Asia-Pacific Network for Global Change Research

Integrative Analysis of the Vulnerability of the SEA Region with respect to Food, Health and Coastal Industry

Addendum Activity to APN project:
ARCP2008-02CMY-David

The following collaborators formed the core team of this addendum activity:

Laura T. David, Ph.D., U.P. Marine Science Institute, Philippines, ldavid@msi.upd.edu.ph
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
Quach Thi Khanh Ngoc , Ph.D. Nha Trang University, Vietnam, quachngoc@gmail.com
Marine Environment and Resources Foundation Inc., Philippines
LOICZ-IPO, Germany

Complete list of collaborators for the APN project ARCP2008-02CMY-David

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, Quach Thi Khanh Ngoc

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

Project Reference Number: ARCP2008-02CMY-David

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.

The project has so far addressed 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 the DINAS-COAST DIVA model (Dynamic Interactive Vulnerability Assessment) (http://diva.demis.nl/; Hinkel, 2005; Hinkel and Klein, 2008; McFadden et al., 2007), the project was able to assess vulnerability of coastal sites to the different SRES scenarios. The advantage of DIVA is that it takes 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. The limitation of DIVA is that the projections are given in country-scale which is useful for cross-country comparisons but insufficient for in-country planning.

On the other end of the spectrum, the project also made use of existing and on-going climate vulnerability assessment case studies within the participating countries. The invited the country-experts were tasked to share case studies that highlight their respective country's coastal zone sensitivity to extreme events. The case studies proved very useful in highlighting the multi-scale dimensionality of the conflicts and competition over lands, sea areas, and resources in the region. From these shared knowledge, country-experts were able to identify the existing common coastal issues which makes the coastal area of SE Asia more vulnerable to climate change effects.

The final component to this study is an integration of these shared knowledge at a scale that policy-makers will find useful in order to make reasonable decisions. 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 this component is to

1. Determine the vulnerability gradients across the coastal areas of the SEA region at the finest possible scale. Specifically the vulnerability of the following anthropogenic concerns:
    - Food Production as it pertains to fisheries potential, and
    - Health and Industry Elements as it pertains to risk of flooding and compromised coastal integrity
2. Recommend strategies for GEC Adaptation-related policy making, governance and conflict resolution.
3. Disseminate project results and recommendations.

Amount received for the addendum activity

The remaining unspent funds USD16730.80 and the USD7000 retained by the APN

Activity undertaken

The 1st activity was concentrated on identifying sites of high climate exposure and natural/societal sensitivity. Areas that will be more prone to increases in sea surface temperature, extremes in water budget, cyclonicity and relative sea level were highlighted. On top of these we overlaid existing food production areas, population centers, coastal development (i.e.airports and seaports) and tourism industry. Both sets of data came from remotely sensed images and sectoral or national databases. From the overlays, we then assessed which specific sites and which specific anthropogenic concerns per site are most vulnerable.

The results of the GIS-based assessment were shared in the subsequent workshop.

The 2nd activity is the workshop, which focused on sharing insights from site-specific, country-wide and regional vulnerability assessments (VAs), commenced October 2013 with old and new participants (Appendix 1.1). Dr. Laura David shared what has transpired since the last workshop and technical report. She then shared the results of the regional GIS-based assessments and asked the participants if the results can be corroborated by in-situ data. The participants then shared their own site-specific or country-wide assessments. Similar to what transpired in the previous project, it was obvious that the VAs cannot easily be compared due to different approaches. The next 2 days were then dedicated to familiarization with a method developed in the Philippines and currently being implemented in the Coral Triangle- namely TURF and CIVAT (Appendix 1.2). TURF focuses on vulnerability of the fisheries while CIVAT focuses attention on coastal integrity. The final exercise for the workshop concentrated on modifying the TURF and CIVAT approaches so that these can be used within each country-site taking into consideration data availability across sites.

The modified TURF and CIVAT were to be used by the participants to assess their sites. Results of this exercise will be used to validate the earlier GIS-based assessments.

Results

From the previous project, DIVA simulations for sea level rise scenarios showed that site-specific interventions are recommended to mitigate flooding, land loss due to submergence/erosion and preservation of coastal hábitats. These climate-related impacts are also perceived as exacerbating factors in 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.

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

These are further distilled to the following anthropogenic concerns:

- Food Production as it pertains to fisheries potential, and

- Health and Industry Elements as it pertains to risk of flooding and compromised coastal integrity

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 addendum project involved four member countries of APN (Indonesia, Malaysia, Philippines, Vietnam) with all four considered developing. It also involved Singapore as collaborator.

Self evaluation

The project had to adjust its schedule to ensure participation of all collaborators. This adjustment allowed additional time for the participating countries to gather relevant data from their respective case studies.

Objectives were met. The GIS-based analysis provided for a regional perspective requested by the previous project reviewers. Hiring of 2 graduate students for this specific task was instrumental in the achievement of the objectives. The training workshop provided the participating countries to proceed with the assessment of their case studies using common tools. This allowed for comparable assessment throughout the region.

The main problem encountered was that two of the original country experts were no longer able to participate. The final synthesis report therefore has input only from, Malaysia, the Philippines, Singapore, VietNam and Indonesia.

Potential for further work

Identified future developments include updating of national datasets.

References

Adger, W.N. 2003. Social capital, collective action, and adaptation to climate change. *Economic Geography* 79(4): 387–404, 2003.

Hinkel, J.. 2005. DIVA: An iterative method for building modular integrated models. *Advances in Geosciences*, 4, 45–50, 2005; SRef-ID: 1680-7359/adgeo/2005-4-45; European Geosciences Union. http://www.adv-geosci.net/4/45/2005/adgeo-4-45-2005.pdf

Hinkel, J. and R.J.T. Klein, 2007: Integrating knowledge for assessing coastal vulnerability to climate change. In: *Managing Coastal Vulnerability: An Integrated Approach*, L. McFadden, R.J. Nicholls and E.C. Penning-Rowsell (eds.), Elsevier Science, Amsterdam, The Netherlands.

Lasco , R.D. and Boer, R.. 2006. An integrated assessment of climate change impacts, adaptations and vulnerability in watershed areas and communities in southeast Asia. A Final Report Submitted to Assessments of Impacts and Adaptations to Climate Change (AIACC), Project No. AS 21. http://www.aiaccproject.org/Final%20Reports/Final%20Reports/FinalRept_AIACC_AS21.pdf

McFadden, L., R.J. Nicholls, A. Vafeidis, R.R.Tol. 2007. A methodology for modelling coastal space for global assessment. Journal of Coastal Research, Vol. 23, No. 4, pp 911-920

Mimura, N. 2001. Distribution of vulnerability and adaptation in the Asia and Pacific region. http://www.survas.mdx.ac.uk/

Nicholls, R., P. Wong, V. Burkett, J. Codignotto, J. Hay, R. McLean, S. Ragoonaden and C. Woodroffe, 2007. Coastal systems and low-lying areas. In: Parry, M., O. Canziani, J. Palutikof, P. van der Linden and C. Hanson (eds.), Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 315–356.

Acknowledgments

Acknowledgments: LOICZ SEasia/Asia Regional Node, Singapore; 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.

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 GIS-based analysis validated by primary and secondary data from collaborating countries. To ensure comparability, a regional training workshop was conducted to expose the regional participants to tools for assessment currently being employed in the Coral Triangle. 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 global environmental changes is site-specific. It depends on the amount of exposure the area receives, the amount of socio-economic development in the area and the ability of affected communities to cope with such changes (Mimura, 2001; Adger, 2003; Lasco and Boer, 2006; Nicholls et al., 2007). There is a necessity therefore to have an integrated spatial analysis to determine their collective effect on vulnerability of coastal communities in SE Asia.

Using the results of the previous project, the most relevant coastal issues were identified and ranked.

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

These are further distilled to the following anthropogenic concerns:

- Food Production as it pertains to fisheries potential, and
- Health and Industry Elements as it pertains to risk of flooding and compromised coastal integrity

Our method of approach therefore was to gather and analyze primary and secondary country-wide data specifically pertaining to exposure and sensitivity of the coastal sites as it relates to food production and coastal integrity.

In summary, this project endeavored to:

1. Determine the vulnerability gradients across the coastal areas of the SEA region at the finest possible scale. Specifically the vulnerability of the following anthropogenic concerns:
   - Food Production as it pertains to fisheries potential, and
   - Health and Industry Elements as it pertains to risk of flooding and compromised coastal integrity
2. Recommend strategies for GEC Adaptation-related policy making, governance and conflict resolution.

2.0 Methodology

Effort was concentrated on identifying sites of high climate/ocean exposure and natural/societal sensitivity. Climate exposure focused on areas that are more prone to increases in sea surface temperature, extremes in rainfall and sea level rise in particular since it is these 2 that have been shown to have direct bearing on coastal food production and coastal integrity. On top of these we overlaid existing food production areas, population centers, coastal development (i.e.airports and seaports) and tourism industry. Both sets of data came from remotely sensed images and sectoral or national databases.

From the overlays, we then assessed which specific sites and which specific anthropogenic concerns per site are most vulnerable. The base map used for all the maps came from the GADM database of Global Administrative Areas ver2.0 (January 2012 http://www.gadm.org/). Making use of common VA tools, the project was then also able to put details to the spatial overlay results using country case studies along with in-country expert opinion.

2.1 Regional GIS-based assessment

Identifying sites of high climate/ocean exposure

Areas that are more prone to increases in sea surface temperature, cyclonicity and relative sea level rise were highlighted. Monthly averages of sea surface temperature (**SST** at °C**)** was taken from NOAA-Coral Reef Watch (coralreefwatch.noaa.gov/satellite/index.php). The data covered the years 1985-2006. Monthly average rainfall (Rain at mm/hr) was from TRMM 3B43(V6) obtained thru Giovanni (disc.sci.gsfc.nasa.gov/Giovanni/overview/index.html). The data covered the years 1998-2010. Monthly average sea surface height was calculated from daily mean absolute dynamic topography (SSH at cm) thru AVISO (www.aviso.oceanobs.com/en/home.html). The data covered the years 1993-2010

All data products are in 0.5^{o} spatial resolution. Rainfall (0.25^{o}) and SSH (0.33^{o}) were regridded to match with SST and DHW's 0.5^{o} resolution. Data was then analyzed using the typology approach (Figure 2.1) similar to what was previously done globally in coastal areas by Buddemeier et al. (2008) and the Coral Triangle waters by Peñaflor et al. (2009). The optimum number of clusters was determined using the highest average silhouette value. Silhouette measures the tightness and separation of clusters (Rousseeuw, 1987). The data used for this process were ocean and atmospheric data that are deemed to be of relevance to climate change vulnerability assessments –these are sea surface temperature (SST). precipitation, sea surface height (SSH), and wind.

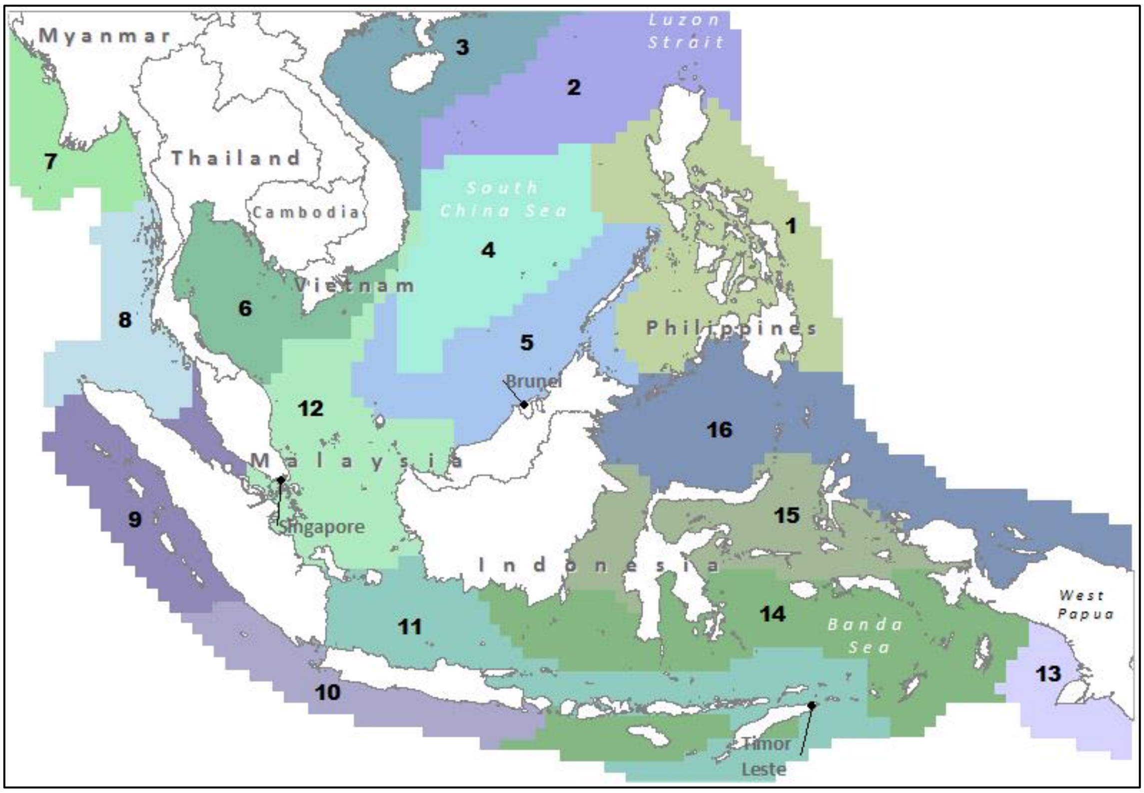


Figure 2.1 SE Asia typology using sea surface temperature (SST). precipitation, sea surface height (SSH), and wind.

Additional analysis was conducted using Degree Heating Weeks (DHW) data for the duration 1985-2006. DHW is an SST-derived product that represents the cumulative effects of thermal stress (Skirving et al., 2006; Strong et al., 2006). The analysis was done by first, calculating the percentage of pixels within a cluster for each month with DHW >=4. DHW values equal to 4 or greater indicate the existence of sufficient thermal stress to cause significant levels of bleaching in corals (Skirving et al., 2006; Strong et al., 2006). After which, the maximum percentages of pixels with DHW >=4 for each year were taken. This was done by taking the maximum value of all monthly calculations within a year. The final value here for each cluster indicates the maximum percentage for all years.

Identifying sites of natural/societal sensitivity

Locations of good reefs were identified using the proxy data of MPA and Protected Area locations. MPA data were downloaded from Reefbase(www.reefbase.org/gis_maps/datasets.aspx) but the data was identified to be originally from UNEP-WCMC (www.unep-wcmc.org/). Protected Area data was from the IUCN and UNEP-WCMC (2010), World Database on Protected Areas (WDPA) at www.protectedplanet.net.

The population centers were identified using Gridded Population of the World and the Global Rural-Urban Mapping Project (sedac.ciesin.columbia.edu/gpw) at 2.5' resolution for the census year 2010. The population was summarized and displayed per province except for the smaller countries of Brunei, Singapore, & Timor Leste. For these three only the total country population was included. Aside from the total population, data analyzed included average population density per 1km2, estimated population under 2m sea level rise scenario (SLR) and percent population affected by 2m SLR.

Seaport data are from the World SeaPorts Database (e-ships.net/country/Philippines.htm) and World Port Source (www.worldportsource.com/ports/region.10.php). These databases include river ports and off-shore terminals. Airport locations were taken from the database of Airports of the World (www.flightstats.com/go/Airport/airportsOfTheWorld.do).

Since one of the highest grossing industry for the coastal areas of SE Asia is tourism, the locations of the resorts were also investigated. Majority of the data points were extracted from Google Earth but additional sites were also tapped (www.agoda.com/ ; www.hotelscombined.com/ ; www.waypoints.ph ; www.asiatravel.com). Beach hotel/resort websites were also used to determine the exact locations of these establishments.

