Asia-Pacific Network for Global Change Research

Integrated Vulnerability Assessment of Coastal Areas in the Southeast Asian Region

Final report for APN project: ARCP2008-02CMY-David

The following collaborators formed the core team of this project:

Laura T. David, Ph.D., U. Philippines Marine Science Institute, Philippines, ldavid@upmsi.ph
Pich Sereywath, Department of Fisheries, Cambodia, sereywath_pich@yahoo.com
Ivonne M. Radjawane, Ph.D., Bandung Inst. of Tech., Indonesia, ivonnemr@geoph.itb.ac.id
Ejria Saleh, Ph.D., University of Malaysia – Sabah, Malaysia, ejsaleh@ums.edu.my
Felino Lansigan, Ph.D. U. Philippines Los Banos, Philippines, fpl@instat.uplb.edu.ph
Beverly Goh, Nanyang Technological University, Singapore, bgoh@nie.edu.sg
Pitiwong Tantichodok, Ph.D., Walailak University, Thailand, tpitiwon@wu.ac.th
Anond Snidvong, Ph.D., Chulalongkorn University, Thailand, anond@start.or.th
Nguyen Hoang Tri, Ph.D. Vietnam National University, Vietnam, nguyenhoangtri@hn.vnn.vn
Kim Anh Thi Nguyen, Ph.D. Nha Trang University of Fisheries, Vietnam, sonanhcc@yahoo.com
Jochen Hinkel, Ph.D., DINAS-COAST, Germany, hinkel@pik-potsdam.de
Marine Environment and Resources Foundation Inc., Philippines
SEA START Regional Centre, Thailand
LOICZ-IPO, Germany

VULNERABILITY ASSESSMENT OF COASTAL AREAS IN THE SOUTHEAST ASIAN REGION

Complete list of collaborators

Cambodia
Pich Sereywath, Buoy Roitana, Norng Sivouthan

Indonesia
Ivonne Milichristi Radjawane, Anastasia Rita Tisiana Dwi Kuswardani, Valentina Dwisasanti Endang Savitri, Fitri Riandini, Siti Hajar Suryawati

Malaysia
Ejria Saleh, Awangkul Hassanal Bahar Bin Pengiran Bagul, Bernardette M. Manjaji Matsumoto, Annadel Cabanban

Philippines
Laura T. David, Felino P Lansigan, Ben S. Malayang III, Nicomedes Briones, Consuelo Habito, Robert Brian Canto, Roselle Borja, Rommel Maneja, Antonia Loyzaga, Emmi Capili, Celine Vicente, Gemma T. Narisma, Rosa Perez, Juan Blenn Huelgas, Mike Atrigenio, Maya Villaluz, Pedro Bueno, Nong C. Rangasa, Ebinezer Florano, Rodel Subade

Singapore
Beverly Goh, Stephen Chua, Elisabeth Bui

Thailand
Anond Snividong, Pitiwong Tantichodok, Wirote Laongmanee, Suppakorn Chinvanno, Pinsak Suraswadi

Vietnam
Nguyen Hoang Tri, Kim Anh Thi Nguyen, Chau Thi An Pham, Nguyen Phong Hai

East Asia
Yoshiki Saito

South Asia
Mohammad Zafar, Indrila Guha, Ramesh Ramachandran

Europe and USA
Jochen Hinkel, Hartwig Kramer, Juergen Weichselgartner, Jane Thomas, Pasky Pascual

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Final Report submitted to APN

Overview of project work and outcomes

Non-technical summary

Vulnerability of coastal areas to sea level rise is driven not only by global environmental changes but likewise by socio-economic development and the ability of affected communities to cope with such changes. As such we endeavored to achieve an integrated analysis of the effect of the complex and dynamic social, economic and environmental factors found in the region to the vulnerability of human communities, and their implications for management and governance of coastal systems and adaptation capacities. Coordinated through the LOICZ Regional Node SEAsia, the method of approach employed was to primarily focus on training workshops (funded by the Asia-Pacific Network, APN and the APN-START) for regional participants to expose them to available assessment tools. The endeavor also allowed for the synthesis of primary and secondary data from all collaborating countries.

The guiding principle of this collaborative effort in the Southeast Asia is to effectively influence policy and decision makers in the selection of strategic and sustainable adaptive measures to reduce the future impact of GEC.

Objectives

The main objectives of the project were to:

1. Determine the vulnerability gradients across the coastal areas of the SEA-EA region considering the coupled human and ecological systems.
2. Understand the multi-scale dimensions and inputs on the adaptive capacities of human communities toward the vulnerability of coasts, of conflicts and competition over lands, sea areas, and resources in the region.
3. Determine efficient and effective strategies to link GEC research results with policy making, governance and conflict resolution.

Amount received and number years supported

APN Secretariat: 28,000 USD (80% of total funding for 2006-09)
International START Secretariat: 36,000 USD (80% of total funding 2006-07)

Activity undertaken

The 1st workshop, which focused on vulnerability assessment and tools evaluation, commenced November 2006 (Appendix 1.1). Dr. Laura David started the workshop with an overview of the project objectives and expectations. Additional funding were solicited from LOICZ-IPO to cover the cost of 1 scientist from the EU who is an expert on coastal vulnerability assessment; Dr. Jochen Hinkel (DINAS-COAST).

The workshop focused on sharing each country's status with respect to coastal vulnerability assessments to climate change and in introducing the participating countries to DIVA – an integrated coastal vulnerability assessment tool (Appendix 1.2). There were interest in using this global approach and applying it to the region. As a result, the group led by Dr. Anond Snidvongs was tasked to assess which data/parameters can be updated in DIVA to suit the regional need and to determine the appropriate spatial scale for update using existing SEA START-LOICZ database. Dr. Laura David and team were also tasked to come up with additional tutorial materials for DIVA. All participating countries were tasked to come up with case studies that will highlight their respective country's sensitivity to extreme events with particular focus on priority issues on coastal zone and resources management. Drs. Felino Lansigan and Ben Malayang III provided a template for describing case studies. Finally, each country participant was also tasked to recruit and mobilize a 'sub-network' of socio-economists in their country who will address common issues on vulnerability assessment e.g. valuation of impacts including development of protocols and guidelines for appropriate pricing of resources and impacts.

The DIVA hands-on tutorial was distributed prior to the 2nd workshop.

The 2nd workshop, which focused on vulnerability assessment and with valuation analysis, commenced September 2007 with old and new participants (Appendix 2.1). Dr. Beverly Goh was tasked to give a climate-change brief and explain the IPCC scenarios (Appendix 2.2) The new participants were mostly social scientists and economist from each collaborating country. Country case studies of vulnerability assessment and valuation thereof were presented (Appendix 2.3). New participants were again exposed to DIVA as an assessment tool. The discussions following the demonstration emphasized that the current DIVA database and resulting vulnerability assessment is acceptable for a regional study and may also be used for relative vulnerability comparison between countries. However, comparisons of results to site-specific case studies cannot be addressed at the current scale of the model. This highlighted the need to make a regional higher resolution assessment tool (perhaps a DIVA SEAsia) as future work.

A member of the IPCC, Dr. Rosa Perez, presented the overview of the Philippine-wide vulnerability assessment of coastal areas (Appendix 2.4). A scientist from the U.S.A. Environmental Protection Agency, Dr. Pasky Pascual shared his insights on translating science results into policy (Appendix 2.5). A policy maker from the UN Habitat, Mr. Blenn Huelgas, shared his experience in development considerations in disaster preparation (Appendix 2.6). The economist member of the Philippine team, Dr. Nicomedes Briones, presented several case studies on climate change valuation (Appendix 2.7). All participating countries were also given hands-on training on visual communication of assessment results to the media and policy makers (conducted by Ms. Jane Thomas) (Appendix 2.8).

LOICZ-IPO provided additional funding for the 2nd workshop to cover the cost of 2 scientists from the EU and the USA who are experts on coastal vulnerability assessment; Dr. Jochen Hinkel (DINAS-COAST) and Ms. Jane Thomas (U. Maryland Center for Environmental Science); and 2 scientist from South Asia; Dr. Indrila Guha (India) and Prof. M. Zafar (Bangladesh) who shall be doing a similar coastal vulnerability assessment with their colleagues from South Asia. It was envisioned that the participation of the South Asian scientist in the SE/E Asia workshop will (1) help jump start their own vulnerability assessment since they can learn fom our experience, and (2) expose the SE/E Asian scientist to other vulnerability conditions that we may not be familiar with (Indian Ocean Dipole Mode) (Appendix 2.9). Partial results from the 2nd workshop were also presented by Dr Ivonne Radjawane to the South Asia workshop on Vulnerability Assessment held in Maldives, with support funds from LOICZ-IPO.

Papers on regional and country-by-country analysis of mitigation practice effectiveness were also presented in the IOC WestPac Conference and IGBP Congress, respectively. The combined paper entitled, "Accomodating Change in SEAsia," was published in LOICZ Inprint December 2008 issue.

The 3rd workshop, which focused on synthesizing the results of the in-country case studies and developing the final communication product for decision-makers, commenced November 2009 with old and new participants (Appendix 3.1). The core members first attended the East Asian Seas Congress held in Manila where the paper on "Accomodating Change in SEAsia," was presented by Dr. Beverly Goh. The core team was also able to familiarize themselves with other vulnerability assessment endeavors being conducted within the region. The rest of the team, composed of social scientists and economists, arrived after the EAS Congress and presented the results of their in-country case studies (Appendix 3.3). Dr. Felino Lansigan was tasked to also give an overview of, "Plausible Scenarios for Vulnerability Assessment of Coastal Systems (Appendix 3.2)."

Invited external participants included Mr. Mike Atrigenio from the UP Marine Science Institute who shared their Vulnerability Assessment of Sorsogon Bay and the consequential IEC and policy recommendations(Appendix 3.4); Dr. Pedro Bueno of the Network of Aquaculture Centres in Asia –Pacific who shared his experiences in climate adaptation of aquaculture (Appendix 3.5); Mr. Nong Rangasa, of the Philippine Centre for Initiatives and Research on Climate Adaptation (CIRCA), who talked about on-the-ground strengthening of the Philippines' Institutional capacity to adapt to climate change (Appendix 3.6); Dr. Ramesh Ramachandran, from LOICZ-South Asia, shared their South Asia experience in hazard mapping and coastal management (Appendix 3.7); and Dr. Gemma Narisma from Manila Observatory, who emphasized the importance of investing in the scaling down of global climate models (Appendix 3.8). Dr. Ebinezer Florano of NCPAG and Dr. Rodel Subade each shared their expertise in and experiences on developing climate-related communication products specifically for local government units and other decision-makers.

Results

DIVA simulations shows

(1) There is a high cost to doing nothing.

(2) Beach nourishment overall more cost-effective for SE Asia. Specifically for the preservation of wetland areas, coastal forests, and mangroves and to minimize net land loss due to erosion, sand loss, and migration due to land loss. It should be noted however, that sustainable coastal nourishment, in the team's point-of-view, should incorporate coastal cover rehabilitation (multi-species mangrove and seagrass reforestation and coral reef protection).

(3) Site-specific engineering intervention is recommended as well to mitigate people actually flooded, land loss due to submergence and associated sea flood costs

(4) No effective mitigation is currently being recommended to mitígate for salt-water intrusion

(5) For SE Asia, a global scenario of balanced source of energy and reduction of population growth (B1 or A1T scenarios) is preferable. For these SRES, beach nourishment and site-specific engineering interventions are still effective.

Climate change is perceived as an exacerbating factor in already existing coastal issues. At the same time existing coastal issues makes the coastal area more vulnerable to climate change effects. Using case studies coupled with in-country expert analysis, the most relevant coastal issues were identified and ranked (see table).

Parameters	Rank
Exploitation & Destruction of Coastal Resources	1.00
Natural & Anthropogenic Changes in Sediment Transport	2.00
Population Growth, Urbanization & Social Equity	3.00
Relative Sea Level Rise (including land subsidence)	4.00
Natural Disasters	5.00
Food Security	6.00

Relevance to APN's Science Agenda and objectives

This project addresses all four foci of the APN Science Agenda (Climate; Ecosystems, biodiversity and land use; Changes in the atmospheric, terrestrial and marine domains; and Use of resources and pathways for sustainable development). The outputs of the proposed project will be of direct relevance to the policy agenda of APN, as the tools developed (from scientific inputs) is targeted to have application to policy and sustainable development decision-making processes. In addition, this collaborative project involved six member countries of APN (Cambodia, Indonesia, Malaysia, Philippines, Thailand, Vietnam) with all six considered developing. It also involves other countries in the Asia-Pacific region as collaborators, many of whom are part of the larger global change research community. It draws on the larger scientific community from Europe and USA as collaborators for resource inputs, and the main focus in the utilization of financial support from APN is capacity building for the region.

Self evaluation

The first 2 years proceeded as scheduled with only minor adjustments to ensure participation of all collaborators. Adjustment to the year 3 schedule was done to take advantage of the East Asia Congress. This adjustment also allowed additional time for the participating countries to gather relevant data from their respective case studies.

Objectives were met. The training workshops (1 and 2) provided the cohesive impetus for the participating countries to proceed with the assessment of their case studies with a regional perspective in mind. Hiring of 3 graduate students for specific tasks (making of the DIVA manual and exercises and simulations of regional and country vulnerability scenarios) was also instrumental in the achievement of the objectives.

The main problem encountered was that by year 3, most of the participating country experts were already being tapped by their respective governments for inputs to national climate change assessments (in preparation to Copenhagen summit). This proved to be taxing on each of the experts' schedule and prevented some of them from actively participating in the integration analysis. The final synthesis report therefore has case study input only from Indonesia, Malaysia, the Philippines, Singapore and VietNam.

Potential for further work

Identified future developments include

(1) Development of smaller-scale or more regional scale CC scenarios and Vulnerability Assessment models (like a DIVA East Asia and on-the-ground assessment tools)
(2) Additional localized on-the-ground case studies for model validation. Site selection should use as guide coastal characteristic typology analysis.

Publications

LOICZ INPRINT December 2008 (Appendix 44)
Invited paper for GAIA (Appendix 4.7)
Booklet on Climate Vulnerabilty of Southeast Asian Coast (Appendix 4.6)

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Acknowledgments

Acknowledgments: LOICZ SEasia/Asia Regional Node, Singapore; Southeast Asia START Regional Center, Thailand; Marine Environment and Resources Foundation, Philippines; LOICZ International Project Office, GKSS Research Centre, Germany. The project goals were also met thanks in a large part to the respective in-country support for the individual case studies (Appendix 5 and 6).

Technical Report

Preface

This project endeavored to assess the vulnerability of Southeast Asia coasts. This collaborative effort was borne from the recognition that there are still considerable gaps in our knowledge with respect to how multiple biogeographical and anthropogenic processes interact to create risk. Our method of approach focuses on training workshops which exposed the regional participants to available tools for assessment and brought together secondary and primary data from collaborating countries. The guiding principle of the whole endeavor is to effectively influence policy and decision makers in the selection of strategic and sustainable adaptive measures to reduce the future impact of GEC.

Table of Contents

1.0 Introduction

Vulnerability of coastal areas to sea level rise is driven by both global environmental changes, socio-economic development, as well as, the ability of affected communities to cope with such changes, which in turn, is influenced by interacting social, economic and environmental factors (Amadore et al., 1996; Mimura, 2001; Adger, 2003; Lasco and Boer, 2006; Nicholls et al., 2007). There is a necessity therefore for an integrated analysis to determine their collective effect on adaptation capacities of human communities.

Our method of approach is to primarily focus on training workshops (funded by the Asia-Pacific Network, APN and the APN-START) which expose regional participants to available assessment tools and synthesize secondary and primary data from collaborating countries. There were two previous studies that involved participatory assessment with local scientists. One is the Regional Workshop on Climate Change Vulnerability and Adaptation Assessment in Asia and the Pacific sponsored mostly by U.S. and Philippine Institutions and the Asian Development Bank which highlighted the GEC vulnerability of islands and coastal nations in general and agriculture, water and forest resources in particular (Amadore et al., 1996). The other is the SURVAS project (Synthesis and Upscaling of Sea-Level Rise Vulnerability Assessment Studies) funded by the EU, the ENRICH Network, the APN, and the IGBP/IHDP-LOICZ core project. This endeavor resulted in inputs from China, Indonesia, Japan, Malaysia, Thailand and Vietnam and provided for validation of ongoing global assessment efforts in the DINAS-COAST Project (Nicholls and de la Vega-Leinert, 2001). It was the LOICZ affiliated DINAS-COAST project that produced the DIVA tool (Dynamic Interactive Vulnerability Assessment) which is one of the primary tools used in this study.

With the active participation of the country-experts, the project also made use of existing and on-going VA country case studies. All participating countries were tasked at the end of the 1st workshop to come up with case studies that highlight their respective country's coastal zone sensitivity to extreme events. Each participant was also asked to mobilize a 'sub-network' of socio-economists in their country who participated in the 2nd workshop which was focused on vulnerability assessment with valuation analysis. The 3rd workshop focused on synthesizing the results of the in-country case studies and developing the final communication product for decision-makers.

In summary, this project endeavored to:

1. Determine, the vulnerability gradients across the coastal areas of the SEA-EA region considering the coupled human and ecological systems.
2. Understand the multi-scale dimensions and inputs on the adaptive capacities of human communities toward the vulnerability of coasts, of conflicts and competition over lands, sea areas, and resources in the region.
3. Determine efficient and effective strategies to link GEC research results with policy making, governance and conflict resolution.

2.0 Methodology

The project endeavored to address the gaps in our knowledge of the vulnerability of Southeast Asian coasts to climate change using modeling and on-the-ground bio-physical and socio-economic evaluations. Making use of available VA tools, the project was able to assess vulnerability of coastal sites to the different SRES scenarios. These assessments took into consideration the complex and dynamic social, economic and environmental factors that have influence on the ability of those affected to cope, recover and adapt to changes. At the same time, the country case studies along with in-country expert opinion, identified the existing coastal issues which makes the coastal area more vulnerable to climate change effects.

2.1 DIVA model simulations

Our method chosen for the regional and country assessment is to apply the DINAS-COAST DIVA model (Dynamic Interactive Vulnerability Assessment) which integrates natural and socio-economic variables in the analysis (http://diva.demis.nl/; Hinkel, 2005; Hinkel and Klein, 2008; McFadden et al., 2007). Cases were simulated with different combinations of adaptive strategies and the scenarios derived from the Intergovernmental Panel on Climate Change Special Report on Emission Scenarios (IPCC SRES) storylines (Figure 2.1). The analysis was done on a regional scale with a high regionalized sea level rise and on a per country scale with low, medium and high regionalized sea level rise. Two adaptation options for coasts under threat of sea level rise are considered in the DIVA model: dike protection and beach nourishment. DIVA implements these options according to several predefined adaptation strategies such as "do nothing",full protection or protection according to a cost-benefit analysis of damage and adaptation cost. Dike protection strategies are further divided into different flood return periods against which to protect (e.g., 10 years, 100 years or 1000 years events).

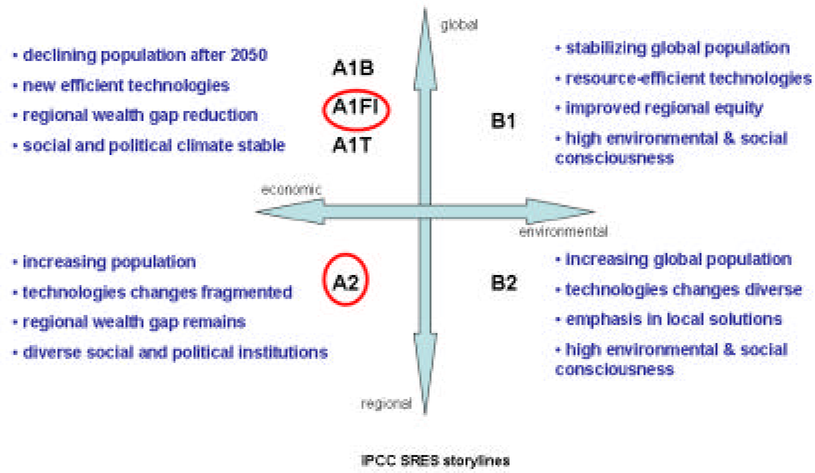

Figure 2.1 Summarized description of the 6 IPCC SRES storylines

In order to get a handle on the inter-country similarity and disparity country data and model results were further analyzed using a geospatial clustering tool produced during LOICZ I, the LOICZ-DISCO (Deluxe Integrated System for Clustering Operations), (http://fangorn.colby.edu/disco-devel/index.php ; Smith and Maxwell, 2002). LOICZ-DISCO makes use of K-means clustering which is a robust clustering method that partitions the entire data set into pre-determined number of groupings based on proximity of values to means. The means are initially randomly selected but are iteratively re-calculated every time a new data is added to the cluster (Buddemeier et al, 2008) (Figure 2.2). Clustering was done using natural and socio-economic country parameters available in the coastal database of the DIVA model, as well as, all the scenario results of the DIVA simulations for the countries of Southeast Asia.

