CORAL TRIANGLE INITIATIVE

ON CORAL REEFS, FISHERIES AND FOOD SECURITY

PHILIPPINES

VULNERABILITY ASSESSMENT TOOLS FOR COASTAL ECOSYSTEMS

A Guidebook

July 2013

This publication was prepared by the Marine Environment and Resources Foundation, Inc. (MERF) in partnership with Conservation International (CI) for the Philippines' National CTI Coordination Committee with funding from the United States Agency for International Development's Coral Triangle Support Partnership (CTSP)

VULNERABILITY ASSESSMENT TOOLS FOR COASTAL ECOSYSTEMS: A GUIDEBOOK

Contributors:

Porfirio M. Aliño, Reniel B. Cabral, Olivia C. Cabrera, Laura T. David, Emerlinda C. Dizon, Maria Victoria A. Doctor, Norievill B. España, Noreen Marie G. Follosco, Rollan C. Geronimo, Wilfredo Y. Licuanan, Antonio Samuel S. Mamauag, Renmar Jun S. Martinez, Evangeline Florence B. Miclat, Richard N. Muallil, Fleurdeliz M. Panga, Miledel Christine C. Quibilan, Rene N. Rollon, Erlinda E. Salamante, Maricar S. Samson, Fernando P. Siringan, Ma. Yvainne Y. Sta. Maria, Cesar L. Villanoy

This publication was produced and printed with support from the United States Agency for International Development (USAID) Philippines through the Coral Triangle Support Partnership (CTSP). The Department of Science and Technology - Philippine Council for Agriculture and Aquatic Resources Research and Development (DOST - PCAARRD), the RESILIENT SEAS for Climate Change Program, and the National Economic Development Authority (NEDA) supported the development of the vulnerability assessment tools presented in this guidebook at various stages.

Vulnerability Assessment Tools for Coastal Ecosystems: A Guidebook

Edited and Compiled by:
Rollan C. Geronimo, Conservation International, Quezon City, Philippines
Noreen Marie G. Follosco, Marine Environment and Resources Foundation, Inc., Quezon City Philippines
Miledel Christine C. Quibilan, Marine Environment and Resources Foundation, Inc., Quezon City, Philippines
Maricar S. Samson, De La Salle University – Science and Technology Complex, Canlubang, Laguna
Ma. Gregoria Joanne P. Tiquio, Marine Environment and Resources Foundation, Inc., Quezon City, Philippines

Key Contributors:
Porfirio M. Aliño, Marine Science Institute, Quezon City, Philippines
Reniel B. Cabral, National Institute of Physics, Quezon City, Philippines
Olivia C. Cabrera, Marine Environment and Resources Foundation, Inc., Quezon City, Philippines
Laura T. David, Marine Science Institute, Quezon City, Philippines
Emerlinda C. Dizon, Conservation International, Quezon City, Philippines
Maria Victoria A. Doctor, Marine Environment and Resources Foundation, Inc., Quezon City, Philippines
Norievill B. España, Br. Alfred Shields, FSC Marine Station, De La Salle University, Manila, Philippines
Noreen Marie G. Follosco, Marine Environment and Resources Foundation, Inc., Quezon City, Philippines
Rollan C. Geronimo, Conservation International, Quezon City, Philippines
Wilfredo Y. Licuanan, Br. Alfred Shields, FSC Marine Station, De La Salle University, Manila, Philippines
Antonio Samuel S. Mamauag, Marine Environment and Resources Foundation, Inc., Quezon City, Philippines
Renmar Jun S. Martinez, Marine Environment and Resources Foundation, Inc., Quezon City, Philippines
Evangeline Florence B. Miclat, Conservation International, Quezon City, Philippines
Richard N. Muallil, Marine Environment and Resources Foundation, Inc., Quezon City, Philippines
Fleurdeliz M. Panga, Marine Environment and Resources Foundation, Inc., Quezon City, Philippines
Miledel Christine C. Quibilan, Marine Environment and Resources Foundation, Inc., Quezon City, Philippines
Rene N. Rollon, Institute of Environmental Science and Meteorology, Quezon City, Philippines
Erlinda E. Salamante, Marine Environment and Resources Foundation, Inc., Quezon City, Philippines
Maricar S. Samson, De La Salle University – Science and Technology Complex, Canlubang, Laguna
Fernando P. Siringan, Marine Science Institute, Quezon City, Philippines
Ma. Yvainne Y. Sta. Maria, Marine Environment and Resources Foundation, Inc., Quezon City, Philippines
Cesar L. Villanoy, Marine Science Institute, Quezon City, Philippines

Layout by Reina Marie C. Gastardo and Johann Nicolas S. Rivera

Citation: MERF. 2013. Vulnerability Assessment Tools for Coastal Ecosystems: A Guidebook. Marine Environment and Resources Foundation, Inc.: Quezon City, Philippines, pp 162.

Suggested citation for guidebook chapters:

Geronimo, R.C., Quibilan, M.C.C., Follosco, N.M.G. 2013. Chapter 2: Assessing vulnerabilities: General process guide. In: MERF. 2013. Vulnerability Assessment Tools for Coastal Ecosystems: A Guidebook. Marine Environment and Resources Foundation, Inc.: Quezon City, Philippines.

Villanoy, C.L., Salamante, E., Cabrera, O. 2013. Chapter 3: Exposure: waves and storm surges. In: MERF. 2013. Vulnerability Assessment Tools for Coastal Ecosystems: A Guidebook. Marine Environment and Resources Foundation, Inc.: Quezon City, Philippines.

Licuanan, W.R.Y., Siringan, F.P., Mamauag, S.S., Samson, M.S., Aliño, P.M., Rollon, R.N., Sta. Maria, M.Y.Y., Quibilan, M.C.C., Martinez, R.J.S., España, N.B., Geronimo, R.C., Villanoy, C.L., Cabrera, O.C., Salamante, E.E., Miclat, E.F.B., David, L.T. 2013. Chapter 4: Integrated Coastal Sensitivity, Exposure, and Adaptive Capacity to Climate Change. In: MERF. 2013. Vulnerability Assessment Tools for Coastal Ecosystems: A Guidebook. Marine Environment and Resources Foundation, Inc.: Quezon City, Philippines.

Siringan, F.P., Sta. Maria, M.Y.Y., Samson, M.I., Licuanan, W.R.Y., Rollon, R. 2013. Chapter 5: Coastal Integrity Vulnerability Assessment Tool. In: MERF. 2013. Vulnerability Assessment Tools for Coastal Ecosystems: A Guidebook. Marine Environment and Resources Foundation, Inc.: Quezon City, Philippines.

Mamauag, S.S., Aliño, P.M., Martinez, R.J.S., Muallil, R.N., Doctor, M.V.A., Dizon, E.C., Geronimo, R.C., Cabral, R.B. 2013. Chapter 6: Tool for Understanding Resilience of Fisheries. In: MERF. 2013. Vulnerability Assessment Tools for Coastal Ecosystems: A Guidebook. Marine Environment and Resources Foundation, Inc.: Quezon City, Philippines.

Aliño, P.M., Follosco, N.M.G., Mamauag, S.S., Martinez, R.J.S., Panga, F.M. 2013. Chapter 7: Linking vulnerability assessment to adaptation. In: MERF. 2013. Vulnerability Assessment Tools for Coastal Ecosystems: A Guidebook. Marine Environment and Resources Foundation, Inc.: Quezon City, Philippines.

Printed in: Quezon City, Philippines, August 2013

Funding for the preparation of this document was provided by the USAID-funded Coral Triangle Support Partnership (CTSP). CTSP is a consortium led by the World Wildlife Fund, The Nature Conservancy, and Conservation International. The Department of Science and Technology, the RESILIENT SEAS for Climate Change Program, and the National Economic Development Authority supported the development of the vulnerability assessment tools presented in this guidebook at various stages.

For more information on the Coral Triangle Initiative, please contact:
Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security Interim-Regional Secretariat
Ministry of Marine Affairs and Fisheries of the Republic of Indonesia
Mina Bahari Building II, 17th Floor
Jalan Medan Merdeka Timur No. 16
Jakarta Pusat 10110, Indonesia
www.coraltriangleinitiative.org

National CTI Coordination Committee - Secretariat
Protected Areas and Wildlife Bureau
Department of Environment and Natural Resources
Ninoy Aquino Parks and Wildlife Center
Telefax Number: (+632) 925-8948; 924-6031 loc. 207

Bureau of Fisheries and Aquatic Resources
Department of Agriculture
DA Compound, Q.C. Circle, Quezon City
Telephone Number: (+632) 929-4894; 929-8183

website: www.cti.pawb.gov.ph

Acknowledgements

This Guidebook was prepared by Filipino marine scientists through the Marine Environment and Resources Foundation, Inc. in partnership with Conservation International – Philippines (CI-Philippines) under the United States Agency for International Development (USAID) Coral Triangle Support Partnership (CTSP) program. The Editors and Authors duly acknowledge the contribution of other agencies who supported the development of the vulnerability assessment tools at various stages and over the course of several years, namely, the Department of Science and Technology, the World Bank, the Philippines' National Economic Development Authority, and the Commission on Higher Education.

Most of the authors of this Guidebook are university professors and researchers. Their contribution would not have been possible without the positive and progressive support provided by their respective institutions, namely, De La Salle University (Br. Alfred Shields, FSC Marine Station), De La Salle University Integrated School, University of the Philippines' Institute of Environmental Science and Meteorology, and the Marine Science Institute.

The Editors and Authors would also like to thank the numerous local governments, coastal communities and development agencies who participated in the various workshops, testing, and application of the tools. Their invaluable comments and inputs helped mold the tools to its current form, making them more participatory and easily applicable to the Philippine coastal context using already available data and local knowledge as much as possible.

Development of this Guidebook was especially targeted to support the six member countries of the Coral Triangle Initiative (CTI) and to contribute to achieving the targets stipulated in the Philippines' National Plan of Action for the CTI. Special thanks are extended to the National CTI Coordination Committee, particularly to the Secretariat headed by the respective Secretaries of the Department of Environment and Natural Resources and the Department of Agriculture.

Preface

This Guidebook is part of the on-going commitment of Filipino marine scientists to provide tools for improving coastal resources management in the Philippines amidst the backdrop of a constantly changing global climate. While the publication of this Guidebook was primarily supported by Conservation International – Philippines through the USAID Coral Triangle Support Partnership program, the development and refinement of the tools spanned several programs, projects, agencies, and support organizations over the course of five years culminating in this Guidebook. These progressive groups are acknowledged in the preceding section. We present here the story leading to this publication and the people and institutions who contributed to its fruition.

The development of these vulnerability assessment tools for coastal systems began in response to the need of several partners to incorporate climate change impacts in conservation planning and coastal resources management programs. In 2008, Conservation International Philippines (CIP) with funding support from the CI headquarters in Arlington (Virginia, USA), commissioned this Guidebook's main authors to conduct one of the first vulnerability assessments in the country which focused on marine biodiversity. The study was conducted for the Verde Island Passage, an important marine biodiversity conservation corridor in the country. The scientists developed and applied initial and novel methods to evaluate vulnerabilities of coastal habitats, fisheries, and human well-being to different climate exposure scenarios and potential impacts.

The methods applied in the VIP climate change vulnerability assessment were further enhanced by the same authors under the Philippines' National Economic Development Authority's Millennium Development Goal Achievement Fund or NEDA - MDG-F 1656: Strengthening the Philippines' Institutional Capacity to Adapt to Climate Change.

The 3-year [Oct 2008- November 2011] DOST-funded Integrated Coastal Enhancement: Coastal Research Evaluation and Adaptive Management (ICE CREAM) Program later renamed to "Remote Sensing Information for Living Environments and Nationwide Tools for Sentinel Ecosystems in our Archipelagic Seas" (ReSILiENT SEAS) also contributed significantly to the refinement of the tools in a form that can be used by non-experts and local stakeholders. In this Program various subnational workshops in Luzon, Visayas and Mindanao, including a national workshop that initially piloted some of the rubrics of the tools developed here and interphased with the NEDA – MDG-F 1656 in 2010.

Finally, CI-Philippines thru the USAID CTSP provided support to complete the two existing tools on fisheries and coastal integrity and improve its documentation. In addition, the workshops sponsored by CI-P, and currently, the Commission on Higher Education, contributed to the development of the third tool termed as the ICSEA-C-Change which incorporates marine biodiversity, fisheries and coastal integrity vulnerabilities at a coarser but integrated level. CI-P helped the main authors to package their tools leading to this Guidebook. Under the mentoring program, which was also supported by USAID CTSP, training was conducted in September 2012 to build the capacity of the faculty members from mentee institutions to assist local governments in undertaking coastal vulnerability assessments in three CTSP priority geographies namely, Batangas, Palawan and Tawi-Tawi. As a result, an initial set of training modules has been developed to facilitate delivery and replication of similar trainings in the future.

Developing climate change vulnerability assessment tools that consider the local context and data availability is important in starting the long process of climate change adaptation and mitigation. Applying a participatory approach for vulnerability assessments ensures ownership of the results by the community and local governments making its translation into empowering adaptation actions easier.

As an archipelagic country, the charming beaches of the Philippines are a major natural asset that is threatened already by unregulated foreshore development and further aggravated by sea level rise and extreme weather events. Sustaining coastal fisheries productivity is undoubtedly valuable for the Philippines' food security amidst changes in sea surface temperature and extreme weather events. While the tools in this Guidebook is a living document of a work in progress, it helps to start to equip local governments and development partners with a powerful yet simple method for determining the potential impacts of the consequent effects of climate change on shorelines and coastal fisheries. We hope that for all who use the guidebook, we can continue our learning together towards enhancing our resiliency to meet the climate change challenge.

Please address correspondence about the Guidebook to:

Ms. Miledel Christine C. Quibilan
The Marine Science Institute
University of the Philippines
mcquibilan@gmail.com

For queries or comments on specific sections of the Guidebook, please contact the corresponding authors directly in the information provided on the first page of each section.

Message

Our 7,107 island archipelago has a coastline totalling around 36,289 kilometers. And the two-thirds of our population that lives along these coasts are vulnerable to rising sea levels, storm surges, heavy flooding, and other calamitous events attendant to this era of climate change. The coastal zone is also susceptible to siltation and the accompanying risks of ecosystem destruction and damage to the livelihoods of our fisherfolk- from landslides and soil erosion in the uplands.

We are thus behooved to carefully develop planning and strategy for climate change adaptation and mitigation, and disaster risk reduction. This Guidebook was drafted and consolidated by various experts in collaboration as a response to this obvious need. Its crux lies in the Coastal Vulnerability Assessment Tools it features to help coastal managers, site-level practitioners, local government units and other stakeholders achieve their mandate of raising this nation's adaptive capacity for the biophysical changes of our ever-evolving Earth.

Enhancing our capabilities in measuring, analyzing and predicting vulnerability translates to a safer and more secure environment for the Filipino people. It is for this reason that we urge all to use this Guidebook to develop and promote skills in scientific vulnerability assessment and adaptation planning.

RAMON J.P. PAJE
Secretary
Department of Environment and Natural Resources

Message

Greetings!

This guidebook, **Vulnerability Assessment Tools for Coastal Ecosystems**, is relevant and timely. The concern for climate change and its effects to the environment is an issue that continually needs to be addressed soon and outright. In fact, the threatening impacts of climate change resulting from irresponsible human activities are now creating felt changes in the ecological balance. Changes in ocean currents and rainfall patterns including the amount of rainfall; global warming/increasing air temperature; changes to the intensity and frequency of extreme events such as storms, droughts, and floods; increasing sea-surface temperature; sea-level rise; and ocean acidification – all of these are climate hazards brought about by climate change that pose threat to nature's balance, well-being, and biodiversity for both present and upcoming generations.

With the abovementioned conditions, it is no less by all means an alarm not just for environmentalists and relevant groups or non-government organizations (NGOs) but most especially for government agencies concerned like the **Department of Agriculture (DA)** and **Bureau of Fisheries and Aquatic Resources (BFAR)**. Global food production is at stake with the very unpredictable changes in the weather conditions. And with decreasing production, the problems of poverty and food insufficiency are further aggravated.

The DA alongside the BFAR is optimistic that this guidebook would be able to achieve its goal of providing guidance for strategic adaptation planning and coping mechanisms for coastal ecosystems to be able to deal with the effects and impacts of climate change. This guidebook provides **Vulnerability Assessment (VA) Tools** that will allow the users to arrive at sound conclusions and thereby implement the necessary actions to help restore and maintain balance in our coastal ecosystems.

Let us make full use of this important guidebook and let me also congratulate the writers in coming up with this important work. MABUHAY KAYONG LAHAT!

PROCESO J. ALCALA
Secretary
Department of Agriculture

Message

As an archipelagic country, the Philippines is surrounded by bodies of water with a rich and varied marine life. No wonder, about 70% of the country's population are situated along or near coastal areas and depend on the bounties of the sea for their food and livelihood.

However, this natural resource is threatened by climate change. Based on our latest statistics, the contribution of fisheries in our economy has declined, with our experts partly attributing it to ocean warming.

Aside from this, melting icecaps and glaciers in our polar regions, coupled with rising sea surface temperature cause sea level rise and inundate coastal communities. In my province alone in Siargao Island, Surigao del Norte, some residents in a coastal barangay had moved their houses away from the coast for at least a couple of times during the last 5 years due to rising sea level.

Indeed, climate change is a real threat not only to the sources of our food and livelihood but more importantly, to the people in coastal communities. That is why there is an urgent need to determine the vulnerabilities of our coastal ecosystem to enable us to come up with a science-based approach to address the threat of climate change. And this Vulnerability Assessment Tools for Coastal Ecosystem will help government planners in this undertaking.

At this point, I would like to express my appreciation to the Philippine and international agencies that extended support to the country's leading marine scientists that enabled them to produce this invaluable tool namely the USAID Coral Triangle Support Partnership (CTSP), DOST-PCAARRD Integrated Coastal Enhancement Coastal Research Evaluation and Adaptive Management (ICE CREAM) program, and Conservation International – Philippines' Verde Island Passage Vulnerability Assessment.

Sec. MARY ANN LUCILLE L. SERING
Vice Chair
Climate Change Commission

Foreword

Climate change is a serious threat to the environment. Its effects are observed to be pervasive and particularly harmful to natural ecosystems and biodiversity. In Asia alone, the Intergovernmental Panel on Climate Change (IPCC) predicted that up to 50 per cent of biodiversity will be at risk and as much as 88 percent of coral reefs may be lost in the next 30 years as a result of climate change.

Economies are also put at risk by climate change. Climate change impacts on biodiversity have already caused water shortages, affected agricultural productivity and threatened food security in the Asian region. In recent years, the Philippines has experienced dramatic economic losses from super typhoons, storm surges, flash floods and droughts that have resulted in major economic impacts. Most of these destructive natural disasters can be directly linked to the adverse effects of climate change.

Adaptation is a fundamental strategy to mitigate the impacts of climate change. To address the compounded effects of climate change, the challenge is to plan for early and strategic adaptation actions at the community, sub-national and national levels. The development of workable and scientific approaches and tools that will strengthen the coping capacities of communities and adaptive capacity of natural ecosystems is both urgent and compelling.

For the Philippines to achieve its goal of inclusive growth, the country must become more environmentally resilient and better able to cope with the impact of natural disasters and to recover quickly. That is why U.S. Embassy Manila's United States Agency for International Development is working with its local counterparts to support the integration of climate and disaster risk reduction into local development plans, and to strengthen the management of natural resources and the environment.

This Guidebook is intended to contribute to the emerging science on climate change and offers a practical set of tools for coastal managers and field practitioners based on best available scientific knowledge. The tools are designed to provide guidance on climate change adaptation planning by measuring the vulnerability of coastal ecosystems to a variety of climate-related hazards. Filipino marine scientists with extensive expertise in the fields of oceanography, geology, marine biology and ecology, fisheries and coastal resource management contributed to the development of these tools. Working with coastal managers, these scientists widely and rigorously tested the tools in several Philippine communities and consulted a wide range of stakeholders from the local government, non-government and academic institutions.

(continued next page)

Foreword

(continued from previous page)

There is no single overarching response to the impacts of climate change but there are multiple adaptation actions that are available. A vulnerability assessment that directs the selection of appropriate adaptation measures is fundamental. The suite of vulnerability assessment tools for coastal ecosystems in this Guidebook provides strategic direction to climate change actions.

Achieving environmental resilience through biodiversity conservation and risk reduction from disasters is one pathway to broad-based and inclusive economic growth for the Philippines. As an initial critical step towards this vision, I hope that local governments, community organizations, universities and other stakeholders will find this Guidebook useful and informative.

Gloria D. Steele
Mission Director
USAID/Philippines

Table of contents

List of Tables, Figures, and Equations

TABLES

FIGURES

EQUATIONS

Acronyms

AC	Adaptive Capacity
CIVAT	Coastal Integrity Vulnerability Assessment Tool
CTI	Coral Triangle Initiative
CTSP	Coral Triangle Support Partnership Program
ENSO	El Niño Southern Oscillation
EO	Executive Order
FGD	Focus Groups Discussion
GDP	Gross Domestic Product
ICE CREAM	Integrated Coastal Enhancement: Coastal Research Evaluation and Adaptation Management
ICSEA CChange	Integrated Coastal Sensitivity, Exposure, and Adaptive Capacity on Climate Change
IPCC	Intergovernmental Panel on Climate Change
MPA	Marine Protected Area
NASA	National Aeronautics and Space Administration
NCCOS	National Centers for Coastal Ocean Service
PAMS	Philippine Association of Marine Science
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PFZ	Philippine Fault Zone
PI	Potential Impact
RSLC	Rates of relative sea level change
RWE	Representative Wave Energy
REI	Relative Wave Exposure Index
SLR	Sea Level Rise
SST	Sea Surface Temperature
SWAN	Simulating Waves Nearshore
SoCR	State of the Coasts Reports
SoPA	State of the Province Address
TURF	Tool for Understanding Resilience of Fisheries
VA	Vulnerability Assessment
WEMo	Wave Exposure Model

1 Introduction

1. INTRODUCTION

In the Philippines, coastal areas are densely populated with more than 65 million of the population living within 822 coastal municipalities and cities (World Bank, 2005). Given the archipelagic nature of the country, there is constant interaction between people and the coastal and marine environment. However, the Philippines ranks seventh on the list of countries most vulnerable to climate change based on long-term trends of exposure and extreme events analyzed from 1990 to 2009 (Harmeling, 2011). Hazards associated with climate change can include increasing air and sea-surface temperatures, sea-level rise, more intense and frequent typhoons, changes in amount and pattern of rainfall, and ocean acidification. These, further combined with climate variability and non-climatic anthropogenic threats, can severely impact both natural and human coastal communities.

Table 1: Observed trends and projections of climate hazards in the Philippines

CLIMATE HAZARD	OBSERVED TRENDS	PROJECTIONS
Increasing air temperature	In the Philippines, the 1990s were the warmest years recorded for the century, with 1998 being the warmest (Hulme and Sheard, 1999).	► The Philippines is expected to be warmer in the 21st century (Castillo and Villarin, unpublished, as cited by Capili et al., 2005) and beyond, but will warm more slowly than the global average (Hulme and Sheard, 1999). ► Temperatures may increase at a rate of 0.1 ° C to 0.3°C per decade, depending on the climate scenario (Hulme and Sheard, 1999).
Increasing sea-surface temperature	► For the period 1985-2006, warming rates around the Philippines were higher relative to other areas in the Coral Triangle (Peñaflor et al., 2009). Although the present state is clearly the result of past processes and events, the descriptors must be easily quantifiable, preferably by visual inspection by non-specialists. Those that require inferences about trends or involve detailed quantitative techniques are avoided (e.g. transects and quadrats). ► Northern portions of the country appear to be highly susceptible to increased SST and warm faster than other areas. They have also been observed to experience more pronounced thermal stress during La Niña (Arceo et al., 2001, as cited by Capili et al., 2005; Peñaflor et al., 2009).	The Sulu Sea will continue to experience higher temperatures in the future. Particularly, the mean annual SST around the Tubbataha Reef may increase to a range of 1.5°C to 3.5°C by 2100 (Hulme and Sheard, 1999).
Increasing sea-surface temperature	► In the last two decades, the Verde Island Passage marine corridor has experienced an increase of 0.15-0.30°C per decade in SST. On the other hand, analysis of a longer time series (1900-2008) revealed a smaller increase at 0.06°C per decade. In addition, it was observed that embayed areas appeared to be particularly sensitive to prolonged extreme heating events (Boquiren, di Carlo, and Quibilan, 2010). ► The mass coral bleaching events of 1998 and 2010 resulted in great ecological and economic damage. A significant decline of nearly 46% was observed for live coral cover after the 1998 bleaching (Capili et al., 2005). In addition, the event significantly affected revenue in areas like El Nido, Palawan where coral reefs are considered tourist attractions (Cesar, 2000). ► The recurrence of toxic algal blooms in Manila Bay (Capili et al., 2005) and the bleaching of giant clams in land-based nurseries in Bolinao, Pangasinan (Gomez and Licuanan, 2004, as cited by Capili et al., 2005) are other effects that have been associated with elevated SSTs.	
Sea-level rise	Observations from Global Sea Level Observing System (GLOSS) sites in Manila and Legaspi show a slight increase in relative sea-level prior to the 1960s and a faster increase (between 0.2 m to 0.4 m) in more recent years to the present. Although other factors like land reclamation and possible ground subsidence exist, there is still a residual rise in sea-level around the Philippines attributed to climate change effects (Hulme and Sheard, 1999).	► A rise in sea-level of 1.0 m, anticipated by the year 2080 given a high emissions scenario, would regularly inundate 5,000 ha of the Manila Bay area, affecting about 2.5 million people in three provinces, Manila, Bulacan, and Cavite. Even a 0.3 m rise in sea-level, expected around 2045 under a moderate emissions scenario, would impact over 2,000 ha and 0.5 million people (Perez et al., 1999 and Hulme and Sheard, 1999). ► Sea-level rise can accelerate beach erosion, which can be damaging to coastal areas, especially Eastern Philippines. This and other effects such as saltwater intrusion are expected to be more pronounced in low-lying small islands like Pag-asa Island and the Kalayaan Island Group (Capili et al., 2005).

Changes in amount and pattern of rainfall	▶ Annual rainfall has decreased by approximately 6% in the last hundred years, the drying most apparent during December to February. On the other hand, the wet season from June to August has gotten wetter (Hulme and Sheard, 1999). ▶ Mindanao is generally receiving more precipitation. Rainfall patterns are also changing where the most significant increase has been observed in the northeast while the decrease is more notable in the south central areas. Croplands and freshwater resources may be affected by such changes, with greater effects in the south central areas (Villarin and Avila, 2006).	Precipitation will increase in the future, with seasonal differences: the dry season (December to February and March to May) will become drier, and the wet season (June to August and September to November) will become wetter. If considering a business-as-usual, high emissions scenario, a 20% change in rainfall is expected by the 2050s (Hulme and Sheard, 1999).
Ocean acidification	No available information for the Philippines yet.	No available information for the Philippines yet.

The potentially extensive and overwhelming effects of climate change call for an integrated and urgent response. National initiatives are described in the National Framework Strategy on Climate Change (2010) and the National Climate Change Action Plan (NCCAP; 2011). The Coral Triangle Initiative (CTI) provides regional support, and relates to country efforts through the National Plan of Action (NPOA; 2009).

Preparing strategic actions or adapting to climate change is an "adaptive and iterative process" (USAID, 2009) that is initiated by vulnerability assessment (VA) or the process of evaluating the susceptibility of a system or specific attributes to climate hazards. Several VA tools are available and a few have been introduced to local governments in the Philippines (Tiquio, 2010). Yet many of them are data-intensive, limiting their use to large governance scales (e.g., regional or national) and areas that have received considerable research.

This Guidebook presents a suite of VA tools that have been developed to address these gaps. They are intended purposely for coastal systems, and are best for measuring vulnerability in a local setting. Designed to be useful and informative for local governments, these Coastal VA Tools aim to uphold the following features:

- ▶ **Able to evaluate vulnerabilities at finer scales, e.g. at the barangay-level, to be useful in municipal planning for appropriate and site-specific adaptation measures**
- ▶ **Make extensive use of commonly collected and available data in coastal municipalities or cities to minimize additional costs**
- ▶ **Participatory and straightforward, so communities are able to understand how results are obtained (Such transparency is important, especially when introducing proposed adaptation measures into a community.)**

2. HOW WERE THE TOOLS DEVELOPED?

The Coastal VA Tools were developed by more than fifteen (15) Philippine marine scientists with a broad range of specializations, including oceanography, geology, marine biology and ecology, fisheries, and coastal resources management. They have undergone several iterations to incorporate various refinements, including those from consultations with other scientists, fishers, local communities, Local Government Units, National Government Agencies, and non-government organizations. The tools as they are described in this Guidebook are their most recent versions. However, they are dynamic and will continue to transform as new science on climate change impacts, vulnerability, adaptation, and resilience emerges. Updates to the tools will be released in succeeding editions of the Guidebook, or if available, in other communications on the individual tools themselves.

3. WHO CAN USE THE COASTAL VA TOOLS?

The Coastal VA Tools were designed for coastal managers and site-level practitioners, including those from subnational to local government (e.g. provincial to barangay), the community, National Government Agencies, development groups, assisting academic and research institutions, and non-government organizations. Vulnerability assessment, as an integrative and participatory undertaking, is best achieved with input from all these various groups.

Experts in the fields of marine biology and ecology, fisheries, coastal geology, oceanography, and/ or coastal resources management can provide technical assistance. Further, training on use of the tools can facilitate correct and appropriate application, as well as enhance the user experience.

The Coastal VA Tool suite at a glance

Tool Name:	COASTAL VA TOOLS
Version:	1.0
Number of tools:	3
Tool name/s:	1. Integrated Coastal Sensitivity, Exposure and Adaptive Capacity to Climate Change Vulnerability Assessment Tool or ICSEA-C-Change (Chapter 4) 2. Coastal Integrity Vulnerability Assessment Tool or CIVAT (Chapter 5) 3. Tool for Understanding Resiliency of Fisheries or TURF (Chapter 6)
Scale:	Barangay or village
Scope:	▶ Coastal ▶ Biophysical, with some socio-economic components ▶ Quantitative to semi-quantitative
Description:	The Coastal VA Tools have been developed to provide guidance in coastal climate change adaptation planning by measuring the vulnerability of coastal systems to a variety of climate-related hazards. The tools support ecosystems-based thinking, regarding coastal and marine habitats in terms of processes, connectivity, and the ecosystem services they provide.
Ecosystem services assessed:	▶ Coastal integrity ▶ Fisheries *Biodiversity as an embedded component
Climate hazards considered:	▶ Sea-level rise ▶ Waves and storm surge ▶ Sea-surface temperature ▶ Rainfall
Data needs:	Primary and secondary data
Technical needs:	May be applied by coastal managers and field practitioners, with assistance from marine scientists whose specializations may include oceanography, marine ecology, coastal geology, fisheries, and CRM. Best if intended users receive training on correct and appropriate application of the tools. (e.g. Climate Change Adaptation for Coastal Communities courses facilitated by the Philippine Coastal Learning Adaptation Network)

4. OVERVIEW OF THE COASTAL VA TOOLS

The first tool called the *Integrated Coastal Sensitivity, Exposure, and Adaptive Capacity to Climate Change VA Tool* or *ICSEA-C-Change* offers a scoping and rapid reconnaissance of the vulnerabilities of integrated ecosystem services to synergistic climate change impacts. It adopts a relative scoring system, which allows users to generate a vulnerability ranking for several simultaneously assessed sites. The present version of ICSEA-C-Change considers sea level rise, waves and storm surges, sea surface temperature, and rainfall as exposure factors vis-à-vis fisheries and coastal integrity functions of the coastal and marine ecosystem. The tool is readily usable because most of the needed data inputs may be found in previous research and resource evaluations, including the assortment of municipal and provincial development plans and participatory coastal resource assessments (PCRA). In centralizing various information sources, it also helps evaluate available data for finer and more detailed vulnerability assessments pertaining to fisheries and/ or coastal integrity.

The second tool, the *Coastal Integrity VA Tool* or *CIVAT*, measures the vulnerability of the physical coast by analyzing natural and anthropogenic factors driving beach processes. The third, referred to as the *Tool for Understanding Fisheries Resilience* or *TURF*, analyzes the vulnerability of fisheries by incorporating variables from three major components, which are fisheries, reef habitat, and socio-economic conditions. Compared to the ICSEA-C-Change, CIVAT and TURF yield more detailed vulnerability assessments and require additional information not usually collected in rapid resource and socio-economic assessments. Gathering the supplementary data will likely entail additional field surveys and specific, but relatively simple, monitoring protocols. The latter can easily be applied by local stakeholders after a brief orientation and training. However, because of the improved resolution, more specific areas of concern are identified and there is better guidance when selecting appropriate responses. These proposed adaptation strategies, when further processed in a prioritization exercise, can then be incorporated into climate change adaptation or action plans.

Table 2: General comparative description of the Coastal VA Tools

TOOL	Scale	Scope	Resolution of analysis	Scoring system	Additional technical expertise		Climate change impacts considered	Is the assessment participatory?	Can you use the results to directly inform selection of specific adaptation options?	Other unique features
ICSEA-C-Change ***Integrated Coastal Sensitivity, Exposure, and Adaptive Capacity to Climate Change VA Tool***	Barangay	Integrated, i.e. biodiversity, coastal integrity, fisheries Biophysical	Coarse (Low)	Relative scoring	Only some technical assistance needed for data interpretation		Sea-level rise Waves and storm surges Sea-surface temperature Rainfall	Yes	No	Provides rapid scoping and reconnaissance Able to compare sites according to their relative vulnerabilities Able to determine which thematic areas – biodiversity, coastal integrity, fisheries – are especially vulnerable and require deeper review Centralizes information and evaluates data available for CIVAT and TURF
CIVAT ***Coastal Integrity VA Tool***	Barangay	Coastal integrity Biophysical	Fine (High)	Absolute values Relative scoring (to some degree	Coastal geologist to assist in data analysis and guide data collection		Sea-level rise Waves	Yes	Yes	Incorporates natural habitats in assessment of physical coastAble to compare sites according to their relative vulnerabilities Considers natural and anthropogenic factors driving physical coastal processes
TURF ***Tool for Understanding Resiliency of Fisheries***	Barangay	Fisheries Biophysical, with a socio-economic component	Fine (High)	Absolute values Relative scoring (to some degree	Fisheries expert to assist in data analysis and guide data collection		Waves and storm surges Sea-surface temperature	Yes	Yes	Incorporates socio-economic variables

5. HOW TO USE THE GUIDEBOOK

Vulnerability Assessment Tools for Coastal Ecosystems: A Guidebook is a practical users' manual for the Coastal VA Tools, intended to assist coastal managers and site-level practitioners in conducting robust, science-based vulnerability assessment towards the development of suitable, site-specific strategies to address climate change effects. Readers will find the following information in this Guidebook:

Chapter 2: VA process guide. This chapter is a general process guide for vulnerability assessment using the Coastal VA Tools. It contains a list of needs for coastal climate change VA, and an overview of the process for applying the tools. The discussion also contains an initial introduction to the individual tools.

Chapter 3: Exposure – Waves and storm surges. This chapter describes the physical environment conditions that drive changes in the state of the biophysical system. The discussion focuses on those conditions resulting from climate changes, including waves and storm surge. Further, the chapter introduces the Wave Exposure Model or WEMo, which can estimate the wave exposure of a given site by using inputs on wind effects, local topography and bathymetry.

Chapter 4: Integrated Coastal Sensitivity, Exposure, and Adaptive Capacity to Climate Change. The ICSEA-C-Change, a tool for broad and rapid assessment of climate change vulnerabilities, is described in this chapter. The discussion includes important reminders when using the tool; an operational framework; criteria used to evaluate vulnerability; and the procedure of arriving at a vulnerability score.

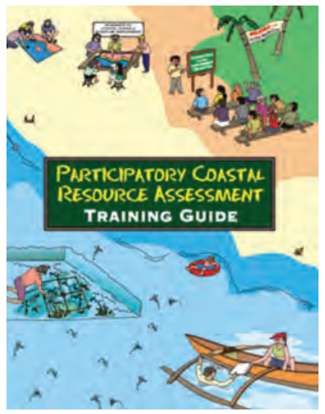
Chapter 5: Coastal Integrity Vulnerability Assessment Tool. This chapter provides instruction on CIVAT, a tool to assess the vulnerability of the physical coast to erosion and inundation resulting from wave impact and sea-level changes. Content includes the scope and limitations of the tool; criteria used to assess vulnerability; unique tool features; the method for analyzing the criteria and obtaining a measurement of vulnerability; and a case study.

Chapter 6: Tool for Understanding Resilience of Fisheries. This chapter discusses TURF, a tool used to measure the vulnerability of fisheries to climate change-related hazards. It contains the rationale for the tool; incorporated variables and their descriptions; and the procedure for analysis and interpretation of results.

Chapter 7: Linking VA to adaptation. The final chapter illustrates how VA results input into climate change adaptation planning. It also presents a suite of adaptation options, and a method to prioritize these actions for more effective and coordinated implementation.

This Guidebook draws all of its case studies from sites and experiences in the Philippines. The variables incorporated in the tools are applicable in any tropical coastal setting, but the scoring thresholds need to be modified to accommodate conditions in other countries.

Accompanying References



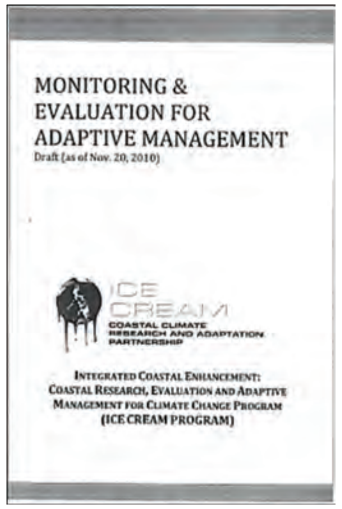
Participatory Coastal Resource Assessment Training Guide, 2004, 134 pp.
Deguit, E.T., R.P. Smith, W.P. Jatulan and A.T. White, Coastal Resource Management Project of the Department of Environment and Natural Resources, Cebu City, Philippines

This guide provides instruction on how to teach Participatory Coastal Resource Assessment. Content includes an introduction to the coastal and existing human impacts; various methods for PCRA; and ways to suitably organize resulting data into a coastal environment profile.

Available for download in:
http://oneocean.org/download/db_files/pcra_training_guide.pdf.

Coral Reef Monitoring for Management Manual, 2nd Edition, 2010, 122 pp.
Uychiaoco, A.J., S.J. Green, M.T. dela Cruz, P.A. Gaite, H.O. Arceo, P.M. Aliño, and A.T. White. University of the Philippines Marine Science Institute, United Nations Development Programme Global Environment Facility- Small Grants Program, Guiuan Development Foundation, Inc., Voluntary Service Overseas, University of the Philippines Center for Integration and Development Studies, Coastal Resource Management Project, Philippine Environmental Governance Project 2, and Fisheries Resource Management Project

The manual provides guidelines on how to properly monitor coral reefs. It discusses essential features of corals; basic coral taxonomy; the value of monitoring reefs; relevant standard survey methods for coral reefs and algae, reef fish, invertebrates, and human activities and natural disturbances; and how to interpret such evaluations to inform management. Copies are available at the Coral Community Ecology Laboratory, UP Marine Science Institute and also available for download in:
http://www.oneocean.org/download/db_files/201001CoralReefMonitoringHandbook2ed.pdf



RESILIENT SEAS Monitoring and Evaluation for Adaptive Management Manual, in prep.
Remote Sensing Information for Living Environments and Nationwide Tools for SENTINEL Ecosystems in our Archipelagic Seas (then, ICE CREAM) Program, DOST-PCAARRD

Contact Person: Porfirio M. Aliño, PhD (pmalino@upmsi.ph)

Climate Change Adaptation training modules

The Coastal Learning Adaptation Network, a knowledge and training hub on vulnerability assessment and climate change adaptation, has been developing modules for CCA trainings and Trainings of Trainers (TOTs). Topics may include basic climate change concepts, vulnerability assessment methodologies, case studies, how to draft CCA action plans, and techniques for effective communication. Although these modules have already been used in previous trainings (e.g. 2nd CTI Regional CCA for Coastal Communities Course and Training of Trainers held in the Philippines on 31 January to February 9, 2012), there are plans to collect these modules into a training guide. In the meantime, for assistance in VA/ CCA trainings, interested individuals may get in touch with the CLAN (See Chapter 2, Box: "The Philippine Coastal Learning Adaptation Network").