These data for potential food production areas (MPAs), population centers, coastal development (i.e. seaports) and tourism industry (i.e. airports and resorts) were overlaid on each other to pinpoint areas of high sensitivity.

2.2 Country Case Studies

Similar to what transpired in the previous project, it was obvious that the existing VAs cannot easily be compared due to different approaches. The team then decided to make use of a tool currently being implemented in the Coral Triangle- namely TURF and CIVAT (Tool for Understanding Resilience of Fisheries and Coastal Integrity Vulnerability Assessment Tool, respectively). TURF focuses on assessing the vulnerability of the fisheries while CIVAT focuses attention on coastal integrity. However, TURF and CIVAT are typically implemented at the scale of townships and cities. Data needed for these analyses are not always available at larger scales. The team therefore decided to modify the TURF and CIVAT approaches so that these can be used within each country taking into consideration data availability across sites.

The modified approach assesses the coastal area vulnerability using intrinsic and extrinsic sensitivities. Intrinsic sensitivity includes presence and extent of coastal habitats; the tonnage of fisheries import versus export; the prices of demersal versus pelagic fish and the socio-economic status of the coastal area (population, number of fishers; average catch and average income). Extrinsic sensitivity pertains to human activities that might further exacerbate the vulnerability of a particular area such as mining activities; presence of ports or seawalls; and any fisheries subsidy.

The project then 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 countries with country-wide assessments while others only have specific site assessments). Nevertheless, all contributions (including background data from previous project) are presented and used in the analysis in this report.

3.0 Results & Discussion

3.1 Regional GIS-based assessment

Identifying sites of high climate exposure

Specifically for the marine environment, slow but persistent change in temperature have been associated in consequences to distribution limits of certain flora or fauna (Cambridge et al., 1990; Gaston, 2000; Carricart-Ganivet, 2004) and have been linked as well to changes in timing of spawning events (Baba et al., 1999; Wilson and Harrison, 2003). Events of rapid heating, on the other hand, have been associated with mass coral bleaching (Hoegh-Guldberg, 1999; Donner et al., 2005) and mass fish kill (Hobbs and McDonald, 2010; Kibria, 2011). For this reason, effort has been maintained in monitoring the intensity and duration of anomalous events (NOAA Coral Reef Watch, 2000). It is valuable therefore for management effort to have a handle on the thermal climate of a given area.

For the long-term trend (Figure 3.1) over the 22 years, a majority of the clusters had a rate of change around positive 0.20-0.25 ^{o}C/decade which is comparable to the northern ocean increase of 0.19±0.134 ^{o}C/decade (Trenberth et al., 2007). The internal seas of Indonesia are either experiencing an increase comparable to that of the global ocean increase of 0.133±0.047 C/decade (Clusters 9, 11, 14, 15) or have had negligible overall change throughout the 22 years (Clusters 10 and 13). The northern clusters (Clusters 2 and 3) have been experiencing the highest rate of increase for the region.

As for episodic events, the occurrence of DHW>=4 involving more than 30% of the pixels in each class were found to be rare (Table 3.1). Observed only once or twice per water cluster for the 22-year dataset, most of these happened during the global ocean warm event of 1998.The more significantly affected regions in 1998 were the westernmost side of southeast Asia (Clusters6, 7, 8, 9, 10) and the Philippines including Luzon Strait (Clusters 1, 2) with 46%-90%of the region experiencing DHW>=4.

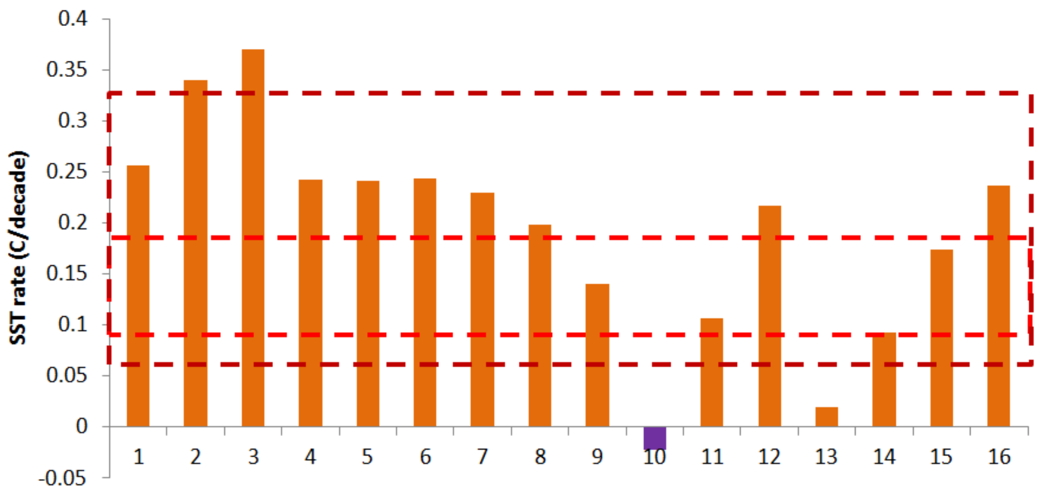


Figure 3.1 Rate of Sea Surface Temperature increase for each cluster

The regions that experienced the least amount of heating are the internal seas of Indonesia (Clusters 11, 13, 14. 15), and the South China Sea (Clusters 4, 5) with no more than 25% of the pixels experiencing DHW>=4. These are also the regions that were least affected by the heating event of 1998, 2010 and 2012.

Table 3.1 Number of events where pixels in each cluster experienced more than 4 Degree Heating Weeks.

Cluster	ND*	<1	<10	<20	<30	<40	<50	<60	<70	<80	<90

ID					(Percentage)						
1	11	3	7					1			
2	8	2	7	2	2						1
3	5	3	8	2	1	2	1				
4	14	2	5		1						
5	13	5	2	2							
6	12	1	4	2	1			1			1
7	11	4	3	2				1		1	
8	14	2	2	2		1	1				
9	11	1	7	2				1			
10	17	1	1	2					1		
11	11	3	7	1							
12	10	7	4				1				
13	16		3	3							
14	9	6	4	3							
15	14	2	6								
16	9	6	4	2		1					

Extreme rainfall can impact coastal habitat health due to nutrient and sediment delivery. High nutrient input can make the waters can trigger algal blooms which can then contribute to water turbidity, anoxia, and toxicity–depending on the algal species. High turbidity can affect the productivity of seagrass, seaweeds and algal turf (Short, 1987). Anoxia and toxicity can cause massive fish kills (David, et al., 2014). High sediment input can make the water turbid and can also physically smother corals (Nugues and Roberts, 2003).

Monthly average rainfall (mm/hr), covering the years 1998-2010, showed that extreme rainfall events mostly happen during the rainy season with cluster 3 and clusters 7 & 15 having received 100mm/hr greater than seasonal average in at least one instance over the last 12 years. Only clusters 10, 14, and 16 experienced extreme rainfall events during the relatively dry season. These events happened between 2008-2010. Both instances can impact coastal habitat health, unlike in the terrestrial environment where anomalous rainfall events have a more significant impact during dry seasons.

The clusters that had no significant anomalous events during the wet season were clusters 1, 13, and 16 . The clusters that had no significant anomalous events during the dry season were clusters 2, 3, 4, 6, and 7.

A similar analysis was conducted using a threshold of 50mm/hr greater than seasonal average. The combined results are shown below (Figure 3.2). Clusters 3 and 7 stand out because of the high occurrence of rainfall anomalies (above 50mm/hr monthly average) during the wet season while clusters 10, 14, and 15 stand out because the rainfall anomalies (above 50 mm/hr) and extreme anomalies (above 100 mm/hr) has occurred in almost any season.

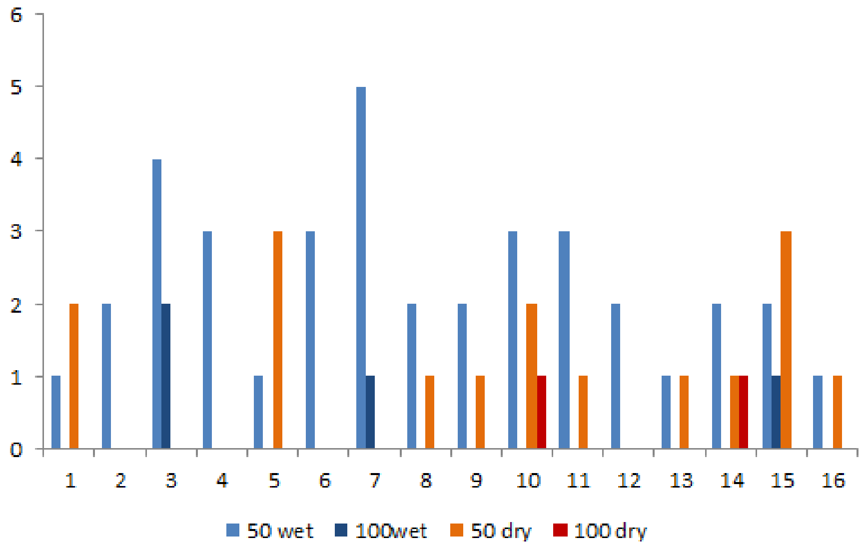


Figure 3.2. Frequency of Anomalies in monthly average rainfall for each cluster. Blues are anomalies that happened during the rainy season while red-orange are those that happened during the dry season.

Increase in sea level will have the most significant effect on mangroves. The main effect is on the establishment of seedlings whose leaves need to be above water surface during daytime for efficient photosynthesis. Site biodiversity may also change with sea level rise favoring faster growing species.

Monthly average sea surface height was calculated from daily mean absolute dynamic topography. The data trend was then calculated over the years 1993-2010 (Figure 3.3). The analysis shows that the entire region experiencing increase in sea level at rates at or above the global average of 3.1 cm/decade. Clusters facing the Pacific (1, 13, 15 and 16) have been experiencing the highest rate of sea level rise at rates double that of global average. The slowest rate of increase is experienced by clusters on the western side (3, 6, 7, 8, and 12).

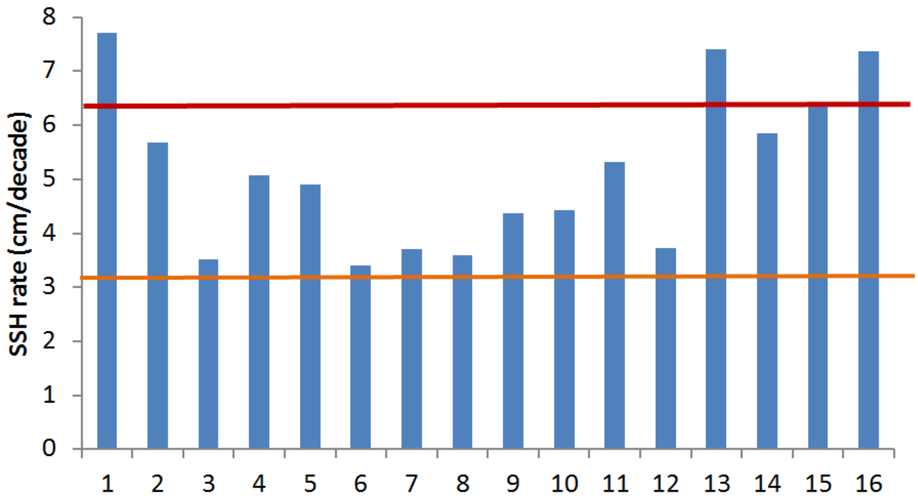


Figure 3.3 Rate of sea-level rise per cluster. Orange line depicts the global average. Color red depicts twice the global average.

Combining the climate/ocean exposures, the highest exposure is seen for clusters 1, 3 and 7. Cluster 1 for temperature anomalies and sea level rise. Cluster 3 and 7 specifically for temperature and extreme anomalies in rainfall. The ranking and potential impacts are shown below (Table 3.2).

Table 3.2 Ranking of clusters based on intensity of exposure. The potential impact of these exposure on food security and coastal integrity are also highlighted

Cluster	Exposure	Possible Impact
I	SSTex, SSH, (SSTlong)	Coral, Mangrove, Landloss & Submergence, (Spawning & Distribution)
III	SSTlong, Rain, (SSH)	Coral, Seagrass, Spawning & Distribution, (Mangrove, Landloss & Submergence)
VII	SSTex, Rain, (SSTlong)	Coral, Seagrass, (Spawning & Distribution)
II	SSTex, SSTlong, (SSH)	Coral, Spawning & Distribution, (Mangrove, Landloss & Submergence)
X	SSTex, Rain, (SSH)	Coral, Seagrass, (Mangrove, Landloss & Submergence)
V	SSTlong, Rain, SSH	Coral, Seagrass, Mangrove, Spawning & Distribution, Landloss & Submergence
XVI	SSH, (SSTlong, SSTex)	Mangrove, Landloss & Submergence, (Spawning & Distribution, Coral)
XV	Rain, SSH	Coral, Seagrass, Mangrove, Landloss & Submergence
IV	SSTlong, SSH	Mangrove, Spawning & Distribution, Landloss & Submergence
VIII	SSTlong, SSTex	Coral, Spawning & Distribution
XII	SSTlong	Spawning & Distribution
VI	SSTlong, SSTex	Coral, Spawning & Distribution
IX	SSTex, SSH	Coral, Mangrove, Landloss & Submergence
XI	Rain, SSH	Coral, Seagrass, Mangrove, Landloss & Submergence
XIV	Rain, SSH	Coral, Seagrass, Mangrove, Landloss & Submergence
XIII	SSH	Mangrove, Landloss & Submergence

Identifying sites of natural/societal sensitivity

A significant amount of daily protein intake comes from food fish especially in the coastal areas of SE Asia. Food fish comes from both open water and coastal resources. For the latter, various studies have shown that the healthier the coastal habitat, the more productive it is. As proxy to the location of these healthy coastal habitats, we look into the location of marine protected areas (Figure 3.4).

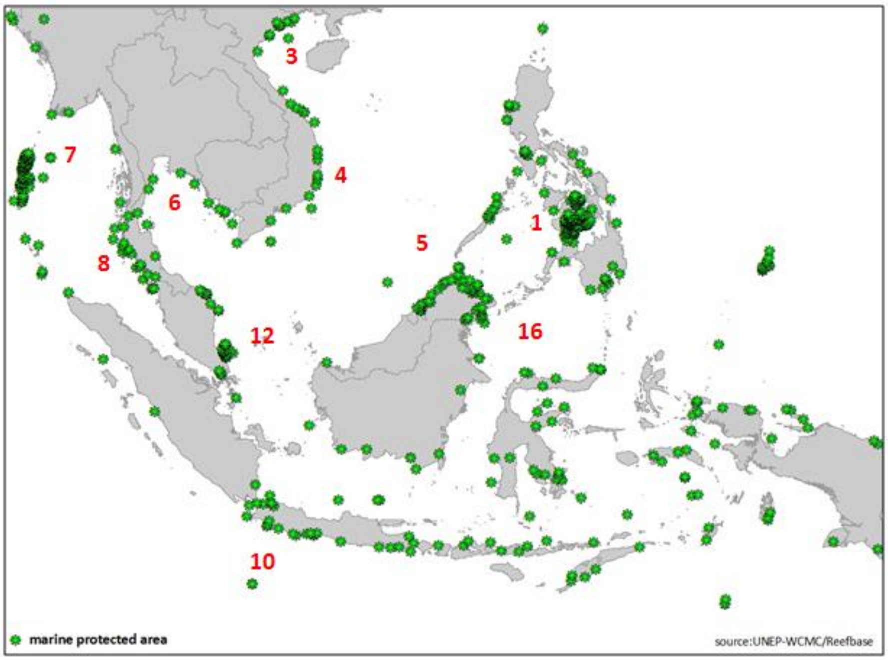


Figure 3.4 Marine protected areas of SE Asia are depicted in green. Numbers highlight clusters that have a high abundance of MPAs

The locations above highlight potential food source while a map of population maps the existing food demand (Figure 3.5).