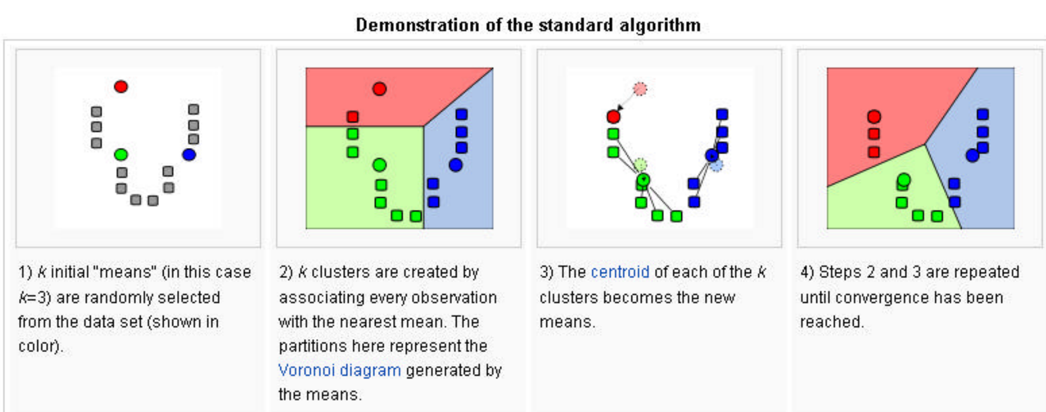

Figure 2.2 Simplified demonstration of K-means clustering process
(Lifted from http://en.wikipedia.org/wiki/K-means_clustering)

2.2 Case Studies and Regional Synthesis

The project relied on contributions from the participating countries in terms of coastal case studies. This being the case, there is a disparity between the levels of accomplishment between each site (i.e. there are sites which already have a thorough bio-physical and socio-economic assessments while others are at the very start of the data gathering process). Nevertheless, we contend that all that is presented here is a major contribution in terms of in-situ knowledge of the state and vulnerability of the coast of Southeast Asia.

Cambodia

The team from Cambodia led by Mr. Pich Sereywath of the Cambodia Ministry of Agriculture, Forestry and Fisheries focused on the selected communities in 2 coastal provinces (Kampot and Koh Kong). The main focus was to identify the root cause and effect of coastal vulnerabilities to climate change with emphasis on potential and current impact of sea level rise on the coastal household socio-economic condition and fishery resources. Secondary and primary data collection were to focus on (1) Socio-economic information; (2) Livelihood and dependency on aquatic resources; (3) State of aquatic resources (coral reefs and seagrass); (4) Review of policy system. The latter will specifically evaluate the policy system in terms of its coping mechanism for coastal vulnerabilities to sea level rise.

Indonesia

Team Indonesia was coordinated by Dr. Ivonne M. Radjawane of the Technological Institute of Bandung. Their primary site of choice was Jakarta. Jakarta is a megapolitan coastal city located in the coastal area of Jakarta Bay and has an important role for transportation, trading, and other many human activities. Jakarta has high population density and growth rate as well. It is expected that sea level rise would have significant economic impacts on urban infrastructure, land use and population in Jakarta. The case study proposed to conduct a comprehensive study on the vulnerability of coastal community of the Jakarta Bay coastal area to climate change-related phenomenon, sea level rise and flooding. Specifically, they focused on 1) Economic Valuation of impact sea level rise, and 2) Vulnerability Assessment.

The value of projected economic loss was calculated using the following equation:

Wetland (t) = Inundation Areas(t) x (Value (t) x wetland value) **(1)**
Dryland (t) = Inundation Areas(t) x (Value (t) x dryland value) **(2)**
Value(t) = Index**scale **(3)**

Where the Index is given as 14 for Dryland and 1.2 for Wetland (Frankhausser,1994) and Scale was calculated based on GDP.

$$scale = \frac{\left(\frac{GDP/Capita}{20000}\right)}{\left(1 + \frac{GDP/Capita}{20000}\right)} \qquad (4)$$

Vulnerability assessment was done combining the natural and socio-economic indices. Natural Vulnerability was determined using the approach of Gornitz (1991)

$$CVI ? \sqrt{((a*b*c*d*e*f*g)/7}$$ **(5)**

With
a = geomorphology
b = coastal slope
c = relative sea-level rise rate
d = shoreline erosion/accretion rate
e = mean tide range
f = mean wave height
g = geology

and using the following table ((Table 2.1) as guide

Table 2.1 Natural Coastal Vulnerability Index (Gornitz, 1991)

Rank	Very Low	Low	Moderate	High	Very high risk
Variable	1	2	3	4	5
Elevation (m)	≥ 30.0	20.1-30.0	10.1-20.0	5.1-10.0	0-5.0
Geology (relative resistance to erosion)	Plutonic, Volcanic (lava) High-medium grade metamorphics	Low-grade metamor. Sandstone and conglomerate (well-cemented)	Most sedimentary rocks	Coarse and/or poorly sorted unconsolidated sediments	Fine unconsolidated sediment Volcanic ash
Landform	Rocky, cliffed Coasts Fiords Fiards	Medium cliffs Indented coasts	Low cliffs Glacial drift Salt marsh Coral Reefs Mangrove	Beaches (pebbles) Estuary Lagoon Alluvial plains	Barrier beaches Beaches (sand) Mud flats Deltas
Vertical movement (RSL change) (mm/year)	< -1.0 Land rising	-1.0-0.99 <------------------	1.0-2.0 within range of eustatic rise	2.1-4.0 Land sinking	> 4.0 ------------------>
Shoreline displacement (m/yr)	> 2.0 Accretion	1.0-2.0 <------------------	-1.0-+1.0 Stable	-1.1--2.0 ------------------>	< -2.0 Erosion
Mean Tidal Range (m)	< 1.0 Microtidal	1.0-1.9 <------------------	2.0-4.0 Mesotidal	4.1-6.0 ------------------>	> 6.0 Macrotidal
Maximum Wave height (m)	0-2.9	3.0-4.9	5.0-5.9	6.0-6.9	> 6.9

Socio-economic vulnerability was determined using the Socio Economic Indicators as indicated by Szlafsztein (2005).

$$\textit{Socio-economic Vulnerability Index} = \frac{\Sigma \text{ Socio-economic Vulnerability Variables}}{\text{Number of Variables}}$$

$$\Sigma \text{ Socio-economic Vulnerability Variables} = 1(a1)_{ij} + 0{,}5\,(a2)_{ij} + 0{,}25\,(a3)_{ij} + 0{,}125\,(a4)_{ij}$$ **(6)**

Where a1 = Total population impact affected
a2 = Population Density
a3 = Land use
a4 = Poverty grade

The vulnerability of two additional sites (Semarang City and Segara Anakan Lagoon) were also briefly presented (Figure 2.3).

Figure 2.3 Location of the 3 study sites of Indonesia : Jakarta to the northwest, Samarang to the northeast and Segara Anakan Lagoon in the south

Malaysia

Team Malaysia was spearheaded byDr. Ejria Saleh of the Universiti Malaysia Sabah. The site selected is Darvel Bay, which is located at in the Lahad Datu and Kunak districts. It is populated by the locals of various races, migratory sea gypsies (*Bajau*) and illegal immigrants. It is an area of high coral diversity and has been identified as an important marine resource in the region. Recently, Darvel Bay has been identified for mariculture (seaweeds), aquaculture (floating cages) and eco-tourisms. At present, large plantations, some medium estates and smallholders are the most important agriculture scale activities that accommodate lowland areas. The new agriculture activities contribute high sediment into coastal area. This project will attempt to find 1) total suspended sediment and sedimentation using field measurement/observation and secondary data; 2) the likely impacts on populations and biodiversity, and impact areas of sedimentation and water currents and; 3) current actions by government and other public and private institutions or entities that could contribute to water marine pollution in the Darvel Bay.

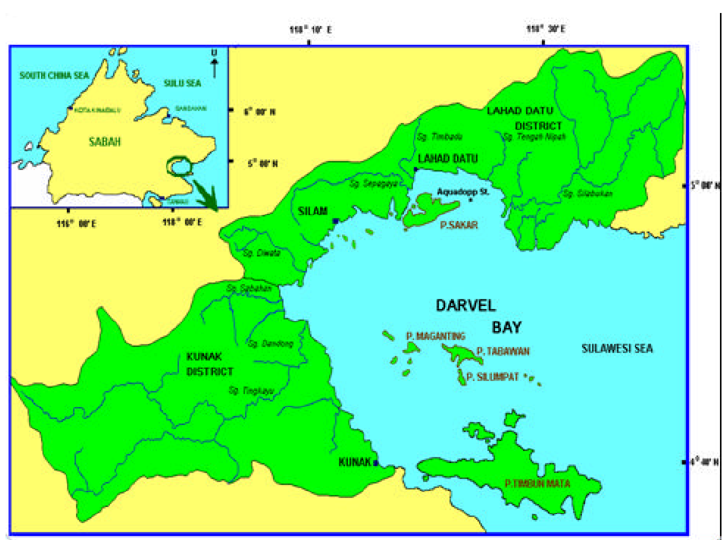

Figure 2.4 Study site in Malaysia – Darvel Bay, Sabah

The Philippines

The prime study sites (Batangas and Talim Bay) were investigated by the University of the Philippines, Los Baños led by Drs. Consuelo Habito and Nicomedes Briones. Batangas Bay is an important economic hub of the CALABARZON and is home to an international maritime port and various manufacturing industries. The medium term development plan for the province projects the transformation of the bay from a purely agricultural to an agro -industrial area. This can have serious environmental repercussions. The biological resources of Batangas Bay provides livelihood for several sectors such as local fisherfolk, tourism-related service providers and land -based activities such as livestock production (poultry, pig and cattle) and agricultural crops. Moreover, it is adjacent to the Verde Island Passage, which is an important marine biodiversity corridor that is under the administrative jurisdiction of Batangas City. The objective of the study in Batangas Bay is to (1) assessment the vulnerability to anthropogenic stressors and future impacts of climate change-related phenomena and (2) determine if there are appropriate response in place to address these vulnerabilties. Talim Bay, on the other hand, was used to demonstrate how economic values of environmental impacts and interactions be factored in reducing vulnerability of communities.

Additional study sites were contributed by the Manila Observatory (Baclayon, Bohol), the Marine Environment and Resources Foundation (Gubat, Sorsogon) and by UP Los Baños (Donsol, Sorsogon).

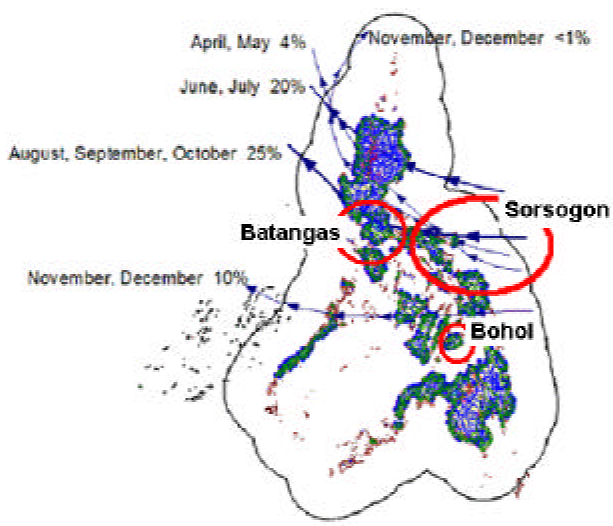

Figure 2.5 Location of study sites encircled in RED. Size of circle depicts relative potential of storm passage. Arrows depict likely path of typhoons passing over the Philippine Area of Responsibility

For all the study sites, primary data was collected from actual field exercise and supplemented by the data obtained from key informants and expert opinions of key players from the government, private sector and NGOs, as appropriate. The features and resources of the coastal area were assessed by rapid ecosystem appraisal. Household surveys and key informant interviews were conducted with the fisher folks, vendors and residents to obtain basic information on the utilization of products from mangroves, fisheries and river ecosystem. Data such as market prices, local population, and other related information were asked from the respondents. Secondary information was also obtained from the Provincial, Municipal and Barangay Offices and officials.

For the sites that were able to do valuation, the following methods (in part or in whole) were applied:

Market Price Method: This primary valuation method is often used in estimating the economic value of ecosystem products or services that are bought and sold in commercial markets (http:/www.ecosystemvaluation.org/). It uses the prevailing market prices for particular goods and services to be valued. In this study, the market price method was used to compute economic values of extractive products derived from mangrove, beach and river and the cost of infrastructures therein.

Travel Cost Method: This method is often used to estimate benefits from recreation in natural sites whose value cannot be obtained through market prices (http:/www.ecosystem valuation.org/). It was computed by determining the willingness to pay to visit the site through the travel and opportunity co sts incurred in a trip. The value of the recreation and ecotourism of the beach resource was estimated using this approach.

Benefit Transfer Method: Benefit transfer method is a secondary means of estimating the value of environmental goods/services through the previously conducted similar studies but subject to some adjustments (http:/www.ecosystemvaluation.org/). It was applied to estimate the value of the following use and non-use values of the beach, mangrove and river ecosystems like the plankton productivity, protection from wave impact, erosion control, research and education, and carbon sequestration.

Damage Cost Method: This approach is one of the cost-based valuation techniques that estimates value of lost ecosystem services through the costs to be incurred in avoiding damages (http:/www.ecosystemvaluation.org/). It was applied in the study to determine the value of protection function of the mangrove ecosystem.

Contingent Valuation Method: This is the most widely-used method in estimating the non-use values of the particular ecosystem (http:/www.ecosystemvaluation.org/). It applies the concept of willingness to pay of the community for specific environmental services. It was used to determine the option value of the three ecosystems.

The data were then used as inputs of the benefit cost analysis (BCA) of the "with conservation scenario" and "without conservation scenario". Considering a 20-year time horizon and a 10% discount rate, the discounted benefits and costs and net present values were projected and compared. To predict sensitivity of the computed total economic values, different discount rates were applied. Discounted benefits, costs and net present values of the two scenarios were then computed at 5, 10, 15 and 20 percent.

Singapore

Team Singapore was coordinated by Dr Beverly Goh of National Institute of Education/Nanyang Technological University. Being an island state of 4.34 million people and a LOW-LYING land area of only 704 km^2, Singapore is naturally interested in determining the potential consequences of climate change. The case study proposed to (1) assess the vulnerability of coastal areas in Singapore to environmental change (particularly SLR) considering coupled human and ecological systems; (2)to understand the multi-scale dimensions and inputs on adaptive capacities of the social systems towards changes in these coastal ecosystems; (3) to determine effective strategies to link GEC (SLR) research results with risk assessment, policy and governance issues; (4) To develop strategies to communicate the scientific research outputs to policy-makers and the general public. As study site, the team chose Pasir Ris Park, a 70.5 hectare urban recreational park in northeastern Singapore (managed by National Parks Board) to isolate climate change effects (Figure 2.6).

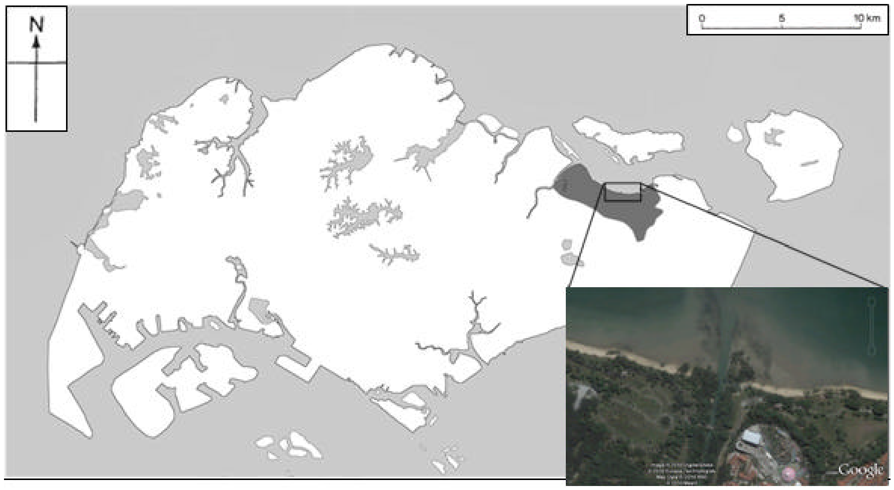

Figure 2.6 Location map of Pasir Ris Park

The case study proposed to integrate secondary datasets at the best available resolution:

i. topography, bathymetry through maps and NASA's Shuttle Radar Topography Mission
ii. ecological data
iii. environmental data (sedimentation, coastal erosion, tidal parameters)
iv. land use data (historical, current, projections)
v. Economic data (GDP, GNP and other economic indicators)
vi. Population and other census data

The primary data collected involved obtaining elevation points (of 10m x 10m grid) via Automatic Level and standard staff (vis-à-vis BM no. 491) and Trimble Juno™ ST GPS handheld model. Geographic Information System (GIS) kriging technique was used to generate 3D image. Additional data on mangrove/beach flora was obtained using the quadrat method.

Various available models (e.g. DIVA model by DINAS-COAST) for integrated vulnerability assessment incorporating biological, geographic and socio-economic variables were validated on the ground. Scenario analyses and risk assessment were conducted to consider possible interactions of socio-economic processes with biophysical processes in Singapore.

Thailand

Dr. Wirote Laongmanee and Dr. Anond Snidvong of SE Asia START Regional Centre proposed to conduct a vulnerability assessment of the Andaman/GOT coast of Thailand. The goal was to determine how sea level rise will affect the coastal land cover, ecology and community.

VietNam

VietNam placed forward two sites Tam Giang–Cau Hai lagoon, of the Thua Thien Hue Province (led by Kim Anh Nguyen Thi of Nha Trang University) and the Red River

Delta (led by Dr. Nguyen Hoang Tri of the Center for Environmental Research and Education) (Figure 2.7).

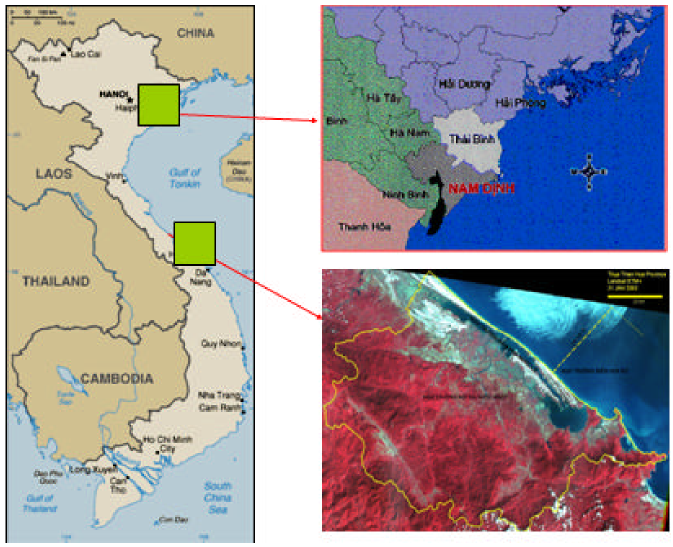

Figure 2.7 Location of the 2 study sites in VietNam.
Red River Delta in the north and Tam Giang–Cau Hai lagoon in the south

Food Security was identified as the main issue and the GEC that were of main concern was the intensity/frequency of typhoons, ocean warming, and sea level rise. Specifically, they focused on (1) identifying potential impacts of climate change on aquaculture; (2) documenting damage that have already been observed due to climate extremes; (3) enumarate existing policies that are in place to assure food security for VietNam; and (4) recommend additional steps necessary for the fish industry.

Regional Synthesis

Within countries and en-bank the participating experts also ranked the coastal issues that exacerbate the effects of climate change and vice versa. This was done using the identified coastal issues in each site. The issues were then given a score of 5.0 (for prevalent) to 0.0 (non-existent) for each site. Countries scores were then taken from the average of the in-country sites. Regional ranking was taken from the average of the country scores – the issue that got the highest score 5.0 got the highest rank of 1.

3.0 Results & Discussion

3.1 For the DIVA simulations, overall vulnerability is given in the number of people affected by flooding and the land being lost near the coast, including wetlands.

3.1.1 DIVA Regional Analysis

The most important message to get across to policy makers and different coastal stakeholders is that there is a high cost to doing nothing. For example, without any adaptation strategy results show a uniform linear increase of migration due to land loss from the present rate of 1000 persons per year to 3000 persons per year by 2040. After 2040 the response diverges with volume of migration depending on the IPCC SRES storyline(Figure 3.1). Highest migration was seen for the A2 followed by the A1FI scenarios. With adaptation measures the migration can be reduced by 40-95%

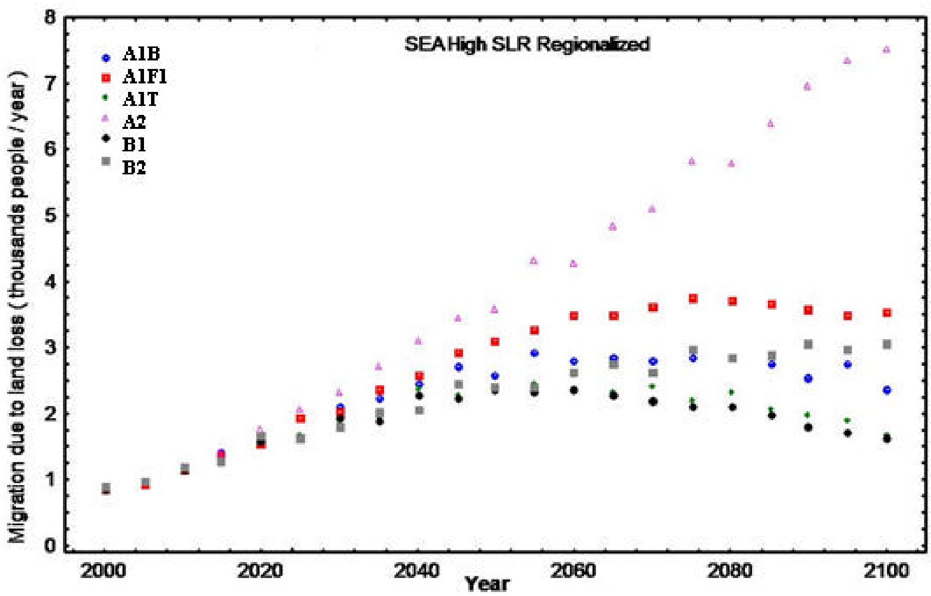

Figure 3.1 Results of DIVA simulation for the different SRES Storylines with no applied adaptation

From the adaptation options in DIVA, dike protection was found to be the better option specifically for mitigating the number of people actually flooded, land loss due to submergence and the costs of damage due to flooding from the sea. There is minimal advantage of the dike height that protect against the one in 100 year flood events over that of one in 10-year events until 2050 (Figure 3.2). Thereafter, the cost-benefit advantage of the higher design return period is significant for the A1B and A1FI scenarios.