Contact Person: Porfirio M. Aliño, PhD (pmalino@upmsi.ph)

6. REFERENCES

Anglo, E. G. (2005). Decadal Change in Tropical Cyclone Activity in the Western Pacific. *Okinawa Typhoon Center Forum*.

Boquiren, R., Di Carlo, G., & Quibilan, M. C. C. (Eds). (2010). Climate Change Vulnerability Assessment of the Verde Island Passage, Philippines. Technical Report. Conservation International, Arlington, Virginia, USA.

Capili, E. B., Ibay, A. C. S., & Villarin, J. R. T. (2005). Climate Change Impacts and Adaptation on Philippine Coasts. *Proceedings of OCEANS 2005 MTS/IEEE,* 1-8 September. doi:10.1109/OCEANS.2005.1640108

Cesar, H. (2000). Impacts of the 1998 Coral Bleaching Event on Tourism in El Nido, Philippines. U.S. Department of State, East Asia and Pacific Environmental Initiative (US-EAP-EI)/ Coastal Resources Center, University of Rhode Island: Narragansett, Rhode Island, 21pp.

Harmeling, Sven (2011). Global Climate Risk Index: Who Suffers Most from Extreme Weather Events? Weather-related Loss Events in 2009 and 1990 to 2009. Briefing Paper. Germanwatch.

Hulme, M., & Sheard, N. (1999). Climate Change Scenarios for the Philippines. Climatic Research Unit: Norwich, UK.

National Climate Change Action Plan, 2011-2028, Climate Change Commission, Office of the President of the Philippines

National Framework Strategy on Climate Change 2010-2022, Climate Change Commission, Office of the President of the Philippines

National Programme of Action for the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security, 2009, National CTI Coordinating Committee

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*. doi:10.1007/s00338-009-0522-8

Perez, R., Amadore, L., & Feir, R. (1999). Climate change impacts and responses in the Philippines coastal sector. *Climate Research*, 12(2), 97-107. doi:10.3354/cr012097

Tiquio, Ma. Gregoria Joanne. (2010). Review of Vulnerability Assessment Approaches and Methods. Conservation International – Philippines: Quezon City, Philippines.

U.S. Agency for International Development (USAID). (2009). Adapting to Coastal Climate Change: A Guidebook for Development Planners, http://www.usaid.gov/our_work/environment/climate/policies_prog/vulnerability.html or http://www.crc.uri.edu/download/CoastalAdaptationGuide.pdf

Villarin, J. R. T., and Avila, F. B. (2006). Is climate changing in Mindanao? *Agham Mindanaw,* 3, 1-12.

World Development Indicators, 2005, The World Bank


JÜRGEN FREUND


JÜRGEN FREUND

2 Assessing Vulnerabilities: General Process Guide

Rollan C. Geronimo[1]
Miledel Christine C. Quibilan[2]
Noreen Marie G. Follosco[2,3]
[1] Conservation International – Philippines
[2] Marine Environment and Resources, Inc.
[3] Institute of Environmental Science and Meteorology, University of the Philippines

Vulnerability assessment is not a one-time evaluation. It must be incorporated into the broader framework of Climate Change Adaptation and Integrated Coastal Management where its results are used extensively for guiding plans and policies.

1. DEFINING VULNERABILITY

The Intergovernmental Panel on Climate Change (IPCC; 2001) defines Vulnerability as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes." It is a function of (1) the degree of the system's Exposure to climate hazards; (2) its Sensitivity to such hazards; and (3) its Adaptive Capacity (IPCC, 2001). Sensitivity and Exposure may be taken together to yield Potential Impact (Allison et al., 2009). The relationship among these three components is illustrated in **Figure 1**.

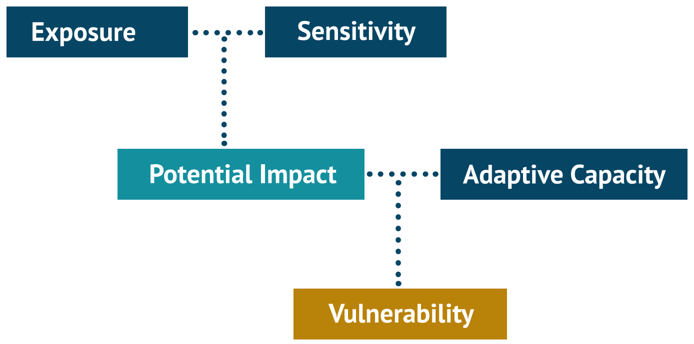


Figure 1: Vulnerability as a function of Exposure, Sensitivity, and Adaptive Capacity

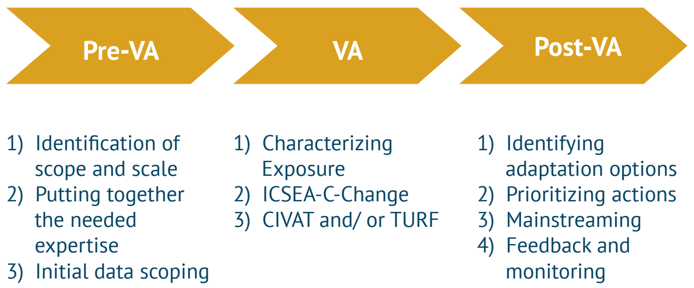
As far as the tools in this Guidebook are concerned, the three components are defined as follows: (1) Exposure quantifies the intensity or severity of physical environment conditions driving changes in the present state of the biophysical system; (2) Sensitivity describes the present state of the system, regarding specific properties that respond to Exposure factors arising from climate changes; (3) Adaptive Capacity is the ability of the system to cope with impacts associated with changes in climate (See **Table 3**). The Vulnerability of a system to climate change impacts is measured by evaluating relevant factors associated with each of the three components.

2. PROCESS FLOW OF VULNERABILITY ASSESSMENT

The primary goal of climate change vulnerability assessment is to "[inform] the development of policies that reduce the risks associated with climate change." (Fussel and Klein, 2006). Methods to assess climate change vulnerability have been proposed as early as 1991 (IPCC Common Methodology), but have since evolved to incorporate advances and new understanding in climate and vulnerability science. For instance, more recent approaches integrate socio-economic and ecological factors; account for uncertainty and non-climatic variables; involve users in the actual assessment; and recommend adaptation options (Fussel and Klein, 2006). Vulnerability assessment uses the best available information, drawing from socio-economic and ecological research; local and traditional knowledge; expert opinion; understanding of the hazards and associated impacts, and development of realistic adaptive capacity; and disaster risk and hazards research (IDRC/ CCAA, 2007; Bizikova et al., 2009).

Vulnerability assessment with the Coastal VA Tools entails analysis of (1) the physical environment conditions driving changes in the biophysical system (Exposure); (2) the present condition of the system as it would respond to Exposure factors (Sensitivity); (3) and the processes affording the system its ability to cope with climate changes (Adaptive Capacity). Integration of these three components yields a measurement of Vulnerability. The tools focus largely on the biophysical aspect of coastal ecosystems. However, in evaluating natural processes underlying ecosystem services, they are able to ultimately link to the prospects of human communities.

Vulnerability assessment must be completed relatively quickly to provide timely guidance in local planning. The following steps are suggested to effectively and efficiently conduct a vulnerability assessment:



3. PRE-VULNERABILITY ASSESSMENT: WHAT DO I NEED TO INITIATE A COASTAL VA?

Making suitable preparations for the actual VA can help facilitate the process and produce better results. First, users must identify the scope and scale of their VA. Second, it is important to identify the individuals or groups that can provide the most relevant inputs prior to and during the assessment. Third, there is a need to determine what information is available and/ or readily accessible.

Table 3: Operational definitions of each Vulnerability component as they are applied in the Coastal VA Tools*

COMPONENT	OPERATIONAL DEFINITION
Exposure	▶ Measures that quantify the intensity or severity of physical environment conditions that drive changes in the state of the biophysical system ▶ Like Adaptive Capacity, projections of future state may be derived from the analyses of historical, long-term trends. ▶ Unlike Adaptive Capacity, Exposure measures may be projections of possible future conditions on which scenarios may be evaluated.
Sensitivity	▶ Measures that describe the system's present state for specific properties that respond to Exposure factors arising from changes in climate ▶ "Here and now" characteristics ▶ Although the present state is clearly the result of past processes and events, the descriptors must be easily quantifiable, preferably by visual inspection by non-specialists. Those that require inferences about trends or involve detailed quantitative techniques are avoided (e.g. transects and quadrats). ▶ Some descriptors are better quantified using specific instruments (e.g. maps) and methods (e.g. beach profiling).
Adaptive capacity	▶ Measures that characterize the ability of the system to cope with impacts associated with changes in climate ▶ Essentially, proxies quantifying processes that renew, replenish, or replace conditions described by Sensitivity variables ▶ Intrinsic characteristics or properties inherent to the biophysical realm, with particular focus on natural processes ▶ May be projections of future state inferred from trends seen in past states (e.g. changes in the position of the shoreline) ▶ In contrast to Sensitivity variables which describe state, Adaptive Capacity factors measure processes (e.g. recruitment potential through availability of reproductively mature individuals; long-term shoreline trends).

*These definitions were developed and refined over a series of workshops and interim meetings attended by the tool authors and consulting experts.

3.1. IDENTIFICATION OF SCOPE AND SCALE

The spatial unit of assessment is the coastal barangay. It is suggested that all coastal barangays in a municipality are rapidly assessed to gain an impression of vulnerabilities across sites, as well as which coastal aspects are especially distressing and need deeper review. Barangays whose vulnerabilities have been found to stem from coastal integrity and/ or fisheries issues are evaluated further. Biodiversity is assessed as an embedded component. Exposure factors considered in the tools are sea-level rise, waves and storm surge, sea-surface temperature, and rainfall.

3.2. PUTTING TOGETHER THE NEEDED EXPERTISE

The Coastal VA Tools are generally participatory in nature, welcoming inputs from technical and local knowledge, and ecological and socio-economic research. The number of people participating in the VA can change depending on the needs of the various stages, but it may be a good idea to assemble a core team to oversee the entire process. It is best for members of a vulnerability assessment team to have a complementary set of skills, fulfilling corresponding roles in (1) facilitation; (2) data collection and analysis; (3) data interpretation; and (4) communication of results.

Facilitating the VA process is usually a task for coastal managers who have been trained in the use of the Coastal VA Tools. These individuals can include members of local government (i.e. provincial to municipal), or technical personnel of development agencies, assisting academic and research institutions, or non-government organizations (e.g. CRM specialists). Roles can include engaging the VA team; consolidating initial and subsequent data; assisting in data interpretation; facilitating workshops and group discussions; leading the preparation of the VA report; and communicating results.

Local capacity can be strengthened for data collection and analysis, which can occur prior to and during the actual assessment. Individuals who have previously participated in PCRA or have been trained in habitat assessment can make valuable contributions. Technical persons, especially those specializing in coastal and marine ecology, fisheries, oceanography, coastal geology and CRM, can have roles in capacity-building activities and in guiding the actual data collection. They are also very prominent in the analysis stage, as well as later on for interpretation (linking VA to adaptation). Team members involved in data collection and analysis may have the following skills:

Field skills:

- Snorkeling or SCUBA diving
- Able to apply coral reef, mangrove, and seagrass monitoring techniques
- Can identify coral lifeforms (e.g. live vs. dead), and mangrove and seagrass species
- Can conduct fisheries surveys
- Can do beach monitoring methods
- Able to use a GPS

Desktop skills:

- Reading and estimating distances from topographic maps, nautical charts, satellite images, and other maps
- Able to use GIS software
- Is computer literate, basically being able to operate document and spreadsheet software (e.g., MS Word and Excel)

The Philippine Coastal Learning Adaptation Network (CLAN)

The Philippine Coastal Learning Adaptation Network or CLAN is a smarting system that aims to build on shared experiences and knowledge on:

- ✓ Vulnerability assessment (VA)
- ✓ Emerging VA methodologies
- ✓ Capacity needs assessments
- ✓ Developing appropriate adaptive management actions
- ✓ Mainstreaming coastal adaptation strategies in existing management plans and programs
- ✓ Development of coastal adaptation action plans
- ✓ Monitoring and evaluation

Through meetings and exchanges, the Philippine CLAN intends to promote greater interaction between academic institutions that can provide technical knowledge (i.e. the knowledge generators) and national government agencies and/or local communities who need it (i.e. knowledge recipients). It will also be an avenue for coastal managers and practitioners to share their insights and lessons learned while working on the field.

The Philippine CLAN is also a training hub, and may tap into a pool of core trainers to facilitate courses on vulnerability assessment, climate change adaptation planning, and even communications and training methods.

If you are interested in joining the CLAN, or need assistance for a VA/ CCA course, you may contact:

MILEDEL CHRISTINE C. QUIBILAN
Marine Science Institute, University of the Philippines Diliman
Quezon City 1101
Email: mcquibilan@gmail.com | Telefax: +632 433 1806

Source: "Initiating the CTI-CLAN," A project implemented by the Marine & Environment Resources Foundation (MERF) through the U.S. Agency for International Development (USAID), 2011-2012

3.3. INITIAL DATA SCOPING

The Coastal VA Tools are intended to allow users to utilize data commonly collected among local governments, National Government Agencies, and academic and research institutions. The information may be spread out across agencies and institutions, but it is likely that some or a great deal already exists. Vulnerability assessment provides an opportunity to centralize and compile this information. And if the data is not available after all, gaps are revealed and can be addressed immediately.

Secondary data may be consolidated earlier to be ready for validation and/ or interpretation in forthcoming workshop or focus-group discussions. On the other hand, one of the tools has the added benefit of scoping data useful for the other two. **Table 4** below provides a checklist of reports, plans and documents users can put together for the VA.

Table 4: Potential data sources for the Coastal VA Tools

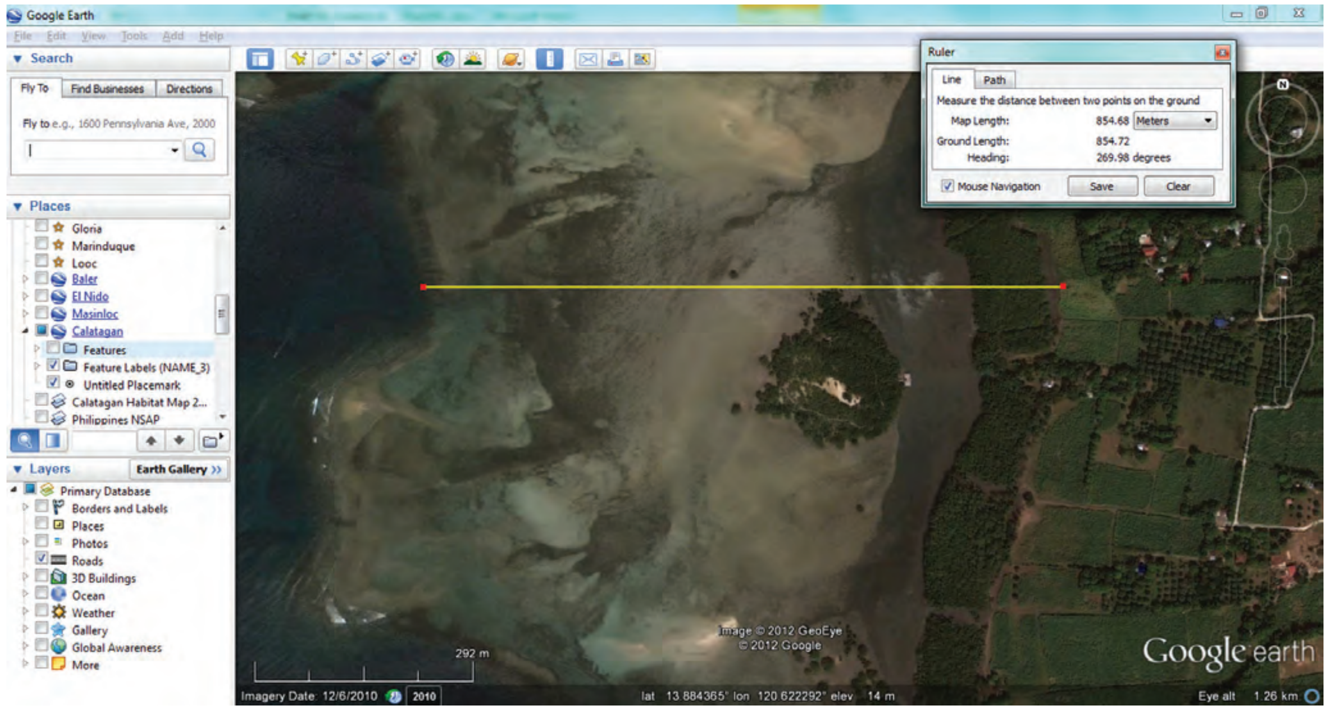
DATA SOURCE	Will this document address a data need in...		
	ICSEA-C-Change?	CIVAT?	TURF?
1. Topographical maps of sites	Yes	Yes	
2. Nautical charts of sites	Yes		
3. Bathymetric maps of sites		Yes	Yes
4. Information on state of coastal resources (including coral reefs, mangroves, seagrass, and fisheries; PCRA documents)	Yes	Yes	Yes
5. Site census data (population density per village, household size, etc.)	Yes	Yes	Yes
6. Site socio-economic profile (sources of income, location of settlements etc.)	Yes	Yes	Yes
7. Site fisheries profile (or related information from respective fisheries or aquatic resources agency; presence or status of fish ponds, if any)	Yes		Yes
8. Fisheries or resource use plans	Yes		
9. Site management plans	Yes	Yes	Yes
10. Land use or zoning plans	Yes	Yes	Yes
11. MPA Management Plan	Yes	Yes	Yes
12. Data on solid waste monitoring	Yes		
13. Data on water quality monitoring	Yes		
14. Information (or database access) on disasters (i.e. earthquakes and tsunamis)		Yes	
15. Coastal barangay/ district/ town (site) profile	Yes	Yes	Yes

Site visits to the areas of interest and talking to coastal residents are cost-effective ways of gathering information. At the minimum, assessors must have seen their sites when initiating a vulnerability assessment.

Google Earth

Google Earth is a free source of satellite images. It is a computer program that may be installed on a personal computer or accessed online. The installer can be downloaded from the following link: http://www.google.com/earth/explore/products/desktop.html.

At the minimum, users must have Internet access to be able to use Google Earth.



4. VULNERABILITY ASSESSMENT

Each of the three components – Exposure, Sensitivity and Adaptive Capacity – is necessary in obtaining a revealing measurement of Vulnerability. The Coastal VA Tools provide a means to objectively and quantitatively measure these elements.

The actual assessment is a combination of expert inputs and participatory efforts. For instance, measuring changes in sea-surface temperature or sea-level rise generally involves individuals with specialized skills while filling out the rubrics or matrices themselves can engage a mix of experts, managers, and local government and community members. The following discussion suggests steps to go about the actual assessment and contains important reminders on appropriate application of the tools.

4.1. CHARACTERIZING EXPOSURE

The Coastal VA Tools assess the vulnerability of coastal systems to different climate factors, including sea-level rise, sea-surface temperature, rainfall, and waves and storm surge. Although associated impacts are apparent and may be recounted through personal observations and/or anecdotal accounts, Exposure factors are most useful in vulnerability assessment and CCA planning if they are measured using actual scientific data.

Long-term data is used to analyze climate changes, as well as to generate projections. There have been studies to measure how sea-surface temperature has changed at the global to regional scale (Peñaflor et al., 2009). Similarly, regional assessments on sea-level rise and how it might potentially impact coastal systems have also been conducted (e.g. McLeod et al., 2010). Such research contributes to understanding the widespread effects of climate changes, and can provide guidance in broad-scale management.

However, the development of appropriate, site-specific adaptation strategies is dependent on vulnerability assessment conducted at finer scales. Likewise, evaluating Exposure factors must take into account local conditions and climate variability. Different sites are affected in a range of ways, given varying biological and physical configurations. Further, monsoonal variability and the tropical climate system ENSO can influence how climate changes impact an area. In the Philippines, current research to characterize local exposure has involved the analysis of physical factors such as sea-surface temperature, rainfall patterns, and sea-level changes (e.g. David et al.). On the other hand, local exposure to waves is being studied using models that incorporate wind effects, local topography and bathymetry (Villanoy et al.; See Chapter 3).

Although users of the Coastal VA Tools are not expected to collect and analyze Exposure data themselves, they are urged to remember that understanding climate and related physical processes is integral in determining potential impacts on a system. Presently, scientists are finding ways to make quantitative, data-based Exposure information freely available on shared media like the Internet. In the meantime, it is suggested that experts such as climate researchers or physical oceanographers be engaged to assist in the VA. In the Philippines, Exposure information already exists for some selected provinces such as Batangas, Cagayan and Ilocos Norte (Villanoy et al.; See Chapter 3, "Results: Exposure index maps").

The scoring matrices for the Coastal VA Tools evaluate variables relating to Sensitivity and Adaptive Capacity. Scores corresponding to Exposure factors are later integrated with these components to finally obtain Vulnerability.

4.2. INITIAL PROFILES WITH THE ICSEA-C-CHANGE

In practice, the ICSEA-C-Change is applied first to obtain initial Vulnerability profiles of several sites (e.g. all coastal barangays in a municipality). Results from the tool are able to guide next steps, prioritizing sites or coastal aspects that are especially vulnerable. Further, the ICSEA-C-Change is an effective communications tool, helping local communities better understand their immediate environment and how it (and they) might be affected by changes in climate.

The tool itself is a couple of rubrics with a list of variables relating either to the present **state** of the system (Sensitivity) or **processes** allowing the system to cope with climate-associated impacts (Adaptive Capacity). Users are to accomplish both rubrics with the guidance of thresholds or standards identified for each variable. Thresholds correspond to numerical scores, which translate to Low, Medium, or High. Each variable is scored based on best available data on the given site. A more thorough description of the tool is found in Chapter 4, but the following is a typical procedure for how one might go about facilitating ICSEA-C-Change:

a. **Scoring Exposure factors.** These are scored based on best available data, expert advice, or knowledge of long-time coastal residents.

b. **Filling out ICSEA-C-Change rubrics in a participatory setting.**

A workshop or focus-group discussion is convened (1) to validate initially gathered data and incorporate local knowledge and community inputs; and (2) to complete the Sensitivity and Adaptive Capacity rubrics. Organizing a VA workshop will necessitate a balanced selection of technical and management individuals, and bearing strong local or site representation. Participants may include:

Rubrics

A rubric is an assessment tool or scoring system for communicating expectations of quality. It comprises a list of criteria to base an assessment. The range of quality for each criterion is divided into an equal number of scores with clear descriptions of each score. Thus, it makes evaluations more objective.

Climate variability vs climate change

Climate Variability	Climate Change
Short-term (inter-annual, annual, seasonal) variations in climate standards and other known states (e.g. floods, prolonged droughts, and conditions resulting from intermittent El Niño and La Niña events)	Long-term (decades or longer) changes in climate means caused by either natural variability or human activity (e.g. global warming trends in the last century)

Modified from USAID, 2009; http://www.climatekelpie.com.au

- Long-time coastal residents from all coastal barangays;
- Technical personnel, experts, and/or scientists with first-hand knowledge of or data on coastal habitats, fisheries, and socioeconomics;
- Local government staff (e.g., from planning & development office, agriculture, fisheries, environment, and disaster risk reduction and management)

c. **Integration.** When Exposure, Sensitivity and Adaptive Capacity variables have been completely scored, the integrated Vulnerability values may then be calculated.

d. **Data scoping.** Available data sources are compiled and reviewed. Data gaps that need to be addressed for CIVAT and/or TURF are identified.

4.3. DETAILED ASSESSMENTS WITH CIVAT AND TURF

From ICSEA-C-Change to CIVAT and TURF. While the ICSEA-C-Change covers a broad, integrated scope, CIVAT and TURF provide more focused assessments that can guide the selection of specific adaptation measures. However, ICSEA-C-Change results, which highlight urgent needs and reveal available data (or data gaps, for that matter), are a valid starting point. Here, it should already be possible to identify which sites and coastal aspects of those sites need to be evaluated further. If it happens that Vulnerability is evidently the result of issues relating to the physical coast, CIVAT is the more appropriate tool. On the other hand, if Vulnerability appears to be caused by fisheries concerns, TURF is more suitably utilized. Still, both tools may be applied simultaneously in a site to maximize time and allocated resources.

Additional data needs. Typically, much of the information needed for either TURF or CIVAT should already be compiled in the ICSEA-C-Change. However, if there are data gaps, there may still be a need for field visits and additional survey assessments. Actually going to the site can be very helpful in filling out the missing information. Don't forget to SWWAT!

Filling out the tool rubrics. As in the ICSEA-C-Change, using CIVAT and TURF involves the evaluation of variables embedded in scoring rubrics or matrices. A unique feature of CIVAT is the incorporation of natural habitat criteria so that there is an additional set of rubrics to use in areas with detailed habitat information. For TURF, variables relating to fisheries, the reef habitat (ecosystem), and the socio-economic aspect are included so that the overall fisheries Vulnerability is an integration of the individual Vulnerabilities of these three elements.

CIVAT and TURF are also participatory tools, but experts and technical individuals can offer extremely useful inputs during the analyses and interpretation stages.

Arriving at a measurement of Vulnerability. In calculating the Vulnerability scores per coastal barangay with TURF and/or CIVAT, a cross-tabulation approach is used for both tools. Then again, it is also helpful to organize the raw scores in a table to pinpoint specific causes or sources of Vulnerability. For instance, it becomes possible to identify factors that promote a High Sensitivity or a Low Adaptive Capacity. In CCA planning, these factors are targeted for intervention.

> **SWWAT**
>
> **SWWAT: Snorkel, wade, walk, ask, and take pictures!**
>
> Even with limited resources, users can use the Coastal VA tools with simple, but reliable, equipment and methods. At the bare minimum, the VA Team must have seen the coastal areas of all coastal barangays. While there, you should:
>
> **Snorkel** to view and estimate coral reef habitat conditions;
>
> **Wade** in the seagrass and mangrove areas to get more habitat information
>
> **Walk** the coast to trace the shoreline with a GPS and conduct beach profiling
>
> **Ask** the fishers to get their perceptions on climate change "exposures", shoreline changes, and fisheries information;
>
> **Take** pictures to document features along the shore (e.g., cliffs, beaches, houses, piers/ports, seawalls, groins, and other structures).

> **Important reminders on the Coastal VA Tools**
>
> The Coastal VA Tools can yield the most informative results when they are used together as complements. It is best to first apply the ICSEA-C-Change for a broad and rapid assessment to determine which sites and key thematic areas are particularly concerning and/ or need further appraisal. It is also effective in scoping available information. CIVAT will then be used in sites where the physical coast is particularly compromised, whereas TURF will be applied in those sites where fisheries issues prevail. It is, of course, possible to use both in a single site.
>
> The rubrics or matrices must not be altered in any way. The variables embedded in the rubrics uphold a delicate balance of scientific rigor and ease of application. Removing or replacing any of these may produce erroneous results. It is advised that the rubrics are kept intact, and answered completely.

5. POST VULNERABILITY ASSESSMENT: WHAT CAN I DO WITH MY VA RESULTS?

Vulnerability assessment is only part of the greater process of CCA planning. Indeed, the ultimate objective of a VA is to be able to inform the development of appropriate adaptation strategies. Next steps following VA include the identification and prioritization of adaptation actions; mainstreaming these actions for implementation; and monitoring and feedback.

In the Guidebook, identification and prioritization of adaptation actions are discussed more thoroughly in the final chapter (See Chapter 7: Linking VA to Adaptation). Brief descriptions of mainstreaming and feedback and monitoring are provided below, but more information on these practices should be sought out in other references.

In the Guidebook, identification and prioritization of adaptation actions are discussed more thoroughly in the final chapter (See Chapter 7: Linking VA to Adaptation). Brief descriptions of mainstreaming and feedback and monitoring are provided below, but more information on these practices should be sought out in other references.

5.1. IDENTIFYING AND PRIORITIZING ACTIONS

Another workshop may be arranged (1) to present the VA results, first, for validation, and second, for interpretation; and (2) to discuss corresponding adaptation options. Participation may include experts and site-level managers, possibly with the addition of decision-makers.

Linking VA to adaptation. The relationships captured in the operative Vulnerability framework guide the interpretation of VA results towards the design and development of adaptation strategies. The level of Vulnerability varies depending on the degree of each of the three components and how they interact with one another. For example, High Sensitivity, High Exposure, and Low Adaptive Capacity are likely to result in High Vulnerability. On the other hand, High Sensitivity, High Exposure, and High Adaptive Capacity may indicate Moderate Vulnerability where some of the potential impact is offset by the great ability of the system to cope. In cases where the Potential Impact is Low and Adaptive Capacity is Moderate, Low to Moderate Vulnerability may be expected. Lowering Vulnerability through adaptation involves targeting problem areas in each component (revealed in the VA), that is, reducing Potential Impact and enhancing Adaptive Capacity.

Urgency and Competency. There is no panacea to climate change and its impacts, but there are numerous adaptation options available. Information from vulnerability assessment directs the selection of the most appropriate strategies. Prioritization of strategies involves determining (1) if they address an URGENT or important need; and (2) if there is COMPETENCY or capacity for implementation (See Chapter 7).

5.2. MAINSTREAMING – THE CLIMATE LENS

Mainstreaming is the process of "integrating climate concerns and adaptation responses into relevant policies, plans, programs, and projects at the national, sub-national, and local scales" (USAID, 2009). Adaptation actions are often enhancements to already existing initiatives. Groups and institutions with on-going conservation and resource management programs are encouraged to incorporate the climate aspect and continue leading the charge. For example, current practices in MPA management are being updated to incorporate principles of resilience.

5.3. FEEDBACK AND MONITORING

Because of the uncertainty characteristic of climate change predictions, it is very challenging to find suitable and cost-effective ways to address associated impacts. Vulnerability assessment reduces some of that uncertainty, consolidating the best available information to help decision-makers select appropriate strategies and efficiently allocate resources. Regular feedback and monitoring mechanisms allow coastal managers to observe the effects of interventions put in place. For instance, they provide a sense of whether or not (habitat) conditions in the site are improving, or if actions should be adjusted, amended or replaced. Long-term monitoring also contributes to the base of site data and information, which can be used in future analyses and assessments.

6. REFERENCES

Allison, E. H., Perry, A. L., Badjeck, M., Adger, W. N., Brown, K., Halls, A. S., Pilling, G. M., et al. (2009). Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries*. 10: 173-196.

Bizikova L, Bellali J, Habtezion Z, Diakhite M, Pinter L (2009) UNEP IEA Training Manual Volume 2: Vulnerability and impact assessments for Adaptation to Climate Change (VIA Module) David, Laura T., et al.

Füssel, H.-M., & Klein, R. J. (2006). Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking. *Climatic Change*, 75(3), 301-329.

IDRC/CCAA. (2007) IDRC/CCAA Capacity Building Workshop on Integrated Climate Risk Assessment: Workshop Training Manual

"Initiating the CTI-CLAN," A project implemented by the Marine & Environment Resources Foundation (MERF) through the U.S. Agency for International Development (USAID), 2011-2012

Intergovernmental Panel on Climate Change. (2001). Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

IPCC CZMS. (1992). A common methodology for assessing vulnerability to sea-level rise. 2nd revision, In: Global Climate Change and the Rising Challenge of the Sea. IPCC CZMS. Ministry of Transport, Public Works and Water Management, The Hague, The Netherlands, Appendix C.

Mcleod, E., Hinkel, J., Vafeidis, A. T., Nicholls, R. J., Harvey, N., & Salm, R. (2010). Sea-level rise vulnerability in the countries of the Coral Triangle. *Sustainability Science*, 5(2), 207-222.

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.

U.S. Agency for International Development (USAID). (2009). Adapting to Coastal Climate Change: A Guidebook for Development Planners,

http://www.usaid.gov/our_work/environment/climate/policies_prog/vulnerability.html
or
http://www.crc.uri.edu/download/CoastalAdaptationGuide.pdf

CI PHILIPPINES

JÜRGEN FREUND

3

Exposure: Waves and Storm Surges

Cesar L. Villanoy[1]*
Erlinda Salamante[2]
Olivia Cabrera[2]

[1]Marine Science Institute, University of the Philippines
[2]Marine Environment and Resources Foundation, Inc.

* c.villanoy@gmail.com

Exposure quantitatively describes the intensity or severity of the conditions of the physical environment, which drive changes in the state or condition of bio-physical systems. Like Adaptive Capacity, these projections of future state can be derived from the analyses of past trends. Unlike Adaptive Capacity, however, Exposure may be projection values, which can input into the analyses of different climate scenarios.

1. INTRODUCTION

Exposure to waves and rising sea levels is one of the impacts of climate change expected to affect low-lying coastal areas. Increasing global temperatures due to rising concentrations of greenhouse gases are driving changes in the abiotic environment. The melting of polar icecaps and thermal expansion has resulted in sea-level rise while stronger atmospheric pressure gradients are leading to stronger winds and changes in storm frequency and intensity patterns (**Figure 2**). These effects are expected to increase in the future as warming trends are expected to accelerate (IPCC 2001).

2. WAVE DYNAMICS

The waves on the surface of the ocean are predominantly generated by the wind. In the open ocean, the height of the wave is a function of wind speed, wind duration (period of time that the wind has blown over a given area), and wave fetch (distance of open sea that the wind has blown over for a given direction). Wave height increases with increasing wind speeds, wind duration and fetch. Predicting wave heights can be complicated because of limited knowledge about wave interactions and momentum fluxes from the wind to the water.

In a developing sea, simple models of wave evolution have been used to create plots that demonstrate the relationships among significant wave height (Hs), wave period (Ps), wind speed, wind duration and fetch (similar to the plot shown in **Figure 3**). For many decades, mariners have relied on the Beaufort Scale to estimate wind speeds based on sea state conditions. The Beaufort Scale was developed by Admiral Sir Francis Beaufort of the British Navy in 1805, which was nearly two centuries ago. However, its estimates are close to predictions of more sophisticated models. A version of the scale is shown in **Figure 4**. The scale assumes a fully developed sea in the open ocean with unlimited fetch.

As waves enter into shallow water, wave height may increase due to shoaling. This is a consequence of the decreased propagation velocity of the wave in shallow water and the need to maintain a constant wave energy

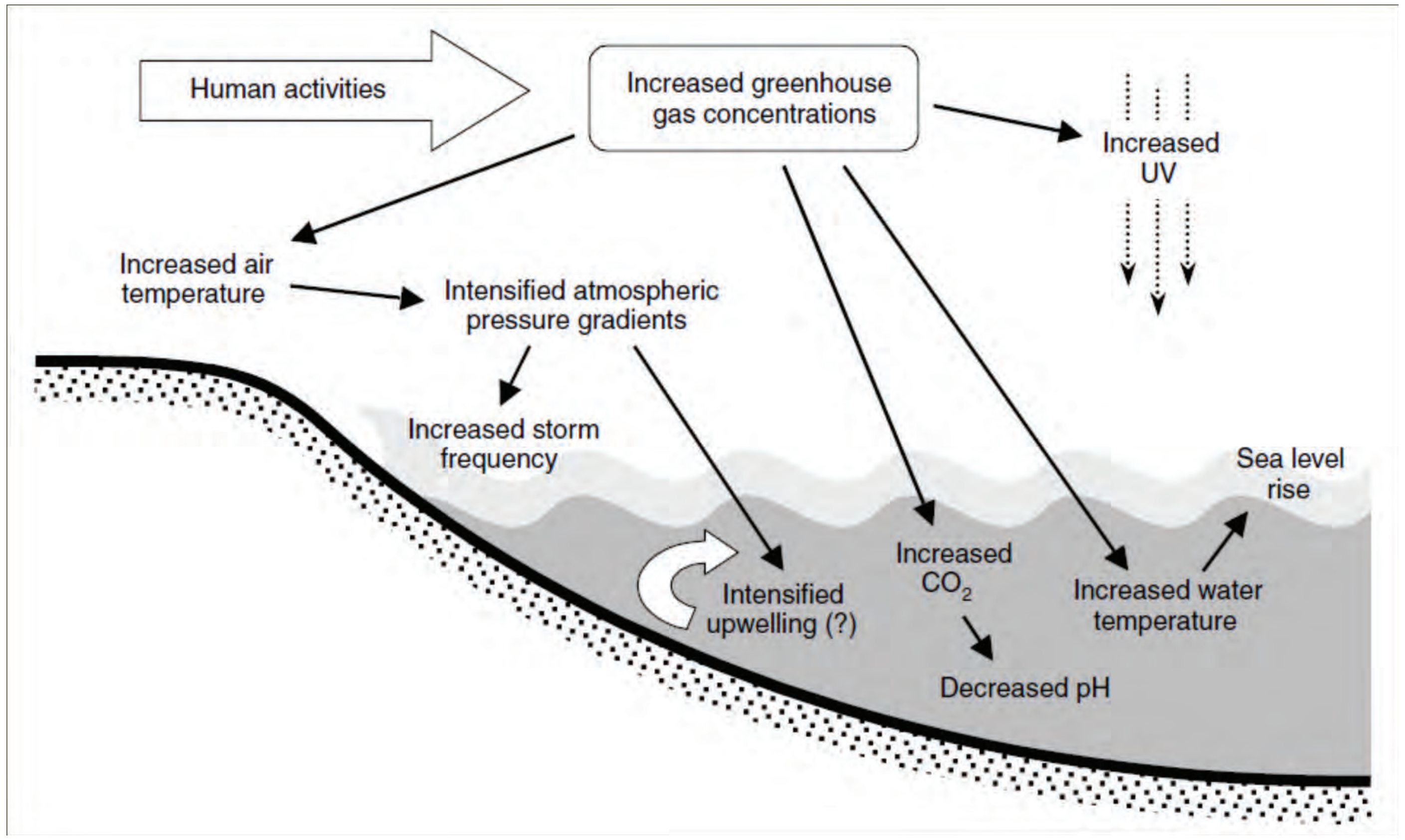


Figure 2: Important abiotic changes associated with climate change (from Harley et al. 2006)

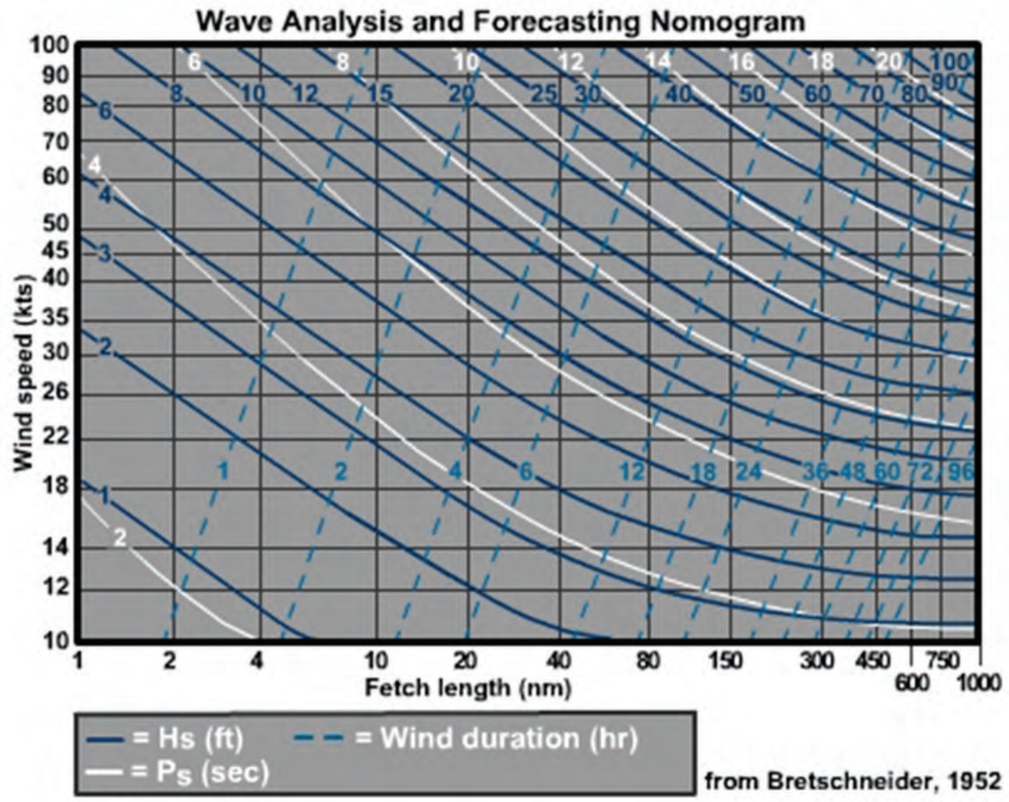


Figure 3: Wave analysis and forecasting nomogram (from Bretschneider, 1952)
Image URL: http://www.meted.ucar.edu/oceans/nearshore_wave_models/media/graphics/nomogram.jpg

flux. Thus, a slower wave will have to have a higher energy density which translates to a higher wave height. This adds to the steepness of the wave and as the depth becomes shallower, the wave amplitudes increase until it reaches a critical point where the wave energy is converted into turbulent kinetic energy and eventually dissipated.