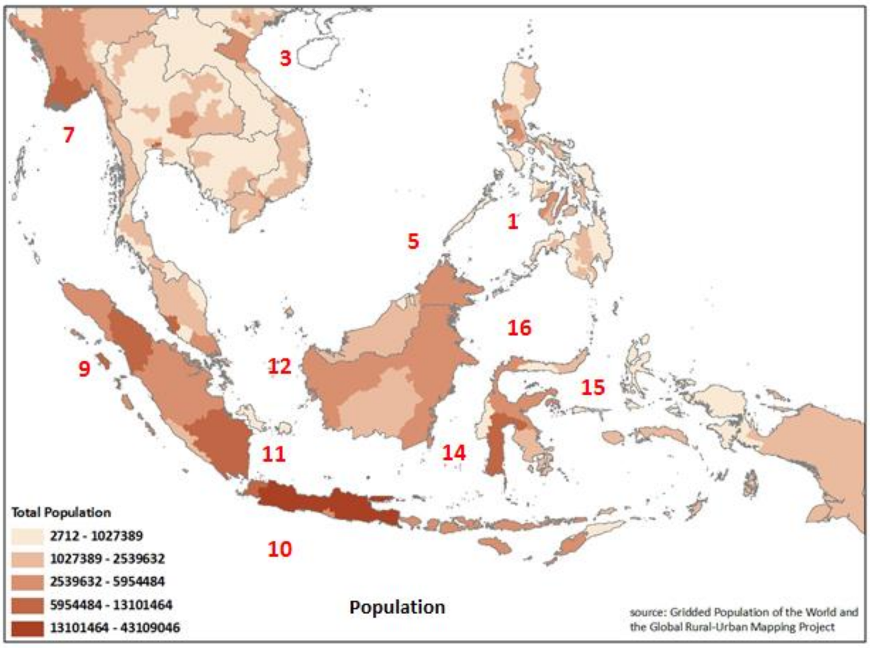


Figure 3.5 Population statistics of each sub-unit of governance in SE Asia. Numbers highlight clusters that have a high population

The most vulnerable clusters are those that are experiencing high exposure, high natural sensitivity and high food demand. Combining the results of table 3.2 and figures 3.4 and 3.5 show that clusters 1, 3, 5, 7, 10, 12 and 16 are the most vulnerable when it comes to food security. These are the areas of Gulf of Tonkin, northern VietNam; the Gulf of Martaban in the southern part of Myanmar; Banten and West Java of Indonesia; Johor Bahru, Malaysia and Singapore; Sabah. East Malaysia; and the highly populated areas of the Philippines – Pangasinan, Manila, West Negros, Cebu, and Davao.

Locations of healthy coastal habitats are often also sites of tourism - a significant economic activity in SE Asia. Figure 3.6 shows the location of coastal resorts and hotels. Combining this with figure 3.4 and the potential temperature and rainfall impact in table 3.2 show that clusters 1, 3, 5, 10 and 16 are the most vulnerable when it comes to eco-tourism sustainability. These are north VietNam, Java of Indonesia, Sabah of Malaysia, and the Philippine seas.

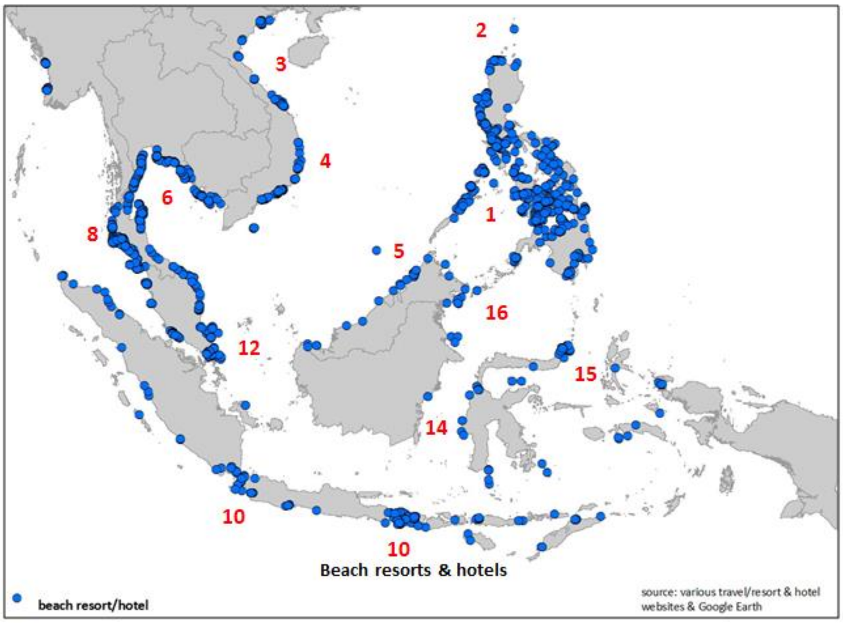


Figure 3.6 Locations of tourism establishments in SE Asia.
Numbers highlight clusters that have a high abundance of resorts and hotels

Transport infrastructures support the economic activities of fisheries and tourism. Seaports and airport located along the coast are sensitive to sea level rise but these coastal structures can also potentially exacerbate the sensitivity of the coast to erosion by blocking the natural transport of sediments along the coast. Shown below are the locations of seaports and airports around SE Asia (Figure 3.7).

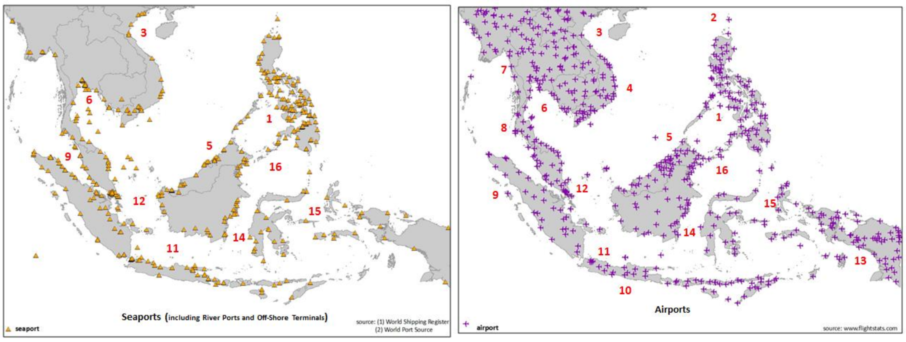


Figure 3.7 Seaports (left) and airport (right) of SE Asia.
Numbers highlight clusters that have a high abundance of seaports and airports

An overlay of MPAs, resorts, seaports and airports is seen in figure 3.8. Combining this with the sea level impact in table 3.2 show that clusters 1, 2, 4, 5, 11, 15, 16 have the most vulnerable coastal industries (tourism and transportation) in terms of landloss and submergence. These are the coasts around Central and South VietNam, most of the coasts of the Philippines, Sumbawa & Flores of Indonesia, the Indonesian islands surrounding the seas of Molucca, Halmahera, & Ceram, and Sabah of Malaysia.

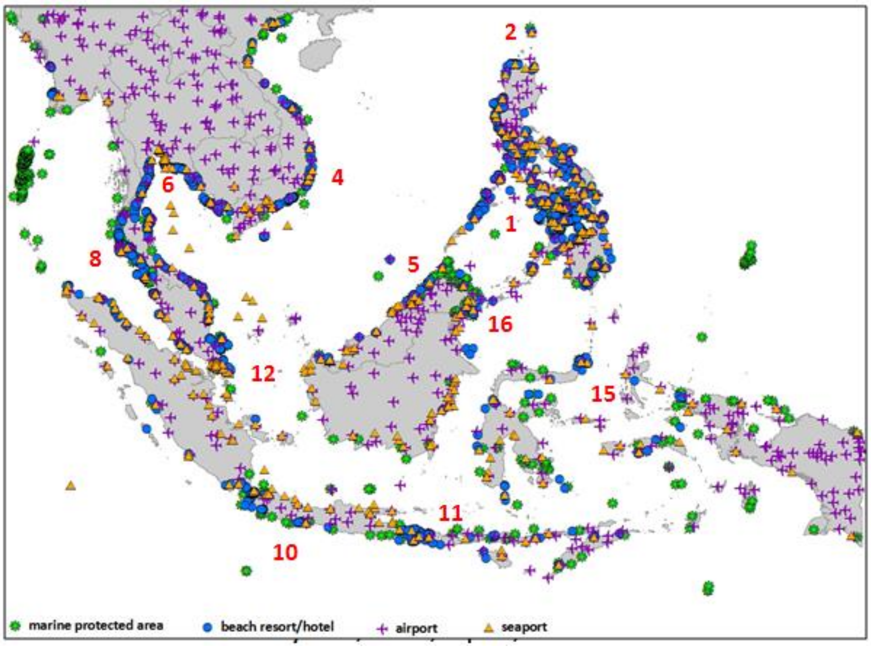


Figure 3.8 Overlay of MPAs, coastal tourism establishments and transportation infrastructure. Numbers highlight clusters with high incidence of overlap.

Beyond the industries, the populace itself is also vulnerable to flooding due to sea level rise. Shown below is the summary of total population that will be vulnerable to a 2m sea level rise scenario (Figure 3.9).

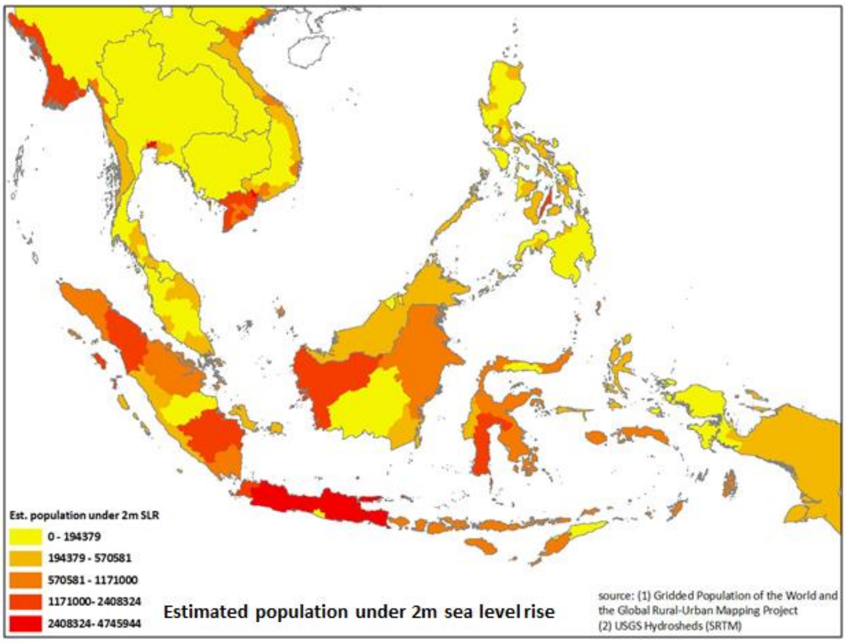


Figure 3.9 Result of overlaying a projected 2m sea level rise onto the coastal population.

Results of these landloss and submergence analyses shown above are comparable to the results of DIVA simulations of the previous project when it comes to VietNam, Singapore, Indonesia, and partially for the Philippines. The results for Malaysia are the only one different.

Vietnam with a high coastal floodplain population is expected to experience a relatively high land loss due to submergence resulting in migration of about 1100 people annually 2040. 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.

DIVA showed Singapore to have a projected low land loss and 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, besides having a high coastal population, also has high coastal forest and mangrove cover. 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.

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. However, DIVA showed the Philippines to fare a little better with a predicted lower total residual damage cost. On the other hand, the analyses shown in figure 3.8 highlights that most of the tourism and transport industry of the Philippines are vulnerable to sea level rise.

DIVA also showed Malaysia to have 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 only 150 people. Figures 3.3 and 3.8 however highlighted the vulnerability to sea level rise of East Malaysia in general and Sabah in particular.

2.2 Case Studies

Results of the global dataset analysis and DIVA simulations are used for the country-wide assessments. The modified CIVAT/TURF approach assesses the coastal area vulnerability using intrinsic and extrinsic sensitivities.

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).

Fish is the most important source of animal protein contributing 40 percent to the total animal protein intake (MOFI, 2007). Home consumption of fish is estimated at more than 19 kg per year (FAO/MOFI, 2003). 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.

Fisheries is also an important economic activity. Viet Nam is ranked third for aquaculture and eleventh for fish exploitation in the world (FAO, 2004) and currently has 850 thousand fishers.

The GIS analysis showed the coastal habitats of northern part of VietNam experiencing high rates of sea temperature increase and anomalous rainfall. This makes the fisheries of the provinces of Quang Ninh and Hai Phong most vulnerable. Data from VietNam shows a potential consequence to at least 100 million USD fisheries export.

Table 3.3 Data used to assess intrinsic sensitivity of VietNam subdivided into 9 provinces.

INTRINSIC SENSITIVITY	Quang Ninh	Hai Phong	Quang Nam	Da Nang	Hue	Khanh Hoa	Ninh Thuan	a Ria Vung Ta	Kien Giang
Habitat Cover									
Coral reef (ha) (Vietnam coral reefs area: 1222 km2)	120		175	105		215	1070	1000	480
Seagrass (ha) (Vietnam seagrass area: 17675 ha)	150	780	500	10	100	32	40	200	10062
Mangrove (ha) (mangrove cover in Vietnam: 323712 ha)	21,702	4,742	18	13	10	33	9	300	3,847
Fisheries									
Import									
Export (million USD) 7 billion USD	100				16	325		200	175
Socio-Economic									
Coastal Population (in '000 for 2012) population of the provinces	1,177.00	1904	1450	973	1,115.00	1183	577	1039	1726
Fishers (850000 fishers in 2011)									
Price of pelagic fish (USD/per kg)	5	5	5	5	5	5	5	5	5
Price of demersal fish (per kg)	3	3	2.8	3	3	3	3	3	3
Average catch (kg) (Tonnes/year -2012)	56790	47853	62797	32848	45724	80160	63685	272987	339001
Average income for village (in USD)			615			765			

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. Reducing the pressure on coastal fisheries has been shown to have positive impact on recovery of coral reefs exposed to increase in temperature.

- Decision 393 was further supported by the Law on Environment Protection and the Master Plan for Development of the fishery sector by 2010.

- 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 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:

- 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 addition to all these efforts, another activity that will mitigate the impact of climate change to fisheries is planting dense vegetation on the watersheds and the coastal area. These will lessen the sedimentation during anomalous rain events. For Quang Ninh and Hai Phong in particular, the extensive mangrove cover is an advantage.

Other industries that might be vulnerable are those located in Kien Giang and the coastal part of Hai Phong as these areas have very low topography. Therefore, any activity that can further exacerbate this such as sand mining, coral mining, and building of solid ports should be terminated (Table 3.4).

Table 3.4 Data used to analyze extrinsic sensitivity of VietNam

EXTRINSIC SENSITIVITY	Quang Ninh	Hai Phong	Quang Nam	Da Nang	Hue	Khanh Hoa	Ninh Thuan	a Ria Vung Ta	Kien Giang
Presence of seawalls	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Presence of solid ports	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Presence of dams	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mining:									
Sand mining (river/inland mining with EIA approval)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Oil mining (Petroleum)	no	no	no	no	no	no	no	Yes	no
Coral mining	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Unregulared/underreported fisheries									
Fisheries subsidy:									
Fuel	no	no	no	no	no	no	No	no	no
Ports	no	no	no	no	no	no	No	no	no
Storage	no	no	no	no	no	no	No	no	no
Ice plants	no	no	no	no	no	no	No	no	no
Efficient fishery technology									

<u>Singapore</u>

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. Much of the modern Singapore coastline is reclaimed. The original coastline measured 106km but is now quoted at 193km (Figure 3.10). These additional lands have been turned mostly into residential areas and key industrial sites (i.e. Shipping ports, Airport, Petro-chemical / Biomedical) (Figure 3.11). 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.