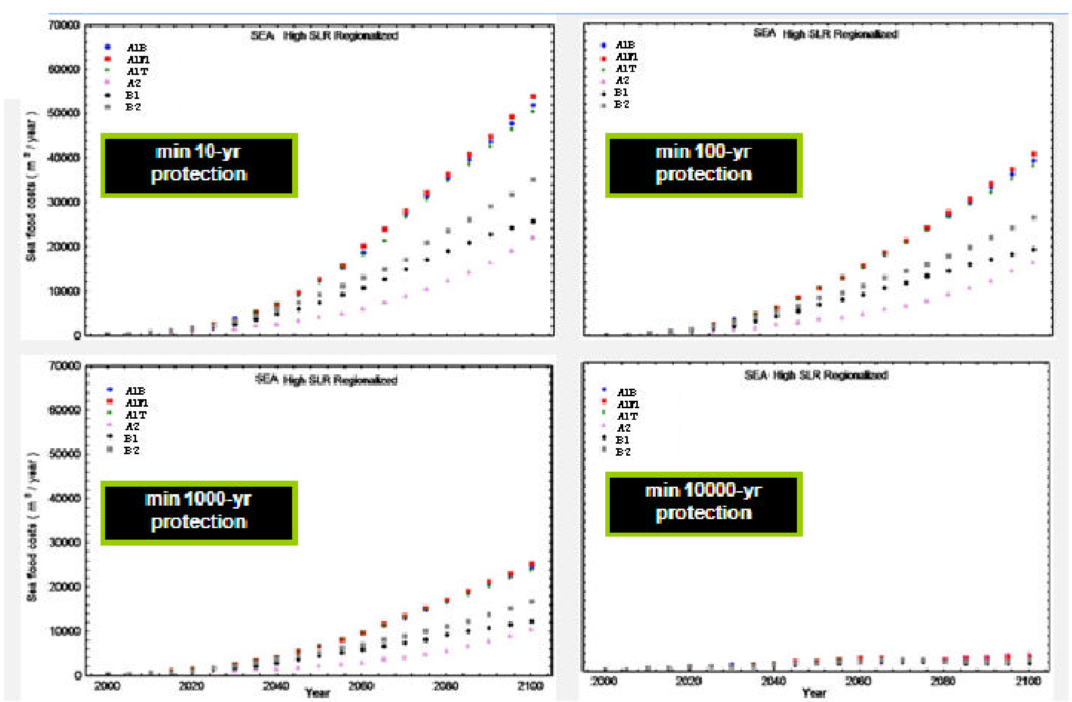

Figure 3.2 DIVA Simulation of consequences of adaptation option using Dike protection for different flood return periods. Efficacy of adaptation option is different for the different SRES storylines

Overall, however, full nourishment seems to be the more cost-effective option with lower total adaptation cost (Figure 3.3). It is also shown to have better efficacy towards minimizing loss of wetland areas, including coastal forests and mangroves; loss sand; net land loss and the consequent migration due to this land loss. It should be noted that sustainable coastal nourishment, in our opinion, should incorporate coastal cover rehabilitation (mangrove and seagrass).

It should be noted however, that whereas hard and soft engineering adaptation response was able to provide solutions for most foreseen climate change consequences, no adaptation measures included in the DIVA model were shown capable of addressing the problem of salinity intrusions to the groundwater induced by sea level rise.

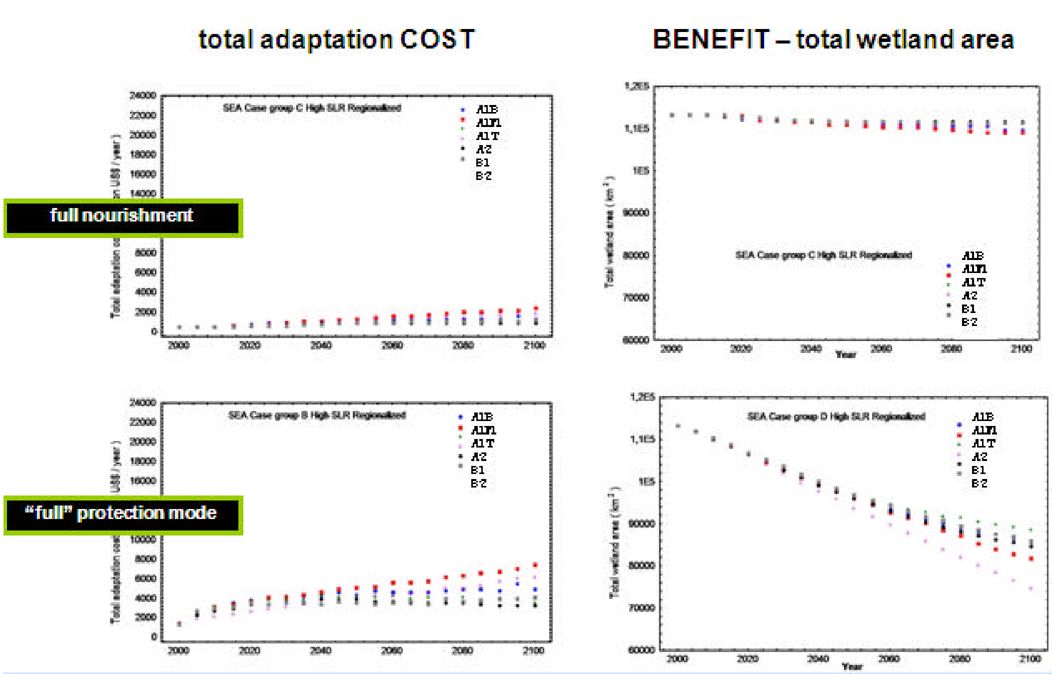

Figure 3.3 Comparison of cost and effectiveness of full nourishment (above) versus Dike Protection (10000 years return period). We see that even with full protection there will still be significant wetland loss as the years progress for all the SRES storylines.

3.1.2 DIVA Per Country Evaluation and Comparison

Results are presented as clusters after typology analysis using LOICZ-DISCO (Figure 3.4). Clustering was done using natural and socio-economic country parameters available in the coastal database of the DIVA model, as well as, all the scenario results of the DIVA simulations for the countries of Southeast Asia.

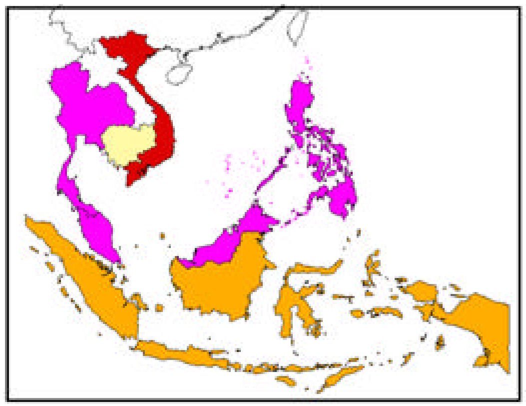

Figure 3.4 Clustering resu lts from LOICZ-DISCO.

Vietnam ended up in a cluster by its self with a characteristic high coastal floodplain population. By 2040, it is expected to experience a relatively high land loss due to submergence resulting in migration of about 1100 people annually. By 2100, the continuing sea level rise is expected to result in a moderate net loss of wetland area and nearly 22 million people experiencing flood every year.

Malaysia, Thailand, and the Philippines exhibit an overall low land loss due to submergence and a moderate net loss of wetland area. This land loss will result in an average annual migration of about 150 to 200 people each for Malaysia and Thailand. No migration is expected for the Philippines. The moderate -size population living on the coastal floodplains is expected to experience flood with up to 2 to 5 million people affected by 2100 in each of these three countries. Overall, the Philippines are expected to fare a little better with a predicted lower total residual damage cost.

Cambodia and Singapore are clustered together due to their small total coastal length. Yet this similarity does not lead to similar consequences. Cambodia, characterized by low coastal exposure will experience only low land loss due to submergence, and a moderate net loss of wetland area. By 2100 about 25 thousand people are expected to experience annual flooding. Singapore also has a projected low land loss but no significant loss of wetland area. Being an island state however, it is expected that a higher amount of their population will experience flooding with around 800 people affected annually in 2040 and up to 660 thousand by 2100.

Indonesia is takes a unique position. Aside from the high coastal population, the vulnerable elements identified for this country include its high coastal forest and mangrove cover. It is expected to experience a high land loss due to submergence with around 800 to 1000 people expected to migrate annually due to land loss. In addition, a high amount of wetland area is expected to be lost by 2100 with up to 26 million people expected to experience flood every year.

The high land loss due to erosion, wetland loss, and migration in response to land loss in Vietnam and Indonesia was modelled to be more effectively mitigated by beach nourishment. In comparison, beach nourishment is only slightly advantageous as compared to dike protection for the mitigation of predicted wetland losses in Malaysia, Thailand, the Philippines, and Cambodia. For Singapore dike protection was recommended to mitigate the predicted land loss. In fact, protection from flooding of tens of millions of people living near the coasts in each of the countries in SE Asia requires dike protection.

3.1.3 Consequence of the Different SRS Storylines

In all the countries, the B1Sea Level Rise Scenario (SRS) exhibits the least amount of damage in terms of natural resources loss due to sea level rise and actual number of people flooded or having to migrate due to submergence (Figure 3.5). Scenario A1T is also an acceptable alternative especially for the countries of Vietnam, Indonesia, Malaysia, and Thailand .

Surprisingly, the rather resource taxing A2 scenario also exhibited a lower total residual damage cost. However, it was noted that mitigation measures specifically addressing loss of total wetland and abating costs of sea flooding are significantly less effective for the A2 scenario.

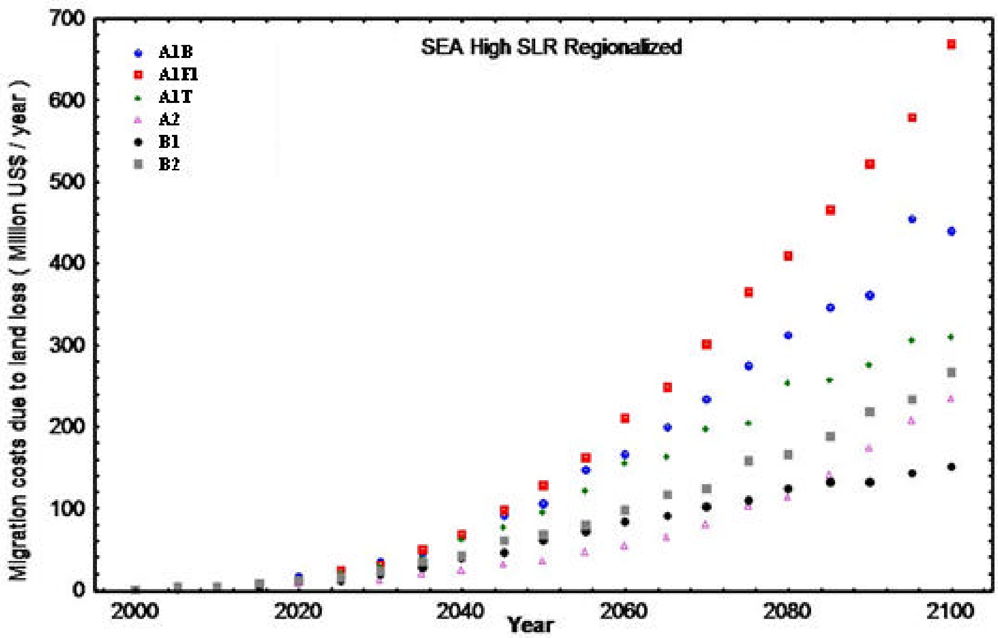

Figure 3.5 Example of cost of damage depending on prevailing SRES storyline. The message here, therefore, is the necessity to make sure we aim for the scenarios that will cause the lesser damage.

3.2 Case Studies

Cambodia

Cambodia has a coastal length of 435 km with 4 provinces directly connected to the coast (Kampot, Kep, Shanouk ville, and Koh Kong). It has a total coastal population of 921,282 (2005) with a reported growth rate of 1.12%. The perceived consequences of sea level rise is that it will cause inundation of coastal communities and low-lying agriculture, as well as, drowning of mangroves and seagrasses which act as nursery ground for their fisheries. There is also a perception of increase in water temperature and increasing frequency of storms. Previous experience in positive temperature anomaly has already been observed to cause massive coral bleaching. The vulnerability to clima te change is seen to be exacerbated by already existing issues of (1) erosion due to logging, (2) increased urbanization and consequential land subsidence, and (3) degradation of coastal resources due both to sewage/solid waste pollution and overfishing. There is also apprehension of potential oil discharge from the nearby port facilities.

In terms of policy analysis, the Cambodia Team shared that there is currently existing information for coastal zone which included statistics on coastal fisheries, National Plan of Action for seagrass and coral reefs and a research for establishment of a demonstration site for seagrass. These are all under the Fishery Administration. However, there is currently no information on sea level rise consequence to fishery resources.

Under the Ministry of Environment there are climate-related supporting policies and projects which include Cambodia's Initial National Communication, the National Adaptation Programme of Action to Climate Change (NAPA), the project on "Vulnerability and Adaptation Assessment to Climate Change in Cambodia", and the Coastal Zone Management project.

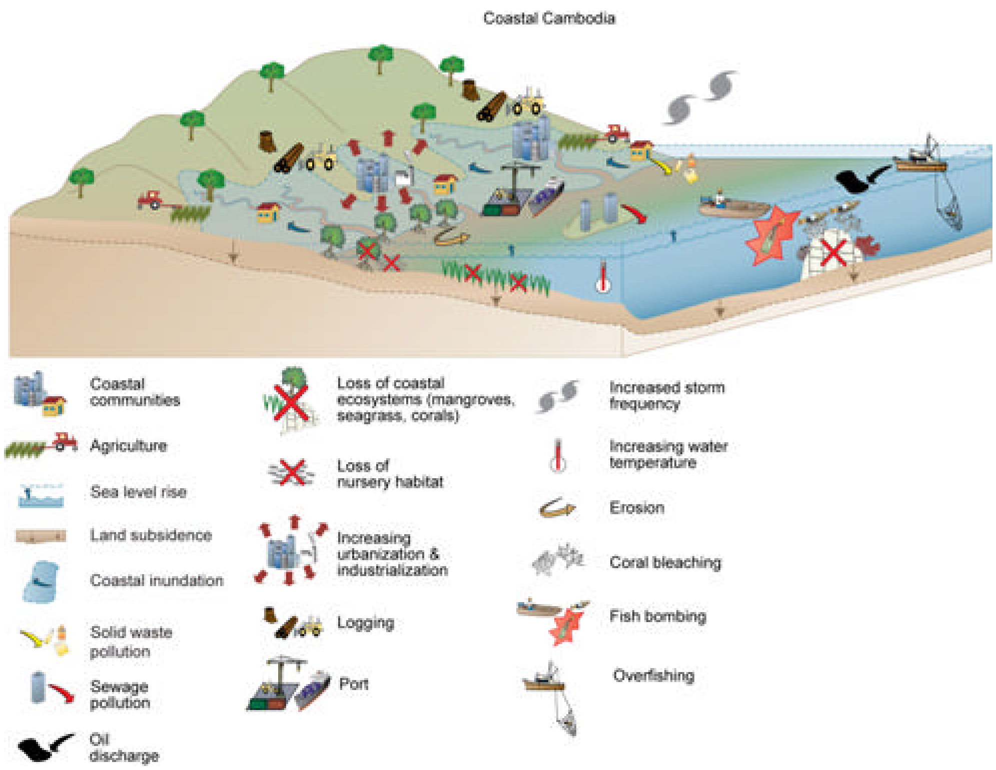

Figure 3.6 Schematic diagram of the issues existing and foreseen for the coast of Cambodia

Indonesia

Indonesia, an archipelagic state with a state-declared 17000 islands, is strongly influenced by the Pacific and Indian Ocean. As such it is sensitive to the state of the ENSO, the Indian Ocean Dipole, the SE Asia monsoon, Madden Julian Oscillation (MJO), the presence of coastally trapped Kelvin waves from the Indian Ocean and of Rossby waves from the Pacific. On top of these cyclical phenomenon, the Oceanography Research Group of Institut Teknologi Bandung have also observed a sea level rise averaging 1cm/decade in four of their observations sites (Figure 3.7). This is comparable to global observations.

There is a perception that SLR will cause drowning of parts of coastal plains and low islands; increasing flood risk in the lower parts of coastal plains; increasing erosion of natural coasts and further threat to man-made structures; increasing salinity of surface waters and extension of tidal influences over wider areas further upstream; increasing salt water intrusion in aquifers and negative ecosystem changes. Much concern is on the fate of the 70% of the Indonesian population living in the Java Island concentrating mostly in the low land coastal city areas.

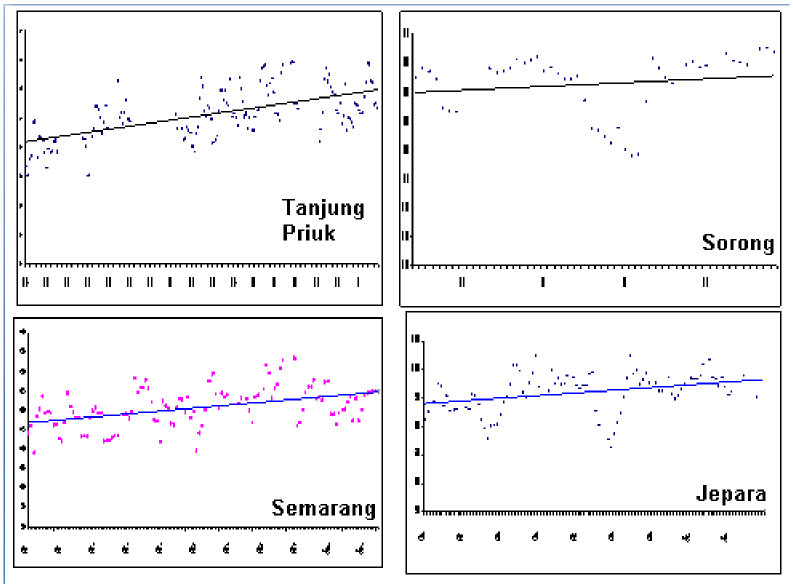

Figure 3.7 Sea level data for 4 sites in Indonesia: 20 year data for Tanjung Priuk and 10 year data for Sorong, Semarang and Jepara. The average increase in sea level is 1cm/decade

Jakarta

It is expected that tendency of sea level rise would have significant economic impacts on urban infrastructure, land use and population in Jakarta.

Exacerbating factors to SLR include land subsidence and seasonal floods. Excessive groundwater extraction in Jakarta has resulted to significant land subsidence (Figure 3.8), In addition this has also resulted in salt water intrusion with measured concentrations of TDS 1000 mg/lt and aquifer chloride of 500 mg/lt. With further population increase and unrestricted development, the subsidence is projected to continue to -16cm more from its current position (Figure 3.9). Flooding during the monsoons 0.1-1.7m is another exacerbating perennial problem for Jakarta (Figure 3.10).

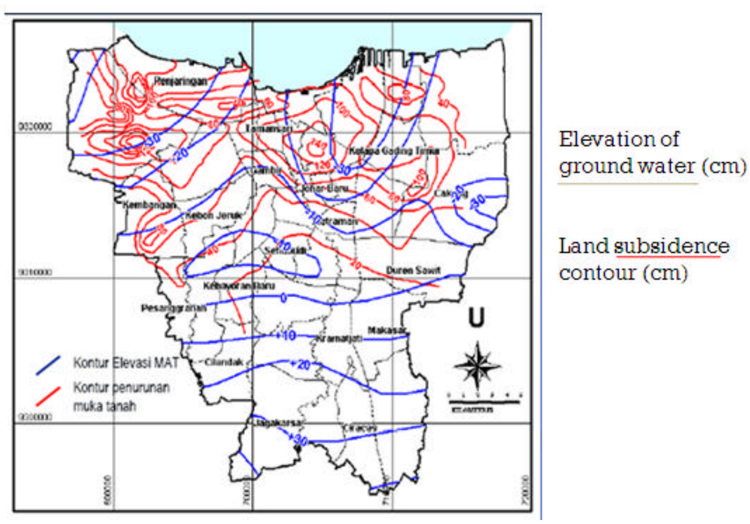

Figure 3.8 Groundwater extraction in Jakarta and the resulting land subsidence

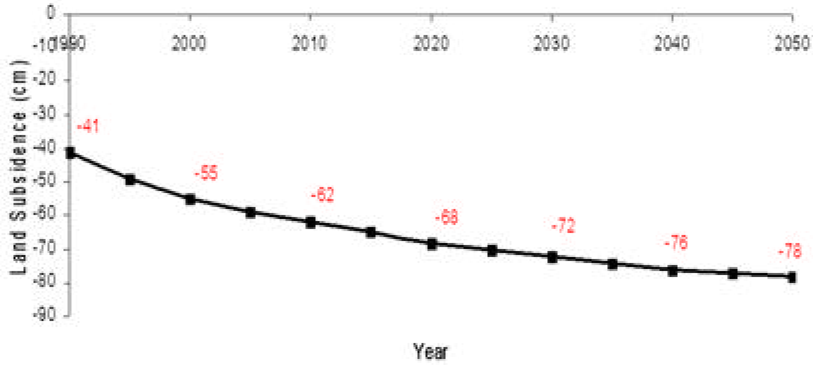

Figure 3.9 Projected land subsidence in the vicinity of Jakarta (Priyambodo, 2005)

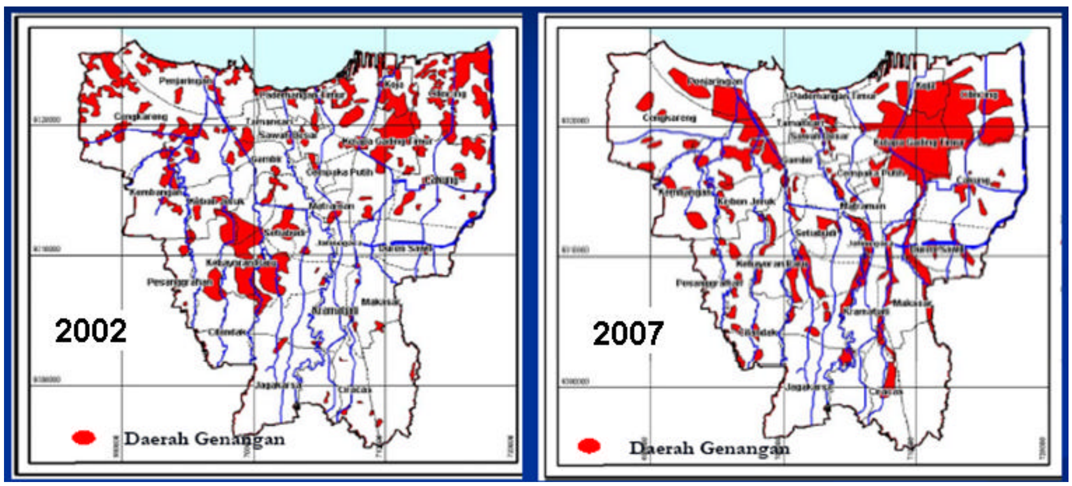

Figure 3.10 Inundation area of Jakarta Floodingin 2002 and 2007 highlighted in RED.