3. IMPORTANCE

Waves are very efficient in transporting energy over very large distances so when waves break at the shore, energy accumulated from the wind over this distance is suddenly released in a very narrow zone along the shoreline. Over a period of time, this energy can transform coastlines, carve up rock, shift beaches and destroy man-made structures. The wave energy flux per unit width of the wave front is given by an equation that incorporates wave energy flux, wave height, wave period, water density, and gravitational acceleration.

$$P = \frac{\rho g^2}{64\pi} H^2 T \approx \left(0.5 \frac{\mathrm{kW}}{\mathrm{m}^3 \cdot \mathrm{s}}\right) H^2 T$$

Equation 1: Wave Energy Flux

Where P is the wave energy flux, H is the wave height, T is the wave period, ρ is water density and g is gravitational acceleration. For a wave height of 1m and a wave period of 3 seconds, the wave energy flux is about 1.5kW per meter of coastline. Waves due to storm events may have heights of about 10m lasting for periods of about 9 seconds. These can yield nearly 440kW/m of coastline. Such large amounts of wave energy dispelled along the coast can cause serious damage, especially on structures inappropriately situated within these wave dissipation zones.

Shifting atmospheric circulation patterns and storm frequencies can lead to changes in long term wave exposure in certain areas along the coast. The highly variable nature of storms makes it difficult to predict future storm frequency and intensity changes due to climate change. Very limited studies based on analysis of storm track data for the past 50-60 years show shifts in genesis, tracks and frequencies in relation to ENSO and with large scale atmospheric oscillations at decadal timescales (Wada and Chan, 2008; Bengtsson et al, 2006; Ho et al, 2004; Walsh, 2004).

4. METHODOLOGY

In quantifying the exposure of the Philippines to waves for use in vulnerability assessment, data on the characteristics of waves reaching our coast is a primary need. However, actual data from measurements by wave gauges are sparse to non-existent. Other methods must be employed to be able to estimate either wave heights or periods, or wave energy. Satellite-based altimetry has been used to make global maps of significant wave heights but numerical models are much more commonly used to simulate the evolution of wind-generated waves in an area.

Today, there are several available models for wave simulation that vary in sophistication and complexity. These models are basically mathematical approximations based on the physics of wave generation by wind and wave propagation and/or dissipation given by bottom or topographic effects. Depending on their computational capability, models may or may not take into account certain variables, including dissipation by whitecapping, refraction, breaking, and non-linear wave-wave interactions.

CI PHILIPPINES

4.1. WAVE EXPOSURE MODEL (WEMO)

One model currently available is the Wave Exposure Model or WEMo. It was developed by the US National Centers for Coastal Ocean Service (NCOOS) as a simple hydrodynamic model that estimates the wave exposure of a site. It incorporates the effects of wind, local topography, and bathymetry (Malhotra and Fonseca, 2007). It is a user-friendly model interfaced with ArcGIS™ 9.3 or higher, and is specially designed for ecologists and coastal managers not necessarily specialized in oceanography.

WEMo has two distinct modes: Representative Wave Energy (RWE) mode and Relative wave Exposure Index (REI) mode. RWE mode estimates wave energy while REI is a unitless index integrated from the effect of wind, fetch, and bottom depth. REI mode was deemed sufficient for use in vulnerability assessment (which only needs L, M, H criteria), so only REI will be discussed here.

The Relative Exposure Index is computed using the following equation:

$$\mathrm{REI} = \left(\sum_{i=1}^{8} EffF_i \ V_i \ D_i \} \right) / 8$$

Equation 2: Relative Exposure Index

where $EffF_i$ is the effective fetch for the i[th] direction, V_i is the wind speed for the i[th] direction and D_i is the wind duration for the i[th] direction.

Stated simply, the REI of a site is the sum of the effect of **fetch**, **speed** and **frequency** of wind at 8 directions (N, NE, E, SE, S, SW, W, and NW). Fetch is defined as the uninterrupted distance from the site to land along a given direction. To determine the effective fetch, the model first creates rays from a site and clips them to the nearest shoreline, accounting for how 'open' or exposed the site is to a given wind direction. Thus the farther the nearest coast is to a given site along a particular direction, the greater the fetch. Similarly, the farther the nearest coast is to a given site, the larger the fetch at the site is. In this study, the maximum fetch distance was set to 10km (also the default for WEMo) since empirical experimentation has shown that 10km was sufficient to generate a maximum wave height effect for coastal systems. The model then incorporates the depth at the end of the clipped line in the effective fetch by prescribing (1) an inverse distance power function (the nearer an area of shallow water is to a given point, the greater its damping effect on waves) and (2) a power function for wind speed at the site, (the greater the wind speed, the less the effect of the bathymetry on the REI). With these functions, the effective fetch thus accounts for the coastline configuration and the bathymetry at a given site. The effective fetch per ray is then multiplied with the speed and frequency of wind at the given direction and the sum of all rays is the relative exposure index.

For wind data, associated wind speed and frequency at each effective ray is determined where frequency is defined as the ratio of the number of hours (or days) the wind blows from the ray direction to the total number of hours (or days) the wind data was obtained. Wind speed may be the mean or modal frequency of speed measured, or even the maximum speed attained, at the given ray direction. Given a wind dataset for a site, it becomes possible to determine the dominant ray direction from which the wind blows in the area. If it happens that the dominant wind blows from a particular ray direction and the site has large fetch for that direction, (i.e., no landmass blocking the site), then the REI is higher.

Computing REI with WEMO

Step 1. Determine effective fetch (the uninterrupted distance from the site to land along a given direction)

Step 2. Consider coastline configuration and bathymetry for effective fetch

Step 3. Multiply effective fetch per ray with wind speed and wind frequency for each direction

Where:

- Wind speed = mean or mode of speed measured at the given ray direction; or maximum speed attained at the given ray direction
- Wind frequency = number of hours (or days) the wind blows from the ray direction/ total number of hours (or days) of wind data

Step 4. Add the product values of all rays to obtain the Relative Exposure Index

4.2. DATA INPUTS

The most important part of running WEMo is assembling the input data. However, it is also the most tedious part. Although finer resolution (both spatial and temporal) datasets are desired for increased precision, they slow down processing time. To fully illustrate the use of WEMo in generating exposure maps, Calatagan, Batangas was chosen as a demonstration site.

Data needs for WEMO
- ✓ Bathymetry
- ✓ Coastline maps
- ✓ Long-term wind data (mean speed and frequency for different angles)
- ✓ Points of analysis

4.3. WIND DATA

The national weather bureau PAGASA has at most 60 weather monitoring stations, and not all of them have wind data appropriate for WEMo use. Satellite altimeter-derived wind was thus used for this endeavor. NASA's Quick scatterometer or QuikSCAT (Lungu, 2001) provided estimates of wind speed and direction for the whole earth at 0.25° spatial resolution (~25 km at the equator) once to twice-daily starting July 20, 1999 until November 19, 2009. Using this dataset, the monsoonal influence on the wind pattern of the Philippines is clearly resolved and topographically induced variability is observed (**Figure 5**). The demonstration site Calatagan was shown to be dominated by 'amihan' or northeasterly winds that blow from November to April and 'habagat' or southwesterly winds from June to September (**Figure 6**). The 10-yr daily QuikSCAT wind data was then analyzed to generate frequency and mean speeds at 8 ray directions.

4.4. SHORELINE

Shoreline datasets for use in WEMo should be as detailed as possible with islands and promontories depicted because they are necessary for fetch ray clipping. The Philippine coastline was extracted from the World Coastline available in the NOAA coastline extractor website (http://www.ngdc.noaa.gov/mgg/coast/). This dataset has a 1:5,000,000 resolution and was exported in ArcGIS shape format.

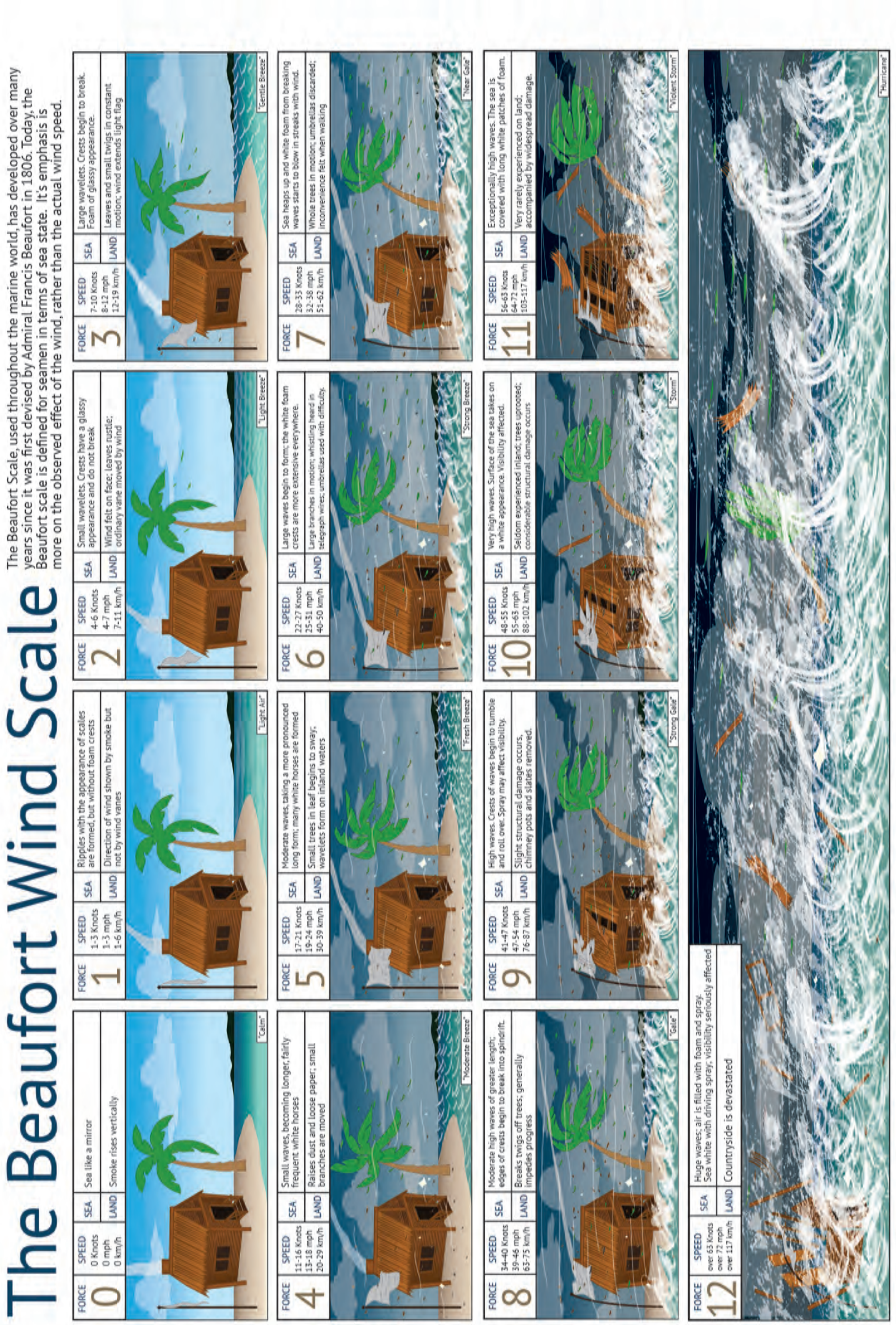


Figure 4: The Beaufort Scale
A common tool to estimate wind speeds from sea state and other visual cues.
(Modified from http://scienceblogs.com/deepseanews/F29F96B736B144DE29DF26BA7D4183DD2.jpg)

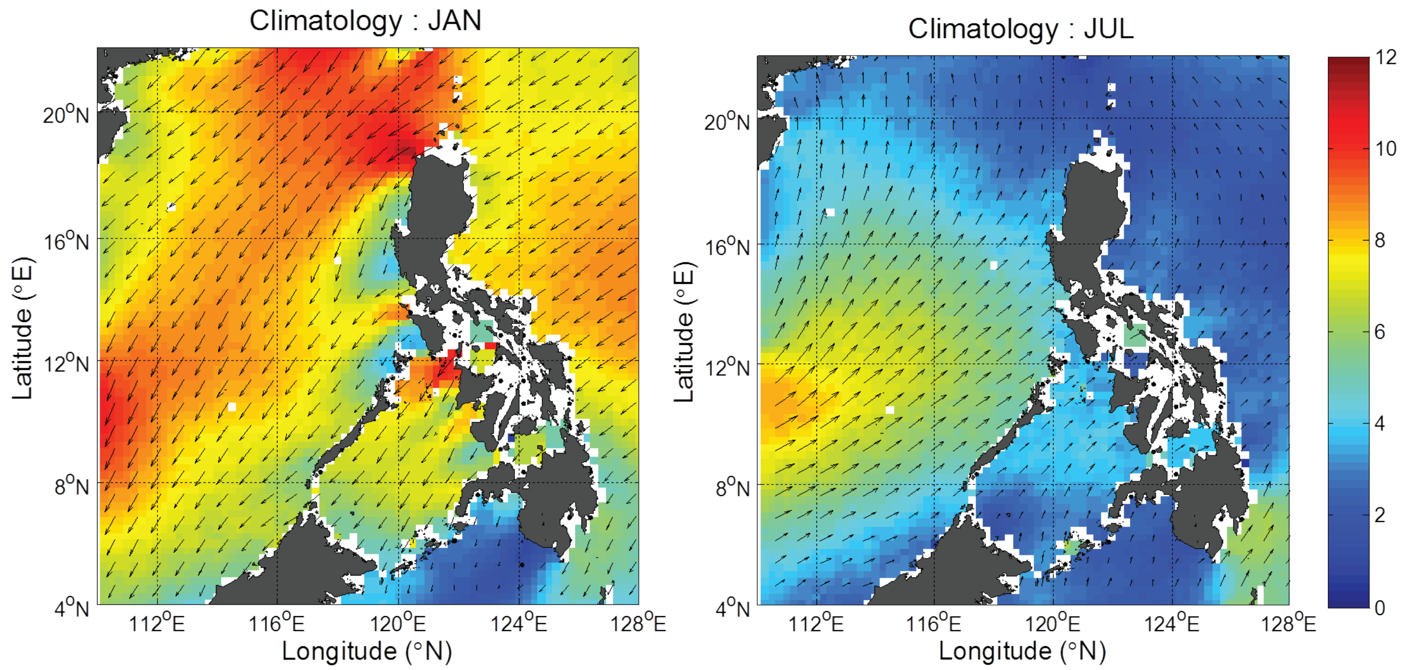


Figure 5: Wind climatology or pattern for the Philippines based on the 10-yr QUIKSCAT dataset.
Colors denote speed (in m/s) while arrow length and angle denote magnitude and direction of wind vectors

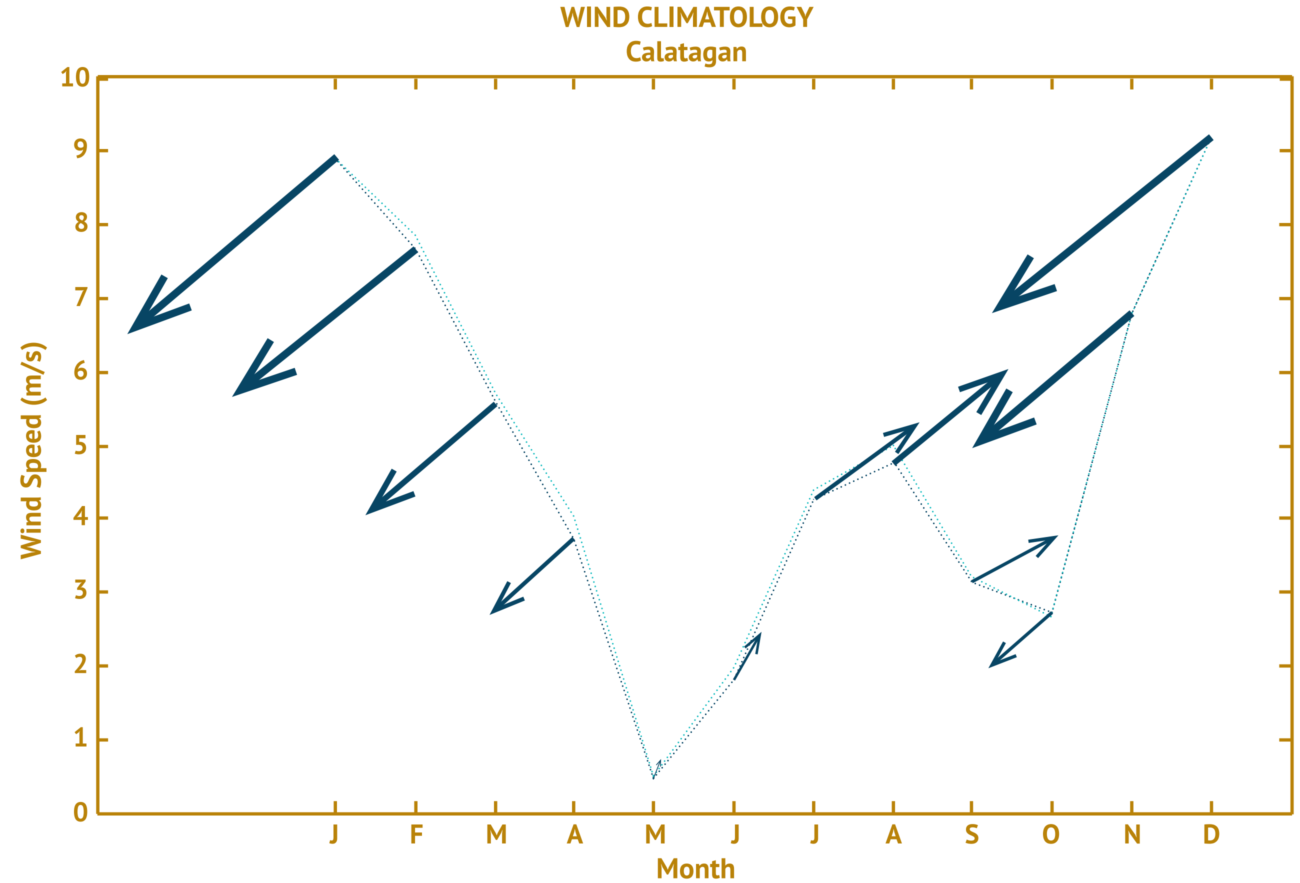


Figure 6: Wind climatology specific for Calatagan, Batangas (Philippines)

4.5. BATHYMETRY

High-resolution bathymetry is also not readily available for Philippine waters. To facilitate analysis, a digital global bathymetric map of the oceans with 1 arc minute or ~2km horizontal resolution was used (Smith and Sandwell, 1997). This dataset was derived by combining available depth soundings with high-resolution marine gravity information from satellite altimeters. The Smith and Sandwell bathymetry was then extracted for the Philippine domain, combined with commercially-bought NOAA Electronic Navigational Charts (ENC), and then interpolated to a 500-m resolution grid.

4.6. COASTAL POINTS FOR ESTIMATING REI

For the Calatagan demonstration site, a total of 374 points were selected for estimation of REI. The points are 500m apart to match the 500-m resolution of the bathymetry. In **Figure 7**, the software interface is shown with all data inputs used for the Calatagan analysis.

4.7. LIMITATIONS (CAVEATS)

The simplicity of WEMo, specially its REI mode, is very attractive because it offers a quick estimation of wave exposure at a very low computational cost. The software is free and downloadable although it needs licensed ArcGIS software to run. WEMo uses a monochromatic approach, meaning waves are propagated along each fetch ray. It does not account for complicated wave processes like refraction, reflection, and wave breaking at reef edges, nor does the model account for remotely-forced ocean swells. It also does not predict significant wave heights. It is more suited for comparing sites under seemingly-like conditions (Fonseca and Malhotra, 2010), emphasizing the **relative** in the Relative Exposure Index.

5. RESULTS: EXPOSURE INDEX MAPS

Output of WEMo is a point shapefile with values of REI (total) as well as REI for each of the 8 ray directions. Based on the range of values, the sites can then be categorized into **L**ow, **M**edium or **H**igh (L, M, H) Exposure. Maps for Wave Exposure Index may be generated in ArcGIS or any mapping software.

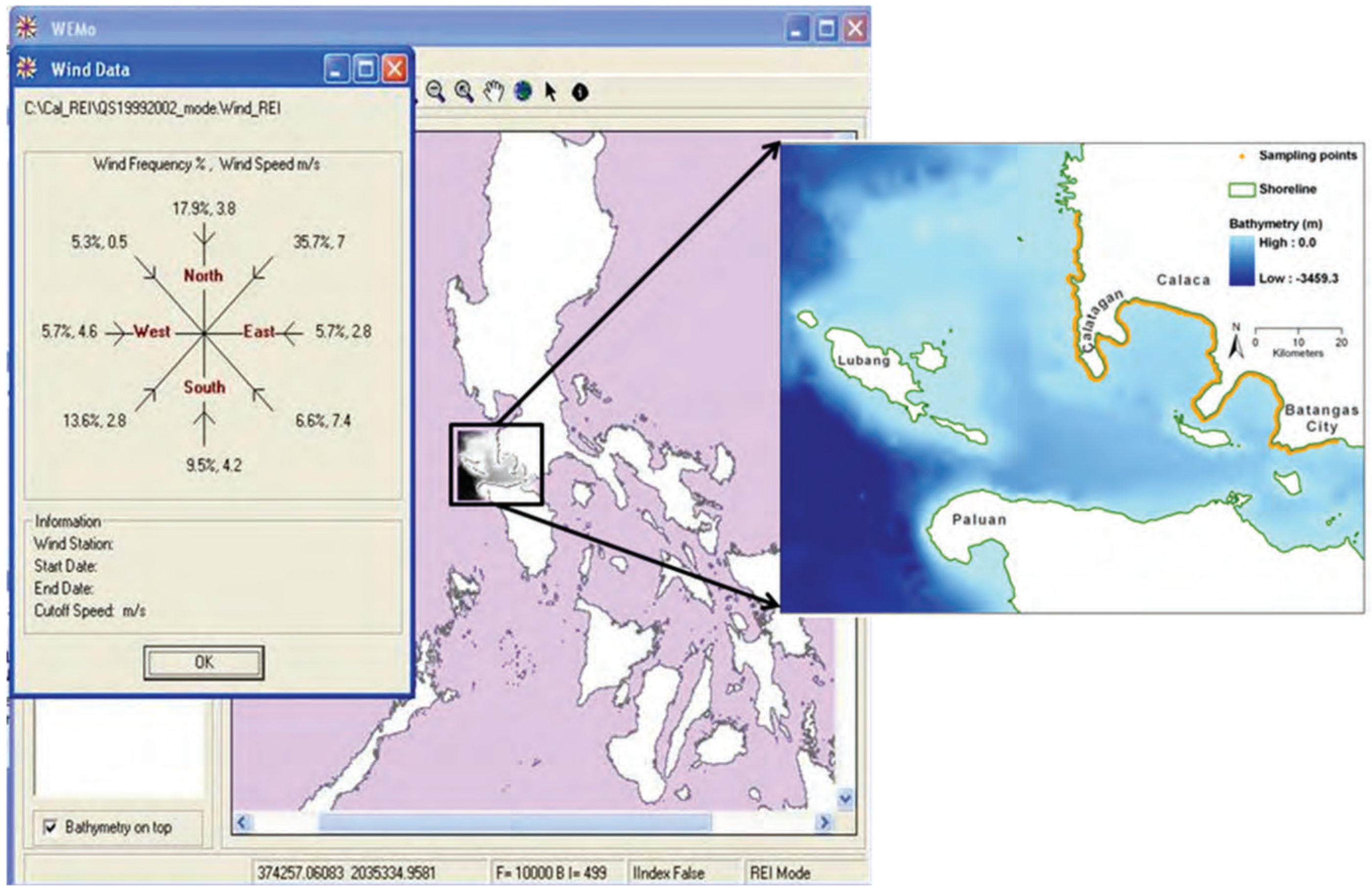


Figure 7: WEMo Interface with input shoreline, bathymetry, wind data and coastal points for the demonstration site Calatagan

For the analysis of Calatagan, the 10-yr wind data showed that the dominant wind is northeasterly, with speeds reaching 7 m/s. However, the REI for the northeast or NE ray is low to medium only as the fetch for the NE ray is small or negligible because of the coastline configuration. For the southwest or SW ray, more sites appear to have medium to high exposure, mainly because of the large fetch values. Both NE and SW rays however show the relatively higher exposure to waves of areas at the tips of the municipality of Calatagan, Mabini, and Batangas City. The TOTAL REI or sum of the REI of all 8 rays further teases out the variability of the wave exposure of the whole Batangas coast with barangays Baha and Bagong Silang of Calatagan; Bagalangit of Mabini; and Pagkilatan and Mabacong (Matoco) of Batangas City having the highest relative exposure index to waves (**Figure 8**).

The classification of low, medium and high exposure indices are based on the range of REIs computed by WEMO for a given domain. For instance, the REIs shown in **Figure 9** are relative to the range of REI values computed for all 4 selected provinces combined.

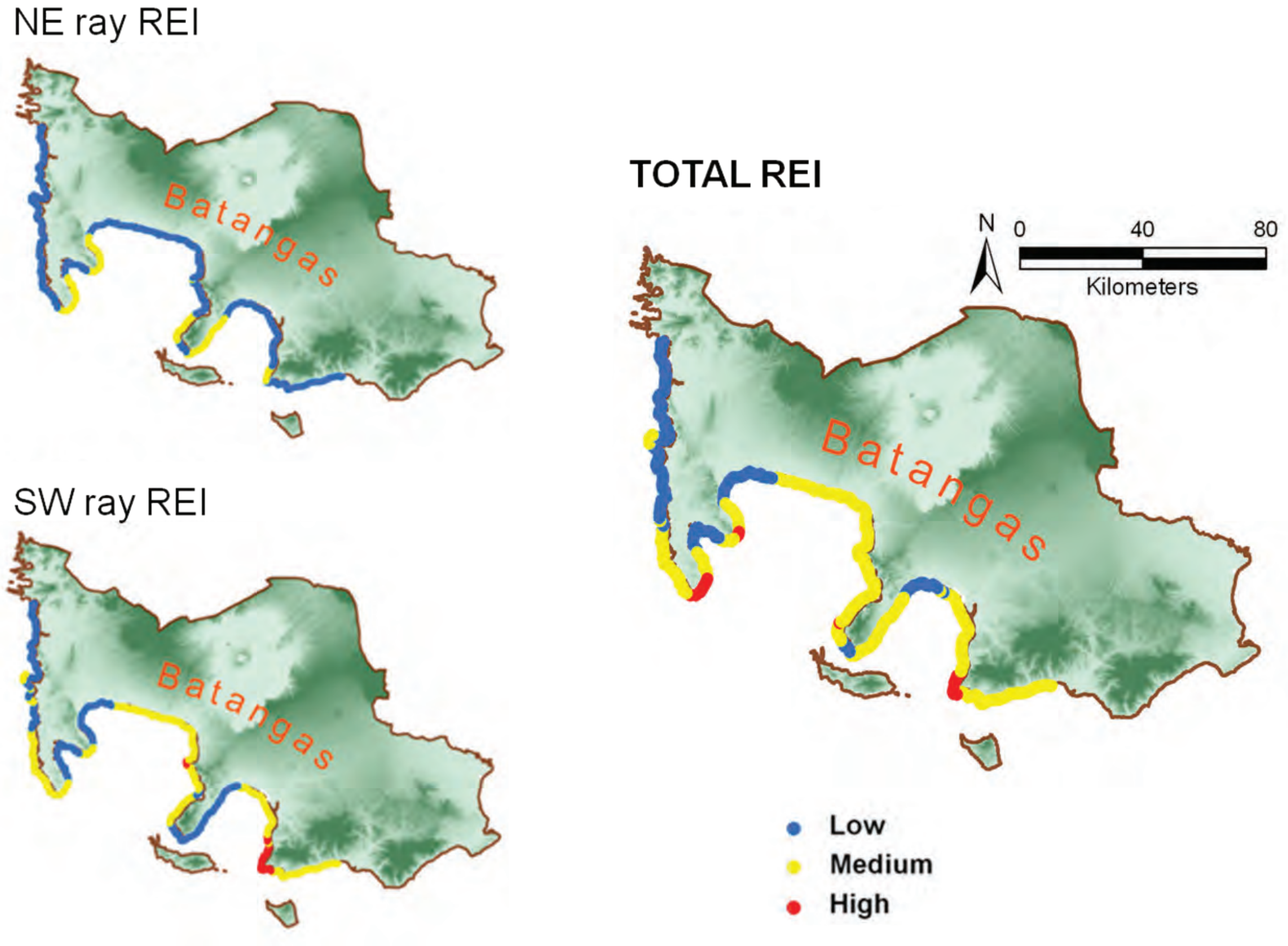


Figure 8: Wave exposure maps based on WEMo-derived Relative Exposure Index for the northeast or NE ray (upper left panel), southwest or SW ray (lower left panel) and the sum of all rays or TOTAL (right panel)

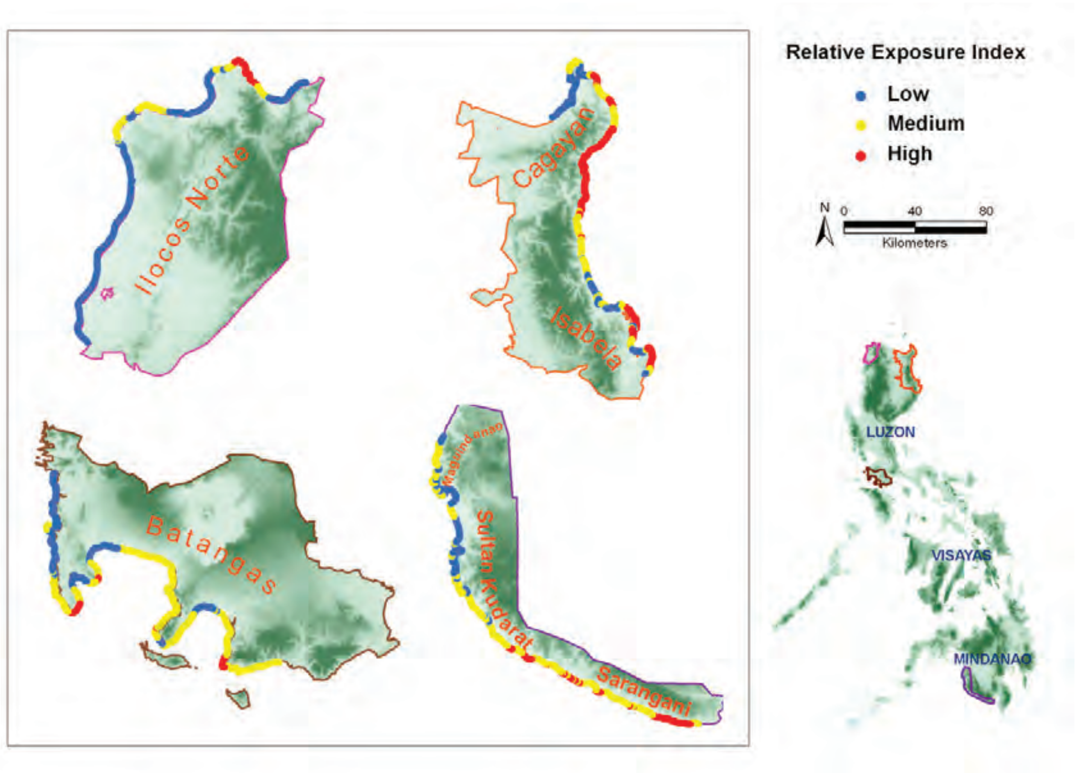


Figure 9: Relative exposure index calculated for 4 selected provinces in the Philippines

For the relative exposure of Calatagan to typhoon winds, WEMo could not be used as extensive wind data is not available during typhoons. What is available is the long term record of the tracks of typhoon that passed the Philippine Area of Responsibility, with record of location and strength of wind at the track every 6 hrs (http://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/RSMC_HP.htm). The number of times that category 5 typhoons passed a 300km-radius from each coastal site was counted and then mapped (**Figure 10**). From this map, it appears that the municipalities of Lemery, Taal, San Luis, Bauan, San Pascual and Batangas City are the most exposed sites while Calatagan is relatively less exposed. However, note that the counts of Category 5 typhoons for all the selected coastal points ranged only from 14 to 17 over a 30-year record.

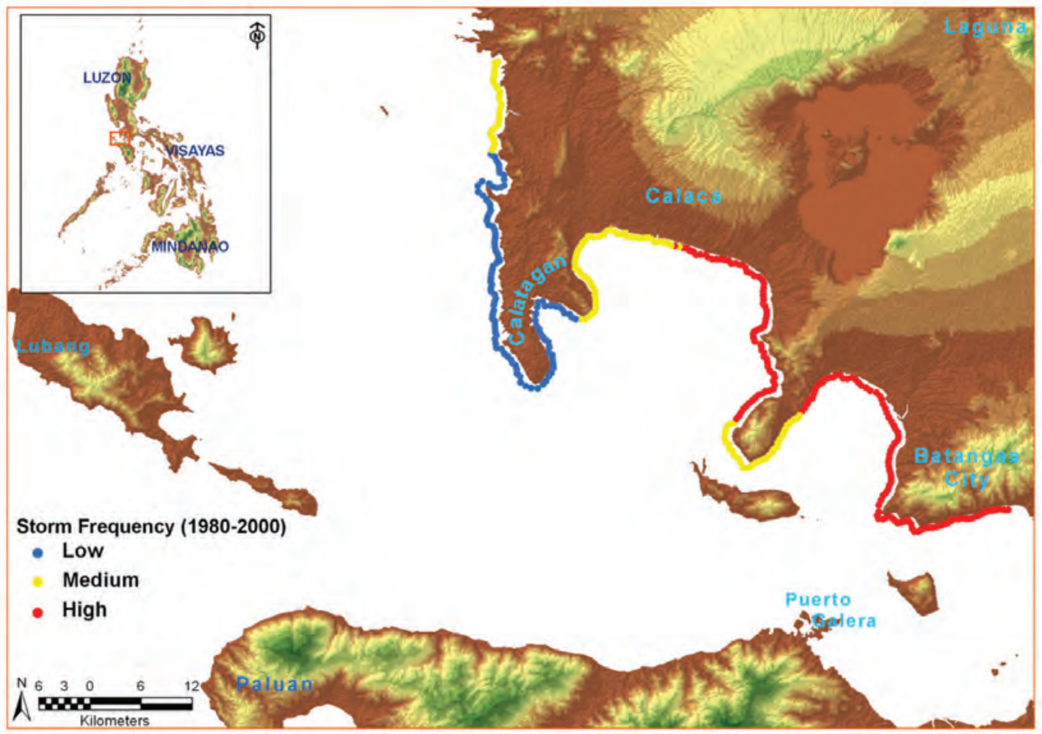


Figure 10: Exposure map of the Batangas coast to Category 5 typhoons

6. REFERENCES

Bengtsson, L., Hodges, K. I., and E. Roeckner. 2006. Storm Tracks and Climate Change. Journal of Climate 19(15): 3518-3543.

Bretschneider, C. L., 1952. The generation and decay of wind waves in deep water. Transactions of the American Geophysical Union 33(3):381-389.

Fonseca, M. S. and A. Malhotra, 2010. WEMo (Wave Exposure Model) for use in Ecological Forecasting. Manual, Version 4.0, Center for Coastal Fisheries and Habitat Research at Beaufort, Beaufort, NC, 74 pp.

Harley, C. D. G., Hughes. A. R., Hultgren, K. M., Miner, B. G., Sorte, C. J. B., Thornber, C. S., Rodriguez, L. F., Tomanek, L. and S. L. Williams. 2006. The impacts of climate change in coastal marine systems." Ecology Letters 9(2): 228-41.

Ho, C. H. , Baik J. J., Kim J. H., Gong, D. Y., and C. H. Sui. 2004. Interdecadal Changes in Summertime Typhoon Tracks. Journal of Climate 17(9): 1767.

Lungu, T., 2001: QuikSCAT science data product user's manual: Overview and geophysical data products. JPL D-18053, Version 2.2, Jet Propulsion Laboratory, Pasadena, CA, 95 pp.

Malhotra, A. and M. S. Fonseca, 2001. WEMo (Wave Exposure Model): Formulation, Procedures, and Validation. NOAA Technical Memorandum NOS NCCOS #65, Center for Coastal Fisheries and Habitat Research at Beaufort, Beaufort, NC, 26 pp.

Smith, W. H. F. and D. T. Sandwell, 1997. Global seafloor topography from satellite altimetry and ship depth soundings. Science, 277:1957-1962

Wada, A. and J. C. L. Chan. 2008. Relationship between typhoon activity and upper ocean heat content. Geophysical Research Letters 35(17): 1-6.

Walsh, K. 2004. Tropical cyclones and climate change: unresolved issues. Climate Research 27(2001): 77-83.


JÜRGEN FREUND

4

Integrated Coastal Sensitivity, Exposure, and Adaptive Capacity to Climate Change

Wilfredo R. Y. Licuanan[1]
Fernando P. Siringan[2]
Samuel S. Mamauag[3]
Maricar S. Samson[1, 4]
Porfirio M. Aliño[2]
Rene N. Rollon[5]
Ma. Yvainne Y. Sta. Maria[3]
Miledel Christine C. Quibilan[3]
Renmar Jun S. Martinez[3]
Norievill B. España[1]
Rollan C. Geronimo[6]
Cesar L. Villanoy[2]
Olivia C. Cabrera[3]
Erlinda E. Salamante[3]
Evangeline Florence B. Miclat[6]
Laura T. David[2]

[1] Br. Alfred Shields, FSC Marine Station, De La Salle University
[2] Marine Science Institute, University of the Philippines
[3] Marine Environment and Resources Foundation, Inc.
[4] Integrated School, De La Salle University – Science and Technology Complex
[5] Institute of Environmental Science and Meteorology, University of the Philippines
[6] Conservation International - Philippines

* wilfredo.licuanan@dlsu.edu.ph

Climate change impacts are complex and synergistic. In order to capture this complexity and synergy, an integrated vulnerability assessment tool has been designed to assess the interplay of key elements for biodiversity, fisheries, coastal integrity, and socio-economic conditions, giving users a synoptic view of their vulnerability to climate change. This tool simultaneously evaluates these elements to integrated climate change impacts, including sea level rise, storm surges and waves, sea surface temperature changes, and variable rainfall. It is a scoping and reconnaissance tool necessary for identifying ecosystem service-specific adaptation options. This tool was designed to encourage as much participation from local stakeholders as possible.