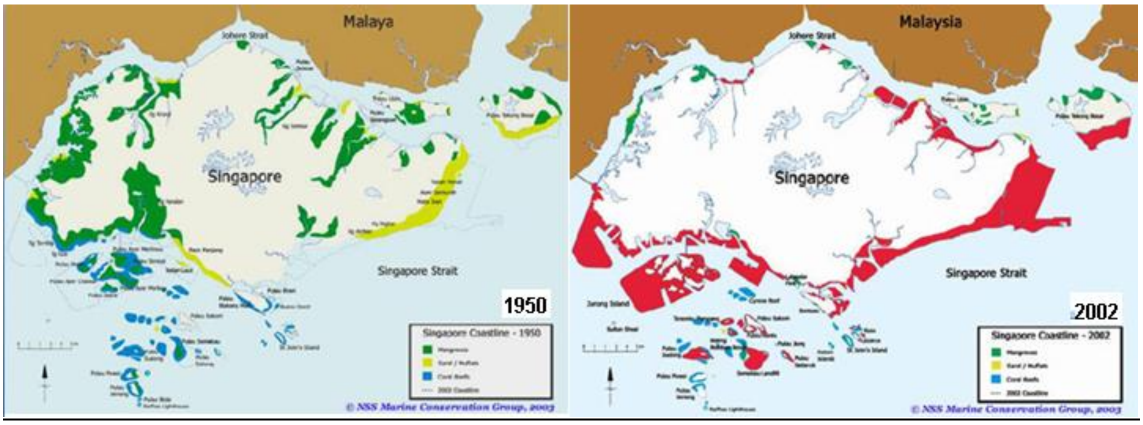


Figure 3.10 Singapore before (left) and after (right) reclamation [RED]

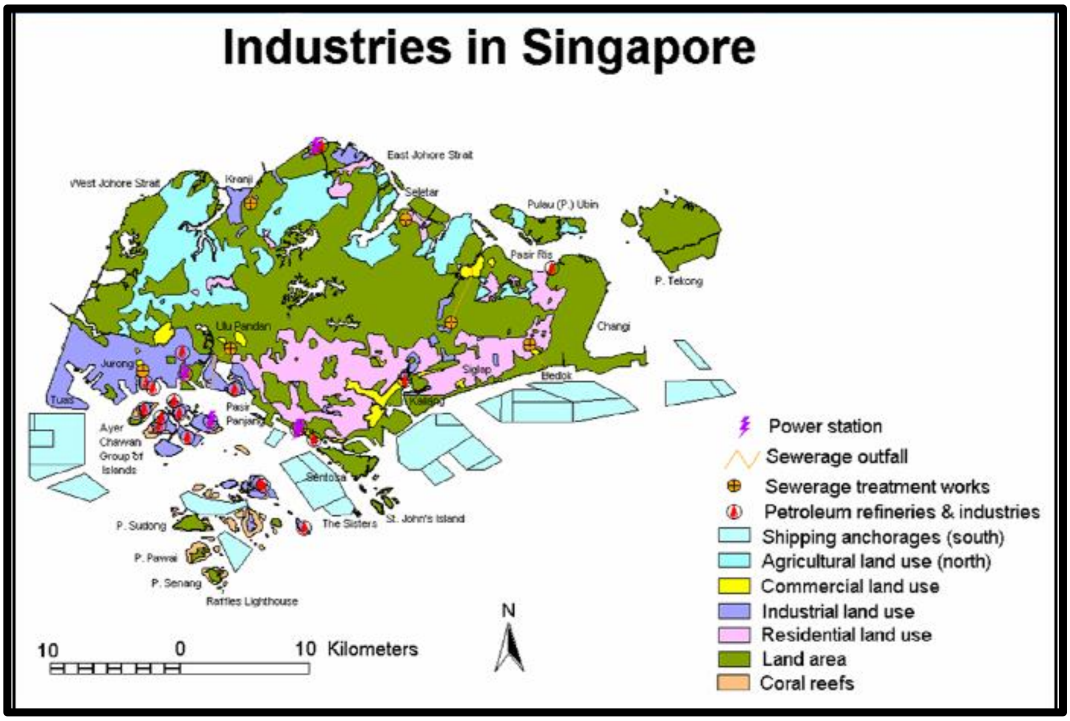


Figure 3.11 Map of Singapore highlighting location of major industries

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.

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. There is also an extensive seawall infrastructure throughout Singapore's coastline.

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 reforestation 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.

Aside from these endeavors, Singapore is exploring management of their remaining coastal habitats. Though not directly used as the local food fish resource, the remaining coastal habitats nevertheless harbors high biodiversity.

Table 3.5 Data used to analyze intrinsic and extrinsic sensitivity of VietNam

INTRINSIC SENSITIVITY	Singapore
Habitat Cover	
Coral reef	9.51 km^2
Seagrass	0.337 km^2
Mangrove	6.44 km^2
Mudflats	7.63 km^2
Fisheries	
Import	Import over 90% of fish
Export	None
Socio-Economic	
Coastal Population	Singapore's population (2012): 5.312 mil
Fishers	
Price of pelagic fish (per kg)	
Price of demersal fish (per kg)	
Average catch (kg)	
Average income for village	

EXTRINSIC SENSITIVITY	
Presence of seawalls	Extensive
Presence of solid ports	Extensive
Presence of dams	One (Marina Barrage)
Mining:	
Sand mining	None
Oil mining	None
Coral mining	None
Unregulared/underreported fisheries	None
Fisheries subsidy:	None?
Fuel	
Ports	
Storage	
Ice plants	
Efficient fishery technology	

The vulnerability of Singapore's food security lies beyond its borders with more than 90% of its fish consumption imported from elsewhere. Future access to food fish might be compromised as supplies from neighboring countries get affected by climate change.

A summary of other vulnerable human activities in Singapore (north and south coasts) is shown in figure 3.12.

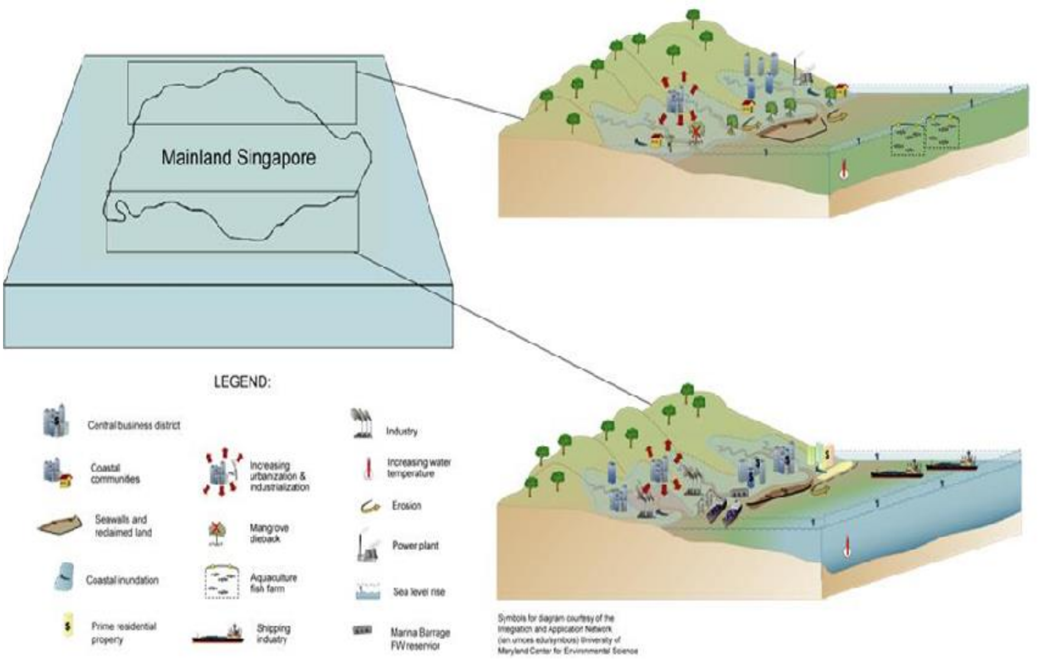


Figure 3.12 Singapore industries and human activities identified to be vulnerable to climate change.

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 3.13). This is comparable to global observations. Similar to the analyses shown in figure 3.5, 3.8 and 3.9, 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.

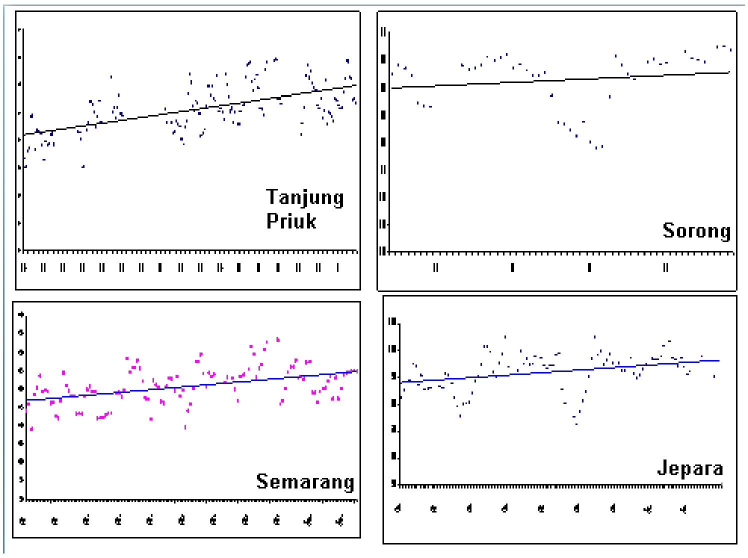


Figure 3.13 Sea level data for 4 sites in Indonesia: 20 year data for Tanjung Priuk and 10 year data for Sorong, Semarang and Jepara. The average increase in sea level is 1cm/decade

Within Java Island, the vulnerability of West Java and East Java were underscored in the analysis shown in figure 3.6 and 3.8. Aside from the high population (Table 3.8b), both these areas are also dense centers for tourism related activities. So even though exposure studies show that cluster 10, to which Java belongs, is experiencing sea level rise at a moderate rate compared to its neighbors, the dense population and dense coastal industry makes this island a highly vulnerable site.

Other human activities, further exacerbate this vulnerability. To underscore this further we present the 2 cases for West Java -Jakarta in the north and Segara Anakan in the south.

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 3.14). 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 3.15). Flooding during the monsoons 0.1-1.7m is another exacerbating perennial problem for Jakarta (Figure 3.16).

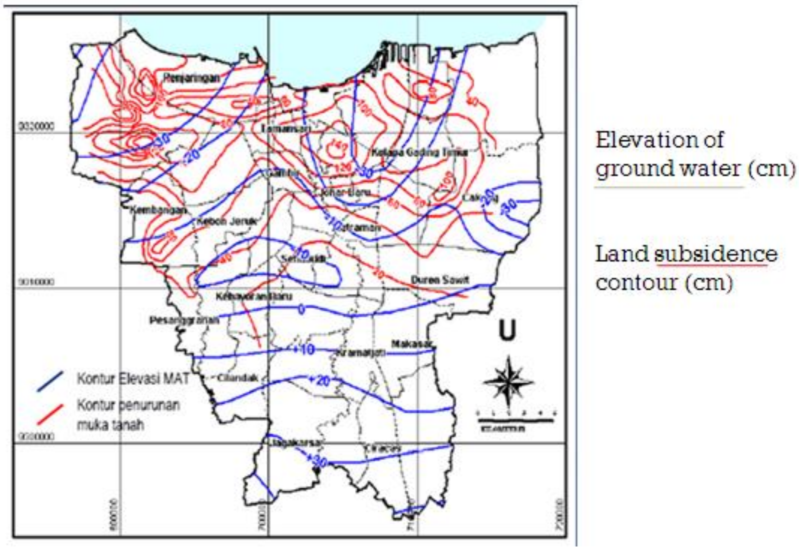


Figure 3.14 Groundwater extraction in Jakarta and the resulting land subsidence

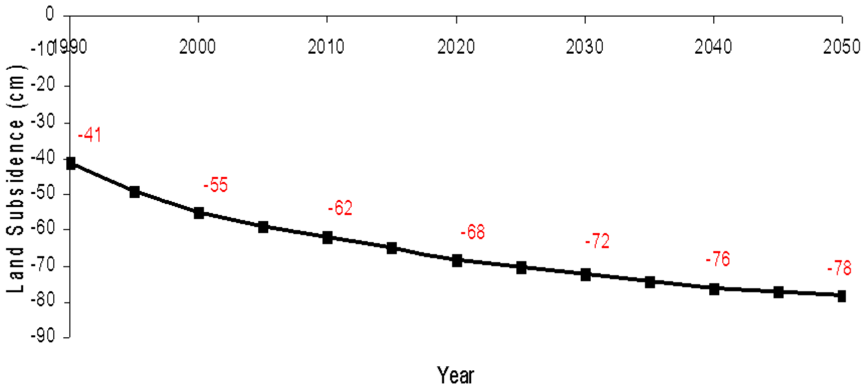


Figure 3.15 Projected land subsidence in the vicinity of Jakarta (Priyambodo, 2005)

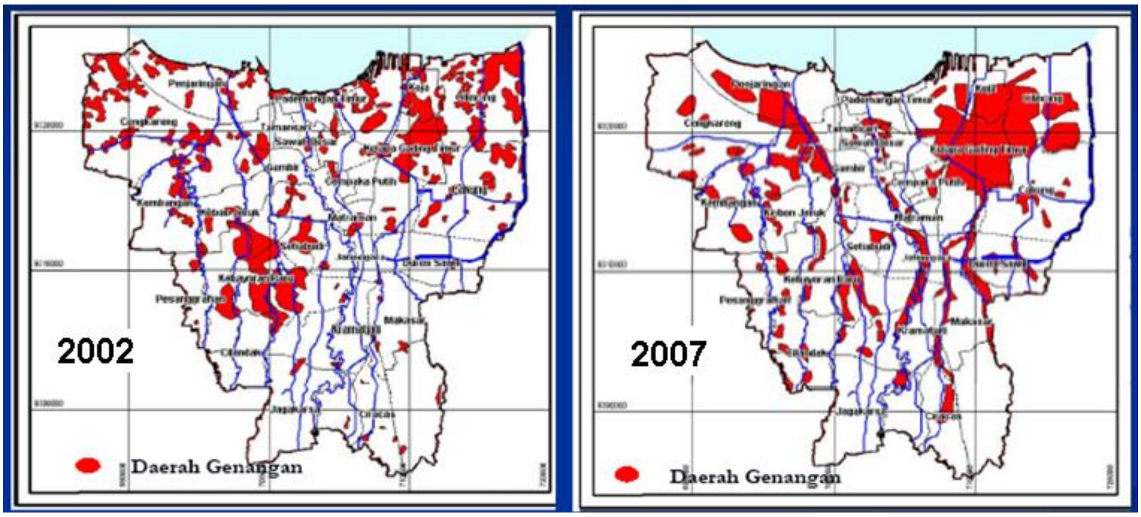


Figure 3.16 Inundation area of Jakarta Floodingin 2002 and 2007 highlighted in RED.

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 3.6).

Table 3.6 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 3.17).

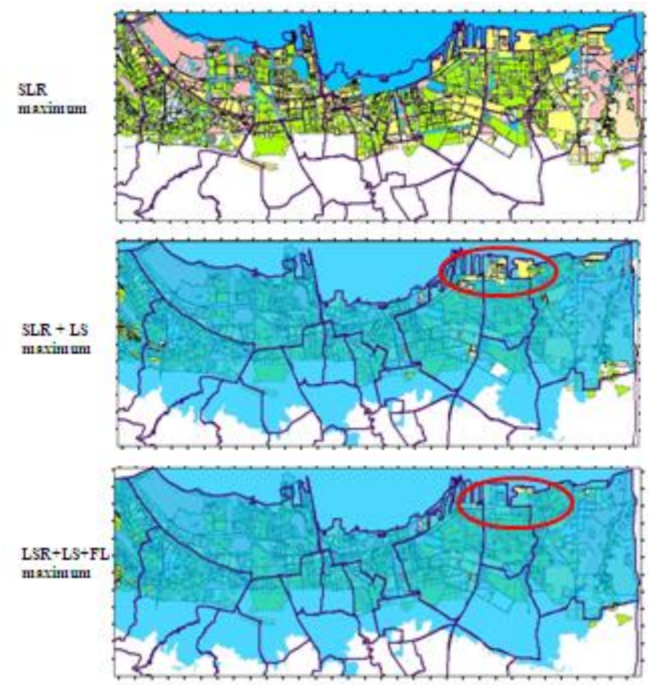


Figure 3.17 Simulation of plausible inundation of Jakarta by 2050 highlighted in light blue. Encircled in RED and highlighted in yellow is what is projected to stay high and dry.