The combined factors of sea level rise, land subsidence and monsoonal flooding is expected to have an increasing amount of area affected as the years progress reaching up to 400% of current situation by 2050 (Table 3.1).

Table 3.1 Projection of Inundation Areas From Model Simulation

Year	Wetland (km^2)	Dryland (km^2)	Total Inundation Area (km^2)
2010	10.26	28.88	39.14
2020	11.55	39.74	51.29
2030	15.56	57.58	73.13
2040	22.33	127.93	150.26
2050	22.56	135.59	158.15

Shown below are the simulations for what may be the likely scenario for Jakarta by 2050 considering Sea Level Rise alone, then SLR with Land Subsidence, and finally SLR + LR with monsoonal flooding (Figure 3.11).

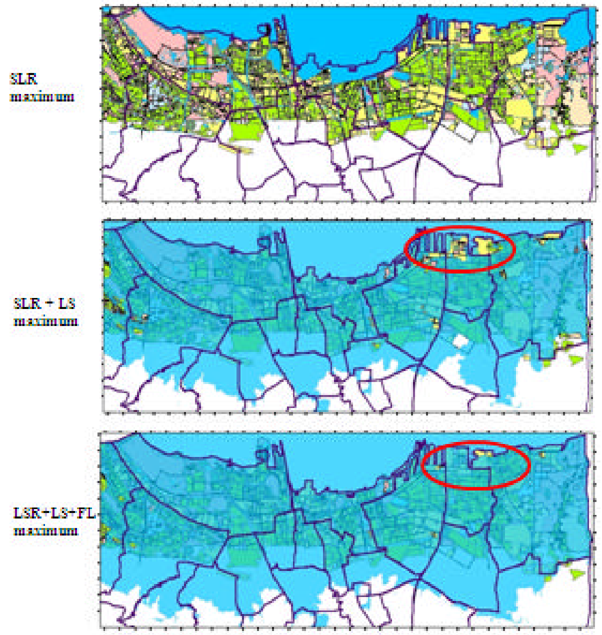

Figure 3.11 Simulation of plausible inundation of Jakarta by 2050 highlighted in light blue. Encircled in RED and highlighted in yellow is what is projected to stay high and dry.

Economic valuation of this projected inundation was done using Frankhausser's assumption (1994) of a value of dryland at 2 million USD/km^2 and wetland at 5million USD/km^2. The projected economic losses are summarized in Table 3.2

Table 3.2 Simulated losses due to inundation of Jakarta

Year	Economic Losses (US$ billion)	% Losses with respect to DKI Jakarta's GDP in appropriate year	% Losses with respect to DKI Jakarta's GDP 2004
2010	0.11	0.17	0.30
2020	0.16	0.17	0.43
2030	0.25	0.18	0.66
2040	0.54	0.26	1.43
2050	0.64	0.22	1.70

The calculated losses are just in terms of dryland/wetland values. In terms of human establishments, the most vulnerable to SLR–exacerbated inundation are the reclaimed areas, the informal settlers, the tourism and recreational areas, the increasing urbanization near the coasts, and the powerplants.

There is also a perception of increase in water temperature (0.7°C / decade from 1956 to 2001) and increasing frequency of storms. Previous experience in positive temperature anomalies have also already been observed to cause massive coral bleaching.

The overall vulnerability to climate change of coastal habitats is seen to be exacerbated by already existing issues of (1) deforestation near rapidly Bogor and Depok, (2) degradation of coastal resources due both to sewage/solid waste pollution and (3) destructive fishing practices. There is also apprehension regarding ballast water discharge and potential oil discharge from the nearby port facilities (Figure 3.12).

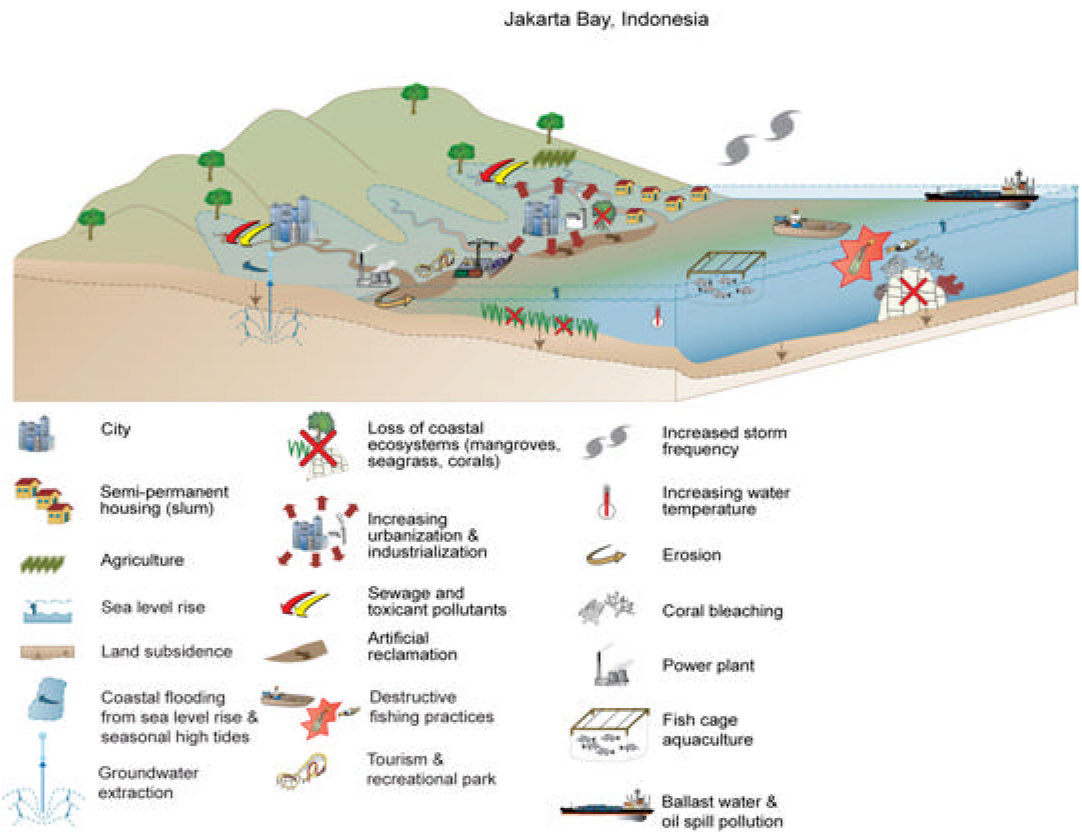

Figure 3.12 Schematic diagram of the issues existing and foreseen for the coast of Jakarta, Indonesia

Assessment of n atural and socio -economic vulnerability to climate change combined gave the following results (Figure 3.13) with most of Jakarta already under high vulnerability situation. This is due to the site being mostly low-lying, with a high tendency fo r land subsidence and movement combined with the high population and population density.

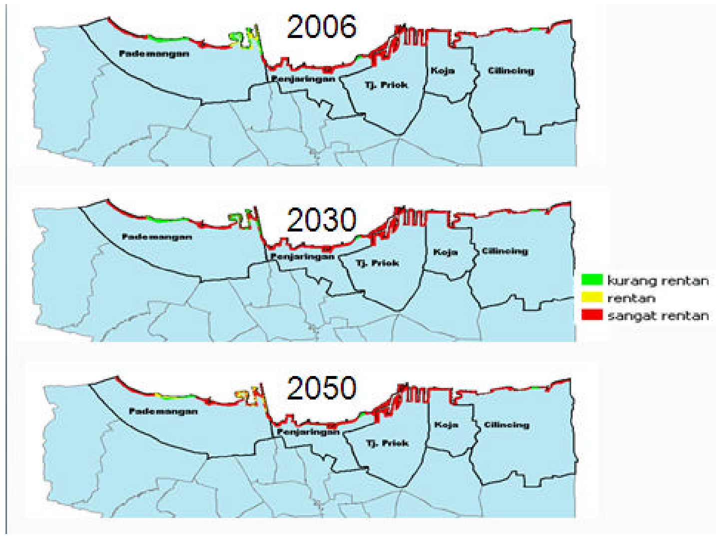

Figure 3.13 Vulnerability assessment was done combining the natural and socio-economic indices. RED indicates high vulnerability, YELLOW is medium and GREEN is low.

Semarang

Semarang is a city on the north coast of the island of Java, Indonesia . It is the capital of the province of Central Java. It has a population of 1.454.593 peoples (2007) , making it Indonesia's fifth largest city. As such, the issues of Semarang are similar to Jakarta with SLR, land subsidence and seasonal flooding. The vulnerability is exacerbated by inadequate urban planning. Inundation in 2009 reached up to 2.5 km inland (Figure 3.14)

Figure 3.14 Semarang during the October 2009 inundation which reached 2.5 km in-shore

Combined natural and socio-economic vulnerability assessment showed the entire coastal area to be highly vulnerable to climate change (Figure 3.15).

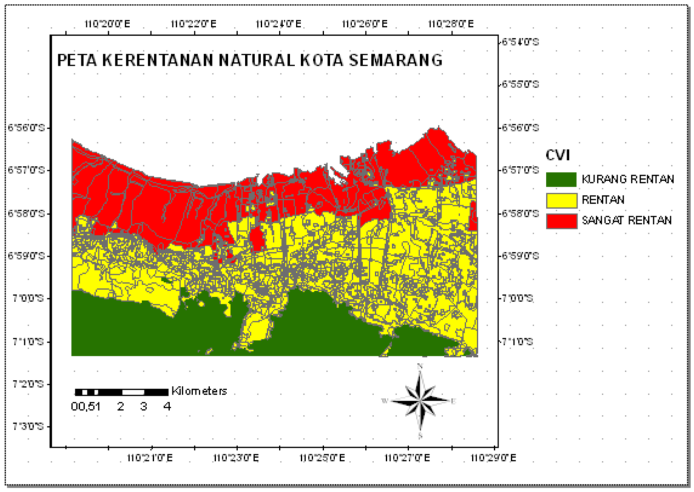

Figure 3.15 Assessed Vulnerability of the Semarang coastal area.
RED indicates high vulnerability, YELLOW is medium and GREEN is low.

Segara Anakan Lagoon

The Segara Anakan Lagoon and estuary is located on the south coast of Java on the border between the provinces of West and Central Java near the port of Cilacap. It is protected from the Indian Ocean by Nusa Kambangan and has two openings to the ocean, one at the southwest corner of lagoon and the other via several easterly passages. The brackish lagoon, which is surrounded by an area of slough, tributaries, mangrove swamps and intertidal land converted to rice fields, its influenced by tidal effects from the Indian Ocean trough the western and eastern passages. The lagoon and its environs provide a unique and abundant aquatic ecosystem and a productive marine nursery. It is a major source of industrial fisheries in coast of southern Java.

Due to various anthropogenic activities, including dredging, the lagoon has suffered siltation and reduction of volume through the years (Figure 3.16). The rate of sedimentation has increased to such an extent that the surface area of the lagoon has decreased from the current 1,400 ha to about 550 ha by the year 2000. This has resulted in environmental degradation and reduction of fish catch (Figure 3.17).

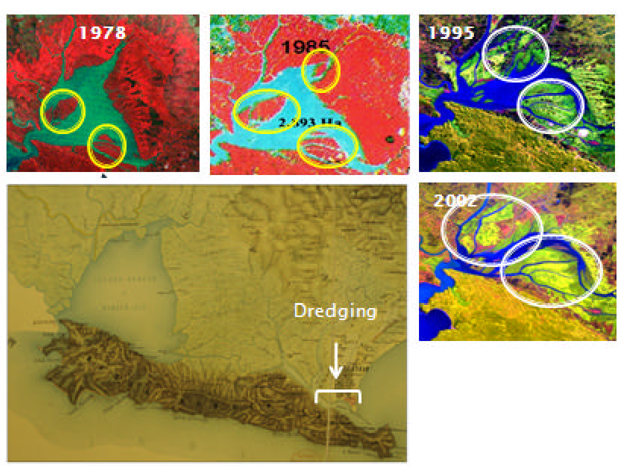

Figure 3.16 Progression of siltation in Segara Anakan Lagoon.
Circles depict areas of most significant changes.

The result is a low capacity of the coastal community for resilience - a low capacity to handle additional pressures, such as sea level rise (Figure 3.18).

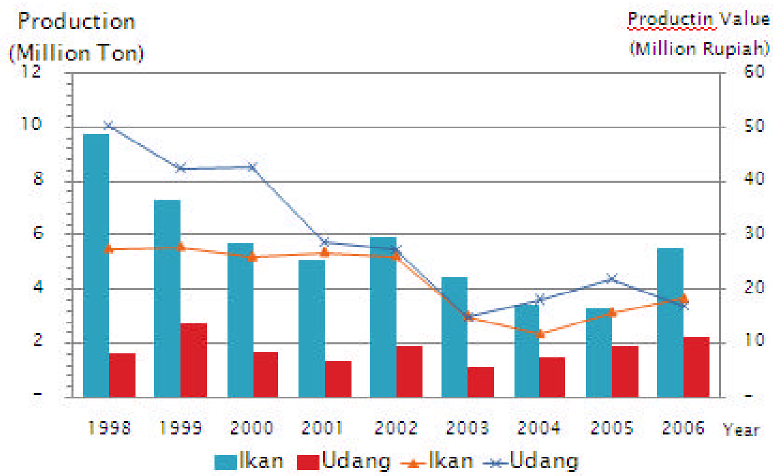

Figure 3.17 Fish (blue) and shrimp (red) production changes in Segara Anakan Lagoon

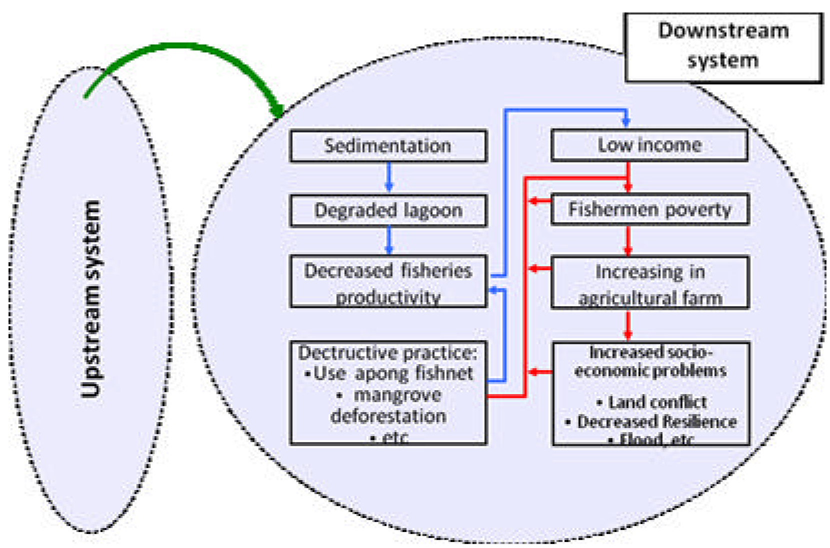

Figure 3.18 Schematic diagram of Problem Cycle in Segara Anakan Lagoon

Recommendations include the need for IEC in order to counter false perceptions about the value of the environment leading to contra-productive attitudes (e.g. Destructive fishing method is acceptable such as the Apong fishnet). The information campaign should however, be a continuous process instead of a one-time deal since in-migration is greater than out-migration with little interaction between new comers and indigeneous communities.

There is also a need for alternative livelihood. Currently, livelihood alternatives are limited to resource extraction (Non-irigated farming & traditional fishing ; Mangrove cutting for firewood).

Finally, there is a need for Institution capacity building. Formal institutions exists (e.g. Policy Prohibition of destructive *apong* net (Perda No 6/2001); The Lagoon

Management Authority (BPKSA); Farmland Certification) but are currently not effective. Specifically, there are not enough patrols to check the implementation of the fishing regulations, and over-fishing has become a problem and the illegal cutting of the mangrove forest has led to severe degradation of the forest, especially in the Karang Anyar area.

Authorities should make use of the assistance of village elders with adequate past knowledges since the community looks up to them as pilars of conflict resolution.

<u>Malaysia</u>

The map of elevation can be used as first level analysis of potential SLR impact to Malaysia (Figure 3.19). Areas in re d highlight sites of possible inundation.

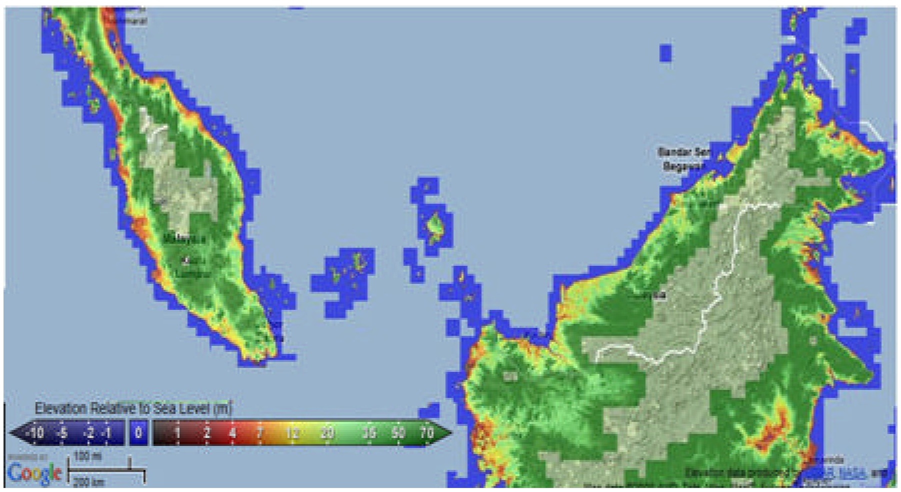

Figure 3.19 Elevaion map of Malaysia.
RED indicates low lying areas prone to inundation

For Sabah, industries are very dependent on natural resources (agriculture, tourism, fisheries) which are generally concentrated in the lowlands. There is an interest therefore, in studying the vulnerability of coastal nature resources and marine ecosystem. The site selected is Darvel Bay, which is located at in the Lahad Datu and Kunak districts (Table 3.3).

Table 3.3 Land and Sea statistics of Lahad Datu and Kunak districts

Districts	Length of coast line (km)			Land area (km^2)			Marine area (km^2)
	Islands	Mainland	Lagoons	Islands	Coastal Zone	Non-coastal	Territorial
Lahad Datu	114	212	32	29	3815	2828	3666
Kunak	25	37	15	4	223	764	317
Total	**139**	**249**	**47**	**33**	**4038**	**3592**	**3983**

Coastal marine ecosystems in Darvel Bay mainly consist of coral reefs, seagrass and mangroves. Sandy beaches are found along the coastline of Tungku to Bakapit area followed by the mangroves swamp area towards Kunak Town. Approximately 11,066 ha and 6,060 ha of mangrove forest under natural forest type class V in Lahad Datu and Kunak districts, respectively, have been declared as Forest Reserve by the Forestry Department. Freshwater sources of Darvel Bay are mainly from Silabukan and Tingkayu rivers, which are located at the northern and the southwestern parts of the area, respectively. However, growing development both land and sea areas disturbs most of the coastal nature resources and marine ecosystem and is likely to aggravate the impact of climate change in general and sea level rise in particular.

The prime issue identified for Darvel Bay is the new palm oil agriculture and production which is observed to contribute high sedimentation into coastal area. Coupled with land subsidence and sea level rise, this is expected to exacerbate the erosion of the coast and the siltation of the Bay. This is additional pressure to the system which is already currently experiencing (1) heavy exploitation on coral reefs by illegal immigrants and migratory sea gypsies; (2) destructive fishing by by sea gypsies and people from Semporna and Tawau ; and (3) Harmful Algal Blooms. There is also a perception of increase in water temperature which, has already been observed to cause massive coral bleaching. Together this poses threat to the coastal habitats which act as nursery for important food fish.