ICSEA-C-Change at a glance

Tool Name:	INTEGRATED COASTAL SENSITIVITY, EXPOSURE, ADAPTIVE CAPACITY TO CLIMATE CHANGE VULNERABILITY ASSESSMENT TOOL (ICSEA-C-Change) v 1.0
Scale:	Barangay
Scope:	Integrated: fisheries, coastal integrity, biodiversity
CC hazards considered:	Sea-level rise, waves and storm surge, SST, and rainfall
Description:	Measures integrated vulnerability of coastal system to synergistic CC impacts Broad scoping and rapid reconnaissance tool Uses a relative scoring system Coarse resolution of analysis Offers comparison of general vulnerabilities across sites Must be complemented with other Coastal VA tools for use in developing specific adaptation measures
Value:	Can guide identification of general adaptation measures Can assist in improving adaptive management Is a communication tool Provides comparison of sites and coastal aspects (prioritization) Scopes available information for other coastal VA tools
Data needs:	Information from existing research and previous resource evaluations (e.g. provincial and municipal development plans, PCRA)
Technical needs:	May be applied by coastal managers and field practitioners, with minimal assistance from marine experts Best if intended users receive training on correct and appropriate application of the tool. (e.g. c/o the Coastal Learning Adaptation Network or CLAN)

Contact information:
Wilfredo Roehl Y. Licuanan
wilfredo.licuanan@dlsu.edu.ph | licuananw@gmail.com
Br. Alfred Shields, FSC Marine Station
De La Salle University

1. INTRODUCTION

The Integrated Sensitivity, Exposure, and Adaptive Capacity to Climate Change Vulnerability Assessment Tool or *I-C-SEA-CChange* provides a rapid, synoptic assessment of the acute, immediate impacts of climate change in coastal areas. It is participatory and relatively simple, seeking to provide coastal communities the means to understand their relative vulnerabilities to climate change impacts, including sea-level rise, ocean warming, increased storminess, extreme rainfall events, and resulting sedimentation of coastal waters. The tool recognizes that human impacts and climate change may have synergistic effects on natural systems and human communities.

ICSEA-C-Change evaluates criteria relevant to biodiversity, coastal integrity, and fisheries concerns. In practice, it is used in complement with the other Coastal VA Tools, CIVAT and TURF (See Chapters 5 and 6). The tool provides an initial profile of vulnerabilities, guiding decisions on prioritization of areas and actions. ICSEA-C-Change may also be useful in economic valuation. More importantly, it also functions as an information, education and communications tool, offering users an appreciation and understanding of how living and non-living elements of coastal ecosystems interact and lead to emergent behaviors and properties.

Figure 11: A typical coastal area in the Philippines

A typical coastal area in the Philippines would have coral communities at the deep end, mangroves along the shore, and seagrass and seaweed zones between the two. These, plus the mountains, catchment, and human settlements make up a coast and are central to ICSEA-C-Change.

2. FRAMEWORK

In assessing the vulnerability of coastal systems, the ICSEA-C-Change incorporates analyses of (1) "here and now" characteristics that describe the present state of the system for specific properties that respond to exposure factors stemming from changes in climate (Sensitivity); (2) the intensity or severity of the conditions of the physical environment that drive changes in the state or condition of bio-physical systems (level or threat of Exposure); and (3) the inability of the system to cope with the changes in climate (Lack of Adaptive Capacity). The understanding of Vulnerability and its components is consistent with the operational definitions presented in Chapter 2. The fundamental relationships among these components are also intact, although Exposure and Sensitivity are not combined as Potential Impact prior to integration with (lack of) Adaptive Capacity (although the scoring for the latter is biased). The ICSEA-C-Change arrives at a measure of Vulnerability that is an intersection of the three components (**Figure 12**).

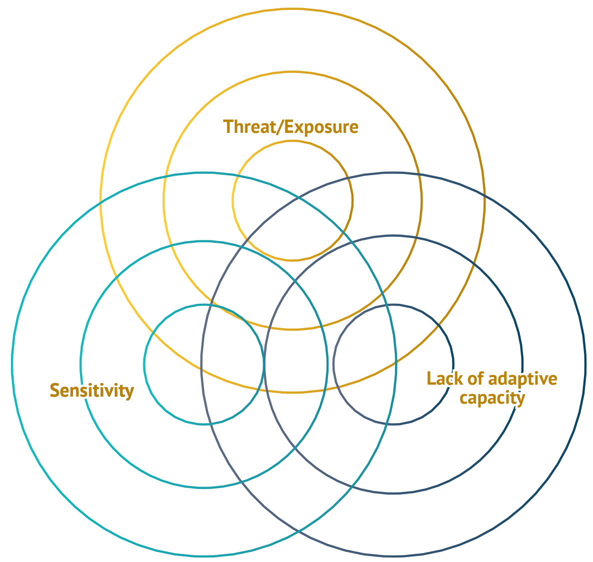


Figure 12: ICSEA-C-Change Vulnerability Framework. Vulnerability can be defined as the intersection of Sensitivity, Exposure or threat, and lack of Adaptive Capacity

Such visual representation is also integral to the scoring rules and interpretation of results. The scores for each of these factors are averaged, rounded off, and combined as in **Figure 12**. Larger scores lead to larger circles and an overlap of any two circles produces a final vulnerability score of Medium or Moderate while an overlap of all three circles leads to High Vulnerability.

3. FEATURES OF ICSEA-C-CHANGE

- ICSEA-C-Change encourages systems thinking, incorporating three thematic coastal aspects, namely biodiversity, fisheries, and coastal integrity.
- The number of criteria is significantly reduced so that there is no excessive detail involved. A majority, if not all, data needs may be addressed by participatory coastal resource assessments (PCRA) and similar existing reports.
- While the tool has been developed to facilitate ease of use, the selection of variables and scoring system have been founded on an implicit weighing system. The balance is necessary for the tool to be able to achieve its comprehensive scope, suitably representing the key coastal thematic aspects in relation to a range of climate change impacts. Hence, it is strongly recommended that the tool rubrics be evaluated completely and as they are, with no replaced or omitted variables. It is also advised that the scoring rules be faithfully observed, with default values used just in case data is not available and cannot be estimated. Any unauthorized changes in the tool may compromise the balance of ICSEA-C-Change and introduce unexpected biases.
- The spatial unit of analysis is the coastal barangay, but may vary according to user needs. For instance, ICSEA-C-Change may also be applied to the level of towns or to smaller sub-barangay units such as the sitio.
- ICSEA-C-Change scores and subscores are on a relative scale (as opposed to one with absolute values). This assessment method is designed to produce scores that allow users to rank several sites according to their Vulnerabilities. For example, ICSEA-C-Change scores can reveal that Site A is more vulnerable than Site B, and Site B is more vulnerable than Site C. Scores must not be interpreted as precise, "knife edge" estimates of how much more vulnerable Site A is than Site B, how much more vulnerable Site B is than Site C, and so on. This is one reason scores are collapsed into "High", "Moderate", and "Low" vulnerability in the final stage of ICSEA-C-Change assessments.
- ICSEA-C-Change evaluates criteria in relation to acute, almost immediate, short-term (~one year) impacts of climate change. The effects of a changing climate are already evident and becoming more so with time, so it is necessary for communities to implement monitoring and data collection schemes to update and improve inputs for regular vulnerability assessments with ICSEA-C-Change.
- ICSEA-C-Change can impact decision-making, first, as a communication tool on coastal ecosystems, as well as climate change and its potential impacts. Further, it provides initial Vulnerability profiles, highlighting sites and coastal aspects that need more comprehensive review. It is able to guide decision-makers in prioritization and resource allocation.

4. EXPOSURE, SENSITIVITY, AND LACK OF ADAPTIVE CAPACITY CRITERIA

Vulnerability assessment using ICSEA-C-Change involves a set of rubrics to guide the assignment of scores for Sensitivity and lack of Adaptive Capacity (LAC). Scores for the level or threat of Exposure may be derived from maps currently being developed by local scientists using long-term, available climate information (See Chapter 3). In most cases, information needed for the ICSEA-C-Change is available in participatory coastal resource assessments or PCRAs (See Chapter 2, "Initial data scoping"). More information can be derived from on-site meetings with coastal residents, snorkelling, and coastal walks in the assessment areas. When data is available, ICSEA-C-Change can be applied to the level of individual sitios and barangays even though exposure scores are typically available at the municipal or city level.

Sensitivity rubrics use a five-point, three-level scoring that requires a distinction be made for scores within the "low" (1 or 2 points) and "moderate" (3 or 4 points) levels whereas only one score (5 points) is allowed for "high". For LAC, four-point, four level scoring rubrics are used, with the assumption that a low LAC cannot completely negate a high sensitivity score. Both scoring systems aim to deter the assignment of "fence sitting" middle scores.

- 🔴 High Sensitivity (5 points)
- 🟡 Moderate Sensitivity (3-4 points)
- 🟢 Low Sensitivity (1-2 points)

Table 5: General vulnerability criteria considered in the ICSEA-C-Change

VARIABLE	# of criteria
EXPOSURE	
1. Sea surface temperature changes	
2. Sea level rise	
3. Waves and storm surgess	
4. Extreme Rainfall	
SENSITIVITY	**15**
1. Health of coral reefs (% cover & extent)	2
2. Health of seagrass (extent & species richness)	2
3. Health of mangroves (remaining cover & forest type)	2
4. Fisheries resources and habitat dependency of fishing activities (catch rates, composition, gears, population density, dependency)	5
5. Predisposition to coastal erosion (seasonal beach changes, erosion / accretion, shore platform width, coastal slope)	4
LACK OF ADAPTIVE CAPACITY	**24**
1. Recovery potential of coral communities (% branching, abundance of recruits, species richness)	3
2. Recovery potential of seagrass meadows (dominant species & continuity)	2
3. Recovery potential of mangrove forests (species type & proportion of large mangroves to propagules)	2
4. Water Quality (turbidity, temperature, & wastes)	3
5. Management (extent of rehabilitation and MPAs: size, design, and habitat coverage)	4
6. Fisheries (per capita consumption, catch rate, fishery mgt plans, fishing experience, other livelihoods)	5
7. Coastal Integrity (historical erosion trends)	1
8. Others (Human settlements, economy, education)	4

4.1. EXPOSURE

The climate change exposure factors used for ICSEA-C-Change are sea surface temperature changes, sea level rise, waves and storm surges, and extreme rainfall. Each of these exposure factors are scored relative to the site of concern. Scores range from 1 to 5 with 1 being the lowest level of exposure and 5 being the highest. Characterizing Exposure is best accomplished with technical assistance from marine scientists, especially those specializing in physical oceanography (See Chapter 3).

Calculate the average of these scores to get the exposure score which will range from 1 to 5.

4.2. SENSITIVITY CRITERIA

The integrated fisheries and coastal integrity (with certain parameters alluding to biodiversity) Sensitivity of an area to climate change impacts depend on six broad questions, namely:

1. Is there a coral reef in your area (with a defined profile)?
2. Are there large seagrass meadows?
3. Are the mangrove areas widespread?
4. What kind of fishery operates in your barangay/area?
5. How important is the fisheries to the community?
6. Is the coastline prone to erosion and maritime flooding?

> ⊗ No coral reefs, seagrass, or mangroves?
>
> ⊗ Missing or no data?
>
> Use the highest sensitivity value (i.e., "5") for the corresponding criteria.

These six questions refer to broad Sensitivity parameters that most influence the fisheries and coastal integrity vulnerability of an area to simultaneous impacts of sea level rise, sea surface temperature change, waves and storm surges, and rainfall.

Habitats affect the Sensitivity of both coastal integrity and fisheries. Habitats that are extensive and in good condition afford an overall reduced sensitivity of fisheries and coastal integrity of an area to climate change impacts.

Fishing communities heavily reliant on demersal fishes, with low catch rates, and using mainly stationary gears are more sensitive to climate change exposures than the opposite type of fishery. If habitats are affected by climate change, these types of fisheries will be heavily affected. Primary dependence on fishing as main livelihood also increases the sensitivity of fishers to climate change.

Coastlines prone to either seasonal or long-term erosion, have narrow shore platforms, and have relatively flat coastal and inland area are more sensitive to the impacts of sea level rise and increased wave action and storm surges. Such features allow waves and tide to move further inland and remove significant amounts of beach material. The state of the habitats can help minimize beach material removal and increase beach material production and supply.

Table 6 provides the detailed Sensitivity rubric for ICSEA-C-Change. In order to calculate the sensitivity score for an area, first, average the six criteria under "coastal habitat", the five criteria under "fish and fisheries", and the four criteria under "coastal integrity". The general mean of these three averaged scores gives you the sensitivity rating.


JÜRGEN FREUND

Table 6: Sensitivity rubric for ICSEA-C-Change

CRITERIA				LOW (1-2)	MEDIUM (3-4)	HIGH 5
COASTAL HABITAT	Is there a coral reef in your area (with a defined profile)?	1	How much of the coastline is lined by coral reefs?	more than 50% is lined by coral reefs	between 25 to 50% is lined by coral reefs	less than 25% is lined by coral reefs
		2	What is the highest hard coral cover (%)?	over 50%	between 25 to 50%	less than 25%
	Are there large seagrass meadows?	3	How much of the shallow areas are covered by seagrass?	seagrasses cover more than half of the reef flat	seagrasses cover more than 1/8 to 1/2 of of the reef flat	seagrasses cover less 1/8 of the reef flat
		4	What is the maximum number of seagrass species?	mixed bed with over 5 species	2 to 4 species	monospecific bed
	Are the mangrove areas widespread?	5	How much of the natural mangrove areas are left?	over 50% of the natural mangrove areas are left	between 25 to 50% of the natural mangrove areas are left	less than 25% of natural mangrove areas are left
		6	What kind of mangrove forest is left?	riverine-basin-fringing type	riverine-fringing type	scrub-fringing type
FISH AND FISHERIES	What kind of fishery operates in your barangay/ area?	7	Dominant catch	catch predominantly pelagics (e.g. tuna, mackerel)	catch a mix of demersal and pelagic species	catch predominantly demersal fish (eg. groupers)
		8	Catch rate	>8kg per day (or equivalent CPUE)	3 to 8kg per day (or equivalent CPUE)	<3kg per day (or equivalent CPUE)
		9	Are the fishing gears used restricted on shallow water (coral, mangrove, seagrass) habitats?	mostly mobile fishing gear	presence of both types	considerable number of habitat-associated gear (e.g. fixed gear on seagrass beds)
	How important is the fisheries to the community?	10	Population density (Concentration of population)	200 persons or less per square kilometer (1 household per 2.5 ha)	between 200 to 500 persons per square kilometers (1 household per 1.25 ha)	more than 500 persons per square kilometer (1 household per 1 ha)
		11	Fisheries ecosystem dependency	35% or less of the population are fishers	36% to 60% of the population are fishers	more than 60% of the population are fishers

Sensitivity example

Two hypothetical barangays each with their own set of site conditions are scored for Sensitivity.

1. All criteria are scored, depending on the respective "here and now" characteristics of the barangays. Remember that for Sensitivity, scores may range from 1 to 5. Refer to columns "BRGY 1" and "BRGY 2."
2. Scores per set of criteria, i.e. Coastal Habitat, Fish and Fisheries and Coastal Integrity, are then averaged. Refer to the shaded rows.
3. Finally, the general mean of these three averages is calculated. Refer to very last row.

Table 7: Sample ICSEA-C-Change Sensitivity scores for two hypothetical barangays

	SENSITIVITY CRITERIA	BRGY 1	BRGY 2
COASTAL HABITAT	1. How much of the coastline is lined by coral reefs?	1	3
	2. What is the highest hard coral cover (%)?	3	3
	3. How much of the shallow areas are covered by seagrass?	2	5
	4. What is the maximum number of seagrass species?	1	3
	5. How much of the natural mangrove areas are left?	1	4
	6. What kind of mangrove forest is left?	4	3
	AVERAGE FOR COASTAL HABITAT	2.0	3.5
FISH AND FISHERIES	7. Dominant catch	2	4
	8. Catch rate	5	5
	9. Are the fishing gears used restricted on shallow water (coral, mangrove, seagrass) habitats?	2	5
	10. Population density (Concentration of population)	3	2
	11. Fisheries ecosystem dependency	5	2
	AVERAGE FOR FISH AND FISHERIES	3.4	3.6
COASTAL INTEGRITY	12. Has the beach changed much in the last 12 months?	2	5
	13. Is the coastline prone to erosion?	4	5
	14. Width of shore platform (m)	1	1
	15. Is the coast steep?	1	1
	AVERAGE FOR COASTAL INTEGRITY	2.0	3.0
	GENERAL MEAN	2.5	3.4

4.3. LACK OF ADAPTIVE CAPACITY

"Lack of Adaptive Capacity" or LAC criteria is the negative representation of the operational definition for Adaptive Capacity presented in Chapter 2. These criteria refer to parameters that help or hinder the recovery of the system after being affected by climate change exposures.

Lack of Adaptive Capacity criteria are grouped into four broad categories, namely:

- Coastal habitats;
- Fish and fisheries;
- Coastal integrity; and,
- Human settlements

The health of coral communities, seagrass meadows, and mangrove forests all contribute to the adaptive capacity of a system. The poor health of these habitats, coupled with poor water quality, and lack of habitat restoration efforts and marine protected areas result to low adaptive capacity both for fisheries and coastal integrity.

In order to calculate for the Lack of Adaptive Capacity score, compute for the average values of criteria under fish and fisheries, coastal integrity, and human activity, separately.

For the coastal habitats average, get the average scores of criteria under health of coral communities, health of seagrass meadows, health of mangrove forests, water quality, habitat restoration efforts, and marine protected areas, separately. Average these scores to get the value for coastal habitats Lack of adaptive capacity.

The overall Lack of Adaptive Capacity score is obtained by calculating the general mean of the average values for coastal habitats, fish and fisheries, coastal integrity, and human settlements.

JÜRGEN FREUND

Table 8: Lack of Adaptive Capacity rubric for ICSEA-C-Change

CRITERIA				SCORING		SCORING			NOTES
				LOW 2		MODERATE 3	MODERATE 4	HIGH 5	
COASTAL HABITAT	Health of coral communities	1	If there are corals, are there more massive corals compared to branching ones?	3 times more branching than massive corals		2 times more branching than massive corals	as many branching as massive corals	more massive than branching; or no corals	Branching corals are faster growing
		2	If there are corals, are there more large colonies compared to small colonies for the species?	number of adult and large colonies is 1/3 that of juvenile and small colonies of the species		number of adult and large colonies is 1/2 that of juvenile and small colonies of the same species	as many large colonies as small ones of the same species	more large adults than juveniles and small colonies of the same species; or no corals	Recruitment potential
		3	Is the coral diversity much reduced?	more than 100 species remaining		between 75 to 100 species remaining	between 50 to 75 species remaining	less than 50 species remaining	Biodiversity
	Health of seagrass meadows	4	If there are seagrasses, is *Enhalus acoroides* density highest among the seagrasses?	*Halophila - Halodule* dominated meadow		*Thalassia - Cymodocea Halodule* dominated meadow	*Enhalus acoroides-Thalassia hemprichii* dominated meadow	*Enhalus acoroides* dominated meadow; or no seagrass	Recruitment potential
		5	Are there more barren areas within the seagrass meadow?	Meadow is continuous and barren area is less than 20%		Barren area is between 20 to 40% of the meadow	Barren area is between 40 to 60% of the meadow	Barren area is more than 60% of the meadow; or there are no meadows	Meadow integrity
	Health of mangrove forests	6	Are the slow growing, slow colonizing species most common in the area?	presence of more than 5 mangrove species capable of colonizing newly available habitat at a rate that keeps pace with the rate of relative sea-level rise		presence of 3 to 4 mangrove species capable of colonizing newly available habitat at a rate that keeps pace with the rate of relative sea-level rise	presence of 1 to 2 mangrove species capable of colonizing newly available habitat at a rate that keeps pace with the rate of relative sea-level rise	Yes, all species are slow growing, slow colonizing	Recruitment potential
		7	Are there more large trees than small propagules (in terms of density)?	seedlings and propagule observed between 8 to 12 months every year		seedlings and propagules observed between 4 to 8 months every year	seedlings and propagules observed between 1 to 4 months every year	Yes, all trees are large, seedlings and propagules are absent	Recruitment potential
	Water quality	8	Is the water murky/ silty in most of the year?	Water is clear all year round		Water is observed to be murky for 1 to 2 quarters a year	Water is observed to be murky/ silty for three quarters a year	Water is murky/ silty all year round	
		9	Does the area experience warm still water?	No		short periods of warm still water prevails and is related to tides	periods of warm still water prevails for several days or weeks at a time	periods of warm still water prevails for several months	Warm water events could be tidal; hence frequent (even if short) warm water events are stressful
		10	Does solid waste accumulate in this coastal area?	No		solid waste are observed in this coastal area between 1 to 4 months every year	solid waste are observed in this coastal area between 4 to 8 months every year	solid waste accumulates in this coastal area all year round	
	Habitat restoration and protected areas	11	How much of the degraded mangrove area remain to be rehabilitated?	Less than 50% of the degraded habitats		Between 50 to 70% of the degraded habitats	Between 70 to 90% of the degraded habitats	More than 90% of the degraded habitats remain to be rehabilitated	

Table 8: Lack of Adaptive Capacity rubric for ICSEA-C-Change (continued)

			12	How much is the need to expand the MPA?	Almost none; MPAs are 15% or more of municipal waters		Total MPA areas is 7.5% to 15% of the municipal waters	Total MPA areas is between 1 to 7.5% of the municipal waters	Total MPA areas is less than 1% of the municipal waters	Based on the RA 8550 provision on 15% of municipal waters
			13	Was the MPA design and management focused on fishery enhancement alone?	No, biodiversity and tourism aims also considered		Fisheries and tourism were considerations	Tourism was the only consideration	Yes	
			14	To what extent do protected areas focus on single habitats (mangrove, seagrass, coral) alone?	No; all habitats represented in MPAs		Only two habitats were included in MPAs	Only one habitat was included in MPAs	No habitats were included in MPAs	Connectivity of habitats
FISH AND FISHERIES			15	What is the contribution of fisheries to the per capita consumption of the area?	less than 20%		between 20 to 40%	between 40 to 60%	more than 60%	In relation to protein food intake
			16	What is the average fish catch (in kilograms) per day per person?	more than 5 kilos		between 2.5 to 5 kilos	between 1 to 2.5 kilos	less than 1 kilo	
			17	Are fishery resource management plans effective?	Yes		management plans are mostly effective	management plans are only partially effective	No; Or there are no management plans	
			18	What is the average fishing experience per fisher?	less than 5 years		between 5 to 10 years	between 10 to 20 years	more than 20 years	The longer the fishing experience, the harder for fishers to shift livelihood
			19	Is fishing the only source of livelihood?	No, more than 3 other sources of livelihood		Fishing plus two other sources of livelihood	Fishing plus another source of livelihood	Yes	
COASTAL INTEGRITY			20	How much has the land eroded in the last 30 years?	0, accreting		between 0 to 15m land loss	between 15 to 30m land loss	more than 30m of land lost	
HUMAN ACTIVITY		Human settlements	21	How much does the present land use pattern deviate from the land use plan?	No deviation		Between 1 to 25%	Between 25 to 50%	More than 50%, or there is no land use plan	
			22	To what extent do coastal modifications (pier, wharf, and seawall construction, reclamation, foreshore use) deviate from CLUP and similar regulations?	No deviation		Between 1 to 25%	Between 25 to 50%	More than 50%, or there is no land use plan	
		Economy	23	How extensive is the conversion of the coastal lands from rural agricultural to residential to commercial and industrial use?	Industrial		Commercial	Residential	Rural agricultural	
		Education	24	How much of the adult population has less than 10 years of schooling?	Less than 20%		Between 20 to 40%	Between 40 to 60%	More than 60%	

Lack of Adaptive Capacity example

1. The same two barangays from the Sensitivity example are scored for lack of Adaptive Capacity. Here, criteria are evaluated based on whether they are able to enhance the coping or recovery ability of the system. Scores for this component range only from 1 to 4. Refer to columns "BRGY 1" and "BRGY 2".
2. Each set of scores per broad category, i.e. Coastal Habitat, Fish and Fisheries, Coastal Integrity, and Human Activity, are averaged. Note that there is only one criterion for Coastal Integrity, and no computation is necessary. Refer to shaded rows.
3. Lastly, the general mean of the four average scores is computed. Refer to the final row.

Table 9: Sample ICSEA-C-Change lack of Adaptive Capacity scores for two hypothetical barangays

		LACK OF ADAPTIVE CAPACITY CRITERIA	BRGY 1	BRGY 2
COASTAL HABITAT	1	If there are corals, are there more massive corals compared to branching ones?	5	5
	2	If there are corals, are there more large colonies compared to small colonies for the species?	3	3
	3	Is the coral diversity much reduced?	2	3
	4	If there are seagrasses, is Enhalus acoroides density highest among the seagrasses?	3	3
	5	Are there more barren areas within the seagrass meadow?	3	5
	6	Are the slow growing, slow colonizing species most common in the area?	3	3
	7	Are there more large trees than small propagules (in terms of density)?	2	2
	8	Is the water murky/ silty in most of the year?	5	5
	9	Does the area experience warm still water?	5	5
	10	Does solid waste accumulate in this coastal area?	5	5
	11	How much of the degraded mangrove area remain to be rehabilitated?	2	4
	12	How much is the need to expand the MPA?	3	5
	13	Was the MPA design and management focused on fishery enhancement alone?	2	5
	14	To what extent do protected areas focus on single habitats (mangrove, seagrass, coral) alone?	2	5
		AVERAGE FOR COASTAL HABITAT	**3.2**	**4.1**
FISH AND FISHERIES	15	What is the contribution of fisheries to the per capita consumption of the area?	4	3
	16	What is the average fish catch (in kilograms) per day per person?	4	4
	17	Are fishery resource management plans effective?	3	5
	18	What is the average fishing experience per fisher?	4	3
	19	Is fishing the only source of livelihood?	3	2
		AVERAGE FOR FISH AND FISHERIES	**3.6**	**3.4**

Lack of Adaptive Capacity example [Table 9] (continued)

COASTAL INTEGRITY	20	How much has the land eroded in the last 30 years?	**2.0**	**5.0**
HUMAN ACTIVITY	21	How much does the present land use pattern deviate from the land use plan?	4	5
	22	To what extent do coastal modifications (pier, wharf, and seawall construction, reclamation, foreshore use) deviate from CLUP and similar regulations?	4	5
	23	How extensive is the conversion of the coastal lands from rural-agricultural to residential to commercial and industrial use?	3	3
	24	How much of the adult population has less than 10 years of schooling?	5	5
		AVERAGE FOR HUMAN ACTIVITY	**4.0**	**4.5**
		GENERAL MEAN	**3.4**	**4.0**

5. INTEGRATION AND OBTAINING VULNERABILITY RATINGS

Vulnerability is computed from the integration of Sensitivity, Exposure, and lack of Adaptive Capacity component scores or subscores. The component scores are averaged and converted to a categorical (low, moderate, high) scale. These component scores are then combined, using the following rules:

- ► If at least one of the three components is a moderate, the final vulnerability rating for that given area is Moderate.
- ► On the other hand, if two components have a score of at least moderate and the third component has a score of high, the final rating for that area will be High Vulnerability.
- ► Otherwise, the site receives a Low Vulnerability rating.

		Sensitivity				
		L (1-2)	M (3-4)	H (5)		
Exposure	L (1-2)	LLL	MLL	HLL	L (2)	LAC
	M (3-4)	LMM	MMM	HMM	M (3-4)	
	H (5)	LHH	MHH	HHH	H (5)	
Sensitivity and Exposure subcore conversion:					Lack of Adaptive Capacity:	
- low is an average of 1.0 to 2.0					- low is an average of less than 3.0	
- moderate is an average of more than 2.0 up to 4.0					- moderate is 3.0 to 4.0	
- high is an average of more than 4.0					- high is more than 4.0	

Self-Quiz

Take this self-quiz to check if you understand the ICSEA-C-Change interpretation rules. Determine the Vulnerability from the given Exposure, Sensitivity and Adaptive Capacity scores. Check your answers with those at the bottom of the table. Good luck!

	Exposure	Sensitivity	Lack of Adaptive Capacity	Vulnerability
1	1	2	5	
2	3	3	4	
3	2	2	3	
4	5	3	4	
5	3	5	5	
6	1	2	3	
7	4	3	4	
8	5	3	2	
9	2	1	2	
10	3	4	5	

ANSWERS:
1) Moderate; 2) Moderate; 3) Low; 4) High; 5) High;
6) Low; 7) Moderate; 8) Moderate; 9) Low; 10) High

Vulnerability example

Sensitivity and Adaptive Capacity scores from the earlier hypothetical 2-barangay example are integrated with the Exposure scores to get the final Vulnerability measurement. The interpretation rules apply.

1. Exposure factors are evaluated for each barangay based on respective physical environment conditions. Let's say, for example, Barangay 2 is more exposed to typhoons than Barangay 1, but Barangay 1 appears to be experiencing a greater increase in sea-surface temperature than Barangay 2. Their scores may look like this:

Table 10: Sample ICSEA-C-Change Exposure scores for two hypothetical barangays

	STORMINESS	INCREASED SST
Barangay 1	3	5
Barangay 2	5	3

2. Now that there are scores for all components, it is possible to obtain Vulnerability. Remember, the scores for Sensitivity and Adaptive Capacity have already been computed in the earlier examples.

Table 11: Sample ICSEA-C-Change Vulnerabilities for two hypothetical barangays

	EXPOSURE	SENSITIVITY	ADAPTIVE CAPACITY	ICSEA-C-CHANGE VULNERABILITY
Storminess				
Barangay 1	3	2	3	Moderate
Barangay 2	5	3	4	High
Increased SST				
Barangay 1	5	2	3	Moderate
Barangay 2	3	3	4	Moderate

a. Barangay 2 is highly vulnerable to storminess, given High Exposure and, evidently, issues relating to specific elements of Sensitivity and Adaptive Capacity. These specific elements are revealed in the raw scores (See following subsection). On the other hand, Barangay 1 has a Moderate Vulnerability to storminess due to relatively lesser degrees of Exposure, Sensitivity and Adaptive Capacity.

b. Both barangays are moderately vulnerable to increased SST. For Barangay 1, the High Exposure is offset by comparatively Low Sensitivity and lack of Adaptive Capacity. Barangay 2, on the other hand, has moderate scores for all three components.

6. INTERPRETATION OF RESULTS

The ICSEA-C-Change is intended to be a synoptic tool that can be applied to most coastal municipalities in the Philippines with minimum additional data collection needed. In order to assess the vulnerability of integrated aspects of fisheries, coastal integrity and, to some degree, biodiversity while maintaining its participatory feature, the tool lacks detailed assessment for identifying specific adaptation options. The development of strategies to specifically address vulnerabilities of fisheries and coastal integrity in a given site is better guided by tools that emphasize such aspects (See chapters on CIVAT and TURF).

On the other hand, results from ICSEA-C-Change can be used to improve adaptive management, providing an overview of the status of a site and its intervention scheme. Further, results can guide the identification of general adaptation measures, as well as the prioritization of areas for actions relating to coastal integrity and fisheries. ICSEA-C-Change is also valuable in evaluating the availability of information useful in CIVAT and TURF.

Various uses and interpretation of the ICSEA-C-Change VA results include:

1. Relative vulnerabilities across sites or barangays. Integrated vulnerability scores can be compared to determine which barangays are relatively most vulnerable to climate change impacts on fisheries and coastal integrity. Actions and more in-depth analyses of sources of vulnerabilities can be targeted towards these highly vulnerable communities or barangays.

2. Vulnerability elements. Sources of Vulnerability can vary across sites. Based on the operative Vulnerability framework, there are three general sources of Vulnerability for a given site: (1) High Exposure, (2) High Sensitivity, and (3) Low Adaptive Capacity (or extremely lacking in Adaptive Capacity in the case of ICSEA-C-Change). Adaptation options for addressing low Adaptive Capacity are often easiest to implement, followed by those addressing Sensitivity. Since Exposure is the direct and physical manifestation of climate change, it is often difficult to address directly. An area with extremely high Exposure might require relocation of communities or other drastic changes in Sensitivity and Adaptive Capacity to compensate for it.

3. Detailed sources of vulnerabilities. Within each Vulnerability element, one can look at the scores and see those criteria that have high scores (e.g., 4 or 5). These criteria contribute to the Vulnerability of an area to climate change impacts. For example, in **Figure 13** below, Barangay 2 has a high overall sensitivity score of "4". If we look at the scores of the different sensitivity criteria for Barangay 2, you will notice that most of the criteria with a score of "5" (cells highlighted in red) are in the fisheries and coastal integrity portions. In addition, coastal habitats appear to have Moderate, bordering on High, Vulnerability. These are the primary sources of Vulnerability for Barangay 2 and would require further evaluation. CIVAT and TURF, tools that highlight coastal integrity and fisheries respectively, should then be applied to Barangay 2 to determine more concrete and targeted adaptation options.

	Sensitivity Criteria	BRGY 1	BRGY 2
1	How much of the coastline is lined by coral reefs/communities?	1	3
2	What is the highest hard coral cover (%)?	3	3
3	How much of the shallow areas are covered by seagrass?	2	5
4	What is the maximum number of seagrass species?	1	3
5	How much of the natural mangrove areas are left?	1	4
6	What kind of mangrove forest is left?	4	3
	AVERAGE SENSITIVITY - COASTAL HABITATS	**2.0**	**3.5**
7	Dominant catch	2	4
8	Catch rate	5	5
9	Are the fishing gears used restricted on shallow water (coral, mangrove, seagrass) habitats?	2	5
10	Population density (Concentration of population)	3	2
11	Fisheries ecosystem dependency	5	2
	AVERAGE SENSITIVITY - FISHERIES	**3.4**	**3.6**
12	Has the beach changed much in the last 12 months?	2	5
13	Is the coastline prone to erosion?	4	5
14	Width of shore platform (m)	1	1
15	Is the coast steep?	1	1
	AVERAGE SENSITIVITY - COASTAL INTEGRITY	**2.0**	**3.0**
	OVERALL AVERAGE SENSITIVITY	**2.5**	**3.4**

Figure 13: Sensitivity scores from the earlier 2-barangay example highlighted
A color spectrum from green to red is applied, where green represents low sensitivity; yellow, moderate sensitivity; and red, high sensitivity. Keeping the raw scores in table form allows users to immediately identify aspects that need particular attention and further evaluation.


CI PHILIPPINES

5 Coastal Integrity Vulnerability Assessment Tool

Fernando P. Siringan[1]
Ma. Yvainne Y. Sta. Maria[2]
Maricar I. Samson[3, 5]
Wilfredo Roehl Y. Licuanan[3]
Rene Rollon[4]

[1] Marine Science Institute, University of the Philippines
[2] Marine Environment and Resources Foundation, Inc.
[3] Br. Alfred Shields, FSC Marine Station, De La Salle University
[4] Institute of Environmental Science and Meteorology, University of the Philippines
[5] Integrated School, De La Salle University – Science and Technology Complex

* ando.msi@gmail.com

The Coastal Integrity Vulnerability Assessment Tool or CIVAT has been designed to promote ecosystems-based management of the coast. Here, we define the coast as the zone delineated by sea cliffs, marine terraces or sand dunes on its landward limit that extends seaward to the shoreface, or a depth at which there is little transport of sediments by wave action. Based on this definition, this zone encompasses natural habitats such as mangroves, seagrasses and coral reefs. It has been documented elsewhere that coral reefs, seagrasses and mangroves are significant sources of beach sediments and effective wave attenuators. Thus, their ecosystem service to the coastal environment is included in this vulnerability assessment tool. Furthermore, this tool also considers processes such as waves and sea level changes, and both intrinsic (e.g., geomorphology, slope, shoreline trends) and extrinsic (e.g., beach mining and coastal structures) characteristics that define the overall state of the coast. External variables are limited to human activities that induce the loss of beach sediments.

Exposure variables such as waves and sea level changes are considered as the main agents of erosion. There is no effort to separate the impact of waves from sea level changes; higher sea levels would allow greater landward penetration of the waves, and thus exacerbate land loss along the coast. Rates of sea level change are computed from satellite-derived sea level anomaly due to their more extensive coverage compared to tide gauges. It is assumed that the values acquired offshore are applicable to the adjacent coast. The effects of other contributors such as vertical land movement due to tectonics or subsidence due to groundwater extraction cannot be included due to scarcity to absence of information.

CIVAT at a glance

Tool Name:	COASTAL INTEGRITY VULNERABILITY ASSESSMENT TOOL (CIVAT) v1.0
Scale:	Barangay
Scope:	Coastal Integrity
CC hazards considered:	Sea-level rise and waves
Description:	Assesses the vulnerability of the physical coast to erosion in relation to CC hazards High (fine) resolution of analysis Incorporates variables relating to natural habitats and processes
Value:	Reveals specific Sensitivity and Adaptive Capacity factors relating to coastal integrity that need particular attention and intervention Able to provide guidance in developing specific CC adaptation strategies to maintain coastal integrity (linked to sustainable fisheries management and biodiversity conservation)
Data needs:	Primary, e.g. beach assessment and monitoring Secondary, e.g. NAMRIA maps and charts, Google earth, tidal records; information scoped by ICSEA-C-Change
Technical needs:	May be applied by coastal managers and field practitioners, with assistance from coastal geology experts in data analysis and interpretation Best if intended users receive training on correct and appropriate application of the tool. (e.g. c/o the Coastal Learning Adaptation Network or CLAN)

Contact information:
Fernando P. Siringan
ando.msi@gmail.com

Ma. Yvainne Y. Sta. Maria
yyvainne@yahoo.com

Marine Science Institute
University of the Philippines Diliman
Quezon City 1101, Philippines

1. INTRODUCTION

Despite the variable nature of the coasts, about 23% of the world's population live both within 100 km of the coast and <100 m above sea level, and population densities in coastal regions are about three times higher than the global average (Small and Nicholls, 2003, cited in Cruz et al., 2007). However, climate change is expected to result in an accelerated rise in sea level of about 60 cm or more by 2100, increase in storm intensity and frequency, and generate larger extreme waves and storm surges among others (Nicholls et al., 2007). With rising seas and more intense storms, coastal communities, especially in low-lying areas, are in danger of permanent marine inundation, episodic inundation by storm surges and/or spring high tides, and enhanced beach erosion.

At present, many shorelines in the Philippines are experiencing erosion not necessarily due to sea level rise, but to other factors such as river channel migration that led to delta switching in the bayhead of Lingayen Gulf (Mateo and Siringan, 2007), changes in river mouth position (e.g., Bauang River delta), and anthropogenic activities such as beach mining in La Union (Siringan et al., 2005). As sea level rises, land loss will worsen in already retreating coastlines while presently stable and accreting shorelines may experience erosion. Thus, there is a need to assess the present-day stability of coastal areas that predisposes it to erosion and marine inundation as a function of the interplay of processes (e.g., waves, tides and sea level change) and both intrinsic (e.g., geomorphology, slope, shoreline trends, natural buffers) and extrinsic (e.g., beach mining) coastal characteristics.