Economic valuation of this projected inundation was done using Frankhausser's assumption (1994) of a value of dryland at 2million USD/km^2 and wetland at 5million USD/km^2. The projected economic losses are summarized in Table 3.7

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.

Table 3.7 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

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 3.18).

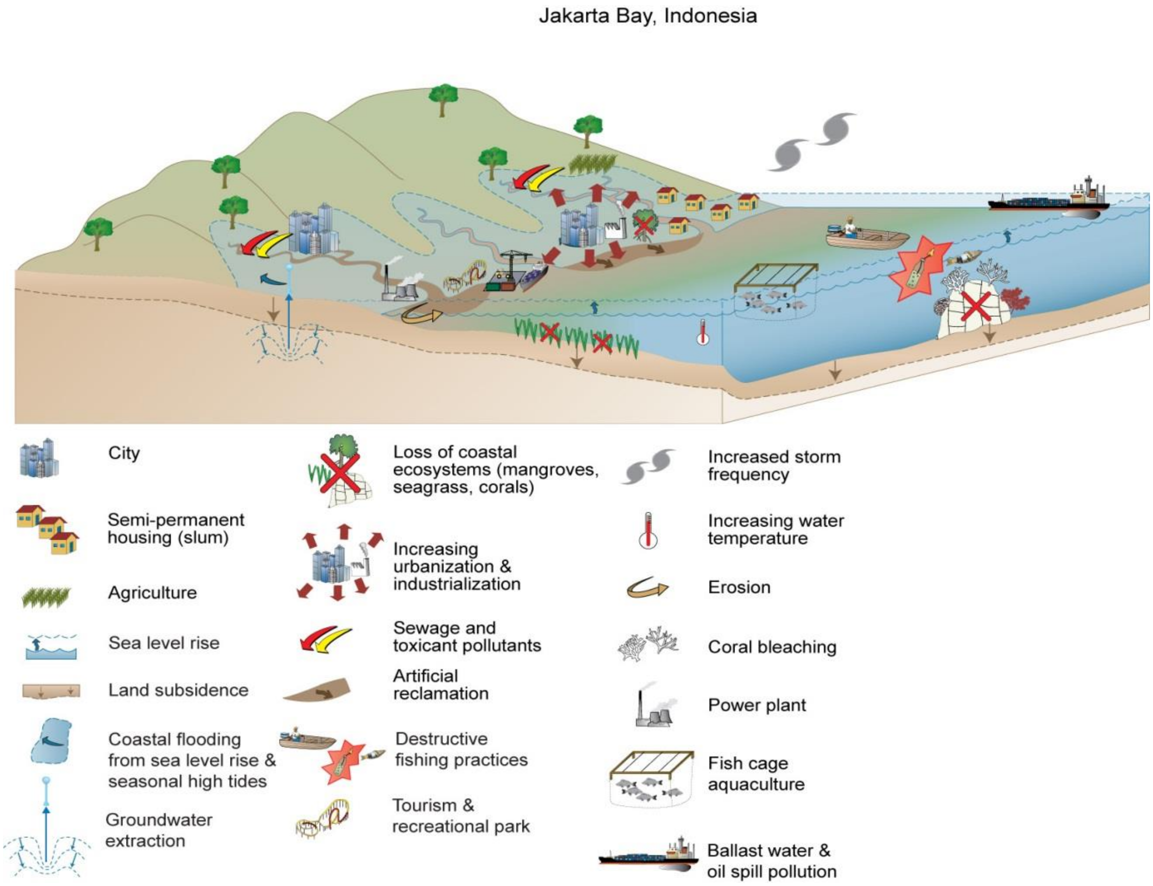


Figure 3.18 Schematic diagram of the issues existing and foreseen for the coast of Jakarta, Indonesia

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 3.19). 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).

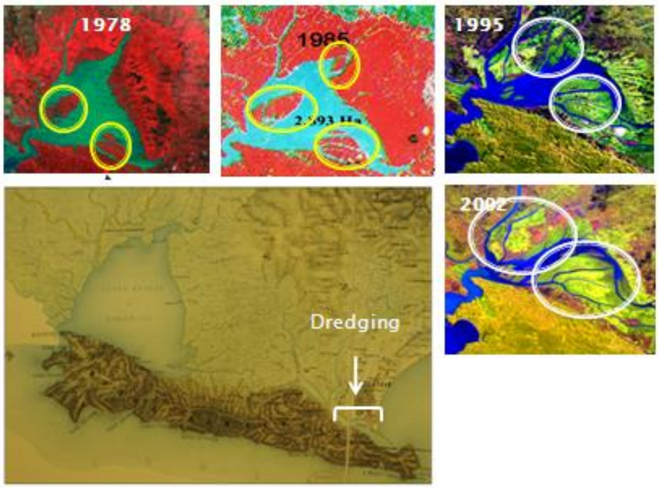


Figure 3.16 Progression of siltation in Segara Anakan Lagoon. Circles depict areas of most significant changes.

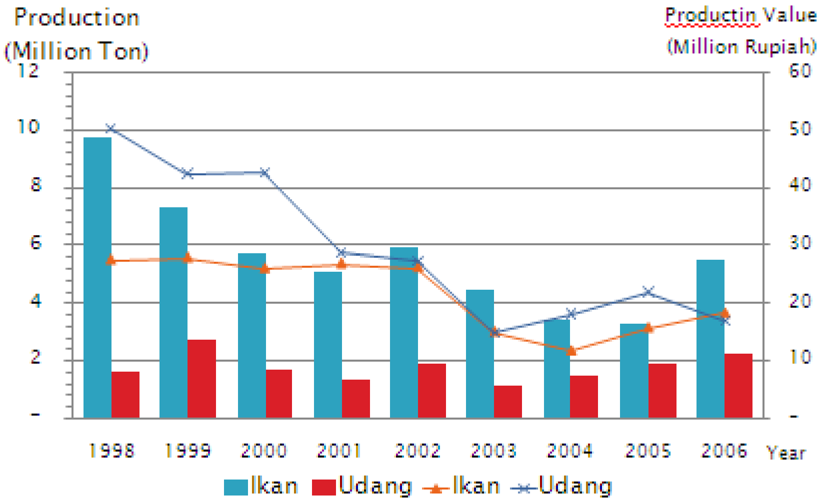


Figure 3.17 Fish (blue) and shrimp (red) production changes in Segara Anakan Lagoon

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.

Other parts of Indonesia are actually already experiencing a higher rate of sea level rise than Java. This makes the high coastal population of North Sumatra, South Sumatra, and Lampung also vulnerable to flooding (Figure 3.5 & 3.9; Table 3.8a). However, there is a discrepancy between the GIS analysis (Figure 3.9) and the country data in Table 3.8b. In the GIS analysis South Sulawesi shows a high population being vulnerable to sea level rise while in the country data it is Central Sulawesi that has a higher coastal population.

The concern for sea level rise is further exacerbated by human activities that causes the land to subside (such as groundwater extraction in Jakarta) or hampers coastal sediment deposition. We see in Table 3.8 a,b,c that all provinces have solid ports. These structures trap sand/sediment on one side, allowing the lee side of the longshore drift to slowly erode due to lack of sand/sediment resource. A port-on-stilts that will allow the currents to pass through underneath will allow continuous sand/sediment deposition along the entire coast.

Table 3.8a Data for west Indonesia

INTRINSIC SENSITIVITY	Aceh	North Sumatera	West Sumatera	Riau	Jambi	South Sumatera	Bengkulu	Lampung	Kep. Bangka Belitung	Kepulauan Riau	DKI Jakarta
Habitat Cover											
Coral reef (coral reef cover in ha in 2012)	No info.	2,533	735	No info.	No info.	No info.	No info.	No info.	No info.	33,437	No info.
Seagrass (no data avialable by state)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Mangrove (mangrove cover in ha in 2012)	60,766	22,355	8,073	37,914	231	597,422	1,327	4,403	31,701	64,821	2,127
Fisheries											
Import (tonnes in 2010)	0	46,913	0	1,290	4,427	0	0	12,142	0	5,637	200,511
Export (tonnes in 2010)	227	68,385	140	8,711	195	2,185	0	26,513	4,618	28,565	210,165
Socio-Economic											
Coastal Population (province population in 2010)	5,201,002	12,450,911	4,566,126	4,579,219	2,635,968	6,782,339	1,549,273	7,116,177	1,043,456	1,274,848	8,860,381
Fishers (No. of fishers in 2010)	73,440	180,809	43,872	59,919	25,375	102,881	20,066	45,369	71,850	98,521	40,479
Price of pelagic fish (per kg)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Price of demersal fish (per kg)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Average catch (kg) (Tonnes/year in 2010)	127,913	365,928	202,599	89,293	50,949	93,151	45,062	150,849	159,421	196,633	172,422
Average production income (in Rupiah for 2010)	1,882,452,743	5,807,259,036	3,087,682,019	1,305,082,700	738,082,901	972,077,399	881,854,280	3,196,995,202	2,400,721,295	1,321,004,500	3,137,027,508
Average production income per fisher (in USD for 2010)	3	3	8	2	3	1	5	8	4	1	8
EXTRINSIC SENSITIVITY											
Presence of seawalls	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Presence of solid ports	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Presence of dams	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Mining:											
Sand mining (river/inland mining with EIA approval)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Oil mining (Petroleum)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Coral mining	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Unregulared/underreported fisheries	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Fisheries subsidy:											
Fuel	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Ports (no of fish landings)	131	41	28	19	5	12	44	30	23	27	6
Storage	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Ice plants	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Efficient fishery technology	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.

Table 3.8b Data for central Indonesia. Highlighted are the high population centers of Java

INTRINSIC SENSITIVITY	West Java	Central Java	DI Yogyakarta	East Java	Banten	Bali	West Nusa Tenggara	East Nusa Tenggara	West Kalimantan	Central Kalimantan	South Kalimantan	East Kalimantan'
Habitat Cover												
Coral reef (coral reef cover in ha in 2012)	No info.	No info.	No info.	No info.	No info.	No info.		3,412	No info.	No info.	No info.	No info.
Seagrass (no data avialable by state)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Mangrove (mangrove cover in ha in 2012)	17,217	133,967	0	77,093	10,202	2,215	13,924	10,800	128,032	63,599	135,181	649,709
Fisheries												
Import (tonnes in 2010)	0	6,307	0	343,039	0	2,148	0	0	3,576	0	0	0
Export (tonnes in 2010)	68	21,025	1	85,612	0	16,576	10	244	1,036	33	322	11,864
Socio-Economic												
Coastal Population (province population in 2010)	38,965,440	31,977,968	3,343,651	36,294,280	9,028,816	3,383,572	4,184,411	4,260,294	4,052,345	1,914,900	3,446,631	2,848,798
Fishers (No. of fishers in 2010)	123,027	144,089	4,840	281,046	32,704	60,844	71,913	67,259	66,682	67,857	109,130	167,375
Price of pelagic fish (per kg)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Price of demersal fish (per kg)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Average catch (kg) (Tonnes/year in 2010)	190,790	231,119	5,101	352,779	60,219	105,567	115,164	90,185	95,921	92,280	178,023	159,709
Average production income (in Rupiah for 2010)	2,219,991,659	1,378,363,308	38,321,835	4,182,723,001	721,235,945	1,004,807,659	1,546,119,883	422,023,313	1,183,996,466	1,559,083,200	3,051,214,170	2,787,430,974
Average production income per fisher (in USD for 2010)	2	1	1	2	2	2	2	1	2	2	3	2

EXTRINSIC SENSITIVITY												
Presence of seawalls	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Presence of solid ports	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Presence of dams	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Mining:												
Sand mining (river/inland mining with EIA approval)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Oil mining (Petroleum)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Coral mining	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Unregulared/underreported fisheries	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Fisheries subsidy:												
Fuel	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Ports (no of fish landings)	100	94	19	115	39	10	35	34	63	14	9	18
Storage	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Ice plants	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Efficient fishery technology	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.

Table 3.8c Data for east Indonesia

INTRINSIC SENSITIVITY	North Sulawesi	South Sulawesi	Central Sulawesi	Southeast Sulawesi	Gorontalo	West Sulawesi	Maluku	North Maluku	Papua	West Papua
Habitat Cover										
Coral reef (coral reef cover in ha in 2012)	No info.	65,366	43,859	No info.	No info.	No info.	No info.	No info.	4,637	30,496
Seagrass (no data avialable by state)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Mangrove (mangrove cover in ha in 2012)	11,546	59,551	181,459	45,332	22,370	1,507	92,170	45,259	415,720	431,257
Fisheries										
Import (tonnes in 2010)	129	92	0	0	0	0	500	0	0	0
Export (tonnes in 2010)	18,820	67,677	511	139	0	0	135,222	94	94,649	42,541
Socio-Economic										
Coastal Population (province population in 2010)	2,128,780	2,294,841	7,509,704	1,963,025	922,176	969,426	1,251,539	1,035,478	2,851,999	760,855
Fishers (No. of fishers in 2010)	83,782	146,966	80,936	80,763	25,037	38,201	78,288	11,719	76,022	39,216
Price of pelagic fish (per kg)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Price of demersal fish (per kg)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Average catch (kg) (Tonnes/year in 2010)	222,256	223,258	141,347	227,238	73,095	71,178	559,049	148,028	271,048	116,844
Average production income (in Rupiah for 2010)	1,380,643,404	2,277,650,805	1,141,345,561	2,279,238,219	752,007,850	505,838,040	2,899,231,791	1,164,808,340	6,063,141,350	1,259,944,921
Average production income per fisher (in USD for 2010)	2	2	2	3	3	1	4	11	9	3
EXTRINSIC SENSITIVITY										
Presence of seawalls	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Presence of solid ports	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Presence of dams	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Mining:										
Sand mining (river/inland mining with EIA approval)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Oil mining (Petroleum)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Coral mining	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Unregulared/underreported fisheries	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Fisheries subsidy:										
Fuel	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Ports (no of fish landings)	41	65	46	37	24	13	34	22	23	22
Storage	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Ice plants	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Efficient fishery technology	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.

As for livelihood, we see that the high number of fishers live in Java, as well as, in South Sumatra, South and East Kalimantan and South Sulawesi. From Table 3.2, we see that except for Java, the climate/ocean exposure being experienced by these sites are sea level rise and anomalous rainfall. SLR can affect mangrove related fisheries while anomalous rainfall (Table 3.2) is potentially detrimental to the productivity of seagrass and coral related fisheries. Mangrove deterioration can be mitigated if there is space for the mangroves to progress landwards as the sea level rises. The deleterious sedimentation from anomalous rainfall can be mitigated by dense vegetation on the watershed and along the coasts. The significant mangrove cover for South Sumatra, Central Java, and South and East Kalimantan is beneficial for the fishers. South Sulawesi will need to make efforts to expand their mangrove area as well. IEC on these adaptation measures 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.

Finally, similar to Singapore, Jakarta and East Java's food security is tenuous with significant food fish being imported into the area.