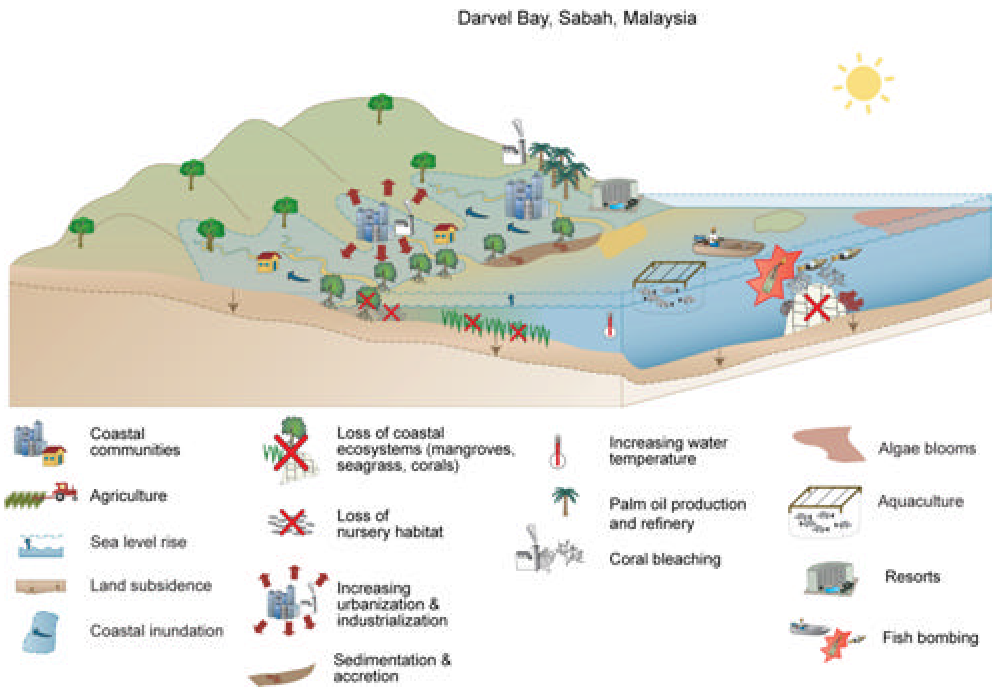

Figure 3.20 Schematic diagram of issues for Darvel Bay

A survey of neighboring sites was conducted along the Sabah's coastline and islands to assess if Darvel Bay is an isolated case. The three areas selected for this study are Tuaran, Pitas and Tawau (Figure 3.21). Results show that these issues of erosion and sedimentation are prevalent in Sabah (Figure 3.22)

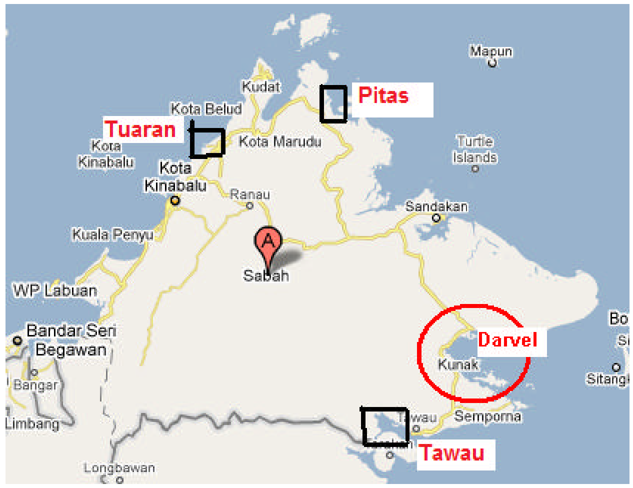

Figure 3.21 Location map of other sites studied for coastal integrity

Figure 3.22 Pictures depicting state of erosion along Sabah's coast

Policy-wise, the Malaysia Team shared that the results of the study are currently being integrated in the Integrated Coastal Zone Management (ICZM), in the Sabah Tourism Master Plan, the Aquaculture Policy of Malaysia and the Aquaculture Policy Studies of the Sabah Foundation.

The Philippines

The Philippine archipelago composed of 7,100 islands, has approximately 36,000 km of extensive coastline. About 64% of the Philippine population reside in 10,000 coastal barangays, including major urban centers. Approxima tely 482,500 fishermen re side and carve their livelihood in these coastal areas. Climate observations have recorded increase in surface water temperature of an average 0.3°C per decade (Figure 3.23), increasing intensity of storms and anomalous wate r delivery (floods and droughts). Combined, these haveresulted in significant agricultural loses (Figure 3.24). Comparable assessment focused on the marine sector do not currently exists.

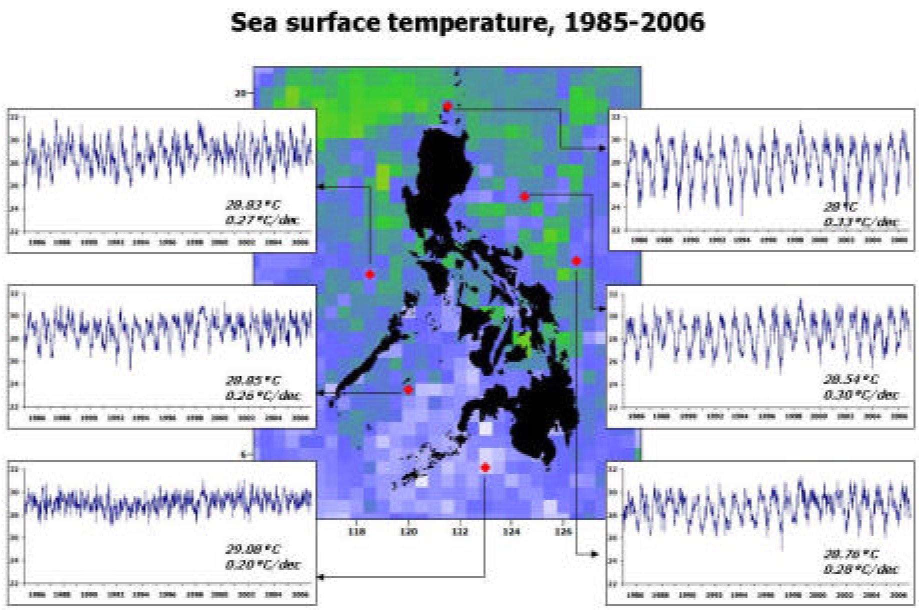

Figure 3.23 Time series of sea surface temperature for the Philippines.

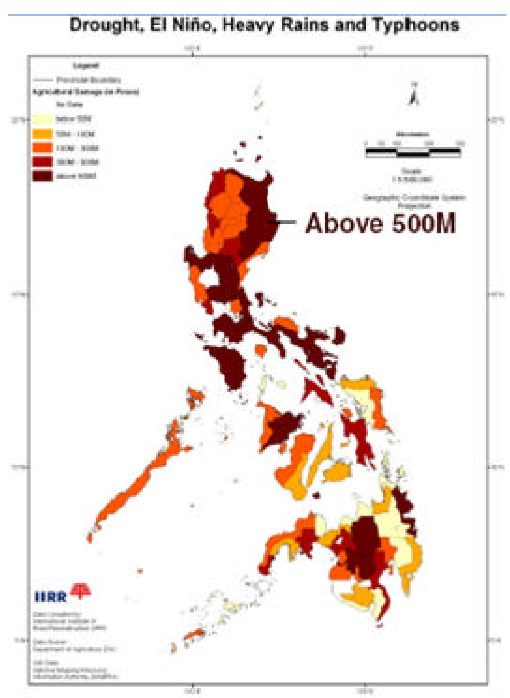

Figure 3.24 Accumulated damage (1992 -2006) to agriculture due to drought, ENSO, Flooding and Typhoons (Department of Agriculture)

However, there is agreement amongst those working in the marine sector that increase in temperature, intensity of storms, and sea level rise will have significant negative impact on the coastal marine environment. This can be further exacerbated by land subsidence due to increased urbanization pressure and erosion triggered by uncontrolled agriculture in the mountain slopes. Consequential coral bleaching, drowning of mangroves and siltation of seagrasses will have deleterious effect on nursery grounds and habitat of economically important food fish (Figure 3.25)
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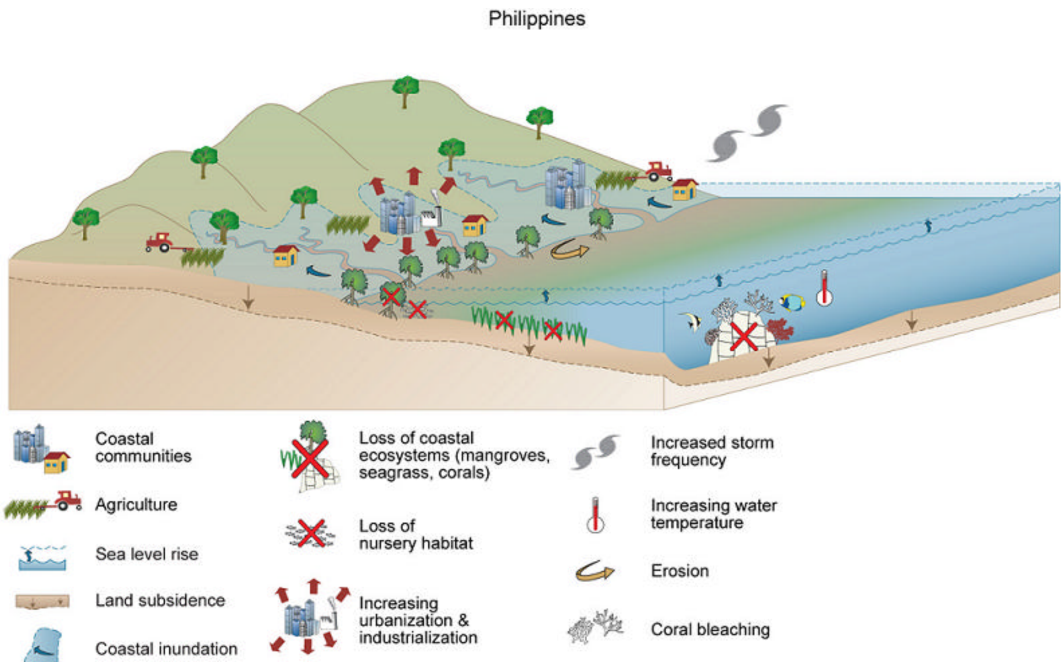

Figure 3.25 Schematic diagram of common climate-related issues in Philippine coastal areas.

Near future projections using the business as usual scenario, show further increase in temperature centralized around major agricultural and fishing zones and increased intensity of drought events (Figure 3.26).

Climate-related consequences may be further aggravated by existing coastal issues. Presented below are examples of issues that need to be addressed as part of climate adaptation.

Batangas Bay

Five local government units border the Batangas Bay with a combined land area of 453.8 km^2 and water surface area of 220 km^2. Batangas Bay (Figure 3.27) provides livelihood for several sectors such as local fisherfolk, tourism-related service providers and land-based activities such as livestock production (poultry, pig and cattle) and agricultural crops. At the same time, it is home to an international maritime port and various manufacturing industries, including oil refineries and mining. Moreover, it is adjacent to the Verde Island Passage, which is an important marine biodiversity corridor.

The main issue therefore is use conflict. Specifically, there is concern in industrial waste and coastal water quality. To address the conflict and impacts of socio-economic activities on the environment, an Environmental Management Atlas of the Batangas Bay Region was developed.

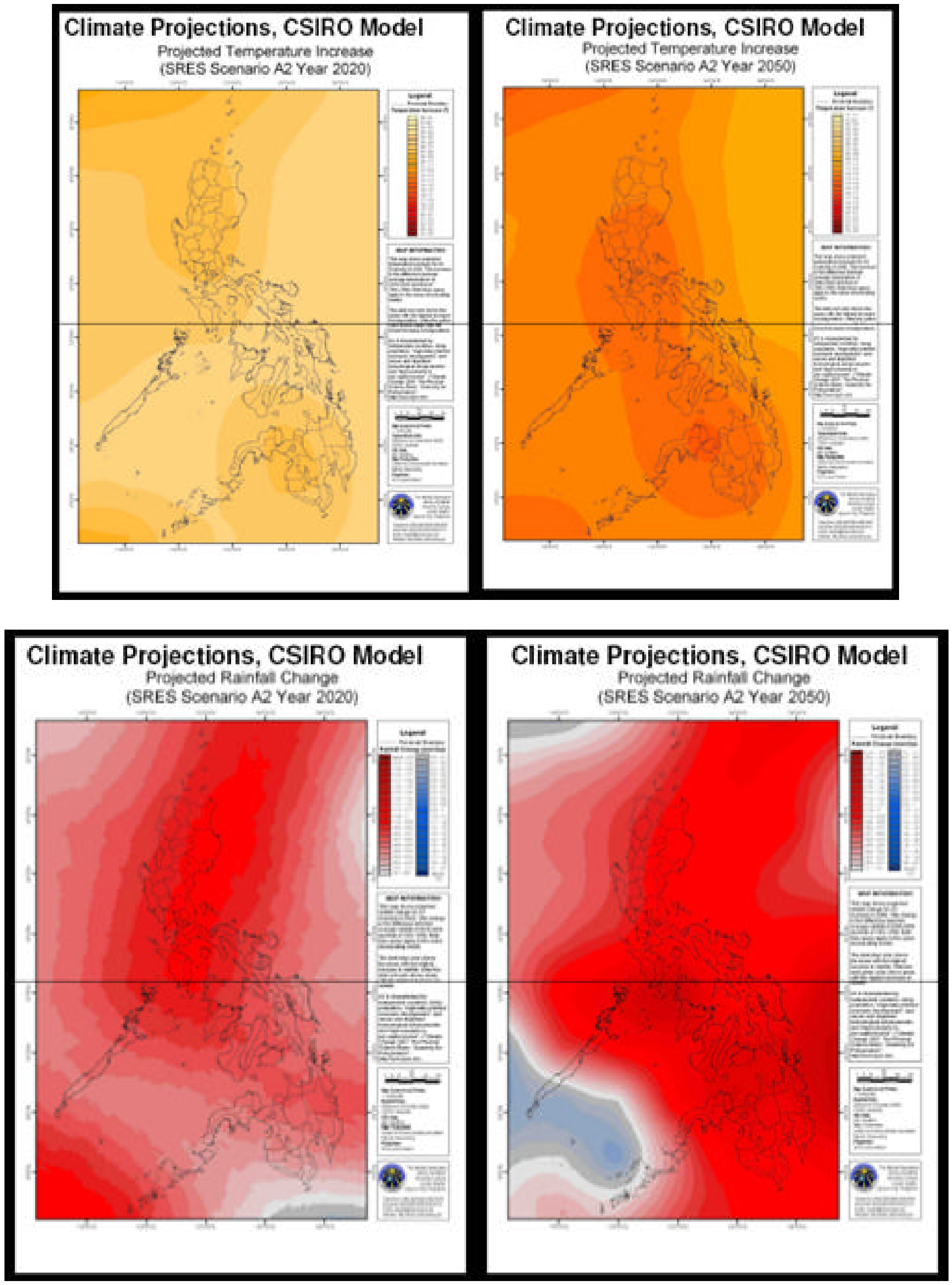

Figure 3.26 Climate projections for the Philippines under the A2 scenario

Eight major areas of concern were addressed:

(i) solid waste generation, collection and disposal;
(ii) water and air pollution;
(iii) municipal fishing;
(iv) mining and quarrying;
(v) shipping and port development;
(vi) human settlements and population growth, especially in coastal areas;
(vii) participation of private sector, and nongovernmental organizations in environmental management; and
(viii) integrated policies, plans, programs and institutional support for the purpose of examining the key environmental management issues and the factors that contribute to their occurrence.

Corollary to the Batangas Bay endeavor, it became evident that conflict is hardest to resolve when the economic advantage of one sector will result in the economic disadvantage of another. The case of Talim Bay (Figure 3.27) is presented to give a simple example of how economic valuation can be used as a tool to objectively decide on a potential conflict of interest.

Figure 3.27 Location of Batangas Bay and Talim Bay.

Talim Bay

Talim Bay is a major source of livelihood for coastal communities in Lian, Batangas. Almost half of the population of the surrounding coastal villages of Lumaniag, Binubusan and Luyahan are dependent on the resources of the bay. Aside from fishing, other livelihoods include tourism and agriculture (occupying 50% and 19% of the land area, respectively). Recently, there has been a proposal to convert a significant part of the land into a golf course. At least 36 percent of the tourism area will be occupied by the proposed tourism project. The primary objective of the study was to conduct an economic analysis of the environmental impacts of the proposed golf course on the coastal ecosystem and communities of Talim Bay.

Local residents are expected to benefit from the numerous job opportunities and training (laborers in the construction, caretakers, security guards, maintenance workers and drivers). The increase of peripheral establishments will likewise provide added income sources and additional revenues from income taxes. Real estate tax revenues are also expected to in crease with increased land values.

From the analysis, expected negative impacts include:
- loss of agricultural land
- soil erosion and sediment deposition in the coastal areas
- ground water depletion since turf grass maintenance requires 500 to 3,000 m^3 of water per year
- soil and water pollution due to application of large doses of fertilizers and pesticides
- leaching out of chemicals to the ground water and eventual seepage to the coastal area

- serious threat of siltation and sedimentation, due to the clearing of the remaining forest areas in Lumaniag
- destruction of seagrass beds and mangrove areas – vital nursery and habitat
- non-access to the usual berthing areas by fishermen that will become a private property
- Loss of livelihood from fishing
- Increased population due to in-migration
- Increase in relocated households or displacement of tenants

Talim Bay's total economic value can be expressed in terms of the direct amenities that the ecosystem provides to the communities as well as to the environmental functions that maintain the biophysical integrity of the area. Keeping the pros and cons in mind, economic valuation gave an overall net benefit NOT to implement the project (Table 3.4). Disturbance of the Bay's ecosystem (by a development project) will have a domino effect on the communities in terms of impacts on fishery resources and tourism, the main sources of livelihood in the place.

Table 3.4 Economic valuation of proposed project and likely consequences

Comparison of Net Present Values

	With Project	With-Out Project
• Total Benefits	P2.36 Billion	P148.66 Million
• Total Costs	4.14	31.58
• Net Benefits	(1.78) (~ US$.04)	117.08 ~ US$2.5

The same approach was utilized for the more complex system of Donsol, Sorsogon. Again the premised that if coastal resources are expressed in monetary terms, then informed decisions can be made to reflect the economic value of the natural resources in a given community.

Donsol, Sorsogon

Donsol is a coastal town located at the northwestern part of the Province of Sorsogon. It is 68 kilometers from the capital town of Sorsogon and 51 kilometers from the City of Legazpi. It is composed of 51 barangays, 11 of which are located in the coastal areas of the municipality. The people generally depend on farming, livestock production and fishing for their income and livelihood. Of these sources of income and livelihood, capture fisheries dominates with an estimated annual contribution of PhP54 million and employing around 3,000 fishers. Other sources of income include cottage industries, food processing, trading and marketing, construction, and transportation. Moreover, the booming whale shark ecotourism, although seasonal in nature, has significantly provided income and employment opportunities in the area (Tolosa and Padilla 2005).

The study was concentrated in one barangay in Donsol – Sibago. Three areas are potential use conflict sites: (1) beach area; (2) mangrove forests; and (3) river-estuary. The beach is being proposed as an ecotourism site. Sibago's mangrove area has been declared as mangrove swamp forest reserve based on Presidential Proclamation 2152. Sixty (60%) is classified as intact while the other 23.1 hectare has sparse growth, degraded or converted into other land use like expansion of residential and agricultural areas along the edge of the settlement and coconut plantation areas. The estuarine portion of Sibago River (Figure 6) serves as nursery ground for the larvae of fishes and crustaceans. As such, several fishery resources can be found in the river ecosystem. However, continuous exploitation such as over-harvesting by the local fishers would bring pressure to this resource. Juveniles of commercially significant fish species such as *bangus*, swordfish, *talakitok* and *banak* inhabit the estuarine portion of the river.

Economic valuation of the beach area was divided into the direct use values, indirect values and non-use values (Figure 3.28). The same approach was done for the mangroves and the river estuarine. Shown in Table 3.5 is the summary of the valuation.

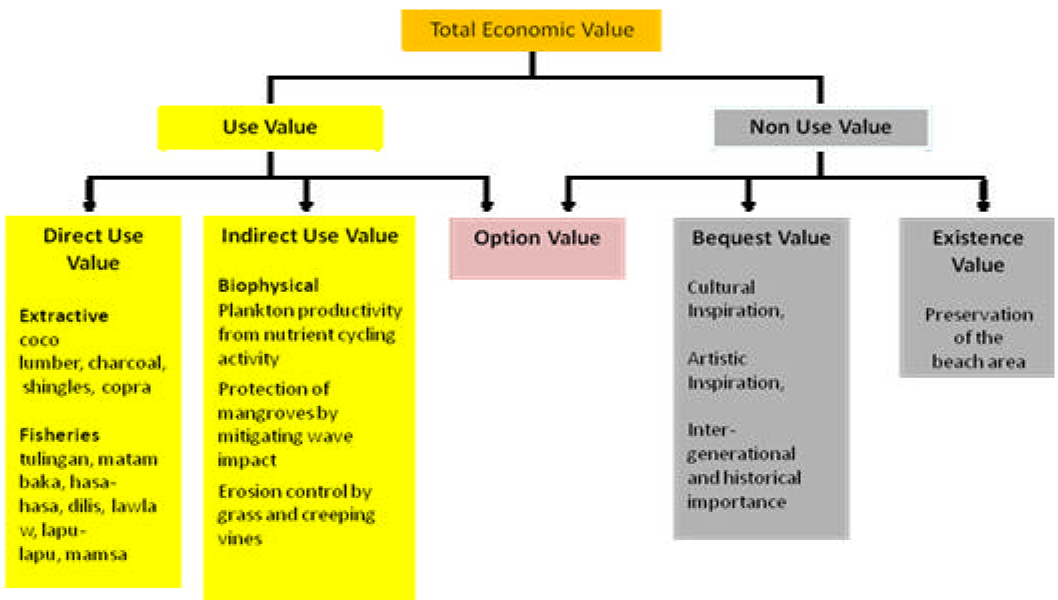

Figure 3.28 Total economic value framework of the beach ecosystem

All in all, the estimated TEV for the three ecosystems is PhP11,941,255 per year or about PhP206,890 per hectare per year. Moreover, The WTP survey showed how much the residents are willing to pay to protect the coastal ecosystems for their option values and bequest values as integral parts of their culture, tradition and celebrations.