2. OBJECTIVES

Coastal integrity refers to the overall state of the coast resulting from its geologic history (e.g., regional setting, geomorphology), the bio-physical processes (e.g., waves, tides, storms) that continuously shape and re-shape it, and human activities. Factors that undermine coastal integrity are erosion and coastal flooding, both of which result in land loss. Waves, particularly storm waves, are the main agent of erosion. Coastal flooding or inundation may occur occasionally with spring high tides coinciding with storm surges or permanently due to sea level rise. This component aims to develop an objective tool for assessing the vulnerability of coastal areas to erosion and inundation resulting from wave impact and sea level rise. This vulnerability assessment (VA) tool is designed for implementation even by non-specialists such as coastal managers to implement. It is designed to "combine the coastal system's susceptibility to change with its natural ability to adapt to changing environmental conditions, yielding a relative measure of the system's natural vulnerability to the effects of sea-level rise" (Aboudha and Woodroffe, 2006, p. 19).

3. SCOPE AND LIMITATIONS

The domain of interest is the coastal zone, which is influenced by the interaction of marine and terrestrial processes. Geomorphologically, this zone includes sea cliffs, marine terraces and sand dunes on its landward limit, which extends seaward to the shoreface, or a depth equivalent to the wave base at which there is little transport of sediments (Komar, 1976). Based on this definition, the coastal zone, in tropical regions, encompasses coastal habitats such as mangroves, seagrasses and coral reefs. Hence, in this assessment, these habitats are considered an intrinsic part of the coastal zone with important roles to play in maintaining the stability of the coast, specifically for carbonate coasts and islands.

The physical drivers of coastal dynamics, referred to as exposure variables, are limited to processes that respond to climate change such as waves, tides and sea level changes. Other non-climate drivers such as earthquakes and tsunamis, though capable of causing considerable coastal modification, are not considered. Rates of sea level change are computed from satellite-derived sea level anomaly due to their more extensive coverage compared to tide gauges. As such, it pertains only to steric and oceanographic-driven sea level changes and does not take into account vertical land movement due to tectonics, which may underestimate (overestimate) rates of sea level change in areas experiencing subsidence (uplift).

Sensitivity is defined as the here-and-now bio-physical attributes of the coast that predispose it to erosion and inundation as a result of stronger waves and higher sea levels, and are grouped into intrinsic and extrinsic variables. In a geomorpohological context, sensitivity means "the degree to which a rise in sea level or storm surge would initiate or accelerate changes such as coastal retreat and beach erosion" (Aboudha and Woodroffe, 2005, p. 21). Many of the intrinsic sensitivity variables employed in this VA tool - geomorphology, shoreline trends, coastal slope as well as exposure criteria such as waves, tides and rates of sea level change - were adopted from the widely accepted coastal vulnerability index (CVI) developed by Gornitz (1991). In this VA tool, geomorphology and lithology are combined to avoid redundancy in the criteria. Another difference is the coastal slope, which in earlier studies (Gornitz, 1991; Thieler and Hammer-Klose, 1999) is computed as the slope from the subaerial coastal plain to the submerged continental shelf. Here, the landward slope is measured only from the shoreline to 20-m elevation contour. It gives an indication of the susceptibility of the coast to marine flooding and erosion, with low-lying coastal plains more likely to experience rapid erosion and permanent submergence. A significant deviation from the original CVI is the inclusion of natural coastal habitats such as coral reefs, seagrasses, and mangroves. This underscores the importance of the natural habitats for maintaining the stability of the coast as wave buffers, and sediment source and/or stabilizer. As a wave buffer, the morphological structure of a fringing reef is incorporated under two items – the width and lateral continuity of the reef flat (or shore platform in siliciclastic systems). Likewise, the role of mangroves as wave buffer is also included. Moreover, attributes relating to their function as a biogenic sediment source and trap, and as sediment stabilizer are also considered. Lastly, this VA incorporates extrinsic factors in the sensitivity criteria that have direct effects on coastal stability. Extrinsic sensitivity criteria include beach mining and structures on the foreshore (e.g., groins and seawalls), which can exacerbate natural erosional processes due to the direct removal of sediments, and disruption of coastal processes such as longshore transport.

Adaptive capacity refers to the ability or capacity of a system to cope with the changes in climate. For coastal integrity, a good descriptor of adaptive capacity is the ability of the coast to maintain sufficient sediment supply that can offset land loss or erosion, and enable the coast to keep up with sea level rise. Ideally, this can be determined by sediment budget calculations; however, it requires estimating the different sources and sinks of sediments, which is a big research topic by itself. In lieu of sediment budget, long-term shoreline trends is considered as it indicates whether the coast is experiencing net accretion, i.e., an excess of sediment supply, or net erosion, i.e., a deficit in sediment supply. The ability of the system to transport sediment to a coastal segment is influenced by man-made structures. Thus, the degree to which such structures interfere with the regional or local sediment drift is included as a variable, as continuity of sediment supply, under adaptive capacity. In addition, the guidelines on coastal structures and setbacks as well as the type of coastal development or land use have been deemed important in assessing the resilience of the coastal environment. The existence and level of implementation of the guidelines for coastal development may provide safeguards against further land loss due to human modifications. Lastly, a measure of the health of natural habitats is also included; it indicates their viability as sediment source and trap. This attribute is particularly significant for maintaining the resilience of carbonate island systems where there could be minimal riverine sources of sediments.

Ideally, from a geomorphological perspective, the unit of assessment should be in terms of geomorphologic units (i.e., coastal segments with same characteristics, or within the same littoral cell). With this approach, however, correlation with socio-economic data, with political units as basis, will be difficult. Thus, the level of assessment is based on political units, and depends on the scale of assessment needed. For this VA, the unit of assessment is on a barangay level, which assumes that the processes and characteristics are variable enough to allow discrimination of their relative vulnerabilities at this level. However, for some variables such as tides, and sea level changes, discrimination on a barangay level is not possible because of limited instrumentation.

4. INDICATORS

Each variable is assigned a relative score between 1 and 5, corresponding to low (1-2), medium (3-4), and high (5) based on the magnitude of their contribution to physical changes on the coast in relation to waves and sea level rise.

4.1. EXPOSURE CRITERIA

Rates of relative sea level change (RSLC; cm/yr): Rates of RSLC can be estimated from tide gauge records and/or altimetry-derived sea surface heights. Here, we use the rates computed from satellite-derived sea surface heights due to their more extensive coverage compared to the sparsely distributed tide gauges. Based on the known range of vulnerabilities of coastal systems to sea level rise, coastal areas experiencing sea level rise (SLR) in excess of 1.5 cm/y is considered highly vulnerable to inundation and thus assigned a value of 5. Low exposure score is given to areas experiencing SLR less than the average eustatic rate of 2mm/y. However, this parameter is more significant for regional comparison.

Wave exposure: Two scenarios – fair-weather (normal) and storm wave conditions – are considered. The values for wave exposure corresponding to high, medium and low can be obtained from the Relative Exposure Index (REI) shown in Chapter 3 of this Guidebook.

Tidal range: Tidal range influences both permanent and episodic inundation hazards. A coastal area with a large tidal range is given a score of 5 due to its high potential for inundation. However, it is not significant on a barangay level due to limited number of tide gauges and thus similar to SLR, it is more applicable on a regional scale.

Table 12: CIVAT Exposure rubric

A rubric for the assessing the potential impact of exposure parameters to coastal integrity

Exposure variables	Low (1-2)	Moderate (3-4)	High (5)
Rates of relative sea level change (RSLC; cm/yr)	≤ 0.2	0.2-1.5	>1.5
Wave exposure during monsoons	*From Oceanography Group*		
Wave exposure during typhoons	*From Oceanography Group*		
Tidal range	≤ 1	(1.0 to 2.0)	≥ 2

4.2. SENSITIVITY CRITERIA

4.2.1. INTRINSIC

Geomorphology/Lithology: Coastal plains consisting of unconsolidated materials have higher erodibility potential than pebbly/gravelly coasts or cliffs; hence the former is given a score of 5. A coast that is rocky or with high to low cliffs, which are more resistant to wave action, is given a score of 1-2 (low), and a score of 3-4 (medium) for pebbly/gravelly coasts, alluvial plains and those with mangrove shorelines.

Seasonal shoreline trend: A direct measure of short-term coastal stability, it demonstrates the ability of the coast to recover from erosion associated with storm events. It can be inferred from actual field observation (e.g., seasonal beach profiling or shoreline tracing) or anecdotal accounts of coastal dwellers. A shoreline that experiences net erosion within a year is given a high score of 5. Whereas a stable shoreline, neither eroding nor accreting, is assigned a medium sensitivity score (3-4), and accreting coast is given a low score (1-2).

Slope from the shoreline to 20m elevation (landward slope): Coastal plains with gentle gradients (slope < 1:200) are most susceptible to inundation and thus assigned a high score of 5. Aside from inundation potential, the landward slope also indicates rapidity of shoreline retreat as low-lying areas tend to retreat faster than steeper areas (Pilkey and Davis, 1987, cited in Thieler and Hammar-Klose, 1999).

Width of reef flat or shore platform: Reef flat and shore platform are morphological structures fringing the coastline, and are relatively flat and shallow and extend for several tens of meters seaward. They are natural barriers where the waves break before reaching the coastline and are thus effective wave attenuators. Reef flat and shore platform with widths greater than 100m are assigned a low sensitivity score (1-2).

Lateral continuity of reef flat or shore platform: Aside from width, the effectiveness of reef flat or shore platform as wave buffer depends on their lateral continuity relative to the shoreline length of the study area. A reef flat or shore platform that protects more than 50% of the total shoreline length of the barangay is given a low sensitivity score. In contrast, a reef flat or shore platform protecting less than 10% of the barangay is given a score of 5.

Beach forest and vegetation: Beach forests and vegetation along sandy coasts are effective sand stabilizers due to their root systems. Their effectiveness in stabilizing sand is assumed to be dependent on the thickness of the vegetation in general, and the relative abundance of the creeping variety in particular. A high score (5) is given to beaches with patchy vegetation, a medium score (3-4) for thin vegetation with few creeping varieties, and a low score (1-2) for thick vegetation with many creeping varieties.

Presence or absence of natural habitats: Coastal habitats such as coral reefs, seagrass beds and mangroves are effective wave attenuators and important source and/or trap of sediments for the adjacent beach. Coastal areas that have no such habitats are given a score of 5 and those with all three habitats, or even just two of the habitats, are assigned a score of 1-2.

If comparing areas where the natural habitats (e.g., reef-fringed coastal system) are present, the following set of rubrics should be used instead of the above criterion (i.e., presence or absence of natural habitats). Data for the

Coral reef as sediment source: It includes how much living coral there is, and the predominant growth form of these corals. These attributes were chosen to indicate the presence of sustainable source of sediment that will help keep the integrity of the coast. The criteria being proposed here suggests that high coral cover of healthy hemispherical corals are less sensitive to abrasion and breakage thereby ensuring a natural and sustainable production of sediments that can be transported to the coast.

CRITERION	LOW	MEDIUM	HIGH
	(1-2 per criterion)	(3-4 per criterion)	(5 per criterion)
living coral cover	over 50%	between 25% to 50%	less than 25%
coral community growth form in the shallow reef	at least half the corals are hemispherical/ massive and encrusting	at least half the corals are tabulate	at least half the corals are branching and foliose

Seagrasses as sediment source and stabilizer: The attributes that will be important are the areal extent of the meadow, type of the meadow in terms of its species composition, and its capacity to withstand storm removal and wave impacts. As in the role of corals in coastal integrity, seagrass meadows are also good sources of sediments by providing some species of foraminiferans a habitat or host where they can attach to. Aside from these, seagrasses also have an important role in stabilizing sediment thereby maintaining the integrity of the coast. The criteria being proposed here suggest that wide, multispecies meadows with extensive root system are less sensitive to wave impact and those which are narrow, monospecific meadows with small sized species are deemed to be more sensitive.

CRITERION	LOW	MEDIUM	HIGH
	(1-2 per criterion)	(3-4 per criterion)	(5 per criterion)
areal extent relative to reef flat	seagrass covers more than half the reef flat	seagrass covers more than 1/8 to 1/2 the reef flat	seagrass covers less than 1/8 the reef flat
capacity to withstand storm removal and wave impacts	root system extensive; *Enhalus acoroldes* and *Thalassia hemprichii* dominated	*Thalassia-Cymodocea-Halodule* beds	small-sized species, i.e. *Halophila- Halodule* meadows
seagrass meadow type	mixed bed with over 5 species	2 to 4 species	monospecific bed

Mangrove as sediment trap: It includes the forest type, mangrove zonation, and their inherent capacity to trap sediments. Forest type will be indicative of the extent and species composition of an area. The remaining two attributes will be dependent on the dominant species assemblage, the root architecture and robustness of the tree such that forests which are extensive and dominated by species with a pneumatophore root system will be more efficient in trapping sediments thereby reducing the sensitivity of the coast to wave impacts. Structurally, pneumatophores are entangled with one another, forming an efficient barrier system for sediment flow to the nearby habitats.

CRITERION	LOW	MEDIUM	HIGH
	(1-2 per criterion)	(3-4 per criterion)	(5 per criterion)
forest type	riverine-basin-fringing type; basin-fringing type	riverine-fringing type; fringing	no mangrove; scrub type
mangrove zonation	3 to 4 mangrove zones (*Avicennia-Sonneratia; Rhizophora; Ceriops-Bruguiera-Xylocarpus; Nypa* zones)	2 mangrove zones	only 1 mangrove zone present
capacity to trap sediments	at least half of the mangrove area are *Avicennia-Sonneratia* dominated	at least half of the mangrove area are dominated by species with pneumatophore *(Avicennia-Sonneratia)* and knee root *(Bruguiera, Ceriops tagal)* system	area is dominated by species with prop (*Rhizophora*) or buttress/plank (*Xylocarpus granatum, Heritiera littoralis*) type of root system

Mangrove as wave buffer: The scores for this rubric will be dependent on the extent and condition of the remaining mangrove areas, as well as the dominant species assemblage, the root architecture and robustness of the tree. The three criteria for the role of mangrove as sediment source are also included here.

CRITERION	LOW	MEDIUM	HIGH
	(1-2 per criterion)	(3-4 per criterion)	(5 per criterion)
forest type	riverine-basin-fringing type	riverine-fringing type	scrub-fringing type
present vs historical mangrove extent	0 to 25% of original mangrove area loss; at least 75% of seaward zone remaining	26 to 50% of original mangrove area loss	over 50% of original mangrove area loss
mangrove zonation	3 to 4 mangrove zones (*Avicennia-Sonneratia; Rhizophora; Ceriops-Bruguiera-Xylocarpus; Nypa* zones)	2 mangrove zones	only 1 mangrove zone present
mangrove canopy cover	mangrove area with over 50% canopy cover	mangrove area with canopy cover that is between 25% to 50%	mangrove area with less than 25% canopy cover
mangrove basal area	more than 50 m^2 per ha	between 25 to 50 m^2 per ha	less than 25 m^2 per ha

natural habitats can be acquired through field surveys or from secondary sources. Since the structural function of a coral reef as a wave buffer is already incorporated under the width and lateral continuity of reef flat and shore platform, its role as sediment source and trap is highlighted here as well as for mangroves and seagrasses. The role of mangroves as wave buffers is also included here.

4.2.2. EXTRINSIC

Beach and offshore mining: The impact of beach and offshore mining on coastal stability depends on the scale of its operation: the larger the operation, the greater the volume of sediments extracted from the coast. Thus, a high sensitivity score (5) is assigned to coastal areas with mining operations on a commercial scale, a medium score (3-4) for household-scale operations, and a low score (1-2) where such activity is negligible to non-existent.

Structures on the foreshore: The sensitivity of the coast is directly proportional to their size (e.g., groins) and extent relative to shoreline length (e.g., seawalls). It is assumed that large structures have far-reaching effects on the disruption of coastal processes and thus are given a score of 5. Since these structures are often constructed to protect the coast from chronic erosion, the absence of these structures suggests that erosion is not yet taking place, so a low score (1-2) is assigned to such areas.

The sensitivity criteria can be further subdivided into two sets of rubrics: (1) sensitivity of the coast to erosion due to waves, and (2) sensitivity of the coast to inundation due to sea level rise. Attributes related to erosion include geomorphology/lithology, seasonal shoreline trends, coastal slope, width and lateral continuity of reef flat and shore platform, beach forest/vegetation, natural habitats (coral reefs, mangroves and seagrasses) as sediment source, mangrove as buffer, and extrinsic variables such as coastal and offshore mining, and coastal protection structures. The rubric for the sensitivity to inundation due to sea level rise has fewer variables: geomorphology, coastal slope, and mangroves as sediment trap. However, the discussion will be limited to the sensitivity of the coast to erosion. The rubric for assessing the sensitivity of the coast to climate change is presented in **Table 13** while the set of rubrics for natural habitat variables is consolidated as **Table 14**.

Table 13: CIVAT Sensitivity rubric

Incorporates the role of natural habitats and extrinsic factors in assessing the sensitivity of the coast in relation to wave impact and sea level rise

	SENSITIVITY CRITERIA	LOW (1-2)	MEDIUM (3-4)	HIGH (5)
INTRINSIC FACTORS	Coastal landform and rock type	Rocky, cliffed coast; beach rock	Low cliff (<5m high); Cobble/gravel beaches; alluvial plains; fringed by mangroves	Sandy beaches; deltas; mud/sandflat
	Seasonal beach recovery	Net Accretion	Stable	Net Erosion
	Slope from the shoreline to 20-m elevation (landward slope)	greater than 1:50	1:50-1:200	less than 1:200
	Width of reef flat or shore platform (m)	greater than 100	(50, 100)	less than 50
	Beach forest/vegetation	Continuous and thick with many creeping variety	Continuous and thin with few creeping variety	Very patchy to none
	Lateral continuity of reef flat or shore platform	greater than 50%	(10-50)	less than 10%
	Coastal habitats	Coral reef, mangroves and seagrasses or coral reef and mangroves are present	Either coral reef or mangrove is present	None
	If habitat assessment is possible, the following set of rubrics are to be evaluated: ▶ Coral reef as sediment source ▶ Mangroves as sediment trap ▶ Seagrasses as sediment source and stabilizer ▶ Mangroves as wave buffer Criteria for these rubrics are consolidated in Table 14.			
EXTRINSIC FACTORS	Coastal and offshore mining (includes removal of fossilized corals on the fringing reef and beach)	None to negligible amount of sediments being removed (i.e., sand and pebbles as souvenir items)	Consumption for household use	Commercial scale
	Structures on the foreshore	None; one or two short groins (i.e., <5m long) and/or few properties on the easement with no apparent shoreline modification	Short groins & short solid-based pier (5 to 10m long); seawalls and properties with aggregate length of less than 10% of the shoreline length of the barangay	Groins and solid-based pier > 10m long; seawalls and other properties with aggregate length of more than 10% of the shoreline length of the barangay

*Range of values may change depending on the attributes of the areas being compared.

Table 14: CIVAT Sensitivity rubric for coastal habitats

Evaluates coastal habitats, i.e. coral reefs, seagrasses, and mangroves, in relation to the sensitivity of the physical coast to wave impact and sea-level rise

	SENSITIVITY CRITERION	LOW (1-2 pts per criterion)	MEDIUM (3 to 4 points per criterion)	HIGH (5 pts per criterion)
Coral as sediment source	Living coral cover	Over 50%	Between 25 to 50%	Less than 25%
	Coral community growth form in the shallow reef	At least half of the corals are hemispherical/ massive and encrusting	At least half of the corals are tabulate	At least half of the corals are branching and foliose
Seagrass bed as sediment source and stabilizer	Areal extent relative to reef flat	Seagrasses cover more than half of the reef flat	Seagrasses cover more than 1/8 to 1/2 of the reef flat	Seagrasses cover less 1/8 of the reef flat
	Capacity to withstand storm removal and wave impacts	Root system extensive; *Enhalus acoroides* and *Thalassia hemprichii* dominated	*Thalassia - Cymodocea- Halodule* beds	Small sized species, i.e. *Halophila - Halodule* meadows
	Seagrass meadow type	Mixed bed with over 5 species	2 to 4 species	Monospecific bed
Mangroves as sediment trap	Forest type	Riverine-basin-fringing type; basin-fringing type	Riverine-fringing type; fringing	No mangrove; scrub type
	Mangrove zonation	3 to 4 mangrove zones (*Avicennia-Sonneratia; Rhizophora; Ceriops- Bruguiera-Xylocarpus; Nypa* zones)	2 mangrove zones	Only 1 mangrove zone present
	Capacity to trap sediments	At least half of the mangrove area are *Avicennia-Sonneratia* dominated	At least half of the mangrove area are dominated by species with pneumatophore (*Avicennia, Sonneratia*) and knee root (*Bruguiera, Ceriops tagal*) system	Area is dominated by species with prop (*Rhizophora*) or buttress/ plank (*Xylocarpus granatum, Heritiera littoralis*) type of root system
Mangroves as wave buffer	Forest type	Riverine-basin-fringing type	Riverine-fringing type	Scrub-fringing type
	Present vs historical mangrove extent	0 to 25% of original mangrove area loss; at least 75% of seaward zone remaining	26 to 50% of original mangrove area loss	over 50% of original mangrove area loss
	Mangrove zonation	3 to 4 mangrove zones (*Avicennia-Sonneratia; Rhizophora; Ceriops- Bruguiera-Xylocarpus; Nypa* zones)	2 mangrove zones	Only 1 mangrove zone present

Table 14: CIVAT Sensitivity rubric for coastal habitats (continued)

	Mangrove canopy cover	Mangrove area with over 50% canopy cover	Mangrove area with canopy cover that is between 25% to 50%	Mangrove area with less than 25% canopy cover
	Mangrove basal area	More than 50 m^2 per ha	Between 25 to 50 m^2 per ha	Less than 25 m^2 per ha

4.3. ADAPTIVE CAPACITY CRITERIA

Long-term shoreline trends: It is a proxy for sediment budget. It indicates the capability of the coast to recover from events that lead to changes in sediment supply such that the net effect is that of a coast experiencing net accretion or net erosion. An accreting coastline is given a high score for adaptive capacity. In contrast, a coastline that experiences more than a meter of erosion per year is given low adaptive capacity score (1-2);

Continuity of sediment supply: This is in relation to coastal structures such that large structures may be more capable of disrupting sediment supply on a regional scale as opposed to smaller ones. A low adaptive capacity score (1-2) is assigned to areas where the scale of interruption in sediment supply is regional, i.e., its effect cuts across barangay boundaries, and a high score (5) if sediment supply is uninterrupted within a littoral cell.

Guidelines on setback/easement: This pertains to the existence and level of implementation of a setback policy. Strict implementation of this policy will ensure uninterrupted supply of sediments within a littoral cell. Thus a coastal area where such policy is strictly implemented is considered to have higher adaptive capacity (5) than an area where no such law exists.

Guidelines on coastal structures: Similar to the setback policy, this relates to the existence and implementation of construction guidelines that promotes uninterrupted supply of sediments. A coastal area that promotes non-permanent structures is given a high score (5) for adaptive capacity. Likewise, an area that has a policy and the means for converting or removing hard structures causing erosion is considered to be highly adaptive.

Type of coastal development: This pertains to the dominant land use along a coast and how easily it can adapt to chronic and persistent erosion due to higher sea level and stronger storms. Thus, in this context, a coastal area that is relatively undeveloped is considered to have higher adaptive capacity than an area that is highly urbanized and industrialized.

Table 15 presents the set of criteria, including those pertaining to natural habitats, for assessing the adaptive capacity of the coast in relation to wave impact and sea level rise. Similar to the sensitivity component, the criteria that highlight the role of natural habitats as sediment source/ trap should be included if assessment is being conducted on a relatively homogeneous system where these habitats are present (e.g., reef-fringed coastal system). These are presented in Table 16.


CI PHILIPPINES


JÜRGEN FREUND

Table 15: CIVAT Adaptive Capacity rubric

Assesses the adaptive capacity of the coast in relation to wave impact and sea level rise

ADAPTIVE CAPACITY CRITERIA	LOW (1-2)	MEDIUM (3-4)	HIGH (5)
Long-term shoreline trends (m/ year)	≤ -1 (eroding)	(-1 and 0)	>0 (accreting)
Continuity of sediment supply	if interruption in sediment supply is regional	if interruption in sediment supply is localized	If sediment supply is uninterrupted
Guidelines regarding the easement (setback zone)	No provision for easement (setback zone) in the CLUP and zoning guidelines	Setback policy is clearly stated in the CLUP and zoning guidelines; with <50% implementation	Implementation of setback policy is at least 50%
Guidelines on coastal structures	CLUP and zoning guidelines promotes the construction of permanent and solid-based structures along the coast	Clearly states the preference for semi-permanent or temporary structures to be built along the coast(e.g., made of light materials and on stilts) is in the CLUP and zoning guidelines	Prohibits construction of solid-based structures; For those already erected, CLUP/zoning guidelines has provision to remove or modify any structure causing obstruction and coastal modification
Type of coastal development	Industrial, commercial, highways, large institutional facility	Residential	Agricultural, open space, greenbelt
Viability of coral reef as sediment source	*See the following discussion on natural habitat criteria and Table 16*		
Viability of seagrasses as sediment source			
Viability of mangroves as sediment trap			
Viability of mangroves as wave buffer			

The criteria for the role of natural habitats as sediment source and trap under adaptive capacity are described below.

Viability of coral reef as a sediment source: Coral cover will be used again. However the range of scoring for the criteria will be reversed such that those with high coral cover will have a high score in terms of its adaptive capacity.

CRITERION	LOW	MEDIUM	HIGH
	(1-2 per criterion)	(3-4 per criterion)	(5 per criterion)
living coral cover	over 50%	between 25% to 50%	less than 25%

Viability of seagrasses as sediment source: The inherent characteristic of the meadow to recover from storm blow-outs will be considered. In this attribute, the ability of the species to re-colonize an area will be important such that those with small sizes and have a faster rate of horizontal elongation will be more adaptive than the more robust and slow colonizing species.

CRITERION	LOW	MEDIUM	HIGH
	(1-2 per criterion)	(3-4 per criterion)	(5 per criterion)
capacity to recover from storm blowouts	*Enhalus-Thalassia* dominated	*Thalassia - Cymodocea - Halodule* dominated	*Halophila - Halodule* dominated

Viability of mangroves as sediment trap: The adaptive capacity attribute will still use the ability of the mangroves to trap sediments, however as in the coral criteria, scores will be reversed such that those which are dominated with pneumatophore-type species will have high scores and those with root systems which are widely spaced will have low adaptive capacity.

CRITERION	LOW	MEDIUM	HIGH
	(1-2 per criterion)	(3-4 per criterion)	(5 per criterion)
capacity to trap sediments	area is dominated by species with prop (*Rhizophora*) or buttress/plank (*Xylocarpus granatum, Heritiera littoralis*) type of root system	at least half of the mangrove area are dominated by species with pneumatophore *(Avicennia-Sonneratia)* and knee root *(Bruguiera, Ceriops tagal)* system	at least half of the mangrove area are *Avicennia-Sonneratia* dominated

Mangrove as wave buffer: The scores for this rubric will be dependent on the extent and condition of the remaining mangrove areas as well as the dominant species assemblage, the root architecture and robustness of the tree.

CRITERION	LOW	MEDIUM	HIGH
	(1-2 per criterion)	(3-4 per criterion)	(5 per criterion)
mangrove canopy cover	mangrove area with less than 25% canopy cover	mangrove area with canopy cover that is between 25% to 50%	mangrove area with over 50% canopy cover
mangrove basal area	less than 25 m^2 per ha	between 25 to 50 m^2 per ha	more than 50 m^2 per ha

Table 16: CIVAT Adaptive Capacity rubric for natural habitats

Evaluates natural habitats in relation to their role as viable sediment sources and/or traps

ADAPTIVE CAPACITY CRITERIA		LOW	MEDIUM	HIGH
		(1-2)	(3-4)	(5)
Viability of coral reef as sediment source	Living coral cover	less than 25%	between 25 to 50%	over 50%
Viability of seagrasses as sediment source	Capacity to recover from storm blow-outs	*Enhalus-Thalassia* dominated	*Thalassia - Cymodocea-Halodule* dominated	*Halophila - Halodule* dominated
Viability of mangroves as sediment trap	Capacity to trap sediments	area is dominated by species with prop (*Rhizophora*)or buttress/ plank (*Xylocarpus granatum, Heritiera littoralis*) type of root system	at least half of the mangrove area are dominated by species with pneumatophore (*Avicennia, Sonneratia*)and knee root (*Bruguiera, Ceriops tagal*) system	at least half of the mangrove area are *Avicennia-Sonneratia* dominated
Viability of mangroves as wave buffer	Mangrove canopy cover	mangrove area with less than 25% canopy cover	mangrove area with canopy cover that is between 25% to 50%	mangrove area with over 50% canopy cover
	Mangrove basal area	less than 25 m^2 per ha	between 25 to 50 m^2 per ha	more than 50 m^2 per ha

5. CALCULATING VULNERABILITY VALUES

5.1. CROSS-TABULATION METHOD

Cross-tabulation is an approach adopted from Samson (2011) and currently used in a tool to assess the vulnerability of fisheries to climate change impacts (see Chapter 6). Aggregate scores obtained respectively for the exposure, sensitivity and adaptive capacity components are rescaled into Low-Medium-High (L-M-H). The range of scores for rescaling depends on the difference between the highest and the lowest scores possible. For example, if the number of criteria is 5, then the highest score that can be obtained is 25 (or 5 x 5) whereas the lowest score possible is 5 (i.e., 1 x 5) for each component. The difference between the highest and lowest scores is then divided into three equal parts for the L-M-H assignment. Alternatively, for a given number of criteria, the appropriate range for rescaling can be obtained from **Table 17**. With rescaling to L-M-H for each component, the concern about the unequal number of criteria for each component is somewhat addressed.

The rescaled exposure component is then cross-tabulated with the rescaled sensitivity component such that their combination would correspond to a certain degree of potential impact (also in terms of L-M-H) as shown in **Figure 14**.

Potential Impact				
		Sensitivity		
Exposure		L	M	H
	L	L	L	M
	M	L	M	H
	H	M	H	H

Figure 14: Potential impact as a function of sensitivity and exposure

Table 17: CIVAT Rescaling Guide

Guide for rescaling the total scores for the Exposure, Sensitivity and Adaptive Capacity components into Low-Medium-High rating

If the no. of criteria = 2	
Maximum score	(2 x 5) = 10
Minimum score	(2 x 1) = 2
Total range	[max - min] = 8
Intervals	8 ÷ 3 = 2.7 or 3
Interval	8/3
	2.7

Rating	Range
Low	2-4
Medium	5-7
High	8-10

If the no. of criteria = 3	
Maximum score	(3 x 5) = 15
Minimum score	(3 x 1) = 3
Total range	[max - min] = 12
Intervals	12 ÷ 3 = 4
Interval	12/3
	4.0

Rating	Range
Low	3-7
Medium	8-11
High	12-15

If the no. of criteria = 4	
Maximum score	(4 x 5) = 20
Minimum score	(4 x 1) = 4
Total range	[max - min] = 16
Intervals	16 ÷ 3 = 5.3 or 5
Interval	16/3
	5.1

Rating	Range
Low	4-9
Medium	10-15
High	16-20

If the no. of criteria = 5	
Maximum score	(5 x 5) = 25
Minimum score	(5 x 1) = 5
Total range	[max - min] = 20
Intervals	20 ÷ 3 = 6.7 or 7
Interval	20/3
	6.7

Rating	Range
Low	5-11
Medium	12-18
High	19-25

If the no. of criteria = 6	
Maximum score	(6 x 5) = 30
Minimum score	(6 x 1) = 6
Total range	[max - min] = 24
Intervals	24 ÷ 3 = 8
Interval	24/3
	8.0

Rating	Range
Low	6-14
Medium	15-22
High	23-30

If the no. of criteria = 7	
Maximum score	(7 x 5) = 35
Minimum score	(7 x 1) = 7
Total range	[max - min] = 28
Intervals	28 ÷ 3 = 9.3 or 9
Interval	28/3
	9.3

Rating	Range
Low	7-16
Medium	17-26
High	27-35

If the no. of criteria = 8	
Maximum score	(8 x 5) = 40
Minimum score	(8 x 1) = 8
Total range	[max - min] = 32
Intervals	32 ÷ 3 = 10.7 or 11
Interval	32/3
	10.7

Rating	Range
Low	8-18
Medium	19-29
High	30-40

If the no. of criteria = 9	
Maximum score	(9 x 5) = 45
Minimum score	(9 x 1) = 9
Total range	[max - min] = 36
Intervals	36 ÷ 3 = 12
Interval	36/3
	12.0

Rating	Range
Low	9-21
Medium	22-33
High	34-45

If the no. of criteria = 10	
Maximum score	(10 x 5) = 50
Minimum score	(10 x 1) = 10
Total range	[max - min] = 40
Intervals	40 ÷ 3 = 13.3 or 13
Interval	40/3
	13.3

Rating	Range
Low	10-23
Medium	24-37
High	38-50

If the no. of criteria = 11	
Maximum score	(11 x 5) = 55
Minimum score	(11 x 1) = 11
Total range	[max - min] = 44
Intervals	44 ÷ 3 = 14.7 or 15
Interval	44/3
	14.7

Rating	Range
Low	11-26
Medium	27-41
High	42-55

If the no. of criteria = 12	
Maximum score	(12 x 5) = 60
Minimum score	(12 x 1) = 12
Total range	[max - min] = 48
Intervals	12 ÷ 3 = 16
Interval	48/3
	16.0

Rating	Range
Low	12-28
Medium	29-44
High	45-60

If the no. of criteria = 13	
Maximum score	(13 x 5) = 65
Minimum score	(13 x 1) = 13
Total range	[max - min] = 52
Intervals	52 ÷ 3 = 17.3 or 17
Interval	52/3
	17.3

Rating	Range
Low	13-30
Medium	31-48
High	49-65

Once the potential impact is determined, it is then cross-tabulated with adaptive capacity to infer the degree of vulnerability (**Figure 15**). Note, however, that the results for vulnerability are interpreted differently from that of potential impact. While L-M-H for potential impact (PI) suggests the worsening state of a system, the L-M-H for adaptive capacity (AC) connotes increasing resilience of the same system due to its inherent capacity to cope. A system is considered highly vulnerable if it has high PI and low AC, medium PI and low AC, and high PI and medium AC. In contrast, a system with low PI and high AC, low PI and medium AC, and medium PI and high AC is considered least vulnerable. Thus, a system whose adaptive capacity scored higher than the potential impact is considered to have lower vulnerability than a system where the potential impact exceeds its capacity to cope. A moderately vulnerable system is one in which the potential impact of climate change can be offset by its adaptive capacity (i.e., LL, MM, HH combinations).

Vulnerability			
	Adaptive Capacity		
Potential Impact	L	M	H
L	M	L	L
M	H	M	L
H	H	H	M

Figure 15: Vulnerability as a function of potential impact and adaptive capacity

5.2. CONSIDERING THE NATURAL HABITAT CRITERIA IN THE ASSESSMENT

If habitat assessment can be conducted, the rubric should include the criteria for the natural habitats (see above tables for the habitats). In this scheme, the role of the habitats in maintaining the stability of the coast will be highlighted, and not the individual attributes of that habitat. However, depending on the inherent geology of the area, there are two ways of treating the natural habitat scores. If the assessment is conducted on a mixed siliciclastic (river-derived) or carbonate (reef-fringed) environment, the natural habitats will be represented as a single line in the rubric with the overall average or arithmetic mean as the score. However, if the assessment is done along a coastal segment with one or more of the habitats being present such as a reef-fringed coast, there will be a single line for each function of the natural habitat, i.e., single line for coral reef as sediment source, a single line for mangroves as wave buffer, etc. For each line, we propose the use of a simple average or arithmetic mean instead of total scores so that the natural habitat scores will not weigh too heavily in the vulnerability assessment. When there is a need to compare such a coastal segment to others that are siliciclastic in nature, the habitats will again be represented by a single line and their scores will have to be collapsed using the arithmetic mean.

It should be noted that there are necessary repetitions of some natural habitat criteria in the sensitivity and adaptive capacity components. But these should be interpreted differently as the sensitivity parameters describe the present state of the system being assessed whereas the adaptive capacity parameters represent some process variables that can contribute to sediment production for the coast. Another caveat is the different directionality of the sensitivity and adaptive capacity components in relation to vulnerability. While sensitivity is directly proportional to vulnerability, the inverse is true for adaptive capacity: a high adaptive capacity lowers vulnerability. This means that although the same variables are used for the sensitivity and adaptive capacity components, scores corresponding to the given thresholds are reversed to reflect this difference in directionality.

6. ANALYSIS AND INTERPRETATION

6.1. APPLICATION OF THE VA TOOL TO SELECTED COASTAL AREAS IN CALAUAG BAY

The rubrics for assessing the vulnerability to wave impact and sea level rise were applied to selected coastal barangays of Calauag, Quezon. Only the barangays located within the embayment and with clear satellite imagery were included in the vulnerability assessment. Likewise, not all the sensitivity and adaptive capacity variables listed in **Tables 13 and 15** were considered. This assessment involved 3 exposure variables (storm waves, waves generated by NE monsoon and rates of SLC), 4 sensitivity variables (geomorphology, landward slope, lateral continuity of reef flat, structures on the foreshore, and the presence of natural buffers) and two for adaptive capacity (long-term shoreline trends, and type of coastal development) for which data are available. Three barangays – Lagay, Pinagsakayan and Ipil - have complete data for the natural habitats.

6.1.1. EXPOSURE FACTORS

The relative exposure of the coastal barangays to waves during the NE monsoon and storm conditions was derived from wave modeling using the SWAN software (**Figure 16**). Here, wave heights of 0.9m and 2.7m were imposed respectively for NE monsoon, and storm simulations. Figure

3 shows the relatively high exposure of the northwestern barangays, from Agoho to Dominlog, to wave impact, especially to storm surges. Barangays on the more protected bayhead and eastern coast have low exposure to waves generated by NE winds except for Lagay with medium exposure. Storm wave simulation, however, had increased the wave exposure of Mulay and Kinamaligan from low to moderate, and the coast from Balibago to Manhulugin from moderately- to highly-exposed to storm surges.

Altimetry-derived sea surface heights provided the data set for estimation of sea level change. The trend of sea level anomaly was used as proxy for the rate of sea level change. The town of Calauag is situated in a region where the rate of sea level rise is about 7 mm/yr, which is equivalent to a score of 3 (**Figure 17**). Since the rate of SLR is uniform on a barangay level, the exposure scores are greatly influenced by wave impact.

6.1.2. COASTAL CHARACTERISTICS

The town of Calauag sits between two major splays of the Philippine Fault Zone (PFZ) that runs through Lamon and Calauag bays (**Figure 18**). It is possible that the origin of Calauag Bay is related to movements of the central PFZ as the embayment is oriented parallel to these faults (**Figure 18, right**). Owing to its tectonic setting, the coasts within Calauag Bay are almost linear. However, there is a stark contrast in landforms at the opposite sides of the bay. To its west, the terrain is generally steep and mountainous, terminating in narrow coastal plains fringed by equally narrow coral reefs (**Figure 18**). In contrast, the eastern side consists of rolling hills descending into gentler and wider coastal plains. Fringing coral reefs, more than a kilometer wide in some areas, occur almost continuously along the eastern coast (**Figure 18, right**). The linearity of the eastern coast is interrupted by two small embayments drained by rivers. For the most part, the coastal plain of Calauag is occupied and protected by mangroves, both old and secondary growth, on its seaward side. The bayhead, where the town proper is located, consists of muddy deltaic sediments with adjoining extensive mudflats on its seaward side.