<u>The Philippines</u>

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. Approximately 482,500 fishermen reside and carve their livelihood in these coastal areas. Globally it has been rated as one of the top 9 countries to be vulnerable to climate change due to extreme exposure (SST, rainfall, SLR) and high concentrations of people living at and dependent on the coast (WRI, 2010). This observation is particularly evident in terms of temperature for Cagayan Valley at the northern tip of the Philippines (cluster 2) as seen from figures 3.1; table 3.1. and may affect the productivity of the pelagic fisheries of this area. The wide-spread temperature anomalies (Table 3.1) for most of the Philippine waters also raises concern for coral-related fisheries.

High SLR is observed for the entire Philippines (Figure 3.3) and in particular in ARMM at the southern end of the Philippines (cluster 16) making landloss, submergence and mangrove decimation a concern. Human activities that further exacerbate this vulnerability include sand mining, building of solid ports, and inappropriate seawalls (Table 3.9a&b). In light of the SLR scenario these activities should cease.

Anomalous rainfall (Figure 3.2) is most significant for west MIMAROPA (cluster 5), in the western side of the Philippines and is a concern for coral and seagrass related fisheries. Combined with the high SLR, this is a concern since coral, seagrass and mangrove related fisheries make up the majority of Philippine capture fisheries (Table 3.9a&b). Moreover, consequential coral bleaching, drowning of mangroves and siltation of seagrasses will have deleterious effect on nursery grounds and habitat of economically important food fish.

The food fish is both for local consumption (30kg/capita) and for export contributing significantly in the GDP.

Table 3.9a Data for northern Philippine regions

INTRINSIC SENSITIVITY	Ilocos	CAR Mountain region	Cagayan Valley	Central Luzon	NCR	CALABARZON	MIMAROPA	Bicol Region
Habitat Cover								
Coral reef (ha) (27,000 sq. km. total)	no info		no info	206	no info	no info	68.38	1918.23
Seagrass (ha)	no info		no info	no info	no info	no info	no info	no info
Mangrove (ha)	no info		no info	no info	no info	no info	52, 693	no info
Fisheries								
Import USD217M								
Export (million USD) USD871M								
Socio-Economic								
Coastal Population (in '000 for 2012) population of the pro	2,900,761.6		1,883,041.6	5,695,030.0	6,432,151.0	6,684,312.8	1,703,145.4	3,202,808.4
Fishers (measured in terms of registered boats)	18,111.0		5,406.0	25,989.0	unknown	130,074.0		105,786.0
Value of pelagic fisheries	256,041.8		1,094,538.1	290,772.5	4,451,168.7	5,498,447.8	1,900,070.0	3,191,283.7
Volume of pelagic fisheries	3,556.5		16,049.9	4,549.0	70,684.6	73,103.1	44,079.5	68,972.7
Price of pelagic fish (USD/per kg)	1.6		1.5	1.4	1.4	1.7	1.0	1.0
Value of demersal fisheries	3,070,695.1		1,600,036.4	2,168,053.0	609,039.4	3,166,187.2	9,374,486.7	8,373,417.7
Volume of demersal fisheries	39,146.3		34,752.5	42,047.1	6,621.0	124,549.2	196,042.3	143,711.9
Price of demersal fish (USD/per kg)	1.7		1.0	1.1	2.0	0.6	1.1	1.3
Total catch	42,702.8		50,802.4	46,596.0	77,305.6	197,652.3	240,121.8	212,684.6
Average catch (kg) Municipal	2.2		6.4	1.6	0.2	2.5	2.5	1.4
Average income (in USD) (1.50-3.50 USD/day)	no info		no info	no info	no info	no info	no info	no info
EXTRINSIC SENSITIVITY								
Presence of seawalls	yes		yes	yes	yes	yes	yes	yes
Presence of solid ports	yes		yes	yes	yes	yes	yes	yes
Presence of dams	3		2	2	1	7	unknown	1
Mining:								
Sand mining (river/inland mining with EIA approval)	yes		yes	yes	unknown	yes	unknown	unknown
Oil mining (Petroleum)	no		no	no	no	no	yes	no
Coral mining	unknown		unknown	unknown	unknown	unknown	unknown	unknown
Unregulared/underreported fisheries	yes		yes	yes	yes	yes	yes	yes
Fisheries subsidy:								
Fuel	no		no	no	no	no	no	no
Ports	yes		yes	yes	yes	yes	yes	yes
Storage (&procesing)	41		no	56	none	no	no	115
Ice plants	unknown		unknown	unknown	unknown	unknown	unknown	unknown
Efficient fishery technology								

Table 3.9b Data for southern Philippine regions

INTRINSIC SENSITIVITY	Western Visayas	Central Visayas	Eastern Visayas	Zamboanga Peninsula	Northern Mindanao	Southern Mindana	Central Mindana	CARAGA	ARMM
Habitat Cover									
Coral reef (ha) (27,000 sq. km. total)	281	390	1653.39	no info	no info	152.05	no info	287.42	no info
Seagrass (ha)	no info	no info	no info	no info	no info	no info	no info	no info	no info
Mangrove (ha)	no info	14,156.37	9, 961.69	no info	no info	no info	no info	16,865.14	no info
Fisheries									
Import USD217M									
Export (million USD) USD871M									
Socio-Economic									
Coastal Population (in '000 for 2012) population of the pro	4,249,388.0	3,944,237.0	2,495,809.8	1,956,785.6	2,441,703.0	2,437,996.0	2,293,266.8	1,429,722.8	1,996,676.0
Fishers (measured in terms of registered boats)	76,722.0	111,126.0	125,439.0	97,110.0	19,707.0	38,151.0	24,264.0	60,243.0	36,579.0
Value of pelagic fisheries	7,167,747.0	2,385,352.8	3,995,970.3	8,948,174.3	2,360,018.3	1,115,298.3	11,747,485.1	405,405.7	3,422,672.3
Volume of pelagic fisheries	103,808.7	39,836.6	61,228.7	214,436.5	39,853.6	13,858.5	174,840.3	6,064.7	97,897.2
Price of pelagic fish (USD/per kg)	1.5	1.3	1.5	0.9	1.3	1.8	1.5	1.5	0.8
Value of demersal fisheries	11,204,594.6	3,758,064.4	7,027,520.5	6,941,822.1	2,818,221.7	1,797,901.8	1,502,580.5	4,313,608.8	4,301,869.4
Volume of demersal fisheries	167,227.7	53,010.5	98,212.0	129,037.9	43,128.3	24,260.6	47,668.6	66,600.7	115,647.9
Price of demersal fish (USD/per kg)	1.5	1.6	1.6	1.2	1.5	1.6	0.7	1.4	0.8
Total catch	271,036.4	92,847.1	159,440.7	343,474.3	82,981.9	38,119.1	222,508.9	72,665.4	213,545.1
Average catch (kg) Municipal	2.2	0.5	0.8	1.3	2.2	0.6	2.0	1.1	3.2
Average income (in USD) (1.50-3.50 USD/day)	no info	no info	no info	no info	no info	no info	no info	no info	no info
EXTRINSIC SENSITIVITY									
Presence of seawalls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Presence of solid ports	yes	yes	yes	yes	yes	yes	yes	yes	yes
Presence of dams	unknown	1	unknown	unknown	2	unknown	unknown	unknown	1
Mining:									
Sand mining (river/inland mining with EIA approval)	yes	yes	yes	yes	yes	yes	unknown	unknown	unknown
Oil mining (Petroleum)	no	no	no	no	no	no	no	no	no
Coral mining	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Unregulared/underreported fisheries	yes	yes	yes	yes	yes	yes	yes	yes	yes
Fisheries subsidy:									
Fuel	no	no	no	no	no	no	no	no	no
Ports	yes	yes	yes	yes	yes	yes	yes	yes	yes
Storage (&procesing)	8	4	33	71	none	none	none	none	none
Ice plants	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Efficient fishery technology									

This can be further exacerbated by land subsidence due to increased urbanization pressure and erosion triggered by uncontrolled agriculture in the mountain slopes. (Figure 3.18)

.

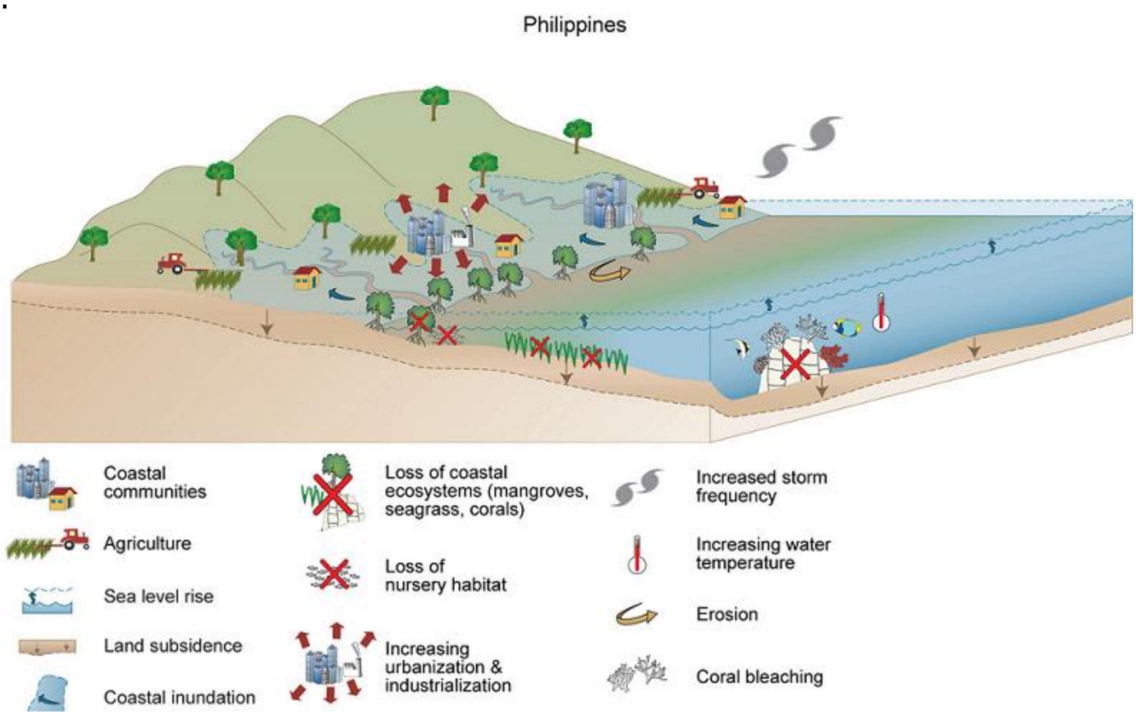
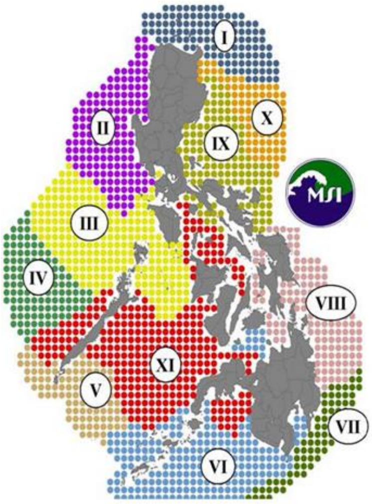


Figure 3.18 Schematic diagram of common climate-related issues in Philippine coastal areas.

The analysis however, is lacking in terms of details for the Philippine waters belonging to cluster 1. Further typology analysis of the Philippine waters generated 11 sub-clusters of varying exposure. Details of the analyses are given in Figure 3.19. Here the high exposure of sub-cluster II, III, and VII are highlighted. Of the 3 sub-cluster III (CALABARZON and MIMAROPA of Table 3.9a) has the most number of fishers.



Cluster	SST long-term	SST extreme	Precip Extreme	Precip Changes	SSH long-term
I	3	5	2	3	4
II	3	5	5	5	5
III	2	4	1	5	5
IV	3	4	1		4
V	2	2	4	3	5
VI	3	3	1	3	5
VII	5	4	3	1	5
VIII	5	4	4	3	4
IX	3	4	4	4	4
X	5	4	4	4	4
XI	3	3	1	3	5

Figure 3.19 Typology analyses of Philippine waters.
Ranking was done against global data (global data =3) and relative to each other.

In order to highlight the issues within this sub-cluster the cases of Batangas and Talim Bay are presented here. 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.

These studies were contributed by investigated by the University of the Philippines, Los Baños led by Drs. Consuelo Habito and Nicomedes Briones

Batangas Bay

Five local government units border the Batangas Bay with a combined land area of 453.8 km² and water surface area of 220 km². Batangas Bay (Figure 3.20) 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.

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 3.21) 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 3.21 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 increase 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 3.10). 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 3.10 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

Malaysia

Malaysia is divided into the west (clusters 6, 8, 9, 12) and the east (clusters 5, 12, 16). West Malaysia relatively ranks as low exposure in SE Asia (Table 3.2). East Malaysia on the other hand, and in particular Sabah rank moderately high with Sabah experiencing increases and temperature, anomalous rain and a high rate of sea level rise. All its coastal resources and livelihood are compromised. This is detrimental to the livelihood of the 21,445 fishers in the area. Care must be given to continually protect and manage the existing extensive mangrove cover of the area.

Moreover, the authorities have to recognize that some human activities further exacerbate this vulnerability such as inappropriate seawalls, solid ports and sand mining (Table 3.11).

Table 3.11Data used for the for Intrinsic and Extrinsic sensitivity of Malaysia

INTRINSIC SENSITIVITY	**Johor**	**Kedah**	**Kelantan**	**Malacca**	N. Sembilar	**Pahang**	**Penang**	**Perak**	**Perlis**	**Selangor**	**Terenggan**	**Sabah**	**Sarawak**	**Labuan**
Habitat Cover														
Coral reef (Malaysia coral reefs area: 3,600km2) - (no data aviala	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Seagrass (no data avialable by state)	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Mangrove (mangrove cover in ha for 2006)	29,688	8,118	744	80	204	4200	870	42,351	13	19,547	1987	341,000		Nil
Fisheries														
Import (Quantity: 438,898.35 tonnes with value of RM 2,236,277,6	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Export (Quantity: 318,402.90 tonnes with value of RM 2,609,976,35	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.	No info.
Socio-Economic														
Coastal Population (in '000 for 2010)	3,305.90	1966.9	1670.5	771.5	1,011.70	1534.8	1596.9	2460.8	240.1	51026	1050	2506.5	2506.5	1722.5
Fishers (No. of fishersin 2007)	9,034	8,531	6,714	1,273	353	5,559	3,193	10,580	5,766	7,078	8,651	21,445	11,440	146
Price of pelagic fish (per kg) (e.g: Round scad in RM)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Price of demersal fish (per kg) (e.g: Threadfin bream in RM)	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Average catch (kg) (Tonnes/month in 2007)	7965.08	6993.5	6236.67	1622.67	35.5	8787.17	3147.83	19971.1	16150	9678.17	6750.58	15346.8	11686.1	2328.75
Average income for village (in RM for 2007)	1715	1632	1300	1350	1240	1927	1549	2550	1560	2100	1400	1292	1251	
EXTRINSIC SENSITIVITY														
Presence of seawalls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Presence of solid ports	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Presence of dams	no	no	Yes	no	no	Yes	yes	yes	no	Yes	Yes	Yes	Yes	No
Mining:														
Sand mining (river/inland mining with EIA approval)	Yes	No	Yes	No	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No
Oil mining (Petroleum)	No	No	No	No	No	No	No	No	No	No	Yes	Yes	yes	No
Coral mining	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Unregulared/underreported fisheries												Yes		
Fisheries subsidy:														
Fuel (LKIM to selected fishers through PNK)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ports (no of fish landings)	7	2	4	1	1	3	5	5	1	5	7	16	15	1
Storage	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ice plants (no. of ice factories in 2011)	19	2	11	1	1	21	26	10	2	4	10	47	52	4
Efficient fishery technology														

To demonstrate the issues in Sabah the case of Darvel Bay is presented.

Dravel Bay

Dravel Bay (Figure 3.22), which is located at in the Lahad Datu and Kunak districts (Table 3.12), 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.

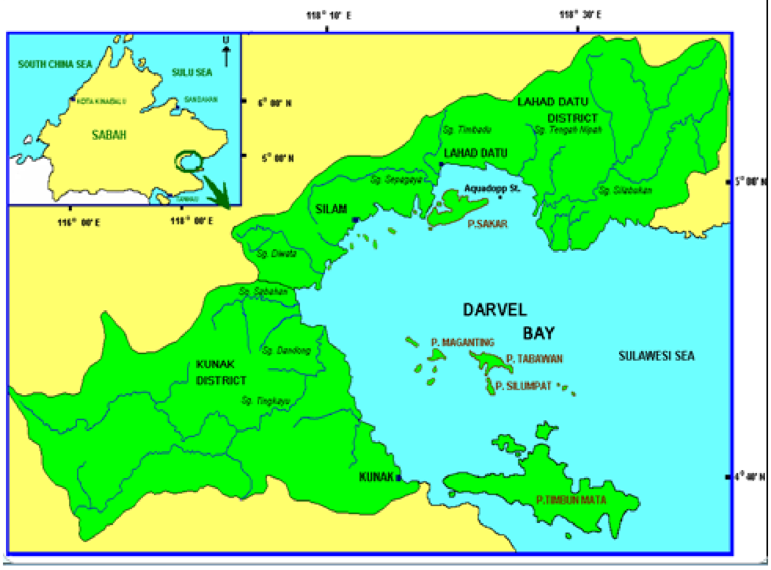


Figure 3.22 Study site in Malaysia – Darvel Bay, Sabah

Table 3.22 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.

Darvel Bay, Sabah, Malaysia

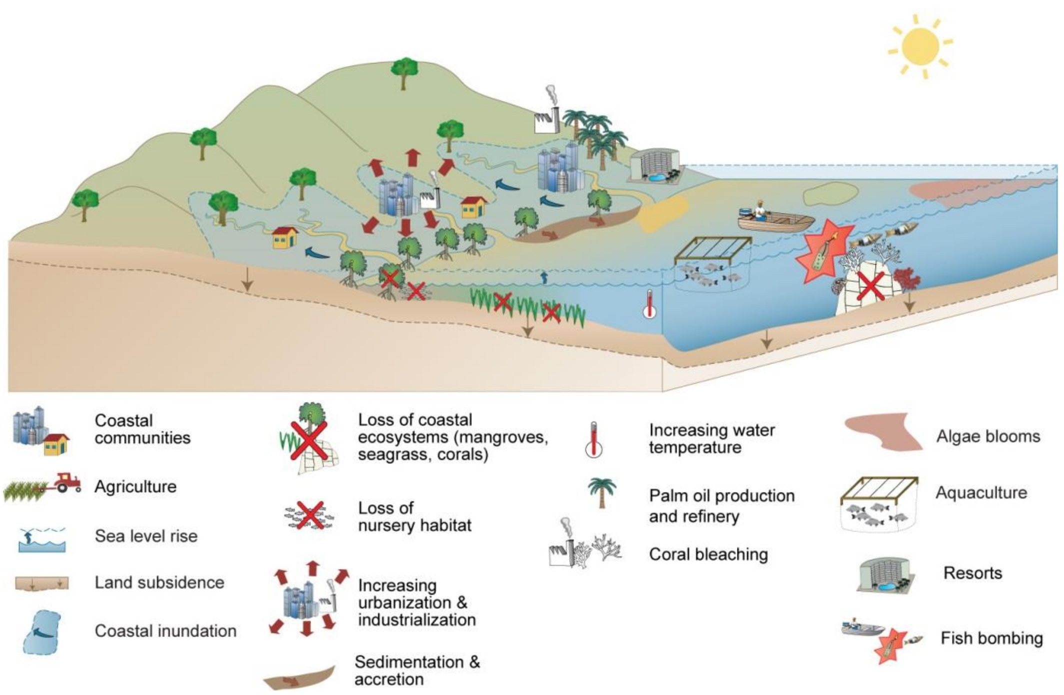


Figure 3.23 Schematic diagram of issues for Darvel Bay

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 3.24). Results show that these issues of erosion and sedimentation are prevalent in Sabah (Figure 3.25)

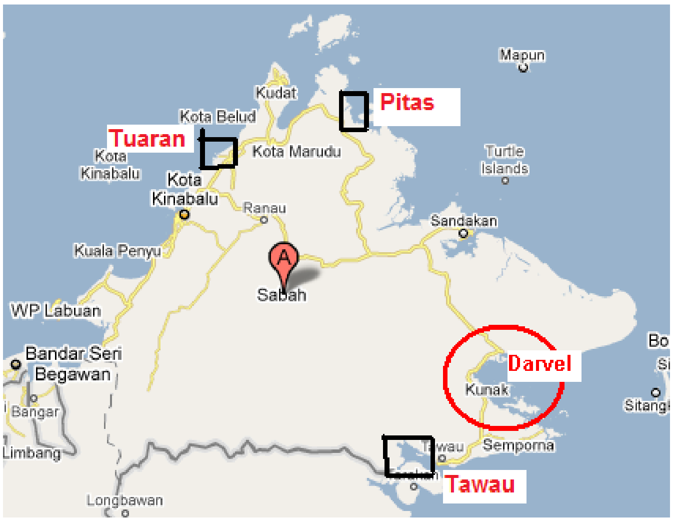


Figure 3.21 Location map of other sites studied for coastal integrity

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.

Though Cambodia and Thailand were not able to participate in the addendum activities, analysis of their previous data showed that issues similar to those mentioned in the other SE Asia countries were also present in their areas.

Cambodia

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). Previous experience in positive temperature anomaly has already been observed to cause massive coral bleaching. The vulnerability to climate 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.

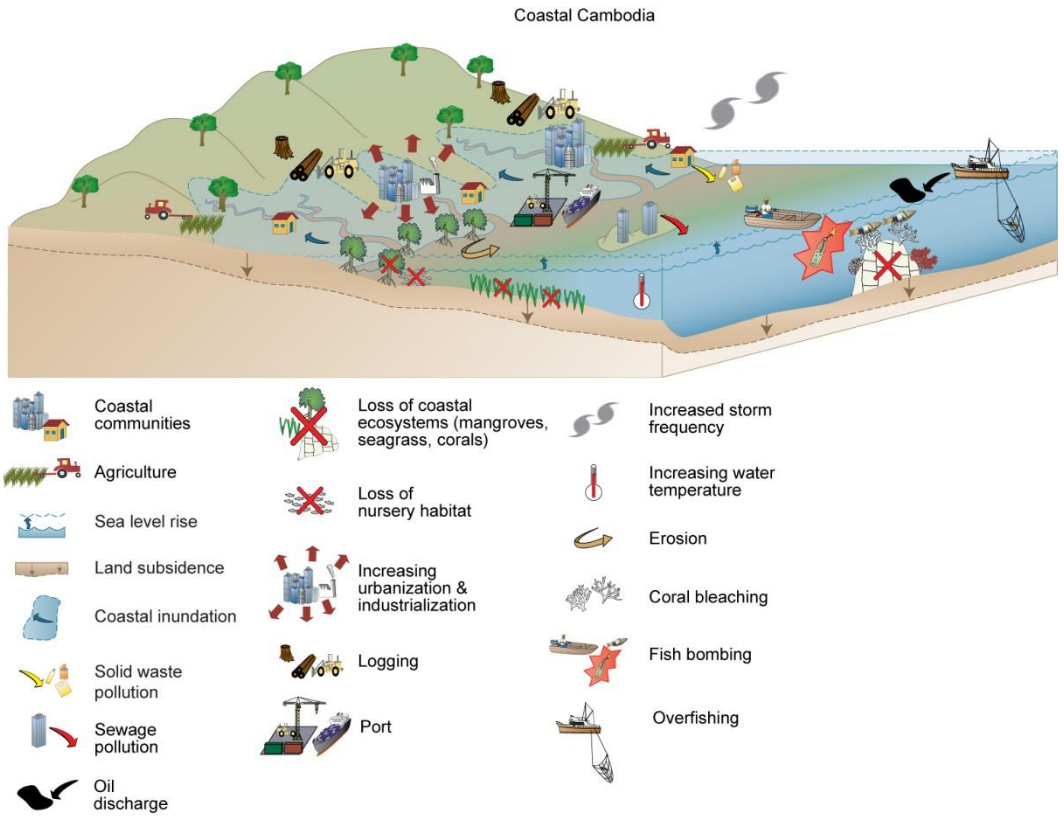


Figure 3.23 Schematic diagram of the issues existing and foreseen for the coast of Cambodia

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 perceived consequences of sea level rise are 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 seagrasses 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 3.24).

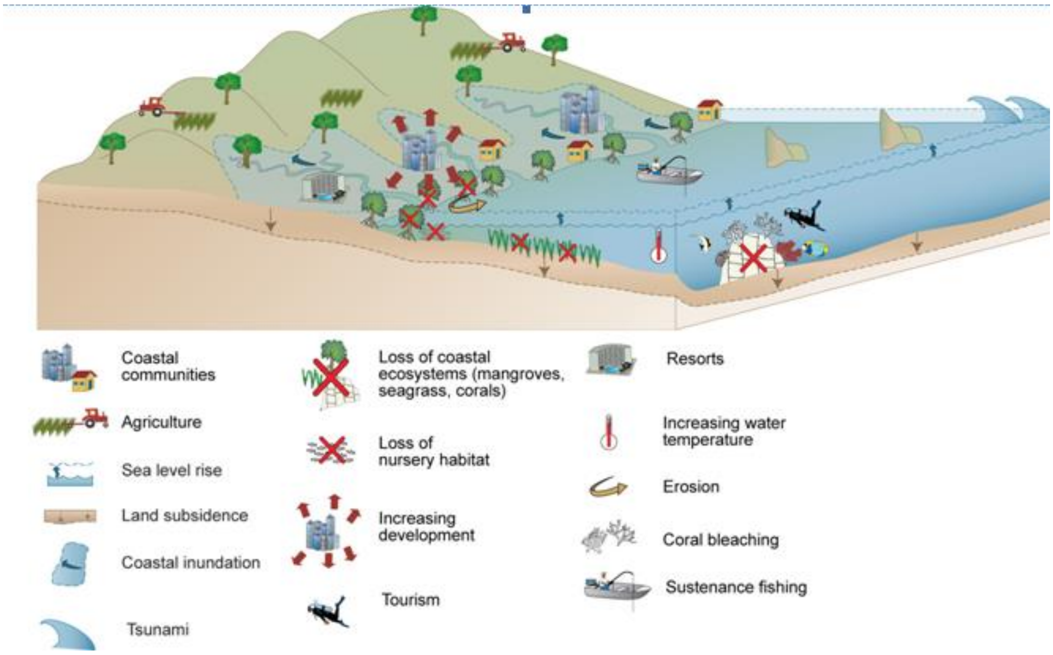


Figure 3.24 Schematic diagram of existing issues in the Andaman coast.

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.

One more study area from the Philippines is shared here to highlight a climate phenomenon that it shares only with north VietNam - the passage of typhoons. Shown in Figure 3.22 are the typical typhoon passage through the Philippines.

Gubat, Sorsogon (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 – Figure 3.25), 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).

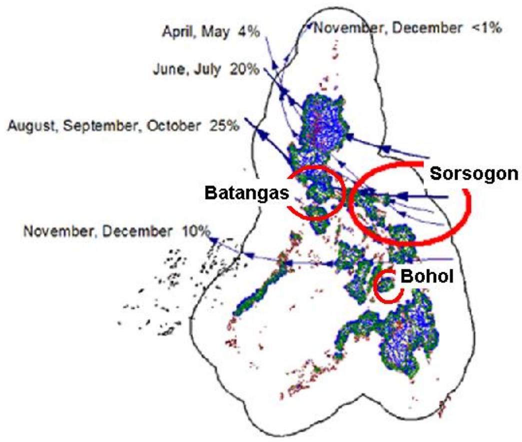


Figure 3.25 Location of study sites encircled in RED. Size of circle depicts relative potential of storm passage. Arrows depict likely path of typhoons passing over the Philippine Area of Responsibility

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

3.3 Regional Synthesis

SE Asia rely heavily on the coast and coastal resources as settlement areas, economic zones and food resource. As such there is much concern on the fate of the coast under the climate change lens. The analysis shared here showed the type and intensity of exposure that is felt by the different areas in SE Asia. Emphasized were the high exposure (SST, rain, SLR) of north VietNam, Java of Indonesia, Sabah of Malaysia, and most of the Philippines. High and anomalous sea surface temperature would compromise reef health and therefore also reef associated fisheries and tourism reliant on the presence of healthy reef as an attraction. For these areas management of reef resources should be a priority. These are the Philippines, Gulf of Martaban, and Java.

Anomalous rain events will compromise both seagrass and coral areas. For these sites, watershed management is imperative. Dense coastal vegetation is an advantage and should be prioritized. These are north VietNam, Gulf of Martaban, Java, Sabah and Central Sulawesi and its neighboring islands. Sedimentation 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) should be studied and managed.

Sea level rise can lead to land loss, submergence, and loss of mangroves. DIVA simulations showed VietNam and Indonesia experiencing the highest number of people flooded. Spatial analysis showed that in particular Kien Giang will have the highest area flooded. Sea level rise per se is also ranked by Singapore as the number 1 climate related issue that Singapore will have to contend with. Also vulnerable are the coasts of the Philippines, Sabah, and the islands around central Sulawesi. Human activities that exacerbate this vulnerability such as sand mining, solid ports, in appropriate seawalls must be ceased or corrected.

The presence of high population or mega-cities puts pressure on freshwater resources. Groundwater extraction is the usual source. This has created an unforeseen consequence of land subsidence resulting to an exaggerated relative sea level rise.

Loss of mangroves can have impact beyond demersal fisheries since both demersal and pelagic fishes use the mangroves as spawning and nursery grounds. Care must be taken to manage still existing dense mangrove forests. This will be beneficial locally and for the entire region in terms of fisheries.

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 provide its ecological service as nursery ground is compromised.

Equally sensitive is the tourism industry. Overlay of MPAs, resort establishments and transportation infrastructure highlight sites that are becoming vulnerable to climate change. These are the coasts around Central and South VietNam, most of the coasts of the Philippines, Sumbawa & Flores of Indonesia, the Indonesian islands surrounding the seas of Molucca, Halmahera, & Ceram, and Sabah of Malaysia.

Finally, it should be noted that non-climate related natural disasters such tsunamis, volcanic eruptions and earthquakes continue to be a threat to parts of the region. 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

4.0 Conclusions

DIVA simulation used in the previous study 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". DIVA however has limitations in terms of applicability at more localized scales.

GIS-analysis was able to give higher spatial resolution details to the exposure, sensitivity and vulnerability of the different sub-regions in SE Asia. For the most part, DIVA simulations were corroborated by the GIS analysis. Additionally however, the GIS analysis was able to pinpoint the vulnerability of the Philippine coastal tourism industry and the overall vulnerability of Sabah, Malaysia.

County data were useful in pinpointing specific intrinsic and extrinsic sensitivity of the different sub-regions in SE Asia. Highlighted were the areas of high dependency on coastal resources as food resource, as livelihood, as settlement.

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.

Common ways of reporting and common assessment tools proved invaluable.

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. The most important message to get across to policy makers and different coastal stakeholders is that there is a high cost to doing nothing.

5.0 Future Directions

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. 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.

It is also desirable to have more representative case studies for the region. Success stories of adaptation options and lessons learned from inappropriate response should also be documented as part of the case study assessments

References

Adger, W.N., (2003), Social capital, collective action, and adaptation to climate change, *Economic Geography* 79(4): 387–404, 2003.

Amadore, L., Bolhofer, W. C., Cruz, R. V., Feir, R. B., Freysinger, C. A., Guill, S., Jalal, K. F., Iglesias, A., Jose, A., Leatherman, S., Lenhart, S., Mukherjee, S., Smith, J. B. and Wisniewski, J., (1996), Climate change vulnerability and adaptation in Asia and the Pacific: Workshop summary. Water, Air, & Soil Pollution, Volume 92, Numbers 1-2 (November, 1996), pp. 1-12

Asian Development Bank, (1996), A Workbook on Economic Valuation of Environmental Impacts, Manila: Asian Development Bank.

Asia-Pacific Forestry Section Outlook Study, Working Paper Series, Working Paper No. APFSOS/WP/23. "Asia Pacific Sector Outlook: Focus on Coconut Wood by Romulo A. Anarcon Jr., FAO-RAP, Bangkok, October 1997, ftp://ftp.fao.org/docrep/fao/w7731E00.pdf.

Baba, K., Tada, M., Kawajiri, T. & Kuwahara, Y., (1999), Effects of temperature and salinity on spawning of the brackish water bivalve Corbicula japonica in Lake Abashiri, Hokkaido, Japan, *Marine Ecology Progress Series*, 180, 213-221.

Bennett, E.L. & Reynolds, C.J. 1993. The Value of a Mangrove Area in Sarawak, *Biodiversity and Conservation* 2:359-375.

Bird, C. F., (1992), Beach Management with a Rising Sea Level, *Bulletin in Oceanology Theory and Application*, Vol. 10.

Bird, C. F., (1993), Submerging Coasts: The Effects of a rising Sea Level on Coastal Environments, Wiley & Sons: England.

Buddemeier, R. W., Smith, S. V., Swaney, D. P., Crossland, C. J. & Maxwell, B. A. (2008). Coastal typology: An integrative "neutral" technique for coastal zone characterization and analysis, *Estuarine, Coastal and Shelf Science*, Volume 77, Issue 2, (10 April 2008) Pages 197-205, Land Ocean Interactions in the Coastal Zone, LOICZ: Lessons from Banda Aceh, Atlantis, and Canute

Bureau of Soils and Water Management, (2006), Soil/Land Resources Survey and Evaluation, Donsol, Province of Sorsogon, DA-BSWM, Diliman, Quezon City.

Burke, L., Reytar, K., Spalding, M. & Perry, A., (2011), Reefs at Risk Revisited, World Resources Institute, Washington, D.C., 114 p.

Cambridge, M.L., Breeman, A.M. & van den Hoek, C., (1990), Temperature limits at the distribution boundaries of four tropical to temperate species of Cladophora (Cladophorales: Chlorophyta) in the North Atlantic Ocean, *Aquatic Botany*, 38, 135-151.

Carricart-Ganivet, J.P., (2004), Sea surface temperature and the growth of the West Atlantic reef-building coral Montastraea annularis, *Journal of Experimental Marine Biology and Ecology*, 302, 249– 260.

Chia, L.S., Khan, H., & Chou, L. M., (1988), The Coastal Environmental Profile of Singapore. ASEAN / US Coastal Resources Management Project, Technical Publications Series 3.

Cabahug, (2004), Mangrove Resource Assessment of Donsol, Sorsogon, WWF-Philippines, Donsol, Sorsogon

Constanza, R. & Folke, C., (1997), Valuing Ecosystem Services with Efficiency, Fairness, and Sustainability as Goals, *Nature's Services* edited by Daily, G. C., Washington, DC.: Island Press. Pp. 49-68

De Groot, et.al. (2006), Valuing wetlands Guidance for valuing the benefits derived from wetland ecosystem services. Ramsar Technical Report 3, CBD Technical Series No. 27. Gland, Switzerland.

Dixon, J. & Pagiola, S. 1998. Economic analysis and environmental assessment, Environmental Assessment Sourcebook Update, April 1998, Number 23. Environment Dept., the World Bank, 14 pp

Donner, S.D., Skirving, W.J., Little, C.M., Oppenheimer, M. & Hoegh-Guldberg, O., (2005), Global assessment of coral bleaching and required rates of adaptation under climate change, *Global Change Biology*, 11, 2251-2265.

EMB-Environment Impact Assessment and Management Division, (2007) Revised Procedural Manual for DENR Administrative Order No.30 Series of 2003 (DAO 2003-30). EMB, DENR, Diliman, Quezon City.

FAO, 2003, Report of the Expert Consultation on International Fish Trade and Food Security, Casbalanca, Morocco, www.fao.org

FAO, 2006, Fisheries Policy Content and Directions in Asian APFIC Member Countries, Malaysia, www.fao.org

FICen/RIMP, 2006, Characteristics of marine product resources. www.fistenet.gov.vn, VASEP, 2008, Viet Nam Seafood Trade. No.2, Hanoi.

Gaston, K.J., (2000), Global patterns in biodiversity, *Nature*, 405, 220-227.

Giselle P. B. Samonte – Tan, et al, (2004), Economic Valuation of Coastal and Marine Resources: Bohol Marine Triangle, Philippines Copyright © Taylor & Francis Group, LLC, ISSN: 0892-0753 print / 1521-0421 online DOI: 10.1080/08920750601169634

Hien T.T., (2007), Why foreign investments for Fisheries sector still limited, *Fisheries Review*, No.7, p 37. Ha Noi

Hinkel, J., (2005), DIVA: An iterative method for building modular integrated models, *Advances in Geosciences*, 4, 45–50, 2005; SRef-ID: 1680-7359/adgeo/2005-4-45; European Geosciences Union. http://www.adv-geosci.net/4/45/2005/adgeo-4-45-2005.pdf

Hinkel, J. and Klein, R.J.T., (2007), Integrating knowledge for assessing coastal vulnerability to climate change. In: *Managing Coastal Vulnerability: An Integrated Approach*, L. McFadden, R.J. Nicholls and E.C. Penning-Rowsell (eds.), Elsevier Science, Amsterdam, The Netherlands.

Hobbs, J-P.A. & McDonald, C.A., (2010), Increased seawater temperature and decreased dissolved oxygen trigger fish kill at the Cocos (Keeling) Islands, Indian Ocean, *Journal of Fish Biology*, 77: 1219-1229.

Hoegh-Guldberg, O., (1999), Climate change, coral bleaching and the future of the world's coral reefs (1999), *Marine Freshwater Research*, 50, 839-866.

Houghton, J. T., (1991), Scientific Assessment of climate change: Summary of the IPCC Working Group I report. pp 23-26 In Jager, J. & Ferguson, H. L., *Climate Change: Science, impacts and policy, Proceedings of the Second World Climate Conference*, Cambridge University Press.

http:/www.ecosystemvaluation.org.

Kibria, G., (2011), Global fish kills: Causes and consequences, *Science & Technology*, 21, 2p, URL: http://www.sydneybashi-bangla.com/

Local Government Unit, Barangay Sibago, Donsol, Prov. Of Sorsogon, (Undated), Barangay Profile

Lasco, R.D. and Boer, R., (2006), An integrated assessment of climate change impacts, adaptations and vulnerability in watershed areas and communities in southeast Asia. A Final Report Submitted to Assessments of Impacts and Adaptations to Climate Change (AIACC), Project No. AS 21. http://www.aiaccproject.org/Final%20Reports/Final%20Reports/FinalRept_AIACC_AS21.pdf

Manila Observatory and Ayala Foundation Inc., (2009), Sustainable Development Guidebook for the Municipality of Baclayon, Bohol, Philippines (Scientific Technical Report and Multi-stakeholders Handbook), Ayala Foundation Inc., Makati City, Philippines.

MARD, (2008), Progress Report 2007 of Fisheries Sector, p2-7, Ha Noi

McFadden, L., Nicholls, R. J., Vafeidis, A., & Tol, R. S., (2007), A methodology for modelling coastal space for global assessment, *Journal of Coastal Research*, Vol. 23, No. 4, pp 911-920

McLeod, E., Moffitt, R., Timmermann, A., Salm, R., Menviel, L., Palmer, M.J., Selig, E.R., Casey, K.S. & Bruno, J.F., (2010), Warming Seas in the Coral Triangle: Coral Reef Vulnerability and Management Implications, *Coastal Management*, 38: 5, 518 — 539

Meehl, G.A., Stocker, T.F., Collins, W.D., Friedlingstein, P., Gaye, A.T., Gregory, J.M., Kitoh, A., Knutti, R., Murphy, J.M., Noda, A., Raper, S.C.B., Watterson, I.G., Weaver, A.J. & Zhao, Z.-C., (2007), Global Climate Projections, In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S.,D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Millennium Ecosystem Assessment, (2003) Ecosystems and human well-being: a framework for assessment, *Millennium Ecosystem Assessment*, Island Press, Washington D.C.

Mimura, N., (2001), Distribution of vulnerability and adaptation in the Asia and Pacific region, *Proceedings of the APN/SURVAS/LOICZ Joint Conference on Coastal Impacts of Climate Change and Adaptation in the Asia–Pacific Region* (pp. 21-25). http://www.survas.mdx.ac.uk/

Ministry of Fisheries, (2006), Progress report 2005 and master work plan 2006 – 2010, p 4-35. Ha Noi.

Ministry of Fisheries, (2007), Progress report 2006 and master work plan 2007, p 2-9. Ha Noi.

MOFI/FICen, (2006), The fisheries sector is one of the country's key economic sectors, www.fistenet.gov.vn

MOFI/FICen, (2006), The role of fisheries sector in development international trade relations,
www.fistenet.gov.vn

MOFI/FICen, (2006), The role of fisheries sector in food security, job creation and poverty elimination, www.fistenet.gov.vn.

MOFI/FICen, (2006), International Co-operation, www.fistenet.gov.vn

MTE (Multidisciplinary Team of Experts), 1996. The coastal environmental profile of the Batangas Bat Region, MPP-EAS Teachnical Report No. 5, 148 p. GEF/UNDPIMO Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas, Quezon City, Philippines.

Municipality of Donsol, Province of Sorsogon. Undated. Comprehensive Land use Plan 2005-2015.

Municipality of Baclayon, Bohol. (2004). Comprehensive Land Use Plan (Planning Period: CY 2002-2011).

Muñoz, J. C., Fisheries and Coastal Resource Management in the Philippines

National Statistics Office, (2007), Sectoral Statistics: Agriculture and Fisheries (http://www.census.gov.ph/data/sectordata/dataagri.html)

NCCC, (2008), Singapore's National Climate Change Strategy,

Nicholls, R.J., & de la Vega-Leinert, A., (2001), Overview of the SURVAS project

Nicholls, R., Wong, P., Burkett, V., Codignotto, J., Hay, J., McLean, R., Ragoonaden, S., & Woodroffe, C., (2007), Coastal systems and low-lying areas, In: Parry, M., Canziani, O., Palutikof, J., van der Linden, P. and Hanson, C., (eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 315–356.

NOAA Coral Reef Watch, (2000, updated twice-weekly), NOAA Coral Reef Watch 50-km Satellite Degree Heating Weeks for East Pacific, 1998, 2010, 2012, Silver Spring, Maryland, USA: NOAA Coral Reef Watch. Data set accessed 2012-06-20 at http://coralreefwatch.noaa.gov/satellite/index.html

Padilla, J. E., (2008), Analysis of coastal and marine resources: A contribution to the Philippine country environmental analysis, http://www.worldbank.org.ph [Accessed: January 10, 2009].

Padilla, J.E.& Janssen, R., (1999), Preservation and Conservation? Valuation and evaluation of mangrove forest in the Philippines, *Environmental and Resource Economics*, 14: 297-331

Padilla, J.E.& Janssen, R., (1996), Extended benefit-cost analysis of management alternatives: Pagbilao mangrove forest, *Journal of Philippine Development*, No. 42, Vol 23, No. 2, 2nd semester

Pearce, D.W. & Warford, J.W., (1993), World without end: economics, environment and sustainable development. Oxford University Press, Oxford.

Peñaflor, E.L., Skirving, W.J., Strong, A.E., Heron, S.F. & David, L.T., (2009), Sea-surface temperature and thermal stress in the Coral Triangle over the past two decades, *Coral Reefs*, 28:841–850.

PG-ENRO (Environment and Natural Resources Office of the Provincial Government of Batangas), 1996, Strategic Envionmental Management Plan for the Batangas Bay Region, MPP-EAS Technical Report No. 3, 96 p. GEF/UNDPIMO Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas, Quezon City, Philippines.

Ronnback, P., (1999), The ecological basis for economic value of seafood production supported by mangrove ecosystems, *Ecological Economics* 29, 235-252.

Rousseeuw, P.J., (1987), Silhouettes: a graphical aid to the interpretation and validation of cluster analysis, *Journal of Computational and Applied Mathematics*, 20, 53-65.

Samonte-Tan, G., White, A., Torcer, M. A., Esperanza, T., & Caballes, C., (2007), Economic Valuation of Coastal and Marine Resources: Bohol Marine Triangle, Philippines, *Coastal Management*, 35:319–338,

Sathirathai, S. & Barbier, E.B. (2001), Valuing mangrove conservation in southern Thailand *Contemporary Economic Policy*, 19:109-122

Skirving, W., Strong, A.E., Liu, G., Arzayus, F., Liu, C. & Sapper, J., (2006), Extreme events and perturbations of coastal ecosystems: Sea surface temperature change and coral bleaching. In *Remote Sensing of Aquatic Coastal Ecosystem Processes: Science and Management Applications*, Richardson, L.L., & LeDrew, E.F., (eds.), Springer, Netherlands, 11-25.

Smith, R., & Smith, T., (2000), Elements of Ecology, 4th ed. Philippines: Addison, Wesley, Longman, Inc.

Smith, C. A., & Maxwell, B. A. (2002), Deluxe Integrated System for Clustering Operations (DISCO), http://fangorn.colby.edu/disco-devel/DISCO.pdf

Strong, A.E., Arzayus, F., Skirving, W. & Heron, S.F., (2006), Identifying coral bleaching remotely via Coral Reef Watch – Improved integration and implications for changing climate, *Coral Reefs and Climate Change: Science and Management, Coastal and Estuarine Studies* 61, Phinney, J.T., Hoegh-Guldberg, O., Kleypas, J., Skirving, W., & Strong, A., (eds.), American Geophysical Union, Washington, D.C., 163-180.

Trenberth, K.E., Jones, P.D., Ambenje, P., Bojariu, R., Easterling, D., Klein Tank, A., Parker, D., Rahimzadeh, F., Renwick, J.A., Rusticucci, M., Soden, B. & Zhai, P., (2007), Observations: Surface and Atmospheric Climate Change. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. & Miller, H.L. (eds.)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 102pp

Tolosa, M.O. & Padilla, J.E, (2005), Towards a business plan for donsol community based ecotourism and coastal resources management project, WWF- Donsol Community-based Ecotourism Project; WWF Sulu-Sulawesi Marine Ecoregion Partnership for Sustainability Program Community-based Ecotourism and Coastal Resources Management Project

UNDP, 2006, Viet Nam Overview, www.undp.org

USDAFAS, (2007), Vietnam Fishery Products Shrimp Report 2007, http://www.thefishsite.com/articles/307/vietnam-fishery-products-shrimp-report-2007

www.singstat.gov.sg (accessed in November 2009)

Umali, L., (1999), Assessment of physico-chemical and socio-economic impacts of the existing landfill in Tingga Labac, Batangas City, (*MS Environmental Science Thesis*), University of the Philippines Los Baños.

VASEP, (2007), Viet Nam Seafood Trade. No.2, Hanoi. VASEP, (2006), Viet Nam Seafood Trade. No.2, Hanoi. VASEP, (2005), Viet Nam Seafood Trade. No.2, Hanoi. VASEP, (2004), Viet Nam Seafood Trade. No.2, Hanoi. VASEP, (2003), Viet Nam Seafood Trade. No.2, Hanoi.

Wilson, J.R. & Harrison, P.L., (2003), Spawning patterns of scleractinian corals at the Solitary Islands – a high latitude coral community in eastern Australia, *Marine Ecology Progress Series*, 260, 115-123.

Wong, P. P. (1992). Impact of a sea level rise on the coasts of Singapore: preliminary observations. *Journal of Southeast Asian Earth Sciences*, Vol. 7, No. 1, pp 65 – 70. Great Britain.