gathering and analyzing environmental, ecological, social and economic information about an area, using perspective of local resources user'. In this activity, we involved with the community to make some group discussions; gathering historical, social, economic condition of community; collecting information about mangrove condition; and presented it in a number of discussions with people. The outcome of this activity is a community activities plan related to mangrove management.

3. Community Mapping

Community mapping is a mapping technique which enable communities to participate in the map making processes, and to bolster the legitimacy of their customary claims to resources by appropriating the state's technique and manner of representation (Fox et al, 2004). Peluso (2003) used term 'counter mapping' for this activity as 'alternative' of government's domination in the map making process. In this activity we taught the community how using GPS, compass and the other map's tools and practiced to make map of their land and coastal area. They measured their surrounding lands, coastal area, cultural and historical places such as cemetery, and border between public and private resources. The outcome of this activity was to prepare a 'language' of claim and rights of resources and to make sure the boundary of community resources and private resources. Long time colonial and state claims to the natural resources in the area have made community lose their self-confidences in claiming their own resources which relatively affected their participation to protect the nature resources.

4. Community Organization

Processes of preparation, PRA and community mapping provide a good correlation to community organization activity. The community organization is a process of bringing together members of a community and empowering them to address common concerns and problems, and to identify community goals and aspirations (DENR et al, 2001). The aim of this activity was to develop awareness and to organize the communities to participate in the project to reach their goal on natural resources management. A Community Organizer (CO) is an individual who stayed with the community and directly participates in their activities especially those related to fishing or farming. However, the COs role is restricted only for facilitating discussions, opening dialogues and offering perspective, not to instigate change whether the issue is economical, political, social or cultural (Kelola, 2004b). Staying with the community, do what they did, and feel empathy their feelings, would make COs have a better understanding of social problem within community. As a result, COs could have a chance to facilitate the process of implementing the community plans which were resulted in the PRA process. Replanting activities, community awareness, and focus group discussions were the activities which were implemented in this process.

5. Focus Group Discussion (FGD)

FGD is a discussion with four to eight members of community who were chosen for their knowledge and involvement in a specific topic. This activity usually served in the specific situation and issues such as preparing to solve an entangle problem, analyzing government policy, or preparing policy advocacy. The FGD required the 'specific persons' who are legible to participate in the discussion and also understand the specific issue. As I have mentioned above, this activity was along with community organization in which we have already known who the person were.

6. Community Awareness

This was a process whereby knowledge was imparted to the coastal communities to increase their awareness, understanding, and appreciation of the coastal environment and its importance (DENR, 2001). Usually we applied it to school-aged children as they are more receptive to environmental education and of mangrove conservation. In addition, it gave indirect impacts to their parents' attitude who engage in mangrove conversion. Both classroom and field learning were part of the curriculum; activities include environmental games, puppet shows, planting mangroves, and many other activities (Kelola, 2004b).

7. Capacity Buildings

A long process of community organization has provided information of strengthens and weaknesses of community. We provided some training to improve their abilities in managing natural resources and organization such as sea weed and grouper culture, organization management and administration, fish marketing. We also involved some of their representations to attend workshops and seminars in district, provincial, and national level. The other activities were village exchanges and field trips to the nearest provinces which has a good experience in community-based coastal resources management. The aim of this activity is to empower community and learn from the other places how build a better commitment for mangrove management.

8. Alternative Incomes

The alternative income was a way for low-profit peoples to increase their income while reducing their dependency on mangrove resources. We facilitated the community with information about sea weed culture, taught them and made a model of a suitable sea weed culture. The most important part of this activity was providing some information about sea weed marketing. Similar to the sea weed culture, we also tried to train them with souvenir production skills especially for women.

B. Outputs Of CBA Activities

One of the most significant results of CBA in Simeulue Island was the establishment of fisherman organization, ‘Serikat Nelayan Teluk Sinabang (SNTS)’. Founded in 2005, SNTS was an accumulation of community organization process in Teluk Sinabang bay. The organization represented of 30 villages in the bay. The SNTS nowadays has 1,700 members from 30 villages. Every village has their representation in SNTS board. Village has its own autonomy to develop program based on its needs. Village representatives have 3 monthly meeting to discuss their programs with the main boards.

Some programs proposed by SNTS including sea weed culture, seaweed and fish marketing, and credit union. The organization tried to find a better market of fish and sea weed. They also developed a ‘warung nelayan’, a small store selling fishing equipments including petroleum. They built a system, which allow the members to save and loan money, of what they called as credit union. Even though there were some problems related to the management and administration of the credit union, it became a starting point for their economical development and a way to take part in solidarity among fishers. In the meeting with them, they asked me some advices to the possibility of providing gasoline to the members of SNTS. Gasoline is a vital component for fishing, which is in Indonesia, it is still monopolized and distributed by the government.

The SNTS also becomes a media of fisherman’s movement. Now they have their office located near the fish market. Everyday, while selling fishes, they come to the office discussing their problems and how to solve them. Some related-issues on natural management and political situation also become important topics on the discussions.

In 2007, there were some fishermen from another province came to the bay and did blast and poison fishing. The organization tried to report the ‘spoiler’ to the police and as a result, they were jailed. Still in 2007, there were also some fishermen who used trawls in the bay. They caught fish in similar fishing ground and this situation became a big problem. The disturbed fishers tried to force the ‘outsiders’ out and it was follow by an accident which the local fishers burn the outsiders’ boat. Local fishers and the ‘outsiders’ fought each other and 2 of the outsiders got injuries. The SNTS finally proposed 3 miles for artisanal fishing ground to the local government. Although it was not regulated by the local government formally, but in a meeting with the SNTS, the Head of District and some of DPRD Simeulue members have already agreed with this idea.

Related to the mangrove conservation, the SNTS also have replanting program. Together with the government, they proposed the rehabilitation program in some places in the bay. The members of SNTS also do not allow their members to cut mangrove for firewood or boat construction. The members, who cut mangrove tree for their basic need such as build their ‘traditional’ houses, are responsible to replant 10 – 100 trees in every piece of mangrove they use. The regulation of mangrove utilization and restoration depends on village’s convention. The SNTS also does not allow their members to do blasted and poisoned fishing, coral reef mining, and/or converse mangrove for fish/shrimp ponds in the green belt.

Event though the SNTS has gain success, I still found some problems in the organization. First, law enforcement in implementing their convention is low because of reluctance to impose restrictions among members. In this case, the roles of government are needed to implement the convention. Second, the organization is sensitive to the political and economic intervention. For example, in our general election last year, some party leaders come to bargain with some SNTS board offering their program and money and it produced a individual conflict interest. For the future of mangrove management in Indonesia, I recommended some important suggestion related to the CBA. First, the idea of CBA is expected to be spreading through out the archipelago. Second, the more fisherfolk organizations should be found and be supported in the other provinces and later built up the network among them. Finally, we need a better cooperation among the governments, non government organizations and the other institutions such as researchers and universities for spreading to idea of CBA.

VI. CONCLUSION

Community Based Approach (CBA) is a more reasonable and democratic approach to involve community in the management of natural resources. Community has their innate capacity to use and conserve their resources because it is part of their everyday life. Failure in top-down approach which is used by the government becomes a reason why CBA is important to implement. Even though there are some critiques to CBA related to the implementation, interpretation, and political economic reasons, CBA is believed as an alternative approach with the holistic concept of sustainability and integration of ecology, economic management and social objectives.

In the context of Indonesia, which has a huge number of natural resources and biodiversity, CBA is an alternative approach to gain a more participation of local people in managing natural resources. CBA is not a difficult concept, but not easy to implement, which need a long process to gain more successful results. Case study from Simeulue Island is an example how CBA have been implemented although there are some weaknesses of this project. Indonesia needs more examples of application of CBA project for the future of the country to conserve natural resources and social justice of people who are mostly depend on the natural resources.

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APPENDIX

WORKSHOP PROGRAM

Date: February 23, 2009 (Monday), 8:30-17:15 (Registration at 8:00 in the morning)
Venue: Room "Harmony", Shima Central Hotel SOCIA (http://www.h-socia.com/index_e.html)

Opening Session: Chaired by Makoto Takahashi

Opening address: Professor Masatomo Umitsu, Coordinator of the Program and Conference Organizer, Nagoya University

Special guest address: Ms Ayako Maesawa, Head of Asian Program Division, Japan Society for the Promotion of Science (JSPS)

Welcome address: Professor Shin-ichi Yamamoto, Vice-president for Research, Nagoya University

Keynote address: Jan Sopaheluwakan: Integrating Tsunami Warning System, Science and the Community: Indonesian Experience and Perspective

Morning Session 1 – Coastal Disaster and its Management: Chaired by Chanchai Thanawood

Ketut Wikantika, Widyastuti S, Djunarsjah E., Darmawan S, Hadi F.: Coastline Change Analysis in the Post Tsunami Disaster with Landsat-Etm Satellite Image: a Case Study in Northern Coast of Aceh

Djati Mardiatno, Muh Aris Marfai, Junun Sartohadi: Multi-risk of Disasters in Cilacap City, Indonesia

Muh. Aris Marfai, Djati Mardiatno, Junun Sartohadi: Potential Loss Estimation of Agricultural Production Due to Tsunami Hazard

Coffee Break/Poster Presentation

Morning Session 2 – Coastal Disaster and its Management: Chaired by Helmi Thomin

Haryadi Permana, M. Dirhamsyah, M. Ridho, Illiza Sa'aduddin, Didik Sugiyanto, Irina Rafliana, Del Afriadi Bustomi, Juriono, Edie Prihantoro, Teddy W. Sudinda: The Banda Aceh Tsunami Drill: First Exercise of Vertical Evacuation in Indonesia (November 2nd, 2008)

Deny Hidayati, Laila Nagib: The Aceh Besar Community Preparedness in Anticipating Earthquake and Tsunami

Junun Sartohadi, Muh Aris Marfai, Djati Mardiatno: Coastal Zone Management due to Abrasion along the Coastal Area of Central Java Indonesia

Rawee Thaworn, Somying Soontornwong: Community-base Restoration in Mangrove Forestland and Livelihood Security, Baan Thong Lhang, Phang Nga, Thailand

Chanchai Thanawood: Tsunami Hazard Management in Thailand

Discussion at Lunch/Poster Presentation

Afternoon Session 1 – Coastal Environment and its Management: Chaired by Kazuaki Hori

Ashraf M. Dewan, Yasushi Yamaguchi: Human Impacts on River Morphology: a Study on the Ganges in Banglades

Shahidul Islam: New Challenges to Cyclone Disaster Management in Bangladesh: Lesson from Super Cyclone Sidr

Md. Ataur Rahman: Coastal Vulnerabilities and Its Integrated Management in Bangladesh Coast

Abdul Hoque: Impacts of Ship Breaking Activity and Sustainable Environmental Management in Bangladesh: a Case Study in the Sitakunda Coastal Area of Chittagong

Van Lap Nguyen, Thi Kim Oanh Ta, Yoshiki Saito: Coastal Landform Variations of the Mekong River Delta, Vietnam in Relation to Monsoon Activities

Thi Kim Oanh Ta, Van Lap Nguyen, Masaaki Tateishi, Iwao Kobayashi, Masatomo Umitsu,Yoshiki Saito: Holocene Coastal Delta Development Patterns and Sediment Discharge of the Mekong River in Vietnam

Coffee Break/Poster Presentation

Afternoon Session 2 – Coastal Environment and its Management: Chaired by Ryota Nagasawa

Hai Quang Hai: Protection and Management of Karstic Geosites of Hatien-Kienluong Coastline, Vietnam

Vien Ngoc Nam, Tran Dinh Hue: Mangrove Flora Biodiversity in Con Dao National Park, Baria - Vung Tau Province, Vietnam

Cao Huy Binh, Vien Ngoc Nam: Carbon Fixation of Ceriops Decandra in Can Gio Mangrove Biosphere Reserve, Ho Chi Minh City, Vietnam

Boonruck Patanakanog, Phanumat Amphat, Akkharasit Naropakarn: Coastal Erosion in Samut Prakan Province and Bangkok in the Past Decades by Using Aerial Photographs

Charlchai Tanavud, Thudchai Sansena: Assessing Potential Impacts of Sea Level Rise on Coastal Areas in Songkla Lake Basin Using GIS and Remotely Sensed Data

Closing Discussion – Discussant: Masatomo Umitsu and other participants

Discussion at Dinner

List of Poster Presentations

Ryota Nagasawa, Yu Takahashi, Amornchai Prokobya, Kridsakron Auynirundronkool, Sitthisak Moukomlo: Paddy Field Mapping using Temporal MODIS and Landsat ETM+ Imageries - A Case Study in Nakhon Sawan Province, Thailand

Tomoaki Nakamura, Norim Mizutani: Numerical Simulation of Tsunami-induced Local Scour Considering Dynamic Response of Sand Bed

Kazuaki Hori: Millennial-scale Floodplain Aggradation: an Example from the Nobi Plain, Japan

Natsuko Hayashi: Relationship between Topography and Ground Damages Caused by Liquefaction in Fukui Plain, Fukui Prefecture, Japan

Janjirawuttikul Naruekamon, Masatomo Umitsu: Relationships between Acid Sulfate Soils and Landforms in Nakhon Si Thammarat, Thailand

Ho Thi Kim Loan: Application of SRTM3 and LANDSAT ETM+ to Generate Geomorphologic Map for the Purpose of Flood Risk Mapping in Hoi An, Vietnam

Helmi Thomin: Community Base Approach in Mangrove Restoration and Management in Simeulue Island Province of NAD, Indonesia

Keisuke Tomita, Satoshi Ishiguro, Makoto Takahashi: Environmental Studies at the Geography Department of Nagoya University

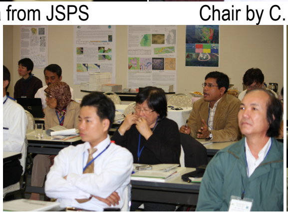
Group photograph at the Workshop

Guest address by A. Maesawa from JSPS

Chair by C. Thanawood & J. Naruekamon

Keynote by J. Sopaheluwakan

Address by S. Yamamoto



Discussions at the workshop

SCHEDULE OF FIELD EXCURSIONS

Day 1: February 22, 2009 (S unday)

Chubu International Airport
Nagoya University
Stop 1: Downtown of Nagoya (Lunch at Taiyo-ro)
Stop 2: Nagoya Port: most active seaport in Japan
Stop 3: Reclaimed land of Nabeta: affected areas of Typhoon Vera (1959)
Stop 4: Nagashima: monitoring of ground subsidence
Stop 5: Ise Shrine and Oharai Town: community-based tourist development
Stop 6: Ise-Shima Miyage Center – Osho (Discussion at dinner)
Shima Central Hotel SOCIA: overnight

Day 3: February 24, 2009 (Tuesday)

Shima Central Hotel SOCIA
Stop 7: Asoura, Minami-Ise Town: coastal embankment, floodgate
Stop 8: Nishiki, Taiki Town: community-based tsunami preparedness (Lunch)
Presented by Mr. Tsugio Nakaseko, Head of Disaster Prevention Section of Taiki-cho
Nagoya University: bringing down Nagoya Dwellers and some others
Chubu International Airport (Hotel Toyoko-inn): overnight

Group photograph at the monument of Typhoon Vera, Kuwana-shi

Coastal Dike of Asoura, Minami-ise-cho

Presentation by T. Nakaseko, Taiki-cho

Early warning system at Taiki-cho

Evacuation room of Nishiki Tower

Group photograph at a temple designated as an evacuation place in Nishiki