Almost the entire coast of Calauag has experienced erosion over the past 50 years, including the coasts fringed by mangroves and coral reefs (**Figure 19; Table 18**). Only the bayhead has shown accretion mainly because of reclamation by more than 100m seaward. The coastal road

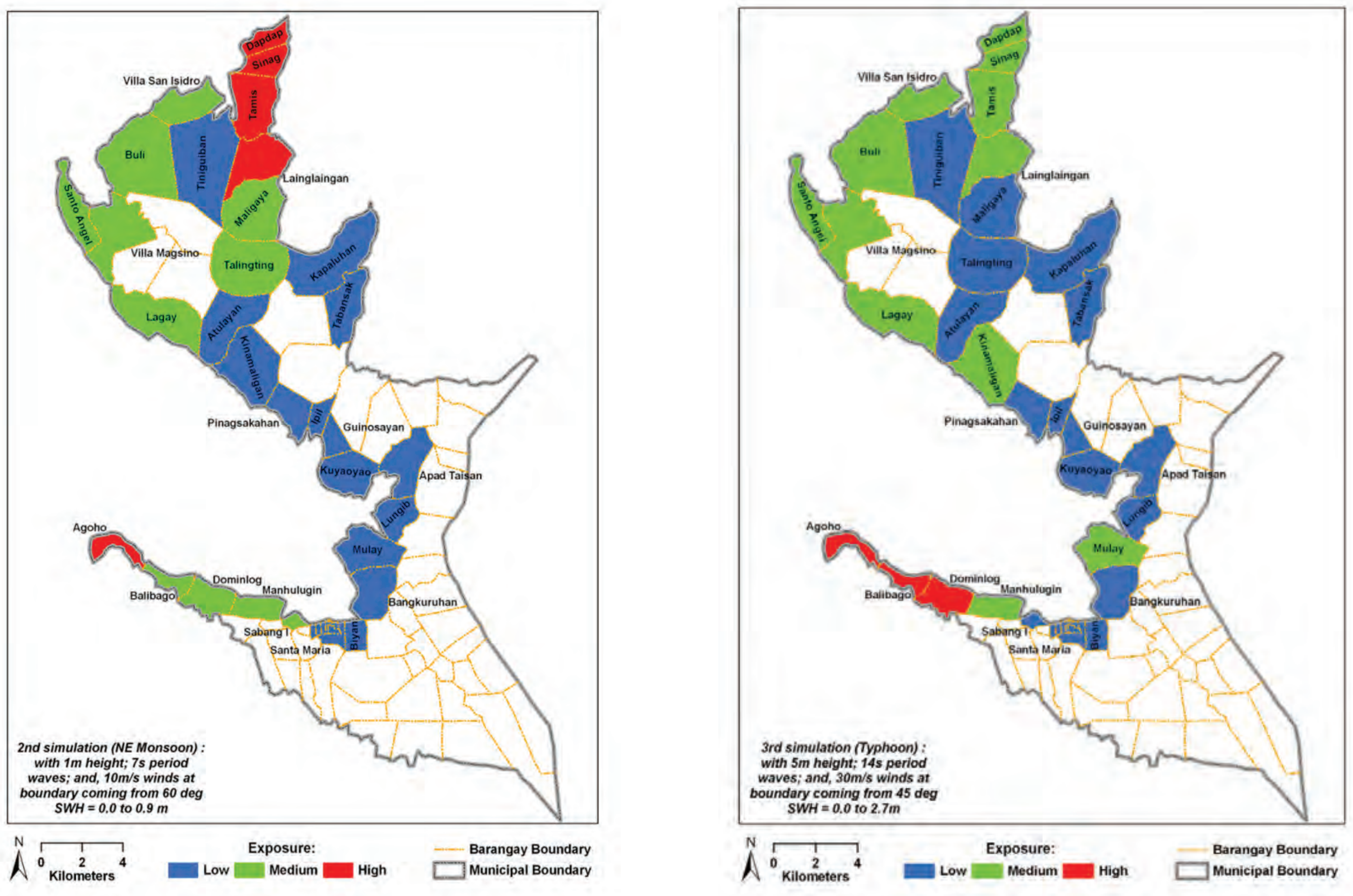


Figure 16: Wave exposure during NE winds (left) and typhoons (right). Scores of 1-3-5 are assigned respectively to low (L), medium (M), and high (H) exposure to waves

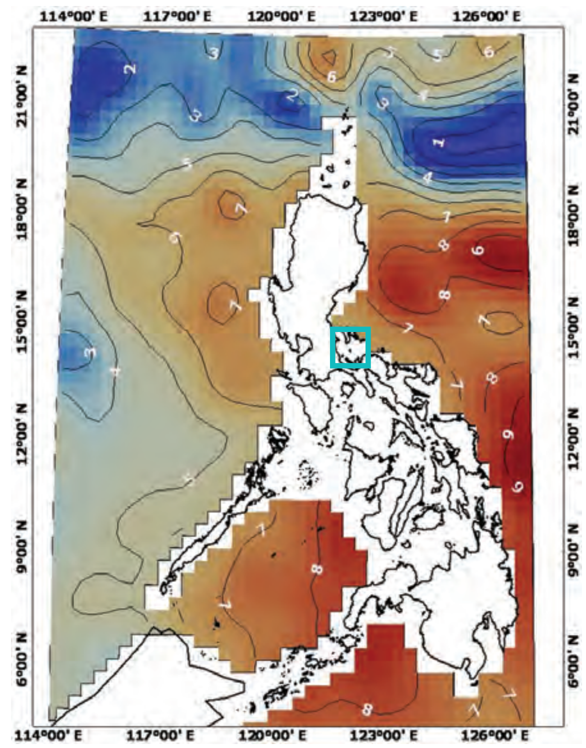


Figure 17: Rates of sea level changes (in mm/yr) between 1993 and 2009. Boxed area is Calauag Bay

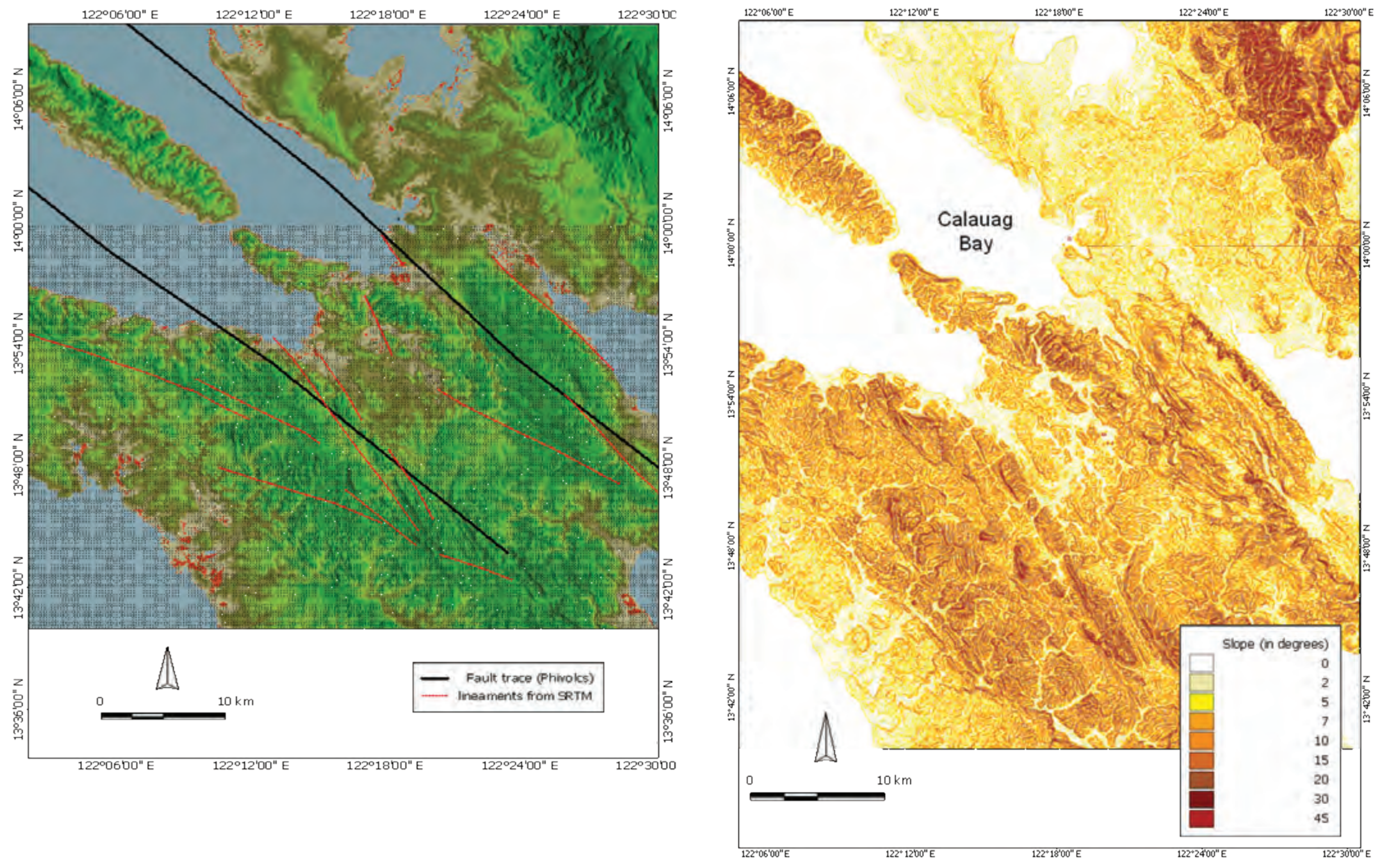


Figure 18: Coastal characteristics of the town of Calauag showing the orientation of Calauag Bay parallel to two major splays of the Philippine Fault Zone (left) and the stark contrast between landforms found on the opposite sides of the Guinyangan Fault (right)

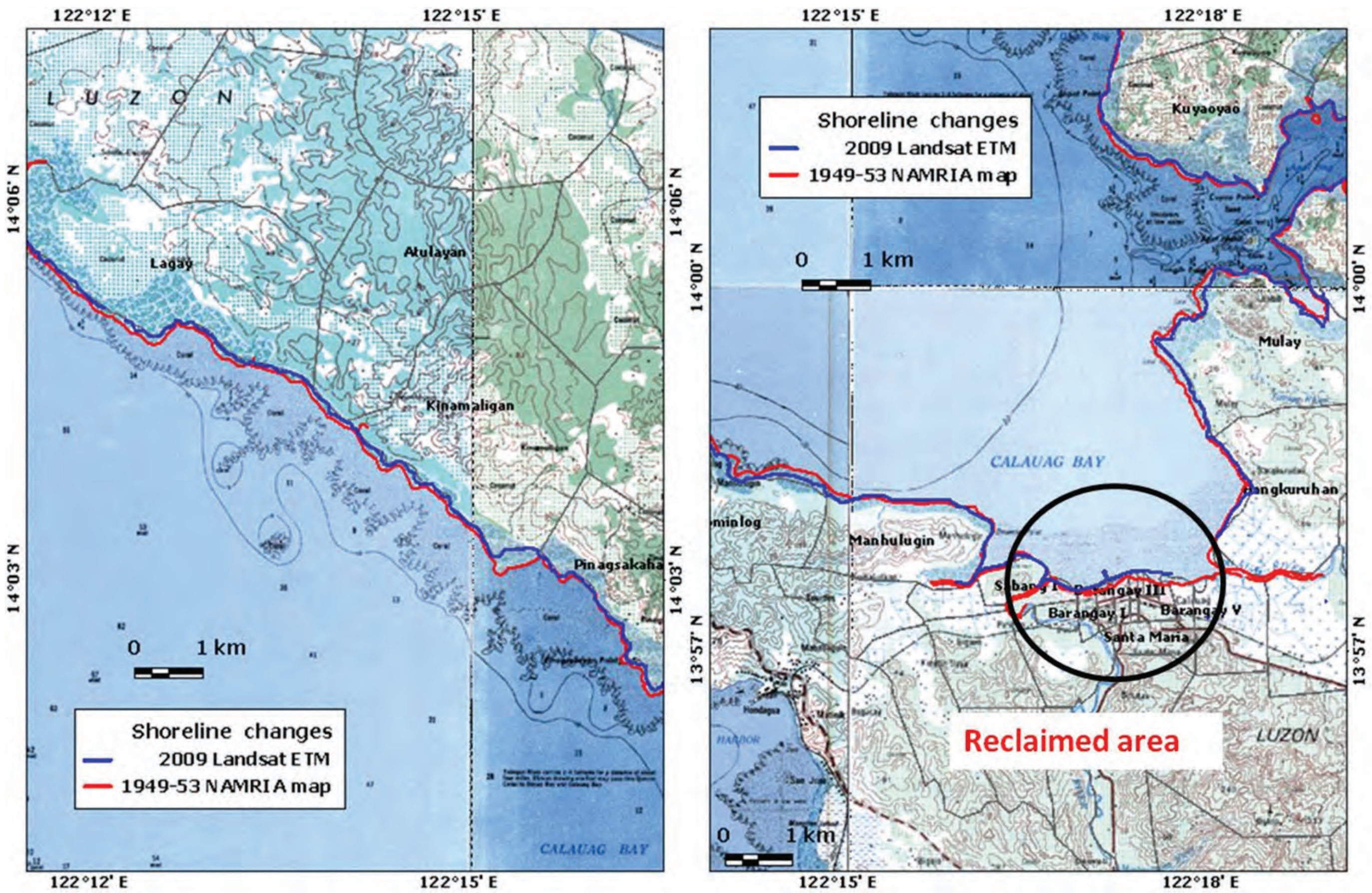


Figure 19: Changes in shoreline position from 1950s to 2009 showing the predominance of erosion except in the reclaimed bayhead

where the market and pier are located, or the boulevard, is part of the reclaimed area that, based on the FGD and map analysis, extends two streets landward from the seawall. The reclaimed bayhead has relatively gentler gradients than the rest of the barangays and, together with the western barangays, has comparatively narrower coastal plains than the eastern barangays (See Table 18).

6.1.3. VULNERABILITY TO EROSION

The results of the scoring and cross-tabulation method are presented respectively in Table 19 and Table 20. Color-coding in Table 19 highlights the parameters that make an area vulnerable while Table 20 indicates which areas scored high with respect to the three components of vulnerability. Combining them will provide better insights towards determining some appropriate adaptation measures that can address or lessen the vulnerability of an area to erosion.

Barangays located on the bayhead have the highest sensitivity to erosion primarily because of its highly erodible substrate (i.e., mudflats), and the absence of natural buffers. The rest of the coastal barangays have moderate sensitivity to erosion, their scores are boosted by the presence of natural habitats, and relatively higher relief.

When sensitivity is cross-tabulated with exposure, the rating for potential impact ranged from low to medium (Table 20). Despite their high sensitivity, the bayhead barangays have medium potential impact due to their low exposure to waves. Agoho and Lagay also have medium potential impact because of their high to medium exposure to waves. The rest of the barangays have low potential impact, mainly due to their low exposure to waves. Moreover, the barangays show medium to high adaptive capacity. Because of their low to medium potential impact and medium to high adaptive capacity ratings, the final vulnerability rank ranges from low to medium. Most of the eastern barangays, because of the combination of low potential impact and relatively high adaptive capacity, ranked low in terms of vulnerability. In contrast, the barangays, with medium potential impact, also have medium vulnerability rating.

6.1.4. CONSIDERING THE NATURAL HABITATS IN THE ASSESSMENT OF COASTAL INTEGRITY

The revised rubric was applied to three barangays, namely Ipil, Pinagsakayan and Lagay, which have complete data for the natural habitats (Table 21 to 23). Table 8 shows the descriptors and the corresponding scores for the natural habitats. Because these barangays are all reef-fringed systems with mangrove fronts, each function of the natural habitats is represented as a single line with the arithmetic mean as scores. This will highlight the variability of this fairly homogeneous system.

The sensitivity scores indicate the more degraded condition of the seagrass beds and mangrove forest in Ipil and Pinagsakayan (Table 21). However, the low exposure of Ipil and Pinagsakayan offset their moderate sensitivity (Table 22), resulting in low potential impact. Combined with a moderate adaptive capacity, these barangays had a low vulnerability rank. Lagay, on the other hand, scored moderate for exposure, sensitivity and adaptive capacity, and thus has moderate vulnerability. As in the original rubric (See Table 20), it seems that the relatively higher exposure of Lagay to waves tipped the scale towards higher vulnerability. The degree of vulnerability for these barangays is the same as in the rubric that considered only the presence or absence of the natural habitats.

CI PHILIPPINES

Table 18: Intrinsic characteristics of the coastal barangays of Calauag

	Sensitivity			Sensitivity		Adaptive Capacity	
Coastal Barangays	Geomorphology	Landslide slope (rise/run)	Natural buffers	Lateral continuity of the reef flat (%)	Structures on the foreshore	Shoreline trends (m)	Type of coastal development
Agoho	fringed by coral reefs	1:3	coral reefs	100%	none	-23	low-density residential
Balibago	fringed by coral reefs	1:2	coral reefs	100%	none	-24	low-density residential
Dominlog	fringed by coral reefs	1:7	coral reefs	50-75%	none	-71	low-density residential
Manhulugin	fringed by corals & mangroves	1:4	coral reefs and mangroves	0	none	-20	low-density residential
Sabang I	low cliffs	1:2	coral reefs and mangroves	0	none	15	low-density residential
Barangay I	mudflats	1:11	none	0	none	59	commercial
Barangay II	mudflats	1:10	none	0	seawall	99	commercial
Barangay III	mudflats	1:7	none	0	seawall	84	commercial
Barangay IV	mudflats	1:10	none	0	seawall	103	commercial
Barangay V	mudflats	1:14	none	0	seawall	125	commercial
Baclaran M	mudflats	1:14	none	0	seawall	135	commercial
Pinagtalleran	mudflats	1:29	none	0	seawall	157	commercial
Bangkuruhan	mudflats	1:6	mangroves	0	seawall	-45	commercial
Mulay	fringed by coral reefs & mangroves	1:5	mangroves	<50%	none	-52	low-density residential
Lungib	fringed by mangroves	1:5	mangroves	none	none	-3	greenbelt
Apad Taisan	fringed by mangroves	1:8	coral reefs and mangroves	none	none	-2	greenbelt
Kuyaoyao	fringed by coral reefs & mangroves	1:6	coral reefs and mangroves	50-75%	none	-24	greenbelt
Guinosayan	fringed by coral reefs & mangroves	1:5	coral reefs and mangroves	100%	none	4	greenbelt
Ipil	fringed by coral reefs & mangroves	1:10	coral reefs and mangroves	50-75%	none	-11	greenbelt
Pinagsakayan	fringed by coral reefs & mangroves	1:6	coral reefs and mangroves	100%	none	-31	greenbelt
Kinamaligan	fringed by coral reefs & mangroves	1:6	coral reefs and mangroves	100%	none	-93	greenbelt
Atulayan	fringed by coral reefs & mangroves	1:8	coral reefs and mangroves	100%	none	-71	greenbelt
Lagay	fringed by coral reefs & mangroves	1:10	coral reefs and mangroves	100%	none	-53	greenbelt

Table 19: Scores for the exposure, sensitivity and adaptive capacity components

	Sensitivity					Sensitivity				Adaptive Capacity	
Coastal barangays	Exposure to NE waves	Exposure to storm waves	SLR	Geo-morphology	Lanward slope (rise/run)	Width of reef flat	Lateral continuity of reef flat	Structures on the foreshore	Natural buffers	Shorline trends (m)	Type of coastal development
Agoho	5	5	3	3	2	3	1	3	3	3	2
Balibago	3	5	3	3	1	4	1	3	3	3	2
Dominlog	3	5	3	3	2	3	2	1	3	5	2
Manhulugin	3	3	3	3	2	5	5	1	2	3	2
Sabang I	1	1	3	2	2	5	5	1	2	1	2
Barangay I	1	1	3	5	2	5	5	5	5	1	5
Barangay II	1	1	3	5	2	5	5	5	5	1	5
Barangay III	1	1	3	5	2	5	5	5	5	1	5
Barangay IV	1	1	3	5	2	5	5	5	5	1	5
Barangay V	1	1	3	5	2	5	5	5	5	1	5
Baclaran M	1	1	3	5	2	5	5	5	5	1	5
Pinagtalleran	1	1	3	5	2	5	5	5	5	1	5
Bangkuruhan	1	1	3	5	5	5	5	1	2	5	2
Mulay	1	3	3	3	2	5	3	1	4	5	1
Lungib	1	1	3	4	2	5	5	1	4	2	1
Apad Taisan	1	1	3	4	3	5	5	1	2	2	1
Kuyaoyao	1	1	3	3	3	2	2	1	2	3	1
Guinosayan	1	1	3	3	2	1	1	1	2	5	1
Ipil	1	1	3	3	4	3	2	1	2	3	1
Pinagsakayan	1	1	3	3	2	2	1	1	2	4	1
Kinamaligan	1	3	3	3	2	1	1	1	2	5	1
Atulayan	1	1	3	3	2	3	1	1	2	5	1
Lagay	3	3	3	3	5	3	1	1	2	5	1

Table 20: Vulnerability of barangays within Calauag Bay to erosion

The rank for potential impact and vulnerability are based on the accompanying tables below.

Potential Impact

		Sensitivity		
		L	M	H
Exposure	L	L	L	M
	M	L	M	H
	H	M	H	H

Vulnerability

		Sensitivity		
		L	M	H
Potential Impact	L	M	L	L
	M	H	M	L
	H	H	H	M

Barangays	Exposure	Sensitivity	Potential Impact	Adaptive Capacity	Vulnerability
Agoho	H	L	M	M	M
Balibago	M	L	L	M	L
Dominlog	M	L	L	M	L
Manhulugin	M	M	M	M	M
Sabang I	L	M	L	H	L
Barangay I	L	H	M	M	M
Barangay II	L	H	M	M	M
Barangay III	L	H	M	M	M
Barangay IV	L	H	M	M	M
Barangay V	L	H	M	M	M
Baclaran M	L	H	M	M	M
Pinagtalleran	L	H	M	M	M
Bangkuruhan	L	H	M	M	M
Mulay	L	M	L	M	L
Lungib	L	M	L	H	L
Apad Taisan	L	M	L	H	L
Kuyaoyao	L	L	L	H	L
Guinosayan	L	L	L	M	L
Ipil	L	M	L	H	L
Pinagsakayan	L	L	L	M	L
Kinamaligan	L	L	L	M	L
Atulayan	L	L	L	M	L
Lagay	M	M	M	M	M

Table 21: CIVAT descriptors used for scoring habitat criteria in Calauag, Quezon

	Lagay	Pinagsakayan	Ipil
SENSITIVITY			
Coral reefs as sediment source			
living coral cover	5	3	2
coral community growth form in the shallow reef	2	5	5
Average score	***4***	***4***	***4***
Seagrasses as sediment source			
areal extent relative to reef flat	4	2	5
capacity to withstand storm removal	2	4	3
seagrass meadow type	1	3	3
Average score	***2***	***3***	***4***
Mangroves as sediment source			
forest type	3	5	3
mangrove zonation	3	4	5
capacity to trap sediments	4	5	3
Average Score	***3***	***5***	***4***
Mangroves as wave buffer			
forest type	3	5	3
present vs historical mangrove extent	2	2	5
mangrove zonation	3	4	5
mangrove canopy cover	3	4	4
mangrove basal area	3	5	5
Average score	***3***	***4***	***4***
ADAPTIVE CAPACITY			
Coral reefs as sediment source	***1***	***3***	***4***
Seagrasses as sediment source	***4***	***3***	***2***
Mangroves as sediment source	***2***	***1***	***3***
Mangroves as wave buffer			
mangrove canopy cover	3	2	2
mangrove basal area	3	1	1
Average score	***3***	***1.5***	***1.5***

The habitat criteria are italicized.

Table 22: CIVAT scores considering natural habitats for selected barangays in Calauag, Quezon

	Barangays	Lagay	Pinagsakayan	Ipil
Exposure	Relative sea level change	3	3	3
	Wave height during NE monsoon	1	1	3
	Wave height during typhoon	1	1	3
Sensitivity	Geomorphology	2	3	3
	Coastal slope	4	2	5
	Width of reef flat	3	1	3
	Lateral continuity of reef flat	2	1	1
	Structures on the foreshore	1	1	1
	Coral reef as sediment source	3	4	4
	Seagrass as sediment source/stabilizer	2	3	4
	Mangrove as sediment trap	4	5	3
	Mangrove as wave buffer	4	4	3
Adaptive Capacity	Shoreline trends	3	2	1
	Type of coastal development	5	5	5
	Viability of coral reefs as sediment source	3	3	4
	Viability of seagrass beds as sediment source/ trap	2	3	4
	Viability of mangrove as sediment trap	3	1	2
	Mangrove as wave buffer	2	2	3

Table 23: Vulnerability assessment results with natural habitat criteria

Barangays	Exposure	Sensitivity	Potential Impact	Adaptive Capacity	Vulnerability
Ipil	L	M	L	M	L
Pinagsakayan	L	M	L	M	L
Lagay	M	M	M	M	M

7. REFERENCES

Aboudha, P.A., & Woodroffe, C.D. (2006). *International assessments of the vulnerability of the coastal zone to climate change, including an Australian perspective.* School of Earth and Environmental Sciences, University of Wollongong for the Australian Greenhouse Office, Department of the Environment and Heritage.

Allison, E. H., Perry, A. L., Badjeck, M.C., Adger, W.N., Brown, K., Conway, D., Halls, A.S., Pilling, G.M., Reynolds, J.D., Andrew, N.L., Dulvy, N.K. (2009). Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries* 10(2): 173 – 196.

Cruz, R.V., Harasawa, H., Lal, M., Wu, S., Anokhin, Y., Punsalmaa, B., Honda, Y., Jafari, M., Li, C., Huu Ninh, N. (2007). Asia. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds.,Cambridge University Press, Cambridge, UK, 469-506.

Gornitz, V. (1990). Vulnerability of the East coast, U.S.A. to future sea level rise. *Journal of Coastal Research*, Special Issue No. 9, pp. 201-237.

Mateo, Z.R.P., & Siringan, F.P. (2007). Tectonic control of high-frequency Holocene delta switching and fluvial migration in Lingayen Gulf bayhead, northwestern Philippines. *Journal of Coastal Research*, v. 23 (1): 182-194.

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

Samson, M.S. (2011). *Environmental management of mangroves and brackish-water ponds in the Philippines.* PhD Dissertation, unpublished

Siringan, F.P., Berdin, R., Jaraula, C.M., Remotigue, C., Yacat-Sta. Maria, M.Y., Zamora, P. (2005). A challenge for coastal management: large and rapid shoreline movements in the Philippines. **Know Risk**. United Nations, pp. 218-219.

Thieler, E.R., & Hammar-Klose, E.S., (1999). *National Assessment of Coastal Vulnerability to Future Sea-Level Rise: Preliminary Results for the U.S. Atlantic Coast.* U.S. Geological Survey, Open-File Report 99-593 (http://pubs.usgs.gov/of/of99-593/).

JÜRGEN FREUND

6

Tool for Understanding Resilience of Fisheries

Samuel S. Mamauag[1]*
Porfirio M. Aliño[2]
Renmar Jun S. Martinez[1]
Richard N. Muallil[1]
Maria Victoria A. Doctor[1]
Emerlinda C. Dizon[3]
Rollan C. Geronimo[3]
Reniel B. Cabral[4]

[1] Marine Environment and Resources Foundation, Inc.
[2] Marine Science Institute, University of the Philippines
[3] Conservation International - Philippines
[4] National Institute of Physics, University of the Philippines
* smamauag@yahoo.com

Tool for Understanding the Resilience of Fisheries or TURF is a tool for assessing the climate change vulnerability of coastal fisheries in the tropics. It is cost-effective and practical, utilizing information that is readily available or easy to generate. It is a first-step assessment in identifying priority areas with site-specific adaptation measures. The spatial unit of analysis is the coastal barangay (or village), the smallest political sub-division with its own governing council. Several of the Sensitivity and Adaptive Capacity variables used in the tool are comprehensible without using highly complex terminologies. In addition, except for the ecosystem attributes, TURF utilizes information engendered through coarser and rapid assessments. Likewise, the analytical approach used is straightforward and devoid of highly sophisticated mathematical methods. The utility of TURF primarily considers the target end-users, the stakeholders of the barangays, and hence allows familiarization of the tool at some level of capacity. Nevertheless, the framework employed by the tool generally conforms to the underlying principles of climate change research on fisheries (e.g. Brander 2007, Allison et al. 2009). TURF has three major components i.e., fisheries aspects, reef ecosystem features, and socio-economic attributes, each with intrinsic properties but are tightly interrelated. This is typical in most artisanal fisheries in the tropics, including the Philippines. The Sensitivity and Adaptive Capacity variables selected in the tool were chosen to be able to identify and correspond with adaptation options.

TURF at a glance

Tool Name:	TOOL FOR UNDERSTANDING RESILIENCE OF FISHERIES (TURF) v1.0
Scale:	Barangay
Scope:	Fisheries
CC hazards considered:	Waves and storm surge, SST
Description:	Assesses the vulnerability of fisheries to CC hazards High (fine) resolution of analysis Incorporates 3 components: fisheries, reef ecosystem (habitat), socio-economic
Value:	Reveals specific Sensitivity and Adaptive Capacity factors relating to different fisheries aspects that need particular attention and intervention Able to provide guidance in developing specific CC adaptation strategies to sustain fisheries management (linked to maintaining coastal integrity and biodiversity conservation)
Data needs:	Primary, e.g. FGD, interviews, fish landing survey, FVC Secondary, e.g. municipal fisheries profile; information scoped by ICSEA-C-Change
Technical needs:	May be applied by coastal managers and field practitioners, with assistance from fisheries and CRM experts in data analysis and interpretation Best if intended users receive training on correct and appropriate application of the tool. (e.g. c/o the Coastal Learning Adaptation Network or CLAN)

Contact information:
Samuel S. Mamauag
smamauag@yahoo.com
Marine Science Institute
University of the Philippines Diliman
Quezon City 1101, Philippines

1. INTRODUCTION

In the Philippines, the high degree of dependence on fisheries by nearly 60% of the population and the declining food fish intake are greatly concerning. Coastal fisheries are estimated to contribute at least 5% of the country's Gross Domestic Product (GDP). However, fishers are considered the poorest of the poor sectors in society (Castro, 2006). These findings indicate that they are the most vulnerable sector to climate change-associated perturbations. Unfortunately, reliable fisheries statistics still remains to be addressed (DA-BFAR, 2004).

Some studies have proposed that regime shifts reflect the vulnerability of tuna, anchovy and sardine fisheries in the eastern Mindanao area (Chavez et al., 2003). There is little information to suggest if ecological processes such as recruitment are affected by climate-related phenomena (Pet-Soede et al., 2001), but anecdotal accounts in Bolinao, Philippines indicate that the second recruitment event for siganid *padas* (juveniles) may have been jeopardized during the 1998 and, apparently, the 2010 El Niño. Siganid fisheries, a predominantly seagrass-coral reef associated fishery, are important fisheries in many coastal areas in the Philippines and may serve as a model to demonstrate fishery interactions with SST and monsoonal variabilities. Such relationships have been obviated by the occurrence of SST anomalies and extremes in monsoons, as well as in increased and more frequent storminess. Mamauag (2011) suggests that the reproduction and recruitment of the orange-spotted grouper *Epinephelus coioides* is associated with SST, tides, lunar periodicity and monsoonal exposure. *Epinephelus coioides* and its behaviour as an ontogenetic habitat shifter (along a creek-mangrove-coral reef habitat continuum) offer valuable opportunities to understand the potential impacts of climate change on fisheries. Brander (2007) summarizes how climate change can potentially impact fisheries species eco-physiologically. Corollary to this, Allison et al. (2009) contextualizes how vulnerability assessment (**Figure 20**) can be useful as an approach for adaptation.

Responses in relation to fisheries present an investigative and communication challenge in understanding how these might impact the coastal seas. Such impact is not easily apparent due to the submarine nature of the resource of concern, their mobile behaviour, and their complex life history and multispecies interactions. Evaluating the vulnerability of fisheries entails understanding linkages, patterns, and habitat processes and associated organisms in the context of VA criteria proposed by the IPCC and adopted by Allison et al. (2009). Development of criteria used in the tool has also been guided by the need to clarify the definitions of the attributes of the system being studied (Fussel, 2007). TURF upholds science-based rigor, but is also simplified in a rubric approach to initiate its eventual use by local governments in coastal areas of the Philippines. Among possible next steps is the development of a layman version of the tool.

TURF extends beyond the scope of basic fisheries aspects (e.g. gears, catch rates), also considering salient ecological and social features such as functionally important fish species; habitat conditions of the fishing grounds; and dependence of human communities on fishing. The tool focuses on the fishing village (*coastal barangay*) as the spatial unit of analysis. As the smallest unit of management, it can be an appropriate model in understanding habitat conditions and fisheries dynamics crucial for strategic responses. Many coastal villages in the Philippines typically have artisanal and subsistence fisheries. However, small scale fisheries tend to be overlooked in national censuses, or aggregated into and hidden within the agricultural sector of a society (Sadovy, 2005; Andrew et al., 2007).

The final section of this chapter briefly discusses how lessons derived from vulnerability assessment through TURF can translate to management practices.

2. VULNERABILITY CRITERIA / VARIABLES

The framework for TURF is consistent with the definitions proposed by the IPCC (2001) where Vulnerability is a function of Exposure, Sensitivity, and Adaptive Capacity. The tool is divided into three sub-components namely, fisheries, reef ecosystem features, and socio-economic attributes. Each of these sub-components incorporates variables relevant to evaluating Sensitivity and Adaptive Capacity. On the other hand, Exposure information is derived from oceanographic studies. This current version of the tool considers different climate hazards, specifically waves and storm surge, and SST.

The fisheries aspect examines the type of fisheries in the study area with emphasis on top gears used and their dominant catches, distribution, and historical patterns.

Basic life history characteristics and the behaviour of target species are important biological features that can provide insights into the vulnerability of fisheries (e.g. Brander, 2007). From this standpoint, the ecological significance of the habitats of these target species is emphasized, given their interaction with these species and their connectivity with other nearshore habitats, which is crucial for survivorship in a temporal and spatial dimension. Other key variables include the community structure of site-attached organisms (e.g. reef fishes) and their associated habitats (e.g. corals), which are acknowledged as best indicators of climate change impacts (e.g. Munday et al., 2009, Pratchett et al., 2008).

Socio-economic factors are extremely important in measuring fisheries vulnerability, given the tight relationship between people and fisheries resources. Communities highly dependent on fishing are likely to be vulnerable to climate-related factors such as elevated sea surface temperature (SST), increasing storm frequency, and wave surge, among others (e.g. Allison et al., 2009). Population density, fisher population size and fishing dependency, and incomes from fishing and other livelihoods are some key indicators for the socio-economic assessment of fisheries (e.g. McClanahan et al., 2006) to climate change (Allison et al., 2009).

The population size and its corresponding degree of dependence on fisheries is a reasonable proxy indicator where the higher the number of fishers that are fisheries-dependent the greater the potential impact. In addition, fishers' capacity to shift to other sources of income affords them greater adaptive capacity (e.g. Cinner et al., 2008). Therefore, socio-economic vulnerability of the fishing community can be measured based on the population size, level of dependence on fisheries, annual household income from fishing, number of fishers having other sources of income, and their annual household income derived from other sources.

2.1. FISHERIES: SENSITIVITY VARIABLES

Dominant species/taxon in the catch: As storms become severe and waves increase in height and frequency, their destructive capacity increases, and can potentially decimate nearshore habitats in varying degrees (Webster et al., 2005).

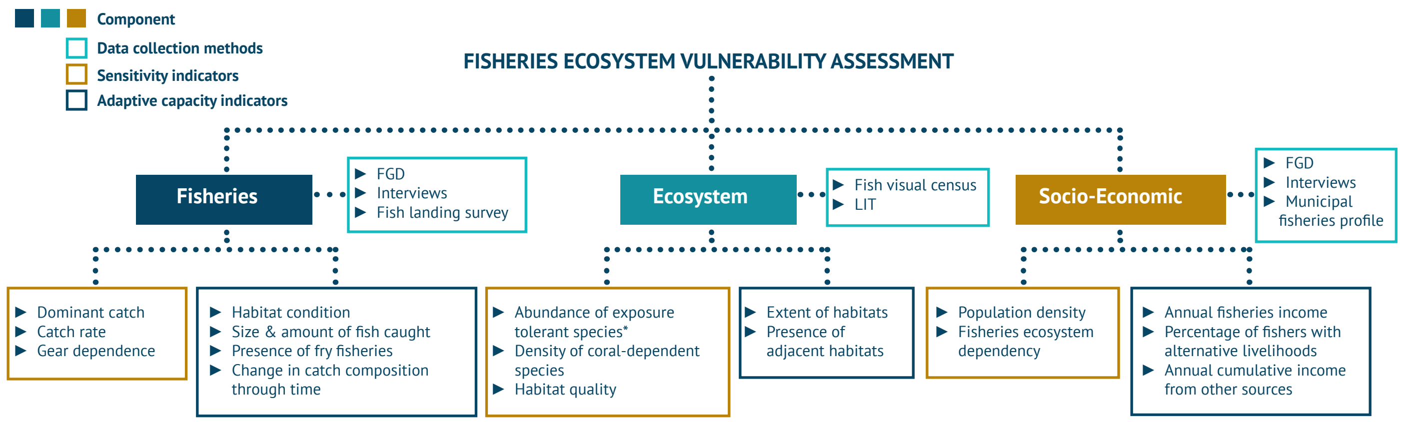


Figure 20: Vulnerability assessment process with TURF

This will certainly disrupt their ecosystems (coral reefs, seagrass beds, mangroves) and will consequently affect fisheries supported by these. Although change will not be observed initially, abundance of top species/ taxa especially demersal types typically associated with nearshore habitats will be reduced through time due to recruitment failure. This may be a consequence of habitat loss or diminished topographic complexity, which can result in low refuge potential of juveniles and/ or adults. This is also a scenario for SST impacts.

Catch rate: This criterion is an independent fisheries variable involving total catch in weight of target species per unit area per unit time of gears. Habitat decimation by destructive waves will most likely result in lower catches especially demersal fish species due to displacement via habitat loss. For a given magnitude of wave, its effect would characteristically be greater on nearshore habitats with lower catches than those with higher catches. The catch rates presented here are within the range of catches observed in many areas in the Philippines (e.g. Maypa et al., 2002; Mamauag et al., 2009). The rate catch-per-day can be used in lieu of more data-intensive estimation of catch-per-hour although the latter can still be applied if there is sufficient data across all sites being evaluated.

Table 24: Sensitivity variables for Fisheries component

Variable	Low (1 or 2)	Medium (3 or 4)	High (5)
Dominant catch composition	Catch composition of gears is predominantly of pelagic types (e.g. tuna, mackerel, roundscad). These fish taxa are highly mobile and migratory in the pelagic realm that it would be less likely that they will be affected by wave impacts.	Catch composition is a mixture of pelagic and demersal fishes. While pelagic fishes are less impacted by waves the demersal species are more vulnerable.	Catch is largely comprised of demersal fishes that are mostly associated with nearshore habitats (e.g. coral reefs, seagrass beds and mangrove areas). These habitats are highly vulnerable to wave impacts. In addition, increasing SST results in coral bleaching and reduces habitat condition and health.
Catch rate	Average catch rate is greater than 8 kg/ fisher/ day	Average catch rate is greater than 3 but less than 8 kg/ fisher/ day	Average catch rate is less than 3 kg/ fisher/ day
Gear dependence on habitats	Fishing gears are mostly of mobile type such as variants of small-sized and large-sized gill nets, and lines used at offshore waters	Presence of both mobile and stationary type of gears	Predominance of habitat-dependent or stationary gears (e.g., fyke nets, traps, fish corrals)

Gear dependence on shallow water habitats: Storm-generated waves will physically damage nearshore habitats, affecting use of gears highly dependent on these habitats to capture target species. Reef habitats will also be degraded from coral bleaching events due to increasing SST. Gear dependence manifests an intrinsic attribute of the fisheries where catch (rate and composition) will be affected by the reduction of this dependence following habitat damage.

2.2. FISHERIES: ADAPTIVE CAPACITY VARIABLES

Change in catch composition: Change in catch composition indicates fishing effect. Due to high fishing intensity, large bodied species will be intensively targeted first and will experience reduction before smaller ones. Catch composition is altered as a reflection of resulting changes in species composition based on size.