Decision on conversion for proposed activities can be evaluated by comparing the projected benefits of conversion versus the current value per hectare (Table 3.6)

Table 3.5. Summary of the computed TEV

Beach

Activity	Valuation	Annual Value
Fishing	P8,565/trip x 20 trips/month x 8 months/year	1,370,400
Extractive value of coconut products	Market Price	132,029
Infrastructure	Market Price	11,072
Plankton Productivity from Nutrient Cycling Activity	P1,370,400/year fishery productivity x 40% plankton population	548,160
Protection of mangrove areas from wave impact	P 9,138,588/year TEV of mangrove ecosystem x 1% mangrove area in the beach ecosystem	91,386
Erosion control by morning glory and other associated grasses	P1,370,400/year fishery production x 2.5 % loss in fishery productivity	34,260
Residents' willingness to pay for the preservation and maintenance of the beach area	1,607 persons x P64/person/month x 12 months	1,234,176
Total		3,421,483

Mangrove

Activity	Valuation	Annual Value
Extractive Products	market value	
Fuelwood		82,305.65
Charcoal		322,767.20
Poles		14,069.35
Posts		140,693.40
Materials for Christmas trees		70,346.70
Propagules		553,308.00
crabs		155,520.00
crablets		51,925.50
Research and education	Education and research value was estimated at $2.73/ha/year (Php 126.26/ha/yr)	7,978
Carbon Sequestration	1.5 mt/ha/yr X 23.0872 ha = 34.6308 mt 34.6308 mt X £79 = £ 2,735.8332 £ 2,735.8332 X 68.9	188,499
Protection	Based on the key informant interview 25% of the total households would be affected by flooding	712,500
Residents' willingness to pay for the preservation and maintenance of the beach area	198.45 X 12 X 1,607	3,826,910
Total		6,126,823

River-estuary

Use and Non-use values	Valuation Method		Total Economic Value (PhP/year)
Direct use value			
1) Extractive - Shrimps	Market Price		96,000
2) Non-extractive			1,004,920
a) as nursery ground for fishes	Market Price	*148,560*	
b) as nursery ground for crabs	Market Price	*9,360*	
c) Research and education	Benefit Transfer	10,000	
d) Recreation and ecotourism	Travel Cost		
i) firefly watching		*832,000*	
ii) bird watching		5,000	
Indirect use value			
Option Value	Contingent Valuation		1,292,028
Total			***2,392,948***

Table 3.6 Summary of computed TEV for the three ecosystems.

ECOSYSTEM	TOTAL ECONOMIC VALUE	
	(PhP/year)	(PhP/ha/year)
Beach	3,421,485	59,279
Mangrove	6,126,822	106,151
River (estuarine portion)	2,392,948	41,459
TOTAL	**11,941,255**	**206,890**

After giving the local stakeholders valuation as an additional tool for decision making and conflict resolution, the next phase is ACTION. Detailing what needs to be done in terms of risk reduction. Presented below are two additional sites contributed for the Philippines that depict the level of detail that goes into the action plans.

Baclayon, Bohol (The study of Baclayon Bohol was spearheaded by Dr. Rosa Perez.)

The Municipality of Baclayon is situated in Southern Bohol facing the Mindanao/Bohol Sea. Samonte, Tan, et. al, (2004) estimates the annual net benefits of the coastal and marine resources of the Bohol Marine Triangle (BMT) to be PhP 182.4 million or US$3.38 million. The main direct use value or market benefits of coastal resources are tourism and fisheries. The net revenues from tourism and fisheries are valued at US$1.48 million (PhP 79.7 million) and US$1.33 million (PhP 71.6 million). The most important non-market benefits that can be derived from coastal ecosystems are shoreline protection with annual values of US$169,674 (PhP 9.1 million) and biodiversity value of US$125,703 (PhP 6.7 million).

Baclayon government officials, local stakeholders, and partners clamored for a tool based on scientific studies to support them in decision-making on resource use in support for economic development and cultural preservation, as well as, provide directions for climate change adaptation, disaster risk reduction, and poverty alleviation. Thus, an evidence-based decision support system for coastal communities was conceptualized to serve as a critical enabling tool to address vulnerability and sustainable development. The preparation of the guidebook involved four important steps as illustrated in the guidebook framework: (i) baseline setting and resource mapping; (ii) projection of future risks; (iii) vulnerability and adaptation assessment; and (iv) monitoring and evaluation.

The Sustainable Development Guidebook for the Municipality of Baclayon consists of multi-disciplinary inputs with cross-sectoral significance, taking into account climate, geo-physical, coastal geology, risk analysis, mapping, responses, and adaptation options. The Guidebook consists of two documents: (1) Scientific Technical Guidebook; and (2) Multi-stakeholder Handbook (Figures 3.29 & 3.30). The cross-sectoral approach addresses vulnerability across all scales and types. The Scientific Technical Guidebook consists of research findings and resources for residents and authorities to have a basis for evaluating development choices. On the other hand, the Multi-stakeholder Handbook is an easy-to-understand evaluation guide for planners and major stakeholders. Enhancing local capacity on mapping tools to help visualize complex inter-relationships would be very valuable steps in moving forward. The Handbook provides a qualitative rating system which considers present and probable future conditions surrounding Baclayon's development. This system consists of four categories of interrelated factors, namely: Climate, Land, Marine and Socio-Economic, when considered together can approximate risk. It aids its users in evaluating development plans to optimize gains and ensure sustainability, but does not prescribe development options or offer solutions.

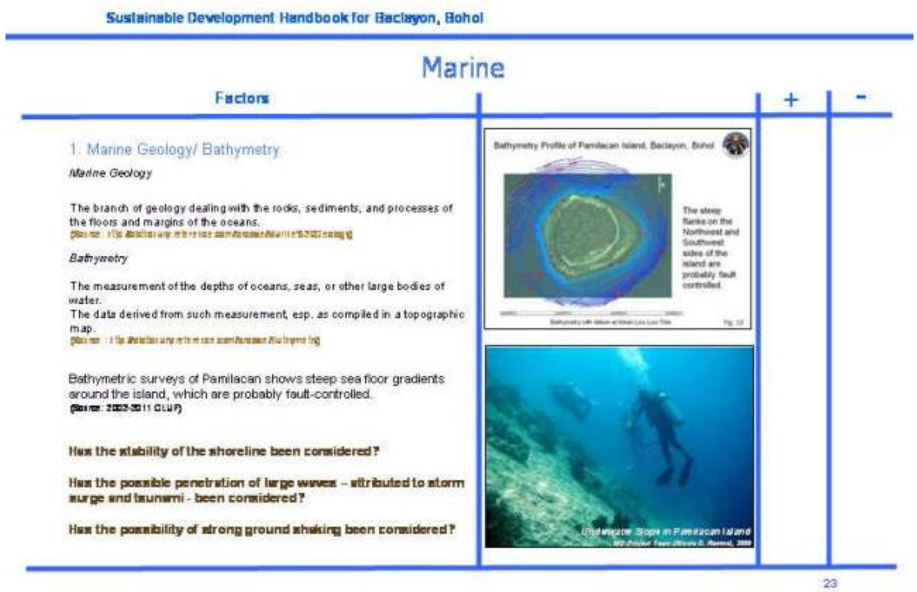

Figure 3.29 Sample Checklist for the Marine Category

Sustainable Development Handbook for Baclayon, Bohol

SAMPLE

Project Name: Pamilacan Coastal Resource Management

Total Tally = 67 (+), 13 (-)

	+	-		+	-
CLIMATE			MARINE		
Temperature	2	1	Marine Geology/ Bathymetry	3	
Rainfall	3		Spatial Distribution	2	
Extreme Events			Biodiversity	2	
• Drought		3	Water Chemistry		
• Typhoon	5		• Wastewater Discharge and Pollution	4	
• El Niño/ La Niña	4		• Red Tide	3	
• Flooding	4		• Ocean Acidification		
• Storm Surge	4		• Coral Bleaching		
• Sea Level Rise (SLR)	4				
Sub-Total	22	4	Sub-Total	14	0
LAND			SOCIO-ECONOMIC PROFILES		
Geology	3	1	Demography	6	3
Elevation/ Slope	2		Poverty Incidence/ Income	2	
Soil	2		• Livelihood	3	
Hydrology/ Drainage	2	3	Heritage and Culture	4	2
Biodiversity	4		Ecotourism	3	
Sub-Total	13	4	Sub-Total	18	5

39

Figure 3.30 Sample tally sheet for all categories.

A higher positive (+) score affirms that more factors have been considered for the feasibility of an environment-friendly and risk sensitive project;
a negative (-) score reflects the presence of gaps that need to be addressed.

The Sustainable Development Guidebook was officially turned over to the Municipality of Baclayon, Bohol during the later part of 2009. It is noteworthy to mention the value of the LGU's support and the strong partnership with a major private institution and community organizations. The local government and private sector partnership was essential in propelling the formulation of a useful policy tool where local stakeholders contributed.

At present, the Guidebook to provides basis for screening probable projects in line with municipal planning and environmental management. A utilization workshop is set to be conducted within the year to promote the proper use and dissemination of the Guidebook.

<u>Gubat, Sorsogon</u> (The study was coordinated by Michael Atrigenio and Maya Villaluz)

Gubat, Sorsogon was identified at high risk to climate change events because of their location (high incidence of typhoons), their coastal topography (narrow low-lying plains bordered by the ocean and the volcanoes), and the population (largest population center facing the Pacific in the province of Sorsogon). Climate change adaptation recommendations were a result of the bio-physical and socio-economic profiling of the potential hazards, exposure and vulnerability (Figure 3.31). Note that recommendations included (1) identification of gaps in existing national and local laws on climate change adaptation; (2) crafting of site-specific technical specifications for the road networks and school buildings; and (3) assessment of site-specific training needs to enhance the capabilities of the community and the Local Government Unit Officials, Staff and Employees to be able to adapt and improve their preparedness to climate change.

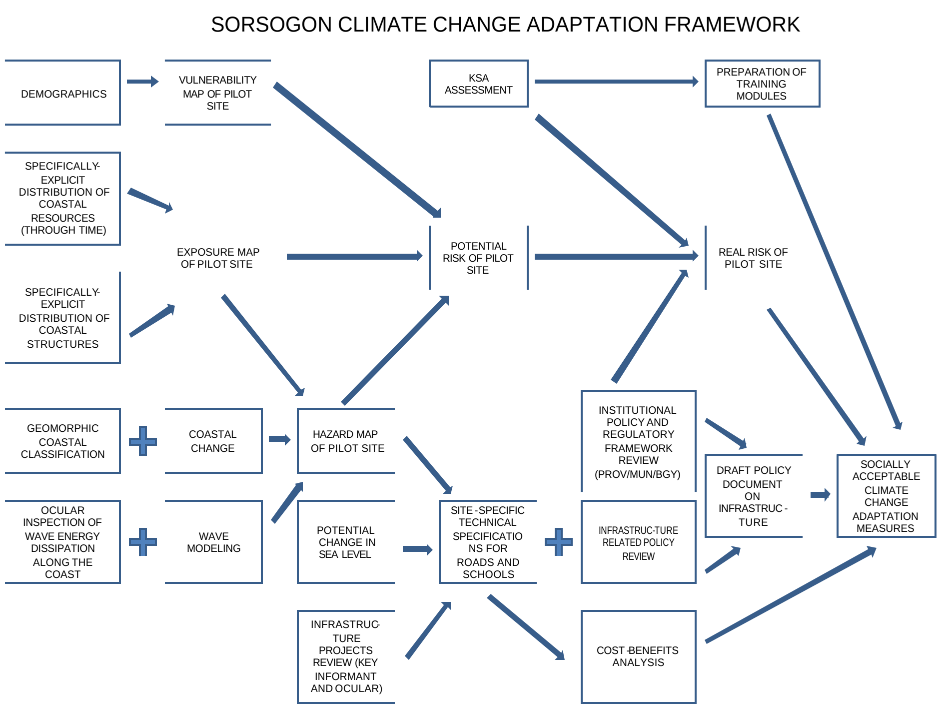

Figure 3.31 Schematic digram of assessment process employed for Gubat, Sorsogon

Center to most of the adaptations measures recommended was the result that natural "protection mechanisms" are important. The wave simulations and in situ assessment demonstrated that coral reefs are as important as seawalls against strong waves and storm surges. There is an added advantage that coral reefs are self-maintaining in contrast to seawalls. A host of other advantages include coral reef fisheries, aesthetic and potential tourism value, and an environment conducive to foraminiferal growth which is the major local source of white sand for the nearby beaches.

The Key Recommendations were:

- Reefs and mangroves are more effective and sustainable in dissipating strong wave action and for protecting coastal communities from storm surges; keeping them healthy must take precedence to infrastructures like seawall project;
- Community participation in coastal management particularly in enforcement activities must be strengthened to promote recovery of coral reefs and deforested mangroves;

- AVOIDANCE - Future developments should be discouraged in those coastal areas that have been shown to be highly variable through the decades (e.g. the coast at Gubat, Rizal);
- RELOCATION - Consider relocation a top option. Existing structures should be moved from highly hazardous areas especially under a 1-m sea level rise scenario;
- ACCOMODATION - Disaster resistant structures are recommended for essential facilities, as well as habitation prone to storm surges;
- COMBINATION OF SOFT AND HARD ENGINEERING APPROACHES - Future developments, such as seawall, jetties and ports, must require environmental impact assessments to avoid adverse effects on the integrity of the coastal property due to beach erosion and destruction of protective coastal habitats. This will ensure sustainability of engineering mitigating measures

- A general orientation of what is climate change, its effects on the environment and to communities, and how to address it utilizing a suite of scientific and management tools, is a necessary first step to raise public awareness on climate change issue;
- A workshop targeting LOCAL LEGISLATORS from various levels (Provincial, Municipal, Barangay) should be carried out aimed at raising awareness and translating it into actions such as crafting of climate change related legislations, e.g., adopting or promulgating new local laws recommendations of engineering component. The best way to deal with disasters, for example, is by public policy application of geophysical and engineering knowledge and instituting adaptive management monitoring, response and feedback mechanisms.
- A training *cum* workshop with LOCAL PLANNERS (MPDO and PPDO) to prepare various plans that will reflect climate change concerns as to zoning, development, investments and other areas of planning. Planning should be guided by good scientific information such as the results of this research;
- Fishery resources will be impacted by climate change. A training with key stakeholders must be undertaken will the goal of demonstrating the importance of an integrated management approach on resource management and bringing about climate change resiliency of coastal ecosystem and communities;
- Disaster preparedness training must be an integral component of good climate change adaptation program with emphasis on prevention rather than on a more expensive rescue and rehabilitation approach.

- At this stage of the project, the Provincial, Municipal and Barangay units should be encouraged to adopt a science-based approach to disaster management and climate change adaptation, particularly the findings of the MERF study in the pilot sites. Through this positive policy pronouncement, local officials and the public alike are guided by a rational study that helps ensure public safety as well as protection of public investments.

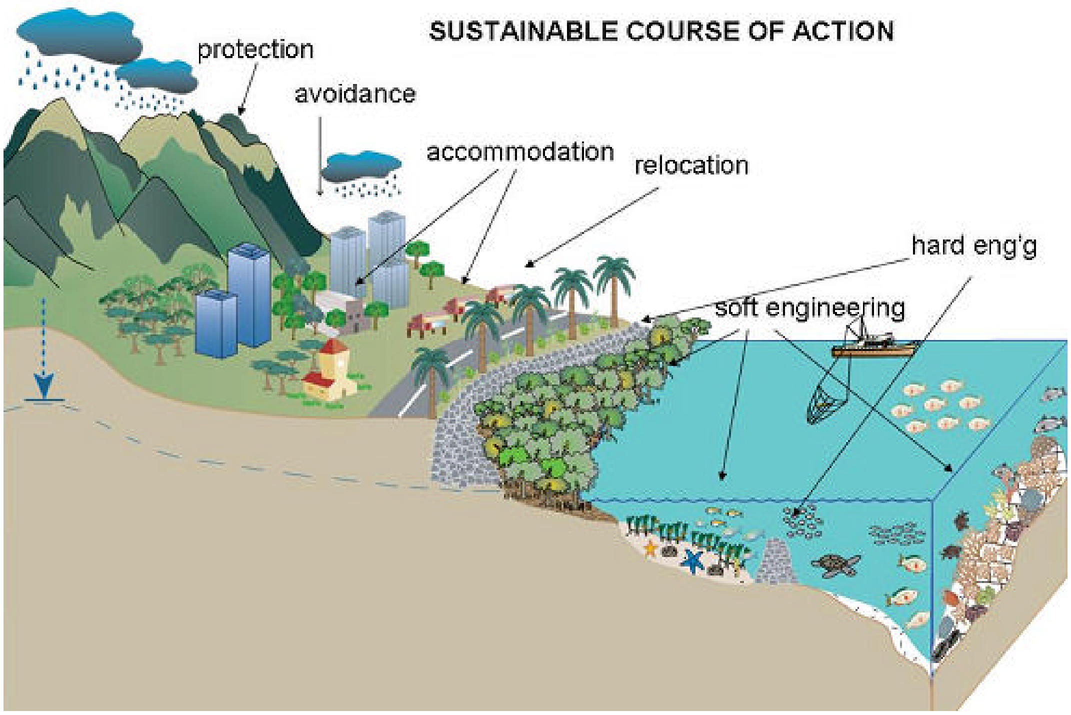

Figure 3.32. A combination of hard engineering and soft engineering approach wherein seawall construction will be coupled with planting of mangrove species in front of the seawall (soft engineering) and the construction of submerged wave breakers (artificial reefs; hard engineering). Seagrass or coral transplantation may also be undertaken where appropriate. All these combined will help dissipate wave energy before they reach the seawall thereby lengthening the life span of the seawall itself.

<u>Singapore</u>

Much of the modern Singapore coastline is reclaimed. The original coastline measured 106km but is now quoted at 193km (Figure 3.33). These additional lands have been turned mostly into residential areas and key industrial sites (i.e. Shipping ports, Airport, Petro-chemical / Biomedical) (Figure 3.34). However, these areas remain low-lying. Consequently, Singapore's National Climate Change Strategy (MEWR, 2008) has highlighted that a sea level rise of up to 59cm can result in coastal erosion and land loss in Singapore. Currently, about 70% to 80% of Singapore's coastal areas have hard wall or stone embankments, which help protect against coastal erosion. The rest are either natural areas such as beaches and mangroves. Increased erosion could impact recreational areas at the coasts, such as East Coast Park, Sungei Buloh, **Pasir Ris Park**, West Coast Park, and Sentosa (MEWR, 2008).

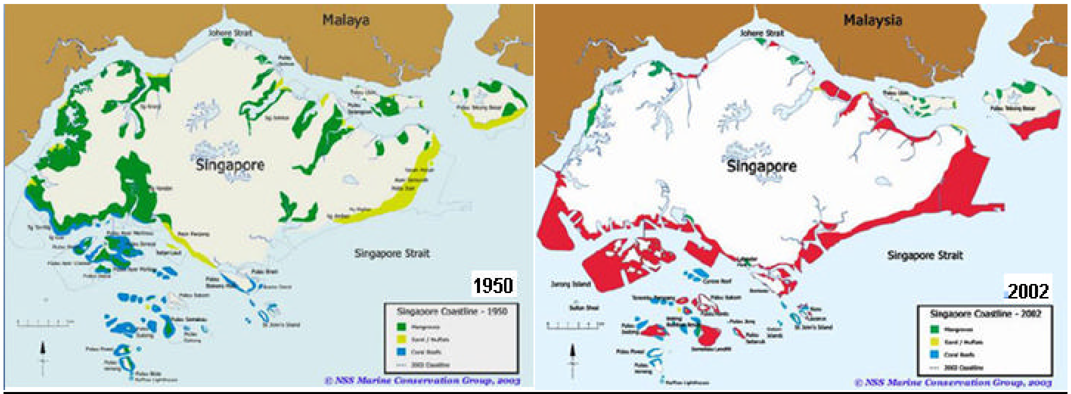

Figure 3.33 Singapore before (left) and after (right) reclamation [RED]

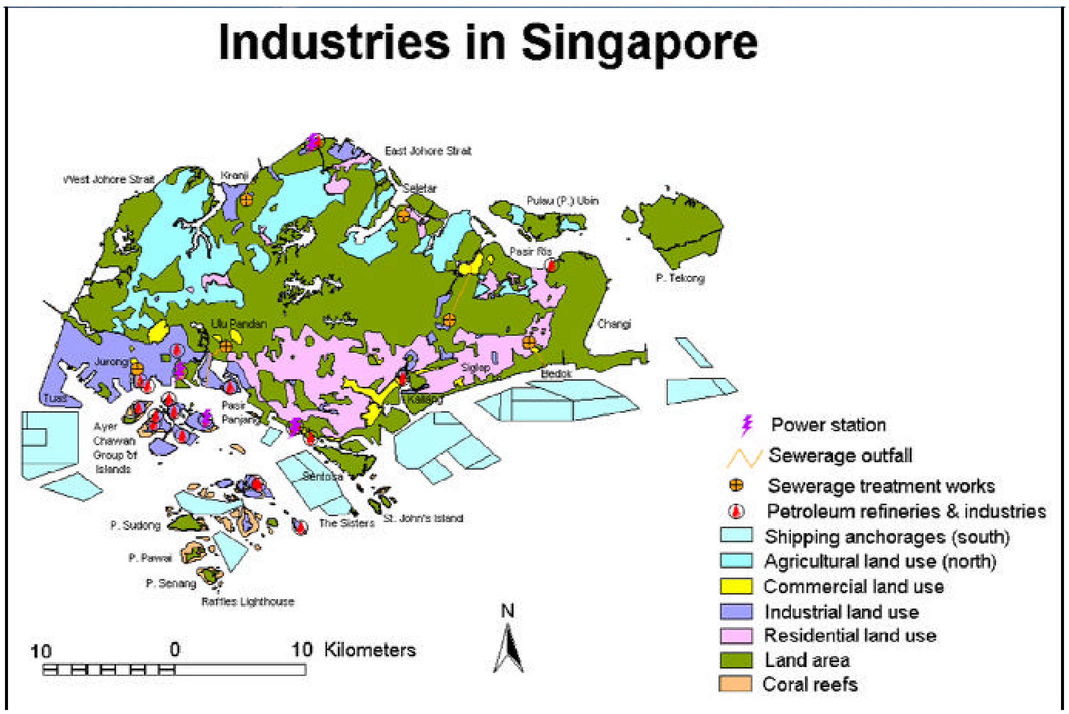

Figure 3.34 Map of Singapore highlighting location of major industries

The current Pasir Ris Park is 4km long, and encompasses a waterbody of approximately 1.5km^2, a sandy beach area of 0.12km^2, coastal mudflats of approximately 0.01km^2, and a 0.07km^2 area of secondary mangrove forests. The area receives an annual rainfall of 2400mm, and has a resident population of approximately 140,000. Most of the original coastal mangrove forest was destroyed during the reclamation process in 1978-1979, but a five hectare patch of mature mangrove forest was preserved and developed into a park beginning in 1988. To ensure the sustainability of the mangrove conservation efforts, “a channel system was constructed to ensure a tidal connection between the patch and the Tampines River” (Karns *et al*, 2002).

The primary data collection focused on the 2 bays (bounded by artificial headlands) adjacent to the estuarine mouth of Sungei Tampines (Bay A is to the east of the river mouth and Bay B is to the west) (Figure 3.35). A cuspate foreland extends beyond the mouth of the estuary and is colonized with foreshore mangrove species. The mouth of the estuary is flanked by sandy coasts with evidence of coastal erosion.

Figure 3.35 Pasir Ris Park with the two sampling sites highlighted in RED

Results show that the low gradient eastern coast of Pasir Ris park is the more vulnerable to sea level rise (Figure 3.36a versus 3.36b). At 1m SLR scenario, the current coastline will be perpetually flooded and mangrove survival is untenable. Tidal intrusion may exceed 35m inland. This is unfortunate since most of the remaining mangrove stands can be found in the east (Figure 3.37).

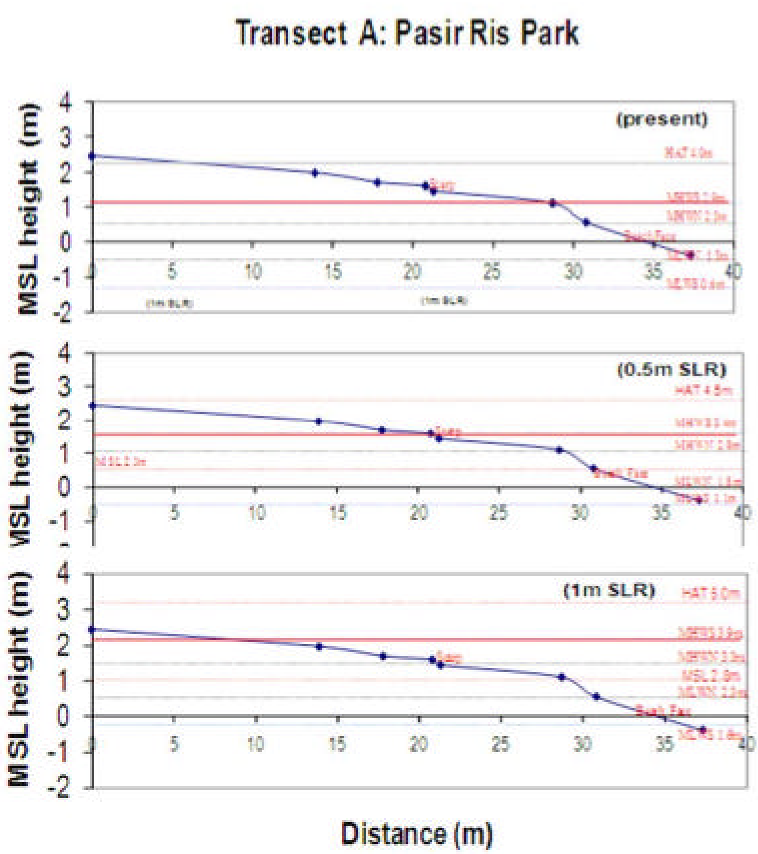

Figure 3.36a projection of sea level rise at the east side of Pasir Ris Park.
RED line indicates mid -high water during spring tide.

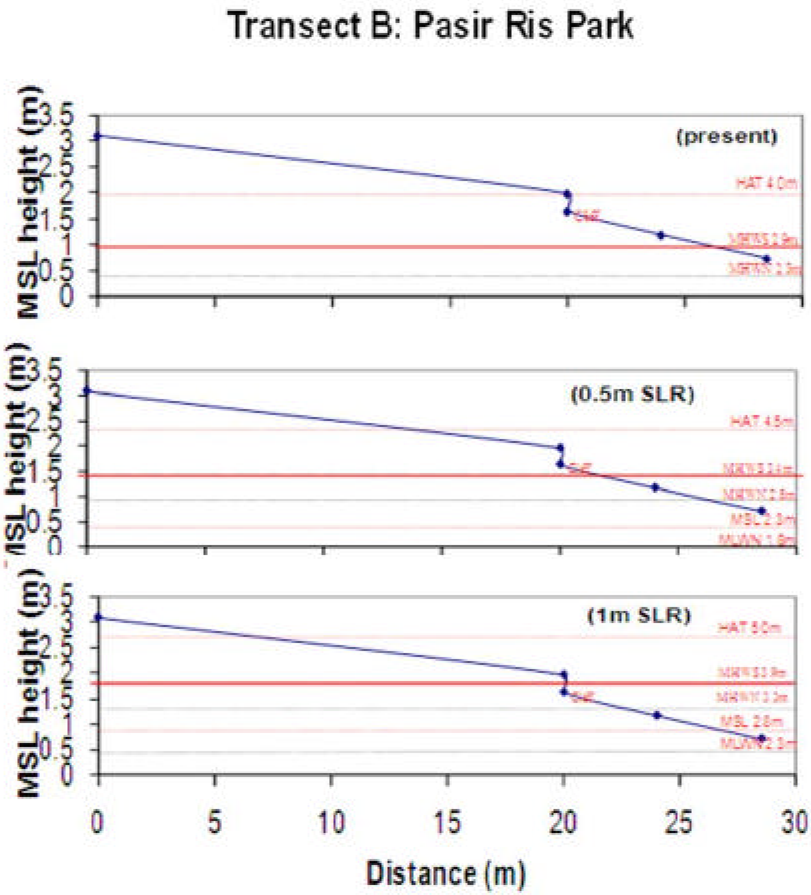

Figure Figure 3.36a projection of sea level rise at the west side of Pasir Ris Park. RED line indicates mid -high water during spring tide.

Running the DIVA under SRES A1F1 scenario with timesteps up to 2100 showed that for Singapore, the predicted total adaptation costs is USD11 mil/ year with 660,000 people affected by SLR and placing the total wetland loss value at 2100 as US$857 million. This is validated with ground assessment of mangroves and other beach vegetation being perpetually inundated given predicted 0.5m – 1m SLR by 2100. Already, mangrove dieback is being observed at the seaward fringe with built-up areas restricting any landward migration. The recommendations therefore include dike protection, replanting of seedlings (*Rhizophora spp*.) and continued monitoring efforts.

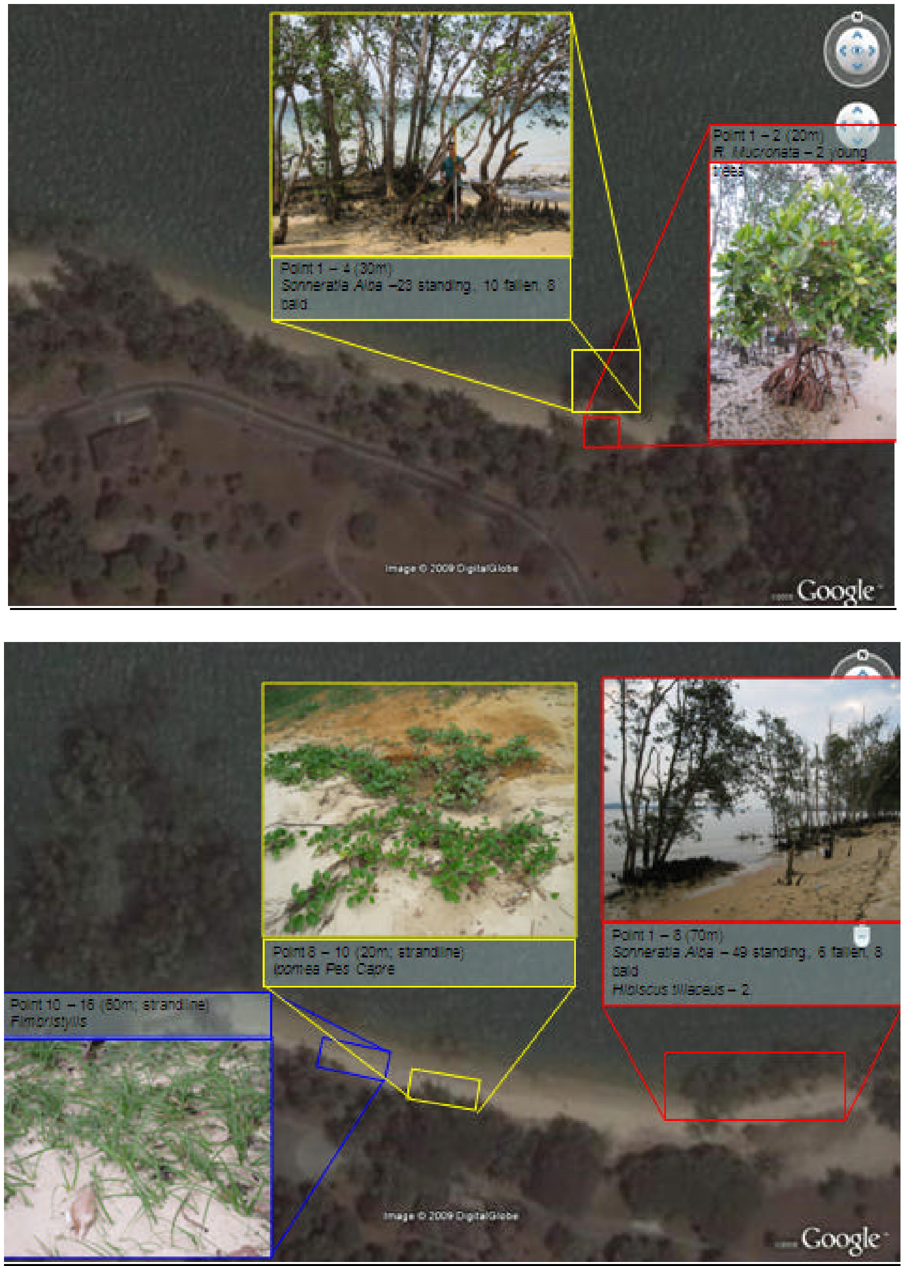

Figure 3.37 Coastal vegetation for Pasir Ris Park

Three options to mitigate coastal erosion are available: defensive action, orderly retreat or abandonment. In general, for Singapore, defensive action is probably the only strategy given its limited land area. Protective o ptions include engineering works to protect coastal areas and to raise the land area where possible (Wong, 1992). Singapore's chief response to beach erosion is construction of sea walls, boulder ramparts, and other structures designed to halt coastline recession. Groynes and nearshore breakwaters have been introduced to coastal and reclaimed beachfronts, to retain beach material. However, solid structures have been observed to cause wave reflection, which scours away beach sediment (Bird, 1992). A 'softer' approach available is the artificial nourishment of beaches. The emplacement and maintenance of artificial beaches is a means of absorbing wave energy and protecting its coastline from further erosion. Artificial beaches usually erode slowly, and have to be replaced at intervals varying from 7 to 20 years (Bird, 1992).

Singapore's National Climate Change Strategy (MEWR, 2008) documents the Singapore Government's commitment to adapting to sea level rise by protecting foreshore and coastal areas. Adaptation measures include the strengthening and reinforcement of existing revetments for protecting against erosion, and protecting natural areas by the use of various coastal defense systems (MEWR, 2008). Currently, beach nourishment through the replenishment of beach sand is carried out on a regular basis, to mitigate erosion along coastal beaches, particularly coastal recreational areas.

The Singapore National Climate Change Strategy (MEWR, 2008) also acknowledges that mangroves can be used to protect coasts against erosion. To date, a mangrove reforestation programme has been developed by the National Parks Board (NParks, Ministry of National Development), as a pre-emptive management strategy to address erosion in coastal mangrove areas. A mangrove refo restation programme is currently being carried out at Pasir Ris Park, and mangroves have been replanted along the banks of the two estuaries, S. Tampines and S. Api Api. This case study illustrates a policy-level response to mitigating the impacts of sea level rise from climate change, in Singapore.

A summary of the vulnerable human activities in Singapore (north and south coasts) is shown in figure 3.38.

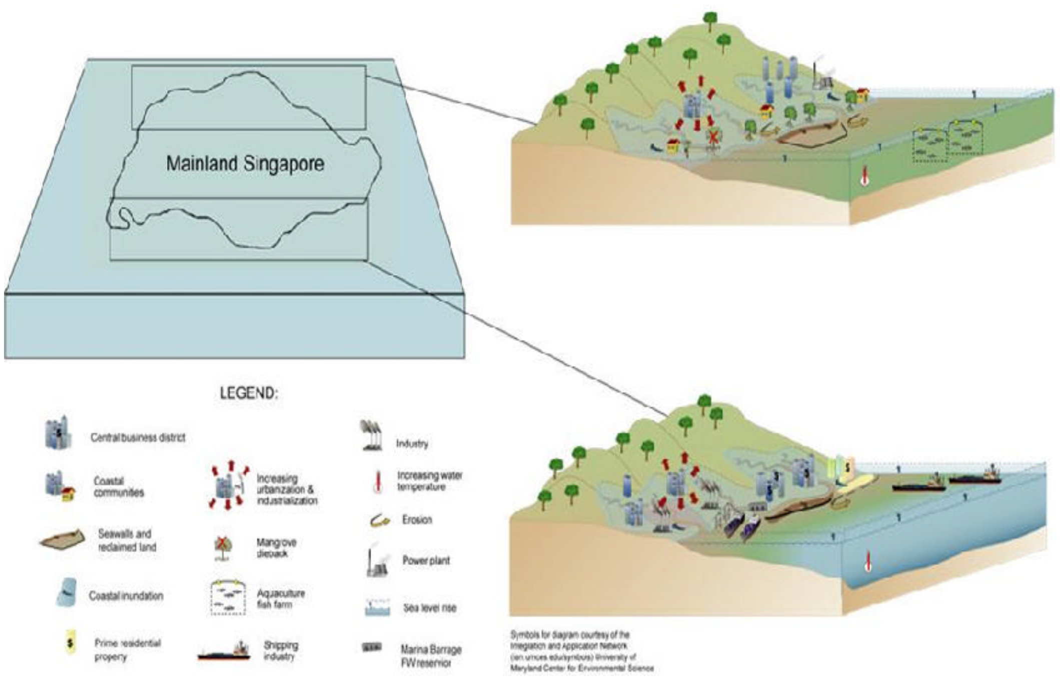

Figure 3.38 Singapore industries and human activities identified to be vulnerable to climate change.

Thailand

The perceived consequences of sea level riseare flooding of coastal communities and resorts. It will also negatively enhance erosion, salt water intrusion, and land cover change. These will cause siltation and drowning of mangroves and sea grasses which act as nursery ground for their fisheries. Along with increase in water temperature, these will also create undue stress for the reefs (e.g. coral bleaching) which in turn will affect sustenance fishery and tourism. Already there are indicators of impacts such as deforestation of mangrove areas, and land loss. In addition to climate change, the Andaman coast is also a potential site for tsunami-related disasters (Figure 3.39).

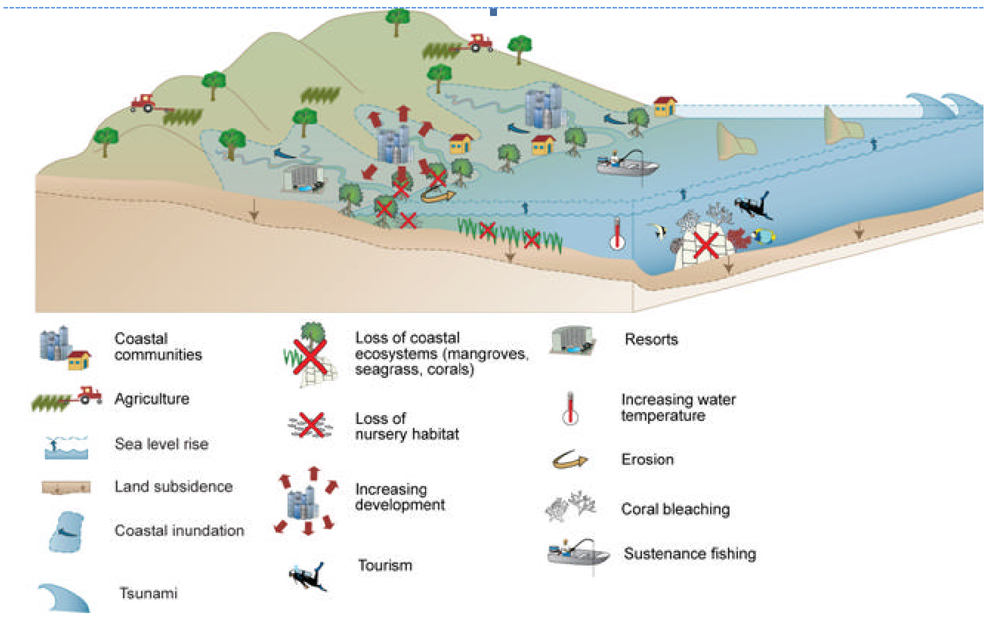

Figure 3.39 Schematic diagram of existing issues in the Andaman coast.

In terms of policy analysis, the team of Thailand recognized that adaptation options will have to be a shared effort between different stakeholders led by the Provincial governor strategies with specific projects being delegated to Local administration, Community groups, Central government agencies, and NGOs.

VietNam

Vietnam has a long tradition of fisheries and aquaculture practices, having a 3,260km long coastline - 1 million km^2 of Exclusive Economic Zone (EEZ). There are 3,000 islands plus up to 2,860 rivers and the Mekong River Delta (one of the most productive fishery zones in the world covering an area of about 40,000 square km). In addition, there are about 4,200 square km of rivers, lakes and other natural water surface as freshwater, brackish water and marine water available for aquaculture purposes (FAO/USDAFAS, 2007).

In 2006, Viet Nam's fishery sector contributed about 6.1 percent to the GDP of the country and the value of aquatic products in export turnover was about US$ 3.3 billion. This accounted for 9-10 percent of the country's total export value (MOFI/USDAFAS, 2007). Home consumption of fish has increased from11.8 kg per capital year in 1993, to 13.5 kg per year in 1995 and is now estimated at more than 19 kg per year (FAO/MOFI, 2003). Fish is the most important source of animal protein contributing 40 percent to the total animal protein intake, and is supporting the people's food security (MOFI, 2007). The latest evaluation of marine fish stock estimated a reserve of about 4.1 million tons with over 2,100 species of marine fishes of which about 130 species high economic value (Table 3.7). Annual allowable catch is about 1.7 million tons per year (RIMF, 2004).

Table 3.7: Total volume of fisheries products of Viet Nam from 2002 – 2007 (million tons)

Year	Total volume	Marine catch	Aquaculture & Inland catch
2002	2.4	1.4	1.0
2003	2.5	1.4	1.1
2004	3.1	1.9	1.2
2005	3.4	2.0	1.4
2006	3.7	2.0	1.7
2007	4.1	1.9	2.2

Source: MARD/FICen, 2008

Viet Nam is ranked third for aquaculture and eleventh for fish exploitation in the world (FAO, 2004) with aquaculture contributing over 41 percent of the gross fish catch of over 3.4 million tons in 2005 and 46 percent over 3.7 million tons in 2006, a massive increase from the 25 percent of gross catch it recorded in 1986.

Tam Giang-Cau Hai Lagoon

Tam Giang-Cau Hai Lagoon has 3250 ha of shrimp ponds and 1200 cages for fish culture providing livelihood for over 6500 households. There are no previous studies in Vietnam regarding possible effects of climate changes on the aquaculture activities at the lagoon. However, the investigators contend that increasing water temperature will decreased available dissolved oxygen, increasing food consumption of the fish and therefore potentially decreased the fish stock due to decreased available fish meal. There are also evidences that increased temperature will increase likelihood of occurrence of harmful algal blooms. In addition, the expected increase in frequency/intensity of storm events is due to decrease the aquaculture seasons/ time if not damage the aquaculture infrastructure. In 2005, for example 5 strong storms were responsible for the destruction of a bout 1200 ha of shrimp ponds and damage to 1000 fish cages. In 2006, 7 strong storms destroyed 1545 ha of shrimp ponds and damaged 1200 fish cages.

Aside from aquaculture, catch fisheries is also vulnerable due to temperature anomalies affecting coral bleaching and changes in species composition for the base of the food chain. Sea dike construction, increased urbanization, in addition to storms, are also responsible for increase in sedimentation thus contributing to the demise of precious coastal hab itat nursery grounds (Figure 3.40).

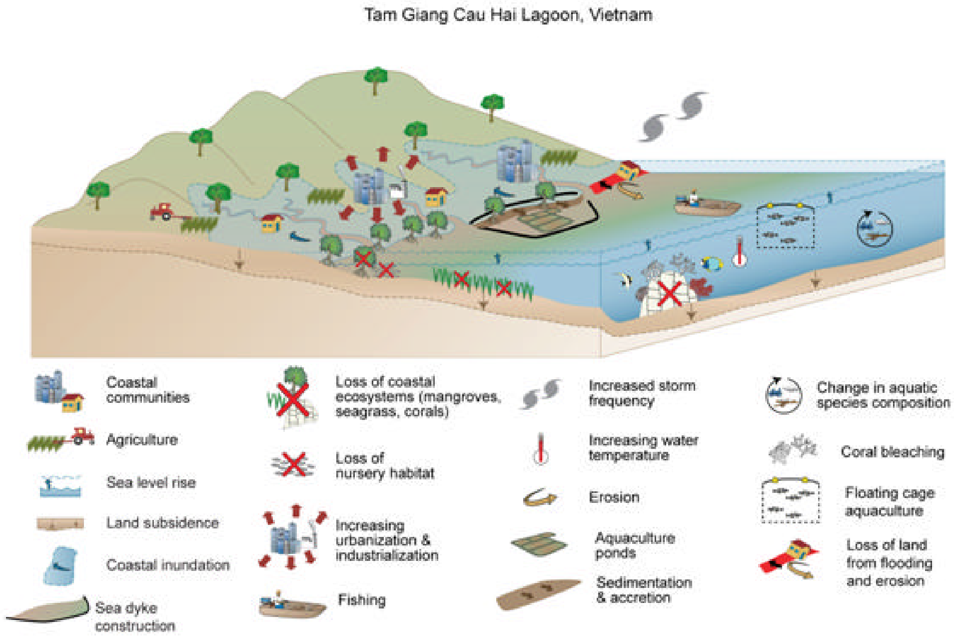

Figure 3.40 Perceived vulnerabilities and existing exacerbating issues for Tam Giang-Cau Hai Lagoon

Red River Delta

Agriculture and aquaculture are also major industries in the vicinity of the Red River Delta. Mangrove conversion into aquaculture sites is a major issue (Figure 3.41). This has led to an increase of intensity of erosion of the coast. With sea level rise and consequential inundation of the coastal area, the erosion is expected to intensify even further compromising the health of the coastal ecosystems. Issues of unabated urbanization, destructive fishing, and increasing temperature will only further negatively impact on the fishery resources (Figure 3.42). All these will have economic impact on the local community (rice farmer, aquaculture owners, shellfish collectors, province authorities, national park authorities).

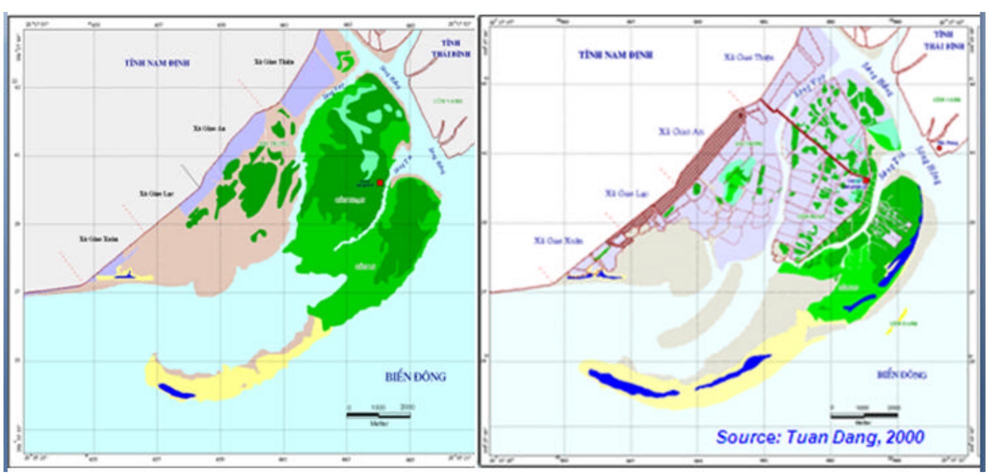

Figure 3.41 Conversion of mangrove into fish ponds evident in Red River Delta land use map

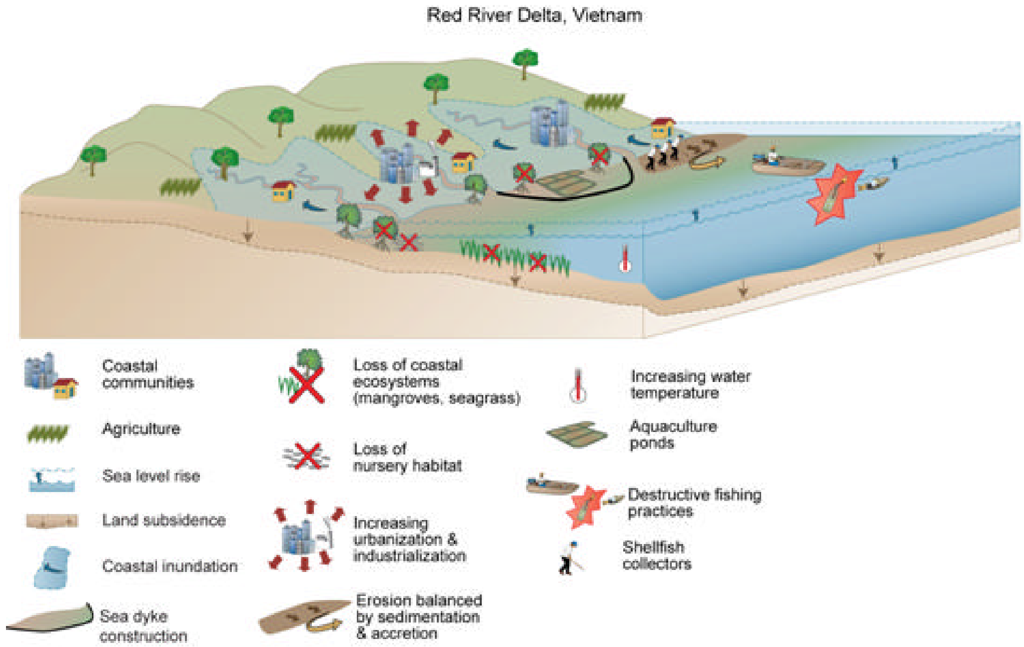

Figure 3.42 Perceived vulnerabilities and existing exacerbating issues for the Red River Delta

For its part the Vietnamese government has taken important steps promulgating the legal frameworks focusing on the strategic orientations for sustainable development of fisheries, precautionary measures and regulations to ensure that sustainable production is reached and maintained. Some of these frameworks are described as follows:

- Decision 393/ 1997QD-TTg, focused firstly on further expansion of marine fish production for domestic consumption and for export; and secondly on reducing the pressure on coastal fisheries resources which have shown signs of full exploitation, while strongly promoting offshore fisheries.

- Decision 09/2000/NQ-CP considered the economic restructuring and transfering of unproductive agricultural land to aquaculture as being a highly productive farming model for agricultural restructuring, raising people's income and contributing to poverty elimination.

- Law of Fisheries, Dec. 2003 (enforced July 2004), is the highest legislation regulating activities of Viet Nam fisheries. The Fisheries Law has 62 articles regulating fishery production, trading and investment and ensuring fishery quality, hygiene and safety in the process of food production and business; and the prevention and overcoming of food poisoning and diseases transmitted via food. The regulation on hygienic conditions applied to fishery production units in the field of farming, processing and trading is based on the fisheries sector's standards for food security (MARD/FICen, 2008).

- The Law on Environment Protection No. 52/2005/QH11, On 22 November 2005 by the National Assembly, regulates that: Environmental protection must be harmonized with economic development and the security of social advancements to ensure the achievement of sustainable development of the country, and actions undertaken to protect the environment at national level must be combined with those at regional and global levels (MARD/FICen, 2008)

- Decision 15/2006/QD-BTS Regulation on aquatic product quarantine. Viet Nam has signed bilateral agreements with some import countries on food hygiene and safety, and the quarantine of animals and plants, for the inspection of quality and quarantine of export goods based on the requirements of the importers (MOFI/FICen, 2007).

- Decision No. 50/2006/QD-TTg of March 7, 2006, regulated feed for aquaculture including fish meal and mixed feed in the form of pellets for black tiger prawn, giant black tiger prawn, tilapia, "Tra" and "Basa" catfish; and feed for other aquatic species (MOFI/FICen, 2006)

- Decision No 10/ 2006 / QD – TTg approved the Master Plan for Development of the fishery sector by 2010. The Ministry of Fisheries is planning to protect the coastal marine resources by depleting the number of small fishing boats and vessels by 2010, reducing 50 percent of inshore fishing, and maintaining the growth of the fishery with a focus on quality and value added fish products. The Fisheries sector has also conducted policies for the restructuring of coastal fisheries and inland aquaculture to develop three target programs – aquaculture, fisheries export and offshore fishing, intended to become powers of fisheries in the world. The major policy goals are contributing to poverty alleviation within fishing communities, creating new occupations and improving the living standards of fishing communities (FAO/FICen, 2007).

To achieve these goals the Viet Nam Government has supporting activities in parallel with issued policies, described as the follows:

- Supporting the hygiene safety control agencies in strengthening the capabilities of implementing the rules of the Government to protect consumers and ensure safety of seafood products through coordination with the Ministry of Science and Technology and the Ministry of Public Health.

- Organizing training short courses in the implementation of issued food hygiene safety standards, quality and safe aquaculture production, information and labeling of fisheries products, and international trade promotion.

- Making laws, regulations and administration procedures more effective: the Fisheries sector is establishing a cooperative training network for sustainable development law in the whole nation through the promotion of public awareness, preparation and distribution of guidance material, and specialized training including workshops, seminars, education programs and conferences.

- Increased funding for workforce education and training in the fisheries sector, and helping poor fishermen to diversify their livelihoods to alleviate poverty and reduce vulnerability of themselves and their families.

- Encouraging development of marine fish cage culture and aquaculture by providing supporting activities and promotion of alternative livelihoods. Also through developing infrastructure for aquaculture, fishery extension and providing financial sources via prior credit programs for fish farmers.

- On implementation of the decision No. 393, the Government granted a loan of capital, lending interest rates and credit debt payment terms to help fishermen build offshore fishing enterprises and fishing service ships. This was aimed at increasing the number of offshore fishing boats exploiting new potentialities and supplying materials for processing (MARD/FICen, 2008).

In summary, strong and effective processes in better management for environment, sustainable aquaculture and fisheries resources, as well as the facilitation of procedures for the involvement of concerned individuals, groups and organizations in international fish trade, are the basis for fisheries sustainable development and food security in Viet Nam.

3.3 Regional Synthesis

Using case studies coupled with in-country expert analysis, the most relevant coastal issues wereidentified and ranked (Table 3.8). It should be noted however, that even as only Indonesia, Malaysia, the Philippines and Singapore were able to participate in this last activity, the previous reports of Cambodia, Thailand and VietNam were considered in the ensuing discussions.

Results show that regionally, climate change is perceived to add to the damage already being done by the exploitation and destruction of coastal resources. All the countries with the exception of Singapore, for example have reported experiencing coral bleaching due to anomalous ocean temperature. At the same time, the Philippines also demonstrated the ability of reefs to act as protective structures against erosion due to sea level rise and intense storms. Therefore, destructive fishery will limit the capacity of reefs to act as protective barriers against climate change.

Table 3.8 The coastal issues that are perceived to exacerbate the effects of climate change and vice versa.

Parameters	Indonesia	Malaysia	Phils	Singapore	Average	Rank
Exploitation & Destruction of Coastal Resources	5.00	5.00	3.00	3.00	4.00	1
Natural & Anthropogenic Changes in Sediment Transport	4.00	4.00	1.50	4.00	3.38	2
Population Growth, Urbanization & Social Equity	3.00	3.00	4.00	0.00	2.50	3
Relative Sea Level Rise (including land subsidence)	2.00	1.00	1.50	5.00	2.38	4
Natural Disasters	1.00	2.00	2.00	1.00	1.50	5
Food Security	0.00	0.00	3.00	2.00	1.25	6

The issue of changes in sediment transport ranked 2 and is seen to further compromise the health of coastal habitats like fringing reefs and seagrasses. Changes can be due to erosion as a consequence of logging activities (e.g. Cambodia) or of low-land unrestrained agriculture (e.g. Darvel Bay, Malaysia) or of reclamation activities (Jakarta Bay, Indonesia and Singapore). Changes in sediment transport can also be due to inappropriate design and placement of ports and other coastal structures.

Increasing urbanization of coastal areas and unrestricted population growth and consequential social inequity ranked 3rd. Exposure factors into vulnerability. If there is no one to suffer then climate change will have less of an impact. The population statistics for SE Asia is shown in Table 3.9. The highest population is in Indonesia but Singapore, the Philippines and VietNam are the higher density countries. High population also results in higher demand on the resources. Additional pressure can make a system less resilient to any change.

Another consequence of high population and the presence of mega-cities is the pressure on freshwater resources. Groundwater extraction is the usual source. This has created an unforeseen consequence of land subsidence (Figure 3.43) resulting to an exaggerated relative sea level rise. This was given the rank of 4 despite the fact that all the countries reported the issue of land subsidence. Sea level rise per se is also ranked by Singapore as the number 1 climate related issue that Singapore will have to contend with.

Non-climate related natural disasters such tsunamis, volcanic eruptions and earthquakes continue to be a threat to parts of the region. This was therefore ranked as issue #5. Earthquakes in particular, can exaggerate the effects of sea level rise with substrate slumping and liquefaction. In some areas, a single earthquake has resulted to a loss of decades-old naturally accreted foreshore. It is strongly recommended therefore that for tectonically active areas, foreshore development of accreted land be limited to mangrove reforestation projects

Table 3.9 Latest population statistics of SE Asia

Rank	Country / Territory	Population	Date of estimate	% of World Population	density
1	People's Republic of China[n2]	1,337,290,000	May 3, 2010	19.61%	139.3
2	India	1,180,335,000	May 3, 2010	17.31%	359
3	United States	309,186,000	May 3, 2010	4.53%	32.1
4	Indonesia	231,369,500	July 2009	3.39%	120.5
12	Philippines	92,226,600	Mid-2009	1.35%	307.4
13	Vietnam	85,789,573	April 1, 2009	1.26%	260.3
21	Thailand	63,525,062	December 31, 2009	0.93%	123.6
43	Malaysia	28,306,700	July 2009	0.42%	85.8
66	Cambodia	14,805,000		0.22%	81.8
115	Singapore	4,987,600	Mid-2009	0.073%	7197.1

TOTAL POPULATION SE ASIA 521,010,035

LOCATION	PERIOD	SUBSIDENCE Meters	SUBSIDENCE cm/year
Tokyo, Japan	1918-87	4.5	6.5
Osaka, Japan	1934-68	2.8	8.2
Shanghai, China	1921-65	2.63	6
Yun-Lin, Taiwan (Fishpond area!)	1989-97	0.66	8.25
Hanoi, Vietnam	1988-93	0.1-0.3	2-6
CAMANAVA	1991-2002	0.3 - 1	2.7 - 9.1
Bangkok, Thailand	1980-90	0.5-1	5-10
Jakarta, Indonesia	1991-99	0.3-0.8	4-10

Figure 3.43 Data on East Asian Coastal Cities Sinking from Excessive Groundwater Usage (Figure contribution by Fernando Siringan)

Finally, the food security issue is a perceived exacerbating feature since limited resources has led to the compromise of coastal habitat health. As mangrove forests get turned into aquaculture sites (e.g. VietNam and the Philippines) the ability of this resource to protect against strong wave action from more intense storms or to protect from erosion as sea level rises is diminished. On the other hand, the ability of the coastal area to keep providing food is also compromised with coral bleaching, drowning of mangroves and siltation of seagrasses. Vital habitat and nursery ground for important food fish are shown to be very vulnerable to climate change impacts.

4.0 Conclusions

The main objectives of the project were to:

1. Determine the vulnerability gradients across the coastal areas of the SEA-EA region considering the coupled human and ecological systems.
2. Understand the multi-scale dimensions and inputs on the adaptive capacities of human communities toward the vulnerability of coasts, of conflicts and competition over lands, sea areas, and resources in the region.
3. Determine efficient and effective strategies to link GEC research results with policy making, governance and conflict resolution.

DIVA proved useful in vulnerability comparison between countries. It has the advantage of incorporating coupled human and ecological systems in the different simulations. It was also able to highlight the high cost of "doing nothing".

For immediate response to the threat of climate change DIVA showed that engineering measures are a necessity in order to ensure limited damage to the human population and coastal resources. The cost-benefit relation between beach nourishment and sea walls/dikes is country-specific and target-specific. The more vulnerable countries like Vietnam and Indonesia, for example, will benefit more from beach nourishment which will have to mitigate their predicted high rate of migration due to land loss. On the other hand, for Singapore whose vulnerability is determined by the 660 thousand people who will be flooded by year 2100, dike protection is recommended.

However, it also showed that the issue of salinity intrusion cannot be addressed in either of these engineering responses.

Finally, DIVA was able to demonstrate that the extent of impact anticipated to affect the coastal zone differs depending on the underlying IPCC SRES storyline. Therefore, on global political and governance scales, effort must be exerted globally towards targeting the B1 or A1T scenario, which in terms of concrete action translates to reduced demographic pressure, a balanced mix of utilized energy resources, and a substantial increase in equity among the global regions. Therefore, despite the fact that as a region , SE Asia is a low Greenhouse gas contributor (as compared to Europe or the Americas), we should still exert effort to contribute to global development towards a scenario favorable to us.

DIVA however has limitations in terms of applicability at more localized scales.

Case studies provided by the different participating countries proved very useful towards understanding the multi-scale dimensions and inputs on the adaptive capacities of human communities toward the vulnerability of coasts, of conflicts and competition over lands, sea areas, and resources in the region.

Initially, there was am expressed preference to have a uniform methodology for data collection, processing and synthesis for vulnerability assessment to ensure inter-comparability of indicators at different scales. This eventually proved impractical and unnecessary.

It is impractical because the vulnerability assessment of each participating country is already in various stages of development. More importantly, it is impractical because each case study site has unique bio-physical and socio-economic characteristic and no single method of assessment will work for all the systems. Southeast Asia is too heterogeneous physically and culturally for any one approach to work. Finally, bear in mind that assessments are done to influence policy and decision making. For this it is critical to be cognizant and respectful of site-specific nuances.

In the end, the preference for a uniform methodology to ensure inter-comparability between sites also proved unnecessary. For as long as common ways of reporting are put in place with common definitions agreed upon, then similarities and uniqueness of relevant issues between case study sites naturally emerged. The communication tool developed during workshop 2 which was initially intended only for communicating risks and vulnerabilities of coastal areas to different stakeholders (planners/managers, policy makers), proved invaluable as a common reporting mechanism between study sites.

From the different case-specific approaches of vulnerability assessment, what emerged is that across the region, there are common issues whose negative effects will only be exacerbated by climate change. At the same time these existing issues also makes the coasts more vulnerable to climate change. The common issues include exploitation and destruction of coastal resource, changes in sediment transport, population growth/urbanization/social inequity, land subsidence, non-climate natural disasters and food security.

In order to adapt to climate change therefore, an integrated management and governance of coastal systems is deemed necessary since compounding interactions of various processes and existing issues have implications to the adaptation capacities of human communities. Management and policy decisions can be enhanced with tools of valuation, communication, and institutional capacity building. Examples of these have been presented in this report.

5.0 Future Directions

A regional higher resolution assessment tool (perhaps a regional DIVA SEAsia) may be a desirable consequent future research target.

The DIVA tool in general is being further developed by the members of the former DINAS-COAST consortium. Recent efforts focus on updating the representation of the coastal slopes and population density based on newly available digital elevation models. A further activity aims to ingrate DIVA into standard GIS software in order to make it easier for users to run DIVA with their own data, a need that has frequently been expressed within this and other applications of the tool. On the longer run it is envisaged to develop regional versions of DIVA applicable at sub-national scales relevant for coastal-zone management. A major challenge to be faced thereby is to move beyond the one-dimensional representation of the coastal zone, a model that has proven to be powerful for the global scale dimension but less appropriate for smaller scale analysis.

Development of different assessment tools that can be applied by local stakeholders is also desirable.

The goal is not to make a uniform assessment tool. As outlined above this is both impractical and unnecessary. However, it would be good to have a toolkit of different assessment tools that may be used on-the-ground by local stakeholders themselves so that they use the results as additional input to local planning.

Finally, it is desirable to have more representative case studies for the region.

The heterogeneity of the region is currently under-represented. Site selection can use projected changes as indicated by the IPCC scenarios overlaid on bio-physical and socio-economic GIS. Finally, success stories of adaptation options and lessons learned from inappropriate response should also be documented as part of the case study assessments.

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Appendices

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- Appendix 1.1 Workshop program & participant list
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Appendix 2 Workshop YEAR 2
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- Appendix 2.5 Translating science results into policy -USA Environmental Protection Agency
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Appendix 3 Workshop YEAR 3
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Appendix 4 Products Developed
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- Appendix 4.2 DIVA guide
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Appendix 5 Funding sources outside the APN

Appendix 6 Acknowledgement

Appendix 7 Glossary of Terms