Fish assemblage with high species richness will intrinsically have more adaptive capacity (high AC) compared to an assemblage with lower richness (low AC). Disturbance by storms and destructive waves, and coral bleaching will impact (by displacement) fish assemblage differentially. After an impact, assemblage or community structure with a greater number of species can likely revert to its former state in a shorter length of time than a community with a reduced (lower) species richness, which would take longer to recover.

Size and amount of fish caught: Size selectivity and intensity of fishing can reduce mean size and abundance of fish, which can have implications on size (age) at sexual maturity and, consequently, reproductive output. Fishing affects the abundance of demographic groups such as that of sexually mature adults (spawning individuals), which are generally targeted due to their larger size. Populations with substantial numbers of large, likely spawning, individuals will have higher adaptive capacity than those with fewer spawners.

Peak occurrence of juveniles or presence of fry fisheries: Observed increasing densities of juveniles of species (recruitment pulse) at particular periods can be a proxy for recruitment patterns. In fisheries, this is exemplified in the harvest of fry, fingerling or juveniles of target fish species at specific periods indicating their recruitment season. Recruitment is important in the replenishment of fish populations as large pulses of recruitment potentially enhance populations or stocks through time. Recruitment studies in some reef fish species have demonstrated seasonality which can be attributed to biological (e.g. reproduction, larval supply) and physical factors (e.g. water circulation, temperature) in sites. Some of these fish exhibit restricted recruitment periods whereas others show extended seasons. In the Philippines, fry fisheries target the juvenile stage of several species such as milkfish, grouper, rabbitfish, and anchovies (dulong) among others. Increasing mortality at this life stage can adversely affect population replenishment. In the context of population replenishment, fishing pressure, and climate change impacts, fish exhibiting

Table 25: Adaptive Capacity variables for Fisheries component

Variable	Low (1 or 2)	Medium (3 or 4)	High (5)
Change in catch composition	Considerable change in the last two decades (e.g., dominant catch replaced; loss of previously common fishes; etc.)	Few changes in the last two decades	Very minimal change in the last two decades
Size and amount of fish caught	Small, immature fishes are abundant; few large spawners caught	Mix of small and large fishes	Most catches are large, mature fishes
Peak occurrence of juveniles or presence of fry fisheries	Absence of peak recruitment or minimal occurrence of juveniles through time; no fry fisheries	Observed seasonality but no large pulses of recruitment; minimal catch in fry fisheries	Large pulses of juvenile abundance during peak recruitment period; fry fisheries is prominent
Habitat (for fishing) condition and extent	Small, fragmented habitats for fishing	Patchy but large habitats for fishing	Large contiguous habitats for fishing such as long fringing reefs relative to coastline

peak recruitment with large pulses albeit time restrictions may indicate higher adaptive capacity compared to those that hardly demonstrate recruitment patterns or periodically undergo weak recruitment.

Habitat (for fishing) condition and extent: Fishery catch rates depend on the condition and extent of the "fishing grounds" which include shallow water habitats such as coral reefs, seagrass beds, mangrove areas, etc. Extensive habitats in good condition (e.g. less perturbed or protected) result in high catch rates due to high habitat complexity or heterogeneity, more suitable sites for recruitment, adequate size for movement, presence of spawning grounds, and thus, high abundance and biomass. In contrast, fragmented and degraded habitats will show lower catch rates resulting from low habitat heterogeneity, low recruitment, etc.

2.3. ECOSYSTEM: SENSITIVITY VARIABLES

Abundance of exposure (wave) tolerant reef fish species relative to total abundance of the community structure: Abundance of wave tolerant species (e.g. strong swimmers) in a reef site manifests an intrinsic property for the fish community structure as a response to climate-related factors such as wave. Fishes that are highly active and mobile are able to withstand wave turbulence than smaller fishes not accustomed to high wave energy environments.

Density of coral dependent species: Coral dependent species are among the reef fishes that are vulnerable to climate-related phenomena such as coral bleaching (Pratchett et al., 2008). Coral bleaching diminishes coral cover and topographic complexity, consequently affecting coral-dependent species through reduced abundance. In relation to wave impact, increasing intensity and wave height (greater than during normal conditions) will likely demolish some species of corals (e.g. branching) and therefore reduce topographic complexity and, to some extent, coral cover. Such damage will have consequences on reef fish species that depend on these types of corals (i.e. branching) for food or shelter, likely resulting in their displacement. Changes in distribution are a short-term effect while impaired recruitment due to habitat loss is a longer term consequence.

Reef habitat quality: This represents the condition and extent of reef habitats as these are recognized to influence the abundance, diversity and population size of reef fishes highly dependent on them (e.g. Booth and Beretta, 2002). Low coral cover and/ or less contiguous reefs likely harbour fewer species and lower abundance whereas reefs with larger cover and/ or more contiguous habitats will have more species and higher abundance. Effects associated with wave and SST impacts are expected to be greater in sites with few species and reduced abundance than those with high species richness and higher abundance. Therefore, habitats with low quality are likely to be more vulnerable to waves and increasing SST.

2.4. ECOSYSTEM: ADAPTIVE CAPACITY VARIABLES

Extent of habitats: Extensive habitats (e.g. expansive reefs) harbour several targeted reef fish species. This can have significant consequences for fish populations and communities (Pratchett et al., 2008). Extensive reef habitats may reflect high coral species richness or high habitat complexity, which would permit more available food and spaces as refuge for adults and as settlement habitats for juveniles, including coral-dependent (Graham et al., 2006) and specialist species (Munday, 2004). Jones et al. (2004) estimated that 65% of fish species on the reefs they studied preferentially settle in or near live coral. Large areas of reefs are also crucial for spawning behaviour in some reef fish especially for highly mobile ones like the groupers. Zeller (1997, 1998) showed that the coral trout *Plectropomus leopardus* moved more than a kilometre from its home range to form spawning aggregations at a site where it has previously spawned.

Presence of adjacent habitats: The presence of adjacent non-reef habitats such as seagrass beds and mangrove forests enhances the connectivity critical for survivorship. Habitats and populations that are connected to each other (Cowen et al., 2000) enhance the health or condition of the interconnected habitats as a whole where the recovery of a devastated portion will depend on adjacent or connected habitats. Habitats not affected by the climate stressor will serve as source of larvae or as refuge site. This also indicates the importance of ontogenetic habitat migration where several species of reef fish also utilize habitats other than coral reefs vital to their survivorship and growth (e.g. Mumby, 2006; Nagelkerken, 2009).

2.5. SOCIO-ECONOMIC: SENSITIVITY VARIABLES

Population density: The number of people living in a coastal community is an important variable to determine sensitivity to any perturbation, including climate change. The state or condition of the coastal fishery is highly dependent on the degree of utilization of the resource users (i.e. human population) where the greater the number of users, the higher the pressure. Therefore, this reflects an intrinsic socio-economic property of fisheries that can demonstrate further impact by climate change. The range of densities for this criterion is based on census information in the Philippines (National Census Office). A major caveat of this criterion is the assumption that some land areas in a coastal barangay are not habitable due to high elevation although this information is not readily known for many areas. Congested areas or crowdedness of built structures

Table 26: Sensitivity variables for Ecosystem (reef habitat) component

Variable	Low (1 or 2)	Medium (3 or 4)	High (5)
Abundance of exposure (wave) tolerant reef fish species relative to total abundance of the community structure	High abundance of wave-tolerant reef fish species such as wrasses, fusiliers, and some butterflyfish relative to the total species abundance	Mix of mobile, wave-tolerant and site-attached reef fish species	Low abundance of wave-tolerant species and preponderance of other site-attached fish families (Chaetodontids, Pomacentrids, Pomacanthids) not adapted to high wave energy environments
Density of coral dependent species	Density of coral-dependent species is less than 5% relative to the total fish density	Coral-dependent fish density is between 5% and 10% to the total fish density	Density of coral-dependent species is greater than 10% to the total fish density
Reef habitat quality	Coral cover is greater than 50% (e.g. Gomez et al. 1981).	Coral cover of the site is between 25% and 50%.	Coral cover is less than 25%.

Table 27: Adaptive Capacity variables for Ecosystem (reef habitat) component

Variable	Low (1 or 2)	Medium (3 or 4)	High (5)
Extent of reef habitats	Small, fragmented reef habitats	Patchy but relatively large reef habitats	Large contiguous reef habitats such as long fringing reefs relative to coastline
Presence of adjacent habitats	Absence of adjacent habitats or extreme degradation of adjacent habitats (e.g. coral reefs, seagrass beds, mangroves)	Presence of one adjacent habitat (e.g., coral reef, seagrass bed, or mangrove forest) in good condition	Presence of 2 more adjacent habitats (e.g., coral reefs, seagrass bed, or mangrove forest) in good condition

Table 28: Sensitivity variables for Socio-economic component

Variable	Low (1 or 2)	Medium (3 or 4)	High (5)
Population density	Population of less than 200 per square kilometer in a fishing village/town; not crowded	200-400 persons per square kilometer	Greater than 500 persons per square kilometre; very crowded
Fisheries ecosystem dependency	Around one-fourth (25%) or less of the adult population are full-time fishers	Greater than 25% up to 50% of the adult population are full-time fishers	Majority in the adult population (> 50%) are full-time fishers

(e.g. houses) at the coasts may be considered as a proxy indicator.

Fisheries ecosystem dependency: This attribute provides vital information on the importance of fisheries to the well-being of the community. The proportion of the fishers relative to total population gives an indication of the significance of fisheries in an area (i.e. main livelihood). The more fishers there are in the community, the higher the dependency on fishing.

2.6. SOCIO-ECONOMIC: ADAPTIVE CAPACITY VARIABLES

Annual livelihood income from fishing: Regular income generated by a person from a livelihood in a community and the average of all income earners is a common currency in characterizing the economic profile of a community (e.g. Muallil et al., 2011). This economic indicator may be considered in a coastal fishing community that will potentially be affected by a climate change stressor (e.g. Allison et al., 2009). This indicator is intrinsic to the socio-economic system of a community, and can then be used as a measurable variable to determine its adaptive capacity when subjected to climate change stressors. The higher the average income of the fishers, the higher the capacity of the community to adapt to a changing climate.

Proportion or percentage of fishers with other sources of income: It has been noted that some fishers in coastal areas, especially large islands, engage in other income-generating livelihoods such as farming, small-scale retail, public transportation services, etc. (e.g. Muallil et al., 2011). Having more fishers with supplemental livelihoods or other sources of income affords the community higher adaptive capacity.

Annual cumulative income from other sources relative to the provincial poverty threshold: The availability of income-generating livelihoods other than fishing would potentially allow a fishing community better capacity to adapt should their fisheries be impacted by climate changes (i.e. decimated nearshore habitats by frequent storms). Many and varied sources of income (e.g. supplemental livelihood) accessible to fishers raise the likelihood of increasing cumulative income.

3. COMPONENT VULNERABILITIES

When all the criteria for Sensitivity and Adaptive Capacity have been evaluated, it is then possible to obtain a Vulnerability measurement for each component. Exposure ratings per site are derived from oceanographic research (See Chapter 3 for more information). Users should be able to determine individual Vulnerabilities for fisheries, for the reef ecosystem, and for the socio-economic attributes.

1. **Re-scaling scores to correspond to Low, Medium, or High**: The scores obtained for Sensitivity and Adaptive Capacity are translated into a rank system where point class intervals correspond to Low, Medium, or High. The point class interval for each rank will vary depending on the total number of criteria considered in each Sensitivity or Adaptive Capacity matrix. Table 30 provides a summary of possible point class intervals and corresponding rank classifications, given 2, 3, or 4 criteria in a matrix.

2. **Cross-tabulation between Sensitivity and Exposure for Potential Impact**: In keeping with the Vulnerability framework, the Sensitivity rank is integrated with that of Exposure to arrive at a measurement for Potential Impact. This is done through a cross-tabulation approach, which is also used in the Coastal Integrity VA Tool and demonstrated in the box "Tip: Using cross-tables" on the following page. Nonetheless, the standard cross-table for Potential Impact is provided as a guide below. A measurement for Potential Impact is obtained for all three components.

Table 29: Adaptive Capacity variables for Socio-economic component

Variable	Low (1 or 2)	Medium (3 or 4)	High (5)
Annual livelihood income from fishing	Per capita income is below the provincial poverty threshold	Income is higher than the provincial poverty threshold up to 60%	Income is higher than 60% of the provincial poverty threshold
Proportion or percentage of fishers with other sources of income	Less than 40% of the fishers have other sources of income	40-60% of the fishers have other sources of income	Greater than 60% of the fishers have other sources of income
Annual cumulative income from other sources relative to the provincial poverty threshold	Annual cumulative per capita income is below provincial poverty threshold	Cumulative income is higher than poverty threshold up to 60%	Cumulative income is greater than 60% of the poverty threshold

Table 30: Summary of point class intervals and corresponding rank classifications

If the no. of criteria = 2	
Maximum score	(2 x 5) = 10
Minimum score	(2 x 1) = 2
Total range	[max - min] = 8
Intervals	8 ÷ 3 = 2.7 or 3
Interval	8/3
	2.7
Rating	**Range**
Low	2-4
Medium	5-7
High	8-10

If the no. of criteria = 3	
Maximum score	(3 x 5) = 15
Minimum score	(3 x 1) = 3
Total range	[max - min] = 12
Intervals	12 ÷ 3 = 4
Interval	12/3
	4.0
Rating	**Range**
Low	3-7
Medium	8-11
High	12-15

If the no. of criteria = 4	
Maximum score	(4 x 5) = 20
Minimum score	(4 x 1) = 4
Total range	[max - min] = 16
Intervals	16 ÷ 3 = 5.3 or 5
Interval	16/3
	5.1
Rating	**Range**
Low	4-9
Medium	10-15
High	16-20

Exposure \ Sensitivity			
PI	L	M	H
L	L	L	M
M	L	M	H
H	M	H	H

Figure 21: Cross-table for Potential Impact (Exposure x Sensitivity)

3. **Cross-tabulation between Potential Impact and Adaptive Capacity for Vulnerability**: Finally, cross-tabulate the resulting Potential Impact with the Adaptive Capacity rank to obtain the Vulnerability for each tool component Users should be able to generate three Vulnerability measurements: one for the fisheries aspect, another for the reef ecosystem (habitat) features, and still another for the socio-economic attributes.

PI \ Adaptive Capacity			
V	L	M	H
L	M	L	L
M	H	M	L
H	H	H	M

Figure 22: Cross-table for Vulnerability (Potential Impact X Adaptive Capacity)

Tip: Using cross-tables

Cross-tables relate two parameters together to obtain a score or rating for a third parameter. The value for the third parameter can be obtained by looking at the intersection of the columns and rows for the parameters identified on the leftmost column and topmost row.

For example, an area with *High* Exposure and *High* Sensitivity results in *High* Potential Impact.

Cross-table for Potential Impact

Exposure \ Sensitivity			
PI	L	M	H
L	L	L	M
M	L	M	H
H	M	H	H

Then, *High* Potential Impact cross-tabulated with, for example, *Low* Adaptive Capacity generates a *High* Vulnerability.

A system with higher adaptive capacity than the measured potential impact would have generally lower vulnerability than a system where the potential impact exceeds its capacity to cope. A moderately vulnerable system is one in which the potential impact of climate change can be offset by its adaptive capacity (i.e., LL, MM, HH combinations).

Table 31: Guide to determining Vulnerability following integration of TURF components

Fisheries	Reef ecosystem: H	Reef ecosystem: M	Reef ecosystem: L	Socioeconomic
H	HHH	HMH	HLH	H
H	HHM	HMM	HLM	M
H	HHL	HML	HLL	L
M	MHH	MMH	MLH	H
M	MHM	MMM	MLM	M
M	MHL	MML	MLL	L
L	LHH	LMH	LLH	H
L	LHM	LMM	LLM	M
L	LHL	LML	LLL	L

4. OVERALL FISHERIES VULNERABILITY

When a Vulnerability measurement has been obtained for each of the tool components, these are integrated for the overall fisheries Vulnerability.

1. **Collate the individual Vulnerability ranks**, such that the first letter corresponds to the Vulnerability rank obtained for the fisheries component, the second letter to that for the reef ecosystem component, and the third to that for the socio-economic component. Users should be able to generate a three-letter combination representing each of the components and their derived Vulnerability rank. There are 27 possible combinations.

2. **Match the resulting three-letter combination with its corresponding Vulnerability rank using the guide table** (Table 31). The color of the cell will give you the resulting Vulnerability: Green = Low; Yellow = Moderate; Red = High. So, for example, if you have a site with a fisheries Vulnerability rank of low (L), a reef ecosystem Vulnerability rank of high (H), and a socio-economic Vulnerability rank of medium (M), the corresponding three-letter combination is LHM. According to the table below, the cell LHM is colored yellow, which means

Table 32: Overall fisheries Vulnerability for coastal barangays in Looc, Occidental Mindoro (Philippines)

Several coastal barangays in the municipality of Looc in the province of Occidental Mindoro were evaluated with TURF. The table below shows the individual Vulnerability of each component per barangay, and the overall Vulnerability of fisheries following integration per barangay.

Barangay	Fisheries	Reef Ecosystem	Socioeconomic	Overall VA
Agkawayan	M	H	M	H
Ambil	M	M	H	H
Balikayas	M	M	H	H
Burol	M	H	M	H
Bonbon	M	L	H	M
Guitna	M	L	M	L
Kanluran	M	M	L	L
Talaotao	H	L	H	H

5. INTERPRETATION

As with the CIVAT, TURF results can be interpreted to be relevant for the prioritization of fisheries vulnerabilities across different coastal barangays and/ or to look at specific causes or sources of vulnerability per coastal barangay. High Vulnerability areas can be prioritized over low ones for immediate changes in policy and implementation of fisheries management interventions. The different Sensitivity and Adaptive Capacity criteria for fisheries, ecosystem, and socioeconomics can directly link up to adaptation options to reduce vulnerabilities. For example, if an area has high Vulnerability because of high fisheries dependency, that barangay can be targeted for intensified diversification of livelihoods.

6. NEXT STEPS

Being a diagnostic tool, TURF aims to appreciate the potential impacts and the vulnerabilities of fisheries ecosystems at the village level. It is expected to allow users to communicate the insights and implications of the risks concordant with a particular climate change situation or scenario. Strategies espoused by TURF (see Alino et al., this volume) are important backbones for establishing adaptation measures for climate change impact on fisheries ecosystems. The TURF approach provides a simple and easy to understand mechanism to integrate scores for each criterion. Focus on how to reduce vulnerabilities looks at various ways to attenuate impacts through minimizing exposure e.g., avoidance of wave surge and relocation to higher ground, and/or mitigation measures such as construction of seawalls at the seafront. Adaptive capacity can be enhanced through several interventions that shows fisheries management linked to ecosystem domain e.g., protected area management. The criteria attributes can serve as bases to come up with the contextual and specific guidelines for each relevant management action such as, for example, fish size and seasonal closure regulations. Explicit operational mechanisms for these management actions are essential and these should be embodied by the governance institutions as critical strategic perspectives. One mechanism is the setting up and implementing monitoring and evaluation protocols for an effective management (i.e. adaptive management cycle) (Mamauag et al. 2012, NEDA Report).

The expected outputs and desired outcomes in applying the VA tools including TURF in the process of mainstreaming climate change adaptation measures will seek to produce resilient adaptive knowledge-based communities on the road to a sustainable development trajectory.

7. REFERENCES

Allison, E. H., Perry, A. L., Badjeck, M., Adger, W. N., Brown, K., Halls, A. S., Pilling, G. M., et al. (2009). Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries*. 10: 173-196.

Andrew, Neil L., et al. (2007). Diagnosis and management of small-scale fisheries in developing countries. *Fish and Fisheries*. 8 (3): 227-240.

Booth, David J. and Giglia A. Beretta. (2002). Changes in a fish assemblage after a coral bleaching event. *Marine Ecology (Progress Series)*. 245: 205-212.

Brander, K. M. (2007). Climate Change and Food Security Special Feature: Global fish production and climate change. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*. 104 (50): 19709-19714.

Castro. (2009). "2006 poverty statistics for the basic sectors". http://www.nscb.gov.ph/ , 2009 [accessed 08/23/12].

Chavez F. P., Ryan, J., Lluch-Cota, S. E. and Niquen, M.C. (2003) From anchovies to sardines and back: Multidecadal change in the Pacific Ocean. *Science*. 299 (5604): 217-221.

Cinner, J. E., et al. (2008). Conservation action in a changing climate. *Conservation Letters*. 1 (2): 53-59.

Cowen R.K., Lwiza, K.M.M., Sponaugle, S., Paris, C.B., and Olson, D.B. (2000). Connectivity of marine populations: Open or closed? *Science*. 287: 857–859.

DENR-DILG-DA/BFAR-CRMP (Department of Environment and Natural Resources, Department of Interior and Local Government, Department of Agriculture - Bureau of Fisheries and Aquatic Resources, and the Coastal Resource Management Project). (1997). Legal and jurisdictional guidebook for coastal resource management in the Philippines. Coastal Resource Management Project, Cebu City, Philippines. 196 p.

Graham, N. A. J., Wilson, S. K., Jennings, S., Polunin, N. V. C., Jude, P., Robinson, J., & Bijoux, J. P. (2006). Dynamic fragility of oceanic coral reef ecosystems. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*. 103: 8425-8429.

Harmeling, S. 2011. Global Climate Risk Index 2011: Who suffers most from extreme weather events? Weather-related loss events in 2009 and 1990 to 2009. A Briefing Paper published by Germanwatch e.V. 24 pp.

Intergovernmental Panel on Climate Change. (2001). Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Intergovernmental Panel on Climate Change. (1995). IPCC Second Assessment: Climate Change 1995. A report of the Intergovernmental Panel on Climate Change. http://www.ipcc.ch/pdf/climate-changes-1995/ipcc-2nd-assessment/2nd-assessment-en.pdf; retrieved 26 January 2012.

Jones, G. P., et al. (2004). Coral decline threatens fish biodiversity in marine reserves. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*. 101 (21): 8251-8253.

Mamauag, S. S. (2011). Status of groupers (Sub-family Epinephilae, Family Serranidae) in the Philippines from their broad-scale and fine-scale distributions with emphasis on *Epinephelus coioides*. A Doctoral Dissertation submitted to the Marine Science Institute, College of Science, University of the Philippines Diliman: Quezon City, 207 pp.

Mamauag, S. S., et al. (2009). Patterns of demersal fish distribution derived from line fishing experiment in Calauag Bay, Philippines. *The Philippine Agricultural Scientist*. 92 (4): 370-387.

Maypa, A.P., Russ, G.R., Alcala, A.C., and Calumpong, H.P. (2002). Long-term trends in yield and catch rates of the coral reef fishery at Apo Island, central Philippines. *Marine and Freshwater Research*. 53: 207-213.

McClanahan, T. R., Marnane, M. J., Cinner, J. E. and Kiene, W. E. (2006). A comparison of marine protected areas and alternative approaches to coral-reef management. *Current Biology*. 16(14): 1408-1413.

Muallil, R. N., et al. (2011). Willingness to exit the artisanal fishery as a response to scenarios of declining catch or increasing monetary incentives. *Fisheries Research*. 111 (1-2): 74-81.

Mumby, P. J. (2006). Connectivity of reef fish between mangroves and coral reefs: algorithms for the design of marine reserves at seascape scales. *Biological Conservation*. 128 (2): 215-222.

Munday, P. L., et al. (2009). Climate change and coral reef connectivity. *Coral Reefs*. 28 (2): 379.

Munday, P. L. (2004). Habitat loss, resource specialization, and extinction on coral reefs. *Global Change Biology*. 10 (10): 1642-1647.

Nagelkerken, I. (2009). Evaluation of nursery function of mangroves and seagrass beds for tropical decapods and reef fishes: patterns and underlying mechanisms. *Ecological Connectivity Among Tropical Ecosystems*. Part 2: 357-399. doi: 10.1007/978-90-481-2406-0_10

Pet-Soede, L., Cesar, H. S. J., Westmacott, S. (2001). Socio-economic Assessment of the Impacts of the 1998 Coral Bleaching in the Indian Ocean: A Summary. http://hdl.handle.net/1834/481.

Pratchett, M., Munday, P., Wilson, K., Jones, G. P., & Mcclanahan, T. R. (2008). Effects of climate-induced coral bleaching on coral reef fishes - ecological and economic consequences. *Oceanography and Marine Biology: An Annual Review*. 46: 251-296.

Sadovy, Y. (2005). Trouble on the reef: the imperative for managing vulnerable and valuable fisheries. *Fish and Fisheries*. 6 (3): 167-185.

Webster P. J., Holland G. J., Curry J. A., Chang H-R. (2005). Changes in tropical cyclone number, duration, and intensity in a warming environment. *Science*. 309:1844-1846.

World Bank. 2005. Philippines Environment Monitor 2005. Coastal and Marine Resource Management. The World Bank Group. Washington, USA. December 2005. http://siteresources.worldbank.org/INTPHILIPPINES/Resources/PEM05-complete.pdf.

Zeller, D. C. (1998). Spawning aggregations: patterns of movement of the coral trout *Plectropomus leopardus* (Serranidae) as determined by ultrasonic telemetry. Marine Ecology Progress Series. 162: 253-263.

Zeller, D. C. (1997). Home range and activity patterns of the coral trout *Plectropomus leopardus* (Serranidae). *Marine Ecology Progress Series*. 154: 65-77.

CI Philippines

CI Philippines

7

Linking Vulnerability Assessment to Adaptation

Porfirio M. Aliño [1,*]
Noreen Marie G. Follosco [1,2]
Samuel S. Mamauag [1]
Renmar Jun S. Martinez [1]
Fleurdeliz M. Panga [1]

[1] Marine Science Institute, University of the Philippines
[2] Marine Environment and Resources Foundation, Inc.

* pmalino2002@yahoo.com

1. DEFINING KEY TERMS

Adaptation is one of the two chief response options to climate change and its effects (the other being mitigation; see definition in box). ***Adaptation*** refers to the adjustment in natural or human systems in response to actual or expected climate change and associated impacts in order to reduce harm or take advantage of beneficial opportunities (IPCC, 2001; USAID, 2009). It is also sometimes described as a process that results in a reduction in harm or risk of harm, and the attainment of benefits relating to climate variability and climate change (UK CIP, 2003).

> ***Mitigation*** is a human action to purposely diminish the production of greenhouse gas emissions or to eliminate such gases from the atmosphere through sequestration (USAID, 2009).

Recommended adaptation strategies are the ultimate outcome of vulnerability assessment with the Coastal VA tools. The VA results guide the identification of adaptation measures that decrease Vulnerability by reducing Potential Impact and enhancing Adaptive Capacity. These actions, in reducing Vulnerability, also seek to strengthen the ***resilience*** of the system. ***Ecosystem resilience*** is the ability of the system to sustain key functions and processes despite stresses and pressures either by withstanding or adapting to change (Marshall and Schuttenberg, 2006). A resilient ecosystem should be able to endure shocks, reestablish itself, and improve its capacity to adapt to change. ***Social resilience*** also considers the human capability of anticipating and preparing for the future. However, because human beings rely on and regularly impact the natural system, resilience and the measures to achieve it must consider the linked ***socio-ecological system (SES)***. As a property of the SES, resilience has three distinguishing features: (1) the degree of change the system is able to resist and still maintain the same processes for function and structure; (2) the capacity of the system for self-organization; and (3) the facility to develop and enhance learning and adaptation (http://www.resalliance.org).

When developing adaptation strategies, a major challenge is the great uncertainty characteristic of climate change projections. However, business-as-usual management is not sufficient to overcome these estimated impacts. The process of ***adaptive management***, which utilizes informed methodologies and input from regular feedback and monitoring, provides a platform for implementing adaptation measures in the face of uncertainty.

Although more information is still needed to describe the true magnitude and extent of climate change impacts, coastal communities must still be prepared to meet them. Such preparedness is further linked to other pressing issues such as those relating to disaster risk reduction. Partnerships across sites and their respective local governments can facilitate coordinated actions that may produce exponential, rather than additive, results. Such linkages accelerate the response of coastal communities in coping with the imminent and potentially overwhelming effects of climate change.

2. REDUCING VULNERABILITY

Insights gained from vulnerability assessment provide critical guidance in the development of appropriate adaptation strategies. Among the Coastal VA Tools, CIVAT and TURF are able to yield results that can inform specific actions relevant to the key thematic concerns of **coastal integrity**, **coastal habitats**, and **fisheries**. Because the tools invoke Vulnerability as a function of Sensitivity, Exposure, and Adaptive Capacity, they are capable of highlighting areas of concern within each of these three components. Adaptation strategies would be directed at reducing Vulnerability by diminishing factors that amplify Sensitivity and Exposure (Potential Impact) and/ or enhancing those that increase Adaptive Capacity.

Reducing Potential Impacts as a means to reduce Vulnerability may be achieved either through *reducing Sensitivity* and/ or *reducing contact to Exposure*. Actions towards reducing Sensitivity may involve improving the health of the natural system or employing bioengineering techniques. On the other hand, those aiming to reduce contact to Exposure entail avoidance, accommodation, protection, relocation, and hard and soft engineering approaches (Figure 23; David et al., in prep.).

- Adaptation measures and institutionalization at all levels
- Community based transectoral action groups and partnerships
- Protection, avoidance, accommodation, soft and hard engineering approaches
- Seeing us all see the sea change each day

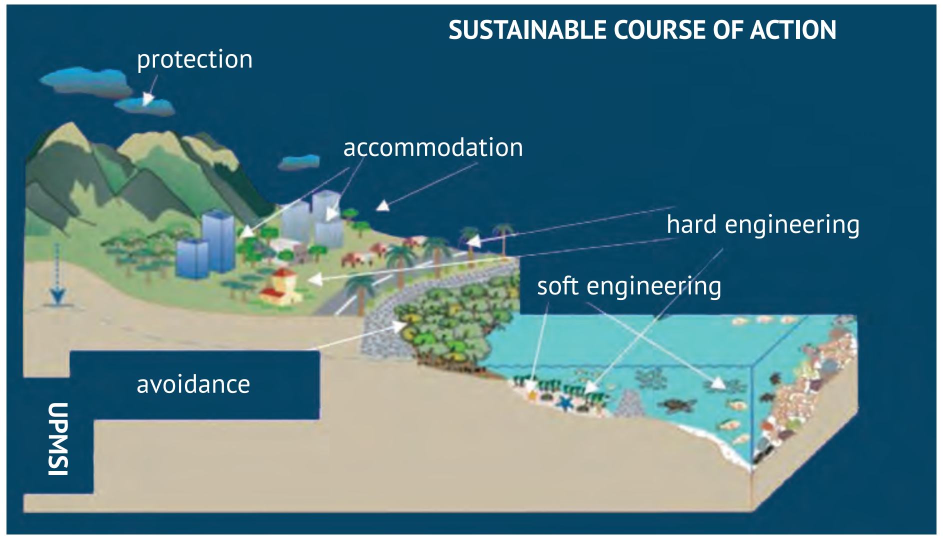


Figure 23: Reducing Exposure through avoidance, accommodation, relocation and soft and hard engineering approaches (David et al., in prep)

Reducing Vulnerability by Increasing Adaptive Capacity can involve improving habitat conditions and minimizing internal and external threats on the socio-ecological system through mitigation and adaptation. Building MPA networks and rehabilitating mangroves are examples of actions that can promote good habitat conditions. On the other hand, diversifying livelihoods and adopting proper design of seawalls and setbacks are actions that can enhance the social system.

3. RESTORED STRATEGIES

The RESTORED Strategies are a set of complementary adaptation options for achieving resilience by targeting three strategic objectives: resiliency through learning, sustainable fisheries, and coastal integrity (See Table 33). The strategies are meant to be cross-cutting, addressing the key thematic areas of habitat and biodiversity conservation, sustainable fisheries, and coastal integrity.

Climate change adaptation adopts a broader and more holistic approach to management, the RESTORED Strategies and corresponding actions seeking to promote such synergies. For example, proper solid waste management can help reduce pollution in coastal ecosystems, elevating their overall health. Healthy habitats, in turn, are able to provide ecosystem services that promote the well-being of human communities. Implementation becomes even more effective when accompanied by information, education, and communication.

Figure 24 attempts to illustrate the inter-relationship of the RESTORED Strategies per thematic objective. Maintaining coastal integrity, an overarching strategy to protect fisher settlements from impacts such as waves and storm surge, is linked to conserving coral reefs, mangroves

Table 33: The RESTORED Strategies

	"RESTORED" STRATEGIES		
	Restoring Resiliency through Learning Communities	**Sustainable Philippine Fisheries Agenda**	**Maintaining Coastal Integrity and Equitable Access**
R	Representative, replicated, resilient reserves	Reducing fishing mortality	Restoring coastal protection
E	Enhancing management effectiveness	Enhancing stock recovery	Effective erosion buffers
S	Sustaining healthy ecosystems	Sustainable fisheries use	Sustaining coastal integrity
T	Threat reduction in coastal ecosystems	Threat reduction to sustain fisheries with ecosystems capacity	Thresholds maintained within acceptable limits
O	Organizing knowledge based communities	Organizing fisher communities	Organizing a coast watch
R	Replenishing MPA networks for resilient reproduction and recruitment	Restoring resiliency and connectivity	Reducing threats and sharing costs
E	Enhancing connectedness	EAFM development with equitability	Enhancing equitable access
D	Doing good governance	Diversifying livelihood options	Disaster risk reduction

Recommended RESTORED adaptation strategies towards enhancing resilience of coastal communities to climate change

Figure 24: Example showing inter-relationship of RESTORED strategies per thematic objective

and seagrasses as these can function as natural buffers. Further, enhancing MPA resilience is connected to fisheries objectives. Strategies per theme should also be viewed relative to their ecological, social, and governance concerns. For example, restoring coastal protection entails the presence of effective buffers that aid in sustaining coastal integrity within thresholds. Further, it would necessitate the presence of organized groups such as coastal watch, as well as equitable access arrangements in achieving disaster risk reduction through good governance.

Specific actions have been suggested to realize each strategy. Many of them are grounded in principles of Integrated Coastal Management, and encourage Reef to Ridge thinking. In climate change adaptation, the link between upland and coastal processes is especially highlighted. Destructive human activities in the highlands can also be detrimental to the marine environment. For example, deforestation and poor agricultural practices can hasten the movement of sediments towards the sea. Increased sedimentation can compromise water quality and limit productivity in coral reefs and seagrass beds. Another example is the improper disposal of solid wastes, which is a substantial source of pollution in natural habitats. Garbage has also been known to be lethal to endangered marine animals, including various species of dolphins and turtles. These known impacts can be exacerbated by climate change. Erosion resulting from poor land use, for example, can be worsened by heavy rains associated with heavier precipitation and more intense typhoons.

Restoring resiliency (Table 34) entails representativeness where protection is expanded to other coastal ecosystems, including seagrasses and mangroves. It is important to replicate such actions in different barangays to foster healthy and resilient reserves. Regular monitoring through adaptive management, which includes incorporating feedback mechanisms to engage and motivate collaboration and complementation, facilitates the continuous learning process. This is further complemented by organizing knowledge-based communities, engaging technical and policy groups in various hierarchical levels. The Coastal Learning Adaptation Network or CLAN is one such learning system (See The Coastal Learning Adaptation Network Box 1 in Page 130). MPA networks and systems are sustained to continuously enhance capacities and improve governance and management effectiveness. Practicing due diligence and good governance is imperative, transparency and

Table 34: Strategies and actions to restore resiliency thru learning communities

- ► **R**epresentativeness with resiliency e.g. expansion to seagrass & other ecosystems; replicated in barangays to make them healthy & resilient reserves
- ► **E**nhancing MPA monitoring thru adaptive management e.g. incorporating feedback mechanisms that engage and motivate collaboration and complementation
- ► **S**ustaining MPA networks and strengthen capacities through MPA and MPA systems to improve governance and management effectiveness e.g. 34 MPA networks in the Philippines
- ► **T**hreat reduction on coastal ecosystems e.g. FLET & CLET complementation
- ► **O**rganizing knowledge-based communities, e.g. composite teams from technical and policy groups that enjoin cooperation at various hierarchical levels e.g. CLAN
- ► **R**eplenishing MPA that help continue the source & sink relations e.g. SPAGS in Palawan & nurseries areas
- ► **E**nhancing connectedness in network designs to include social & ecological concerns e.g. Danajon Bank
- ► **D**oing due diligence and good governance e.g. regular state of the coasts reports and partnership forums

accessibility encouraged through regular state of the coast reporting and partnership forums. Connectivity is a fundamental consideration where MPA network design must incorporate social and ecological concerns. Further, it is also recommended that MPAs supporting source and sink relations be replenished. Finally, reducing threats on coastal ecosystems is an essential strategy towards climate change adaptation.

Maintaining coastal integrity and achieving equitable access (Table 35) among stakeholder groups will help sustain ecosystem services and function of coastal areas. This requires integrating soft and hard engineering science and technology approaches. Restoring coastal protection involves appropriate technologies such as mangrove rehabilitation and MPA design that covers representative habitats. In moving towards effectively sustaining coastal integrity, thresholds are evaluated using best available knowledge and tools that are able to gauge the acceptable limits of erosion, flooding and wave surge considerations (e.g. WEMo, See Chapter 3; CIVAT, See Chapter 5). Multiple, integrated functions for biodiversity conservation, fisheries management and integrated coastal management are considered when improving governance effectiveness and establishing the requisite management bodies; organizing early warning systems processes and standards; and setting up monitoring mechanisms such as coast watch (i.e. Bantay Dagat, in the Philippines). Reducing threats may be initiated through a review of Comprehensive Land Use Plans in relation to water use and/ or coastal development. In addition, it may also involve effective implementation of guidelines for setbacks and human settlements and evaluation of the cost and benefits of restructuring. On the other hand, social and economic incentives (such as the plough back of payments for ecosystem services), enhance equitable access. Disaster risk reduction measures must be integrated with climate change adaptation plans, together with the appropriate financing schemes.

In order to implement a more sustainable fisheries agenda (Table 36), reduction of fishing mortality is considered a primary concern in many areas of the Philippines. It has been pointed out by many authors that reducing fishing mortality is a necessary prerequisite towards adaptation

Table 35: Strategies and actions to maintain coastal integrity and equitable access

- ► **R**estoring coastal protection e.g. using appropriate mangrove technologies
- ► **E**ffective erosion buffers e.g. marine sanctuaries & proper structures
- ► **S**ustaining coastal integrity e.g. adjust CLUP based on VA lessons
- ► **T**hresholds maintained within acceptable limits *vis-a-vis* coastal erosion, sedimentation and thermal anomalies
- ► **O**rganizing coast watch e.g. with early warning systems
- ► **R**educing threats and sharing costs e.g. stop illegal settlements and land uses
- ► **E**nhancing equitable access e.g. payments for ecosystem services
- ► **D**isaster risk reduction e.g. integrate DRRM & climate adaptation mainstreaming

Table 36: Strategies and actions to implement a more sustainable fisheries agenda

- **R**educing overfishing e,g. Review licensing and implement adjustments
- **E**nhancing grow out of fry /fingerling in refugias
- **S**ustainable fisheries based on ABC (Allowable Biomass Catch)
- **T**hreat reduction integrated with ICM and refugias e.g. siltation, IUU and CCT++
- **O**rganizing CLAN (Climate Learning Action Network) integrated with EAFM
- **R**estoring fisheries resiliency program based on ecological & social connectivity
- **E**AFM (Ecosystem approach to Fisheries Management) development applying fisheries linked to ICM using spatial planning
- **D**iversifying livelihood for fisher and coastal communities (Conditional Cash Transfers ++ with fisheries stewardship targeted+ with climate adaptation+)

to climate change (e.g. Chavez et al., 2003; Brander, 2007). The strategy would require review of fisheries management regulations, as well as the adjustment of licensing, permits and concession fees to improve the effectiveness of implementation. In areas where overcapacity has exceeded the fishing capacity, it is necessary to undertake enhancement measures such as re-seeding and grow-out of fry and fingerlings in combination with establishing marine reserves and refugia. Prevention of overcapacity would require that fishing capacity is based on Allowable Biomass Catch or other tools (e.g. FISH-BE, Licuanan et al., 2006). Threat reduction as integrated with ICM requires that measures to diminish or mitigate habitat modification and siltation be undertaken with habitat protection and fisheries management (e.g. close and open season). Organizing climate learning adaptation networks that integrate EAFM within and among municipalities would contribute to restoring fisheries resiliency. Incorporating an ecological dimension (source, e.g. spawning areas including SPAGs; and sink areas, e.g. nursery grounds) have been highlighted in TURF (See Chapter 6). Establishing an ecosystem approach to fisheries management combined with ICM and spatial planning would enhance coastal climate adaptation. Diversifying livelihood for fisher and coastal communities calls for capacity building, empowering these vulnerable groups, e.g. Conditional Cash Transfers ++ (CCT; where the first + refers to preferential targeting of fisher groups since they are the poorest of the poor sector in Philippine society, preferably if they are managing MPAs or undertaking Bantay Dagat functions; and the second + indicates areas that are highly vulnerable to CC, e.g. low-lying, small island communities).

For biodiversity conservation considerations, users may consult the guidelines for MPA networks as suggested by Fernandes et al. (2012), which provide valuable discussion on achieving resiliency through representativeness of habitats and species, establishment of key biodiversity areas, and replication at various governance scales. Furthermore, the "Quick Reference Guide for Adaptation Options" from the Climate Change Adaptation Toolkit for Coastal Communities in the Coral Triangle (USCTI Support Program, 2012) may also be referred to when reflecting on the ecological, social and governance criteria and may be used as a complementary checklist for the RESTORED Strategies.

To facilitate a streamlined process of selecting the most appropriate, cost-effective actions from the RESTORED and other proposed adaptation options, inputs from coastal vulnerability assessment are necessary. The ICSEA-C-Change, because of its scoring system, can yield a ranking of sites according to their relative vulnerabilities. Further, as an integrated tool, it can also determine which key thematic areas of these barangays are most problematic and require deeper examination. Detailed vulnerability assessment of fisheries and coastal integrity are supplied by TURF and CIVAT respectively. Variables embedded in these tools can also offer some information on biodiversity. Results from TURF and CIVAT reveal which areas of concern require specific intervention: should actions be more directed towards reducing Potential Impact or should there be more focus on those enhancing Adaptive Capacity?

For example, in assessing factors relating to the natural buffering capacity of coral reef habitats (i.e. coral reefs, seagrasses, and mangroves), the CIVAT can guide sites requiring habitat rehabilitation and/ or protection. In considering factors such as coastal plain width and rates of accretion, it can direct communities on how to adjust their setback regulations or if it is necessary to shift development away from the coast. TURF, in considering the health of the reef habitat, can inform decisions regarding gear and/ or species restrictions. Further, insights gained from an assessment of fisheries offers direction in adjusting MPA management (e.g. adjustment of size and/ or location).

Table 37: Scoring for Urgency (Importance) and Capacity

Each action is scored based on whether they are important and/ or address an urgent need, and if there is capacity for implementation.

ADAPTATION ACTION	URGENCY	CAPACITY
1) 2) 3) **(1)** *List of top three actions most relevant to the highest vulnerabilities of each barangay, as guided by the VA*	**(2)** *Does the action address an URGENT need?* High: **3** Medium: **2** Low: **1**	**(3)** *Is there operational CAPACITY to implement activities?*

4. PRIORITIZING ACTIONS

The barangay ("village") as the smallest governance unit will serve as the unit of entry for actions. Using the information from the Coastal VAs, the three actions most relevant to these high vulnerabilities are proposed for each barangay. The actions are then evaluated according to whether they address urgent needs and if there is capacity for effective implementation. The relative Urgency or need for each action is gauged by assigning scores from 1 to 3, where "3" represents the most urgent need. In appraising the relative operational Capacity to implement activities, scores from 1 to 3 are also designated, where "3" similarly expresses the highest level of capacity (**Table 37**).

The actions are then visualized on an inter-relational diagram or matrix where their scores for Urgency (X-axis) are plotted against their scores for level of operational Capacity (Y-axis; **Figure 25**). The plot reveals priority actions, i.e. actions with highest urgency and can be implemented at highest capacity are considered Priority 1 (upper right quadrat); actions addressing an urgent need, but whose implementation is challenged by low capacity are Priority 2 (lower right quadrant); actions whose results are impeded by low implementation capacity, but address a relatively less urgent need are Priority 3 (lower left quadrant); and actions that may be implemented with high capacity and target a relatively less urgent need are Priority 4 (upper left quadrant)."

The actions for several barangays may be plotted simultaneously on a single matrix to learn where coordination and complementation among local governments can take place (**Figure 26**). Doing so can also reveal common areas of concern across sites, allowing for more efficient decision-making when allocating for technical and financial support. For example, a barangay whose urgent actions may be hindered by a lack of capacity may be assisted by a barangay with a better level of expertise. Similarly, if an action must be undertaken at a broader scale to achieve discernible results, the barangays may decide to engage in complementary activities that contribute to the greater goal of ecosystem-based management. Inter-LGU cooperation also allows for more inclusive, ecosystem-wide programs.

While the barangay as the basic functional governance unit offers good opportunities to propose actions that may eventually be resolved into local ordinances, it is more

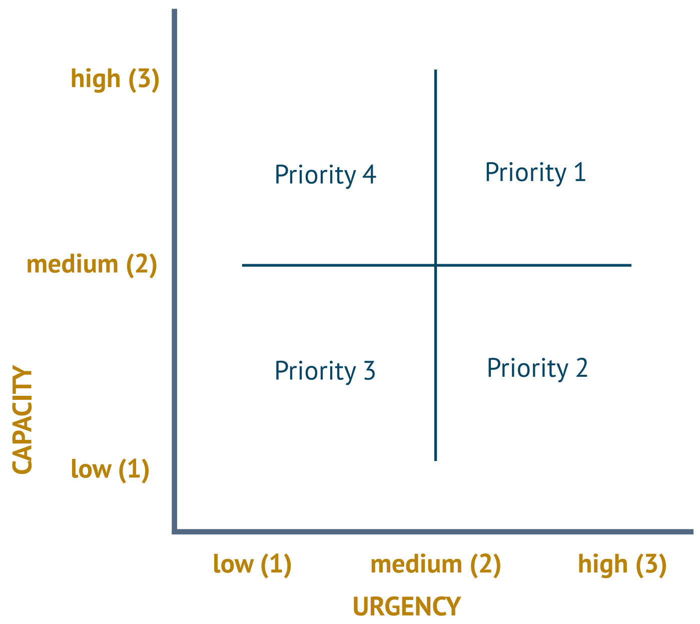


Figure 25: Urgency X Capacity inter-relational diagram (or matrix)

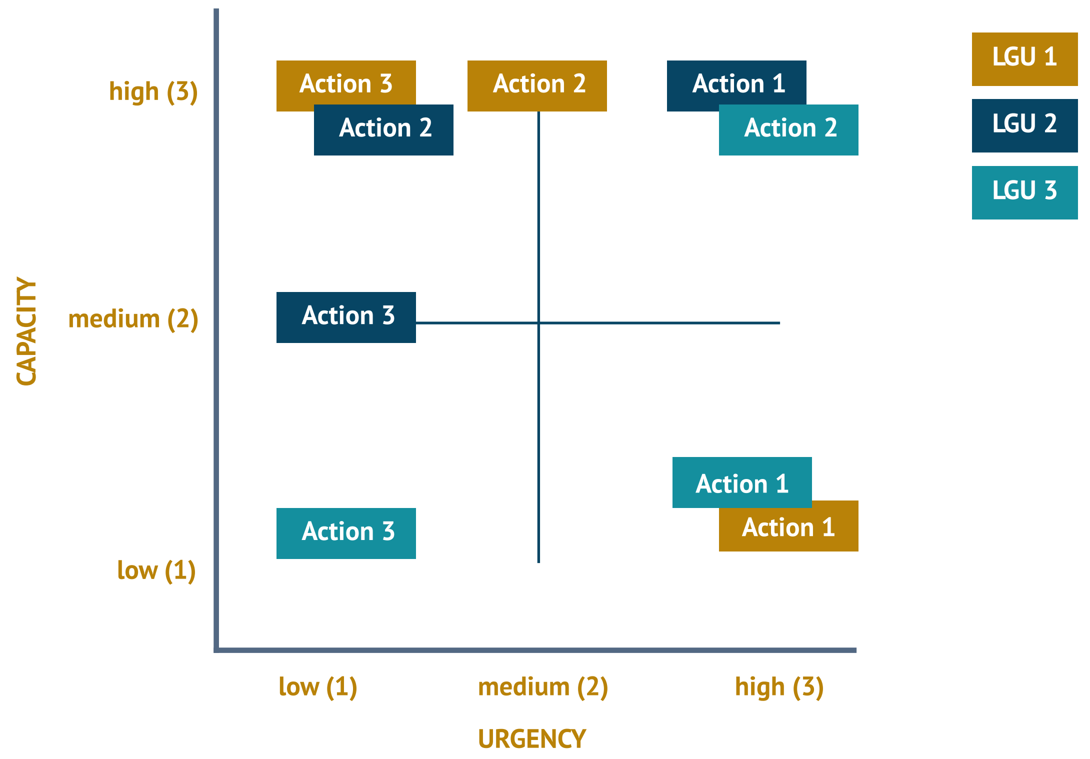


Figure 26: Figure shows a sample Urgency X Capacity plot incorporating the top 3 actions of 3 barangays.

sustainable to find convergence at the municipal level. For instance, barangays are able to fund proposed adaptation actions and programs via internal revenue allocations, but linking into broader municipal and provincial programs can open up more opportunities for financing and other support. Barangays are suggested to harmonize their actions with their municipal/ city-wide climate change adaptation and disaster risk reduction programs. When all actions are integrated, areas of convergence may be identified. Then, the top three concerns for all barangays may also be scored to gauge Urgency and Capacity at this scale.

5. EXAMPLES FROM THE RESILIENT SEAS PROGRAM

Three sites studied in the RESILIENT SEAS (previously called ICE CREAM) Program are discussed as examples to illustrate how users of the Coastal VA Tools managed to derive insights from VA results to determine important and urgent adaptation actions towards reducing Vulnerability and increasing Adaptive Capacity. ICSEA-C-Change was applied first to determine general vulnerabilities, followed by CIVAT and TURF to provide finer assessments.

5.1. MASINLOC, ZAMBALES

A VA orientation and CCA workshop was conducted in Masinloc, Zambales in the Philippines. In this example, it is valuable to observe the efforts to integrate livelihood activities with conservation and fisheries initiatives. Four barangays (villages), namely Bani, Poblacion, San Lorenzo and San Salvador, participated in the activity. Many of the High Vulnerability scores revolved around reef fisheries, seen primarily in San Salvador, San Lorenzo and Bani. On the other hand, there was Low Vulnerability of reef fish and socio-economic aspects in the relatively urban Poblacion area.

Based on these results and input lectures on adaptation options using the RESTORED Strategies, the participants were able to plot their actions on an Urgency and Capacity relational diagram (as in Figure 25; see Figure 27). Notably, San Salvador, which has a protected area, found the need to provide livelihood support and strengthen the capacity of fisher stewards as urgent. This was combined with a third action to implement open and closed seasons. For Poblacion, a rural area, capacity-building for diversification and strengthening of livelihood was identified as an urgent need. On the other hand, Bani and San Lorenzo indicated high capacity for livelihood enhancement. However, these barangays also recognized an urgent need in expanding their MPAs and integrating this with their sea cucumber and sea ranching activities.

5.2. EL NIDO, PALAWAN

El, Nido, Palawan in the Philippines provides an example that highlights coastal integrity concerns as linked to

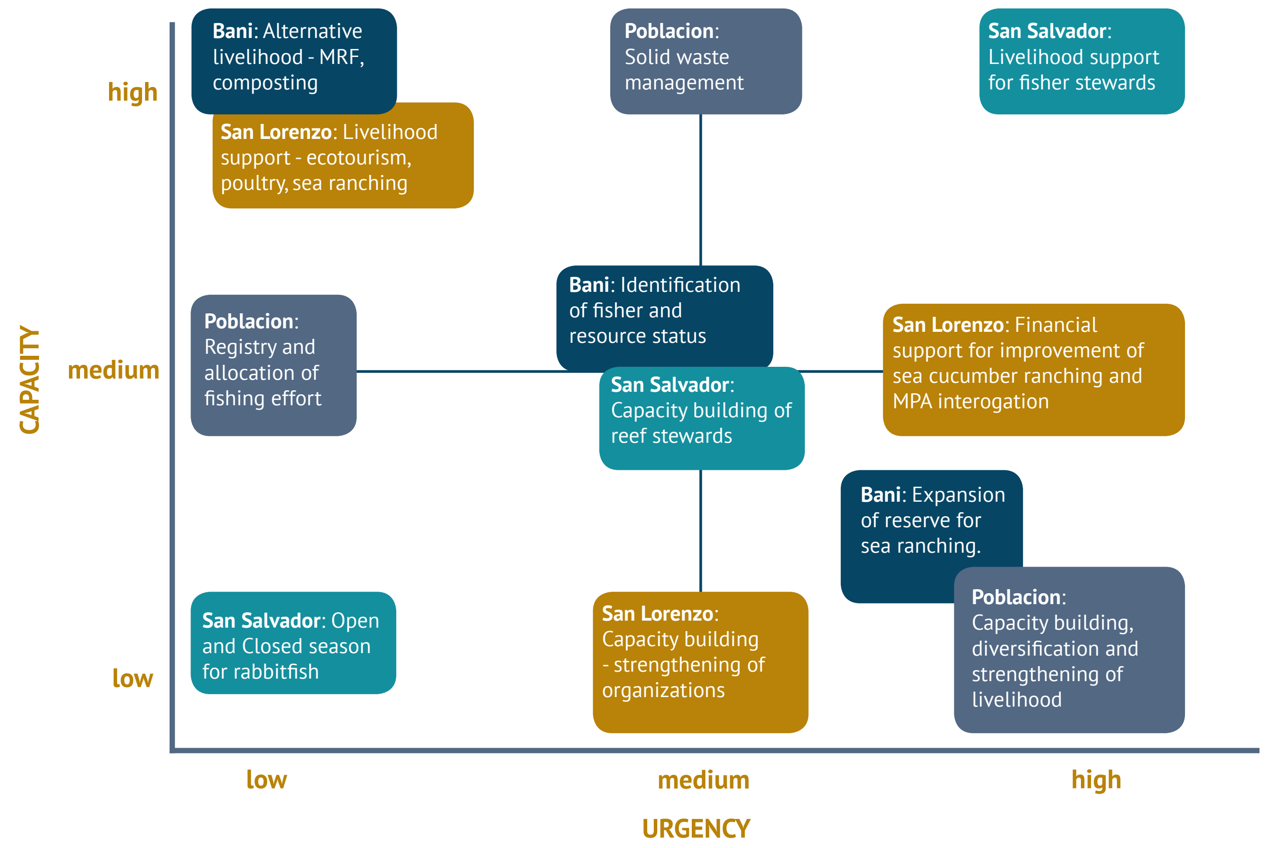


Figure 27: Urgency x Capacity diagram for four barangays in Masinloc, Zambales

sustainable fisheries and biodiversity conservation. During the VA orientation and CCA workshop conducted in El Nido, four barangays, particularly Buena Suerte, Bebeladan (Sitio Vigan), Corong-corong and Pasedena, were engaged. The highest Vulnerability for reef fish and socio-economic aspects was identified for Buena Suerte and Bebeladan, with Low coastal integrity and fisheries concerns for Corong-corong and also for Bebeladan. Pasadena had relatively Moderate Vulnerability overall.

Based on these considerations, the clarification of setback guidelines and building codes was proposed as the highest priority for Buena Suerte, given high local capacity. Further, participants recommended expanding their MPA, accompanied with sustainable financing supported through legislation and building the capacity of enforcement groups. Strengthening local community groups was also highlighted as a third adaptation action.

For Sitio Vigan in Barangay Bebeladan, capacity building programs for livelihood such as Conditional Cash Transfers were considered urgent. Clarification and strengthening of regulatory fishing permits and collection of fees, integrated with the review and strengthening of the Eco-Tourism Development Fee (ETDF) were identified as the following measures.

In Corong-corong where there are considerable built-up areas, suggested strategies were the improvement of monitoring and implementation of waste disposal guidelines and setbacks and easement policies; the establishment of incentives to enforce coastal zoning and land use plans; and complementary capacity-building and IEC.

Barangay Pasadena, with its overall Moderate Vulnerability and being adjacent to a river, highlighted measures were the improvement of watershed integrity and expansion of their MPA to include Mapdet Island. In addition, encouraging developers to participate in coastal planning with the local communities was recommended.

Finally, the participants developed a municipal-wide prioritization strategy where the importance of a technical working group to integrate their CCA measures with their CLUWP was emphasized. Further actions included the utilization of ETDF as a source of support for conservation and management, and for strengthening their waste management system. Finally, improving the allocation of benefits from fishery fees is to be reviewed by the Fisheries and Aquatic Resources Management Councils (FARMC) and the Municipal Agriculture Office (MAO).

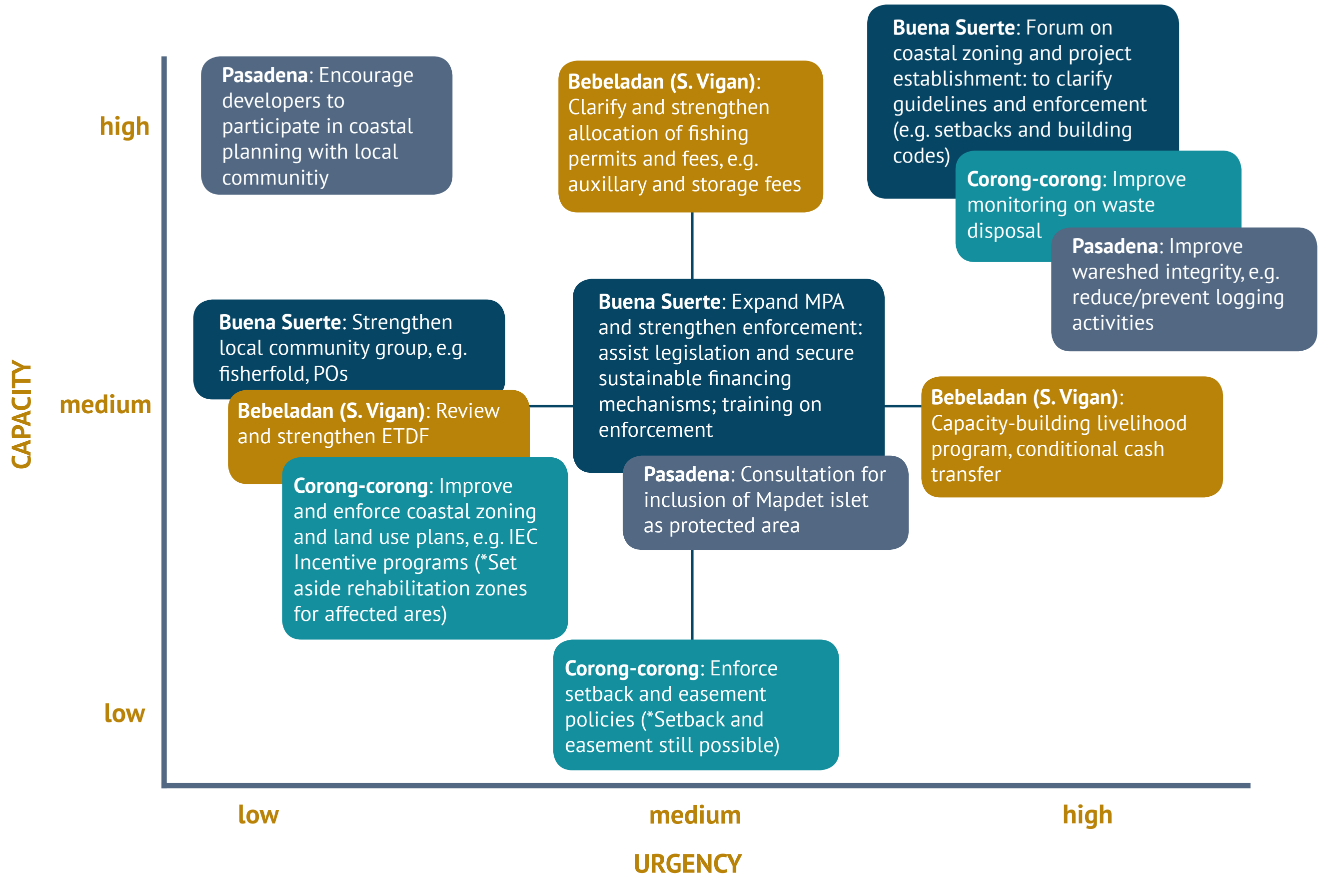


Figure 28: Urgency x Capacity for four barangays of El Nido, Palawan

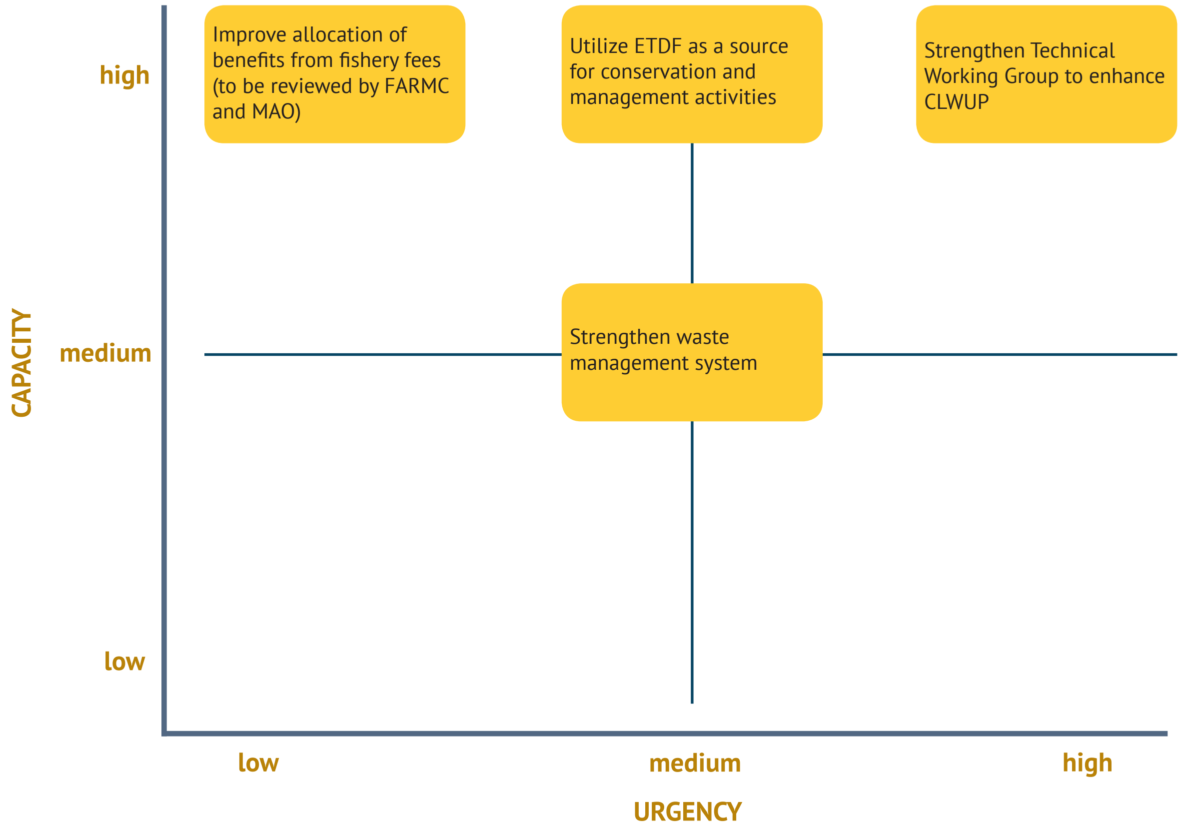


Figure 29: Urgency x Capacity diagram at the municipal level for El Nido

5.3. BOLINAO, PANGASINAN

Bolinao, Pangasinan in the Philippines, out of all the RESILIENT SEAS sites, has been found to have the highest Vulnerability and the biggest fisher density. This example provides insights on the importance of linking fisheries concerns with habitat protection. Barangays Dewey, Luciente I, Balingasay and Binabalian were engaged for the VA orientation and CCA workshop. Dewey was shown to have the highest Vulnerability according to TURF and CIVAT, followed by Binabalian being the most Vulnerable for fisheries. Both Luciente I and Balingasay have overall Low Vulnerability, although Luciente I has Moderate Vulnerability for reef fish and coastal integrity.

Based on the vulnerability assessment, for Dewey, recommended strategies were to enforce seasonal regulations for the siganid padas recruitment period and to ensure the facilitation of movement in migratory paths in the Dewey-Balingasay area. Dewey was also suggested as a candidate for Conditional Cash Transfers. The group also prioritized the regulation of quarrying activities, given urgent coastal integrity concerns. They also indicated that it was important to establish an MPA, and that there was high capacity to facilitate this.

Binabalian, on the other hand, proposed the expansion and integration of a seagrass-mangrove-coral continuum as a protected area. The workshop group also identified the implementation, regulation and enforcement of fisheries guidelines as a most urgent need. They specifically indicated that open/ close seasons be incorporated in the Revised Municipal Ordinance and that these be strictly enforced. The group also identified the development of a mangrove rehabilitation plan as an important strategy, indicating high capacity.

Luciente I with the lowest Vulnerability and Balingasay with Low to Moderate Vulnerability highlighted the importance of improving and enhancing fisheries regulations. It is noteworthy that these two areas with comparatively low Vulnerability have linked MPA management with fisheries management. On another note, based on a Moderate Vulnerability for coastal integrity in Luciente I, the group also noted that it was urgent for the CLUP to be approved and implemented to regulate buildings along the coast.

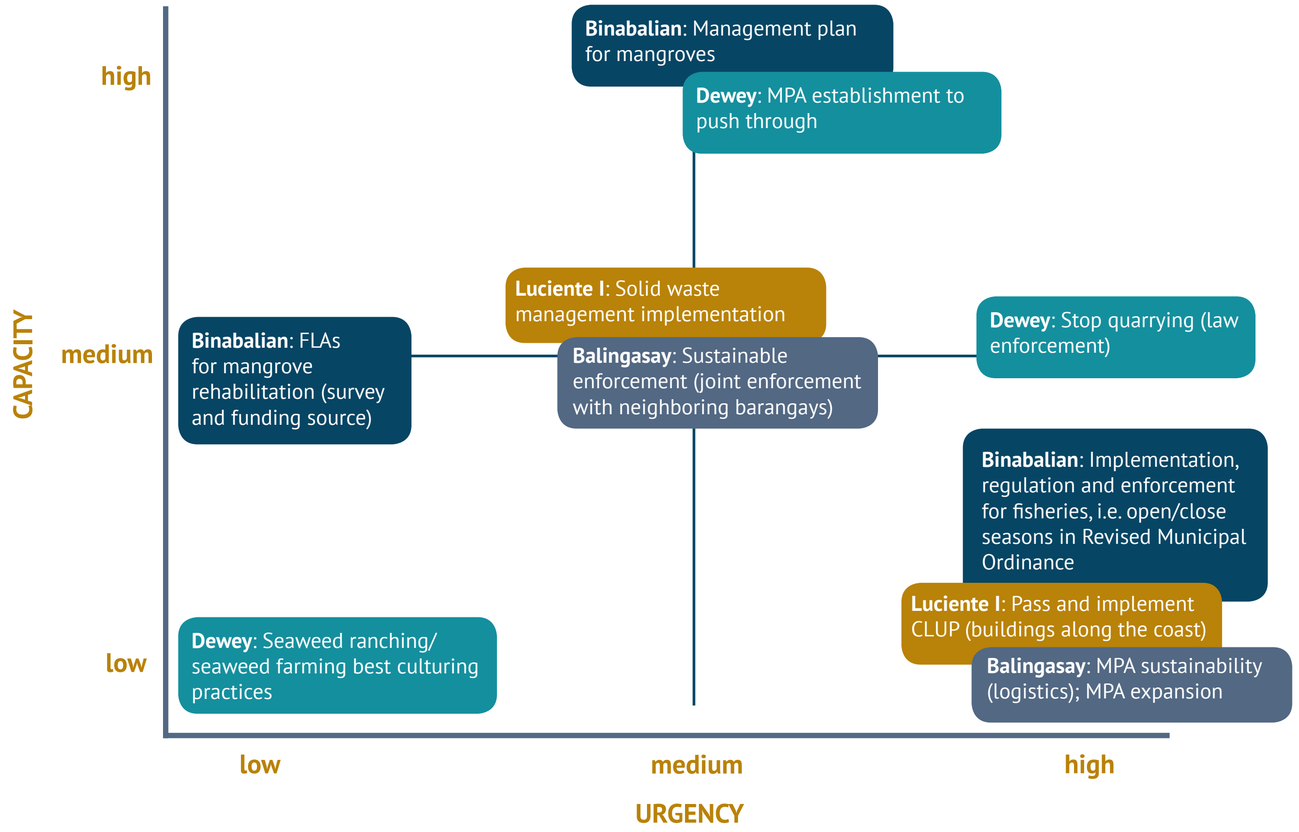


Figure 30: Urgency x Capacity diagram for four barangays in Bolinao, Pangasinan

The Coastal Learning Adaptation Network

The Philippine Coastal Learning Adaptation Network or CLAN is a smarting system that aims to build on shared experiences and knowledge on:

- ✓ Vulnerability assessment (VA)
- ✓ Emerging VA methodologies
- ✓ Capacity needs assessments
- ✓ Developing appropriate adaptive management actions
- ✓ Mainstreaming coastal adaptation strategies in existing management plans and programs
- ✓ Development of coastal adaptation action plans
- ✓ Monitoring and evaluation

The Philippine CLAN seeks to promote greater interaction between academic institutions that can provide technical knowledge (i.e. the knowledge generators) and national government agencies and/or local communities who need it (i.e. knowledge recipients). It will also be an avenue for coastal managers and practitioners to share their insights and lessons learned while working on the field. The Philippine CLAN is also a training hub, and may tap into a pool of core trainers to facilitate courses on vulnerability assessment, climate change adaptation planning, and even communications and training methods.

Through a series of preliminary meetings beginning in 2011, the Philippine CLAN was initiated as part of a larger effort to kickstart a regional network for the Coral Triangle. Existing learning communities such as the MPA Support Network (MSN) and the Philippine Association of Marine Science (PAMS) have been tapped as entry points. For instance, one of the earliest gatherings for the CLAN was during the 11th National Symposium on Marine Science by PAMS in October 2011. Engaging members was further pursued during the Philippine State of the Coasts workshop in May 2012. At the regional level, participants and trainers of the 2nd Regional CCA for Coastal Communities Course and Training of Trainers on February 2012 expressed their commitment to the network and continue to participate in exchanges via a virtual workspace.

Participants of the 2nd Course on Climate Change Adaptation for Coastal Communities and Training of Trainers in February 2012 signify membership to the CTI Coastal Learning Adaptation Network. (Photo © MC Quibilan 2012)

If you are interested in joining the CLAN, or need assistance for a VA/ CCA course, you may contact:

MILEDEL CHRISTINE C. QUIBILAN
Marine Science Institute, University of the Philippines Diliman
Quezon City 1101
Email: mcquibilan@gmail.com | Telefax: +632 433 1806

6. REFERENCES

Brander, K. M. (2007). Climate Change and Food Security Special Feature: Global fish production and climate change. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*. 104 (50): 19709-19714.

Chavez F. P., Ryan, J., Lluch-Cota, S. E. and Niquen, M.C. (2003). From anchovies to sardines and back: Multidecadal change in the Pacific Ocean. *Science*. 299 (5604): 217-221.

Fernandes, L., Green, A., Tanzer, J., White, A., Aliño, P.M., Jompa, J., Lokani, P., Soemodinoto, A., Knight, M., Pomeroy, B., Possingham, H., Pressey, B. (2012). Biophysical principles for designing resilient networks of marine protected areas to integrate fisheries, biodiversity and climate change objectives in the Coral Triangle. Report prepared by The Nature Conservancy for the Coral Triangle Support Partnership, 152 pp.

Intergovernmental Panel on Climate Change. (2001). Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Levina, E., Tirpak, D. (2006). Key Adaptation Concepts and Terms (Draft paper, Agenda document 1). Organisation for Economic Co-operation and Development. An OECD/ IEA Project for the Annex I Expert Group on the UNFCCC.

Licuanan, W.Y., Aliño, P.M., Campos, W.L., Castillo, G.B., Juinio-Menez, M.A. A decision support model for determining sizes of marine protected areas: biophysical considerations. *Philippine Agricultural Scientist*. 89: 507–519.

Marine Environment & Resources Foundation (2012). 2nd Regional Climate Change Adaptation for Coastal Communities Course and Training of Trainers Training Report (Working Draft). Prepared for the US Agency for International Development by the Marine Environment and Resources Foundation, University of the Philippines Diliman, Quezon City.

Marshall, P., Schuttenberg, H. (2006). A Reef Manager's Guide to Coral Bleaching. Great Barrier Reef Marine Park Authority, Townsville, Australia.

Philippine Environmental Governance 2 (EcoGov 2) Project. (2007). FISH-BE Model. Philippine Environmental Governance 2 Project, Pasig City, Philippines.

"Resilience" in Resilience Alliance, http://www.resalliance.org

UK CIP (2003). Climate Adaptation: Risk, Uncertainty and Decision-making. UKCIP Technical Report, Oxford, Willows, R. I. and R. K. Cornell (eds).

US Agency for International Development (USAID). (2009). Adapting to Coastal Climate Change: A Guidebook for Development Planners, http://www.usaid.gov/our_work/environment/climate/policies_prog/vulnerability.html or http://www.crc.uri.edu/download/CoastalAdaptationGuide.pdf

US Coral Triangle Initiative Support Program. 2012. Tool 5 – Quick Reference Guide to Adaptation Options. In US Coral Triangle Initiative Support Program (Ed.). 2012. Climate Change Adaptation Toolkit for Coastal Communities in the Coral Triangle—Version 1. The U.S Coral Triangle Initiative Support Program is supported by United States Agency for International Development (USAID) and partners, Bangkok, Thailand, 262 pp.

US Coral Triangle Initiative Support Program (Ed.). (2012). Climate Change Adaptation Toolkit for Coastal Communities in the Coral Triangle – Version 1. The US Coral Triangle Initiative Support Program is supported by the United States Agency for International Development (USAID) and partners, Bangkok, Thailand, 262 pp.

Vulnerability assessment orientation and adaptation workshops for Masinloc, Zambales, El Nido, Palawan and Bolinao, Pangasinan convened by the RESILIENT SEAS Program, DOST – PCAARD, Philippines in 2011

CI Philippines

ANNEXES: Facilitating a VA

ICSEA-C-CHANGE DATA CHECKLIST

The following table is a checklist of the minimum information users will need when conducting a VA with the ICSEA-C-Change. Other sources of information such as project reports (e.g. from research institutions, NGOs) or Provincial and Municipal development plans from the respective LGUs are also very helpful. It can help to put such information together prior to the actual VA to better facilitate the process. The shaded items necessitate going to the site for the information.

☐	1. Participatory Coastal Resource Assessment (PCRA)
☐	2. Topographical maps, e.g. from national mapping and agency (NAMRIA in the Philippines)
☐	3. Nautical charts, e.g. from national mapping and agency (NAMRIA in the Philippines)
☐	4. Satellite images, e.g. from Google Earth
☐	5. Municipal socio-economic profile
☐	6. Census data, e.g. from national census/ statistics agency (NSO in the Philippines)
☐	7. Information from mapping exercises
☐	8. Anecdotal accounts on coastal characteristics
☐	9. Field observations

DATA NEEDS AND POTENTIAL SOURCES PER ICSEA-C-CHANGE CRITERION

Sensitivity

	CRITERIA			DATA NEEDS	SOURCES
COASTAL HABITAT	Is there a coral reef in your area (with a defined profile)?	1	How much of the coastline is lined by coral reefs/ communities?	Reef extent	Topographical maps from NAMRIA and satellite images (i.e. Google Earth); mapping exercises
		2	What is the highest hard coral cover (%)?	Coral cover	PCRA
	Are there large seagrass meadows?	3	How much of the shallow areas are covered by seagrass?	Seagrass extent	Topographical maps from NAMRIA and satellite images (i.e. Google Earth); mapping exercises
		4	What is the maximum number of seagrass species?	Species composition	PCRA
	Are the mangrove areas widespread?	5	How much of the natural mangrove areas are left?	Present mangrove extent	Topographical maps from NAMRIA and satellite images (i.e. Google Earth); mapping exercises
		6	What kind of mangrove forest is left?	Forest type	PCRA
FISH AND FISHERIES	What kind of fishery operates in your barangay/ area?	7	Dominant catch	Fish catch composition	PCRA
		8	Catch rate	CPUE	PCRA
		9	Are the fishing gears used restricted on shallow water (coral, mangrove, seagrass) habitats?	Gear types and fishing ground	PCRA
	How important is the fisheries to the community?	10	Population density (Concentration of population)	Population census	NSO, Municipal socio-economic profile
		11	Fisheries ecosystem dependency	Number of fishers per barangay	PCRA
COASTAL INTEGRITY	Is the coastline prone to erosion and marine flooding?	12	Has the beach changed much in the last 12 months?	Shoreline trends	Anecdotal accounts or field observations on the erosional features of the beach/ coast.
		13	Is the coastline prone to erosion?	Lithology/rock or sediment types	DENR-MGB; UP NIGS; Field observation
		14	Width of shore platform (m)	Width of reef flat	Topographical and nautical maps from NAMRIA
		15	Is the coast steep?	Coastal slope	Topographical and nautical maps from NAMRIA

Lack of Adaptive Capacity

	CRITERIA			NOTES	DATA NEEDS	SOURCES
COASTAL HABITAT	Health of coral communities	1	If there are corals, are there more massive corals compared to branching ones?	Branching corals are faster growing	Lifeforms	PCRA
		2	If there are corals, are there more large colonies compared to small colonies for the species?	Recruitment potential	Coral size structure	Monitoring (coral recruitment)
		3	Is the coral diversity much reduced?	Biodiversity	Species composition	PCRA
	Health of seagrass meadows	4	If there are seagrasses, is Enhalus acoroides density highest among the seagrasses?	Recruitment potential	Species composition	PCRA
		5	Are there more barren areas within the seagrass meadow?	Meadow integrity	Seagrass extent	Topographical maps from NAMRIA and satellite images (i.e. Google Earth); mapping exercises
	Health of mangrove forests	6	Are the slow growing, slow colonizing species most common in the area?	Recruitment potential	Species composition	PCRA
		7	Are there more large trees than small propagules (in terms of density)?	Recruitment potential	Community structure	PCRA
	Water quality	8	Is the water murky/ silty in most of the year?		Water clarity	Personal observation; water quality monitoring
		9	Does the area experience warm still water?	Warm water events could be tidal; hence frequent (even if short) warm water events are stressful	Sea surface temperature	Personal observation; water quality monitoring

		10	Does solid waste accumulate in this coastal area?		Garbage/ solid waste mapping	Solid waste monitoring
	Level of biodiversity management					
	Habitat restoration efforts	11	How much of the degraded area remain to be rehabilitated?		Description of restoration, rehabilitation efforts	LGU
	Marine protected area	12	How much is the need to expand the MPA?	Based on the RA 8550 provision on 15% of municipal waters	Description of restoration, rehabilitation efforts	LGU
		13	Was the MPA design and management focussed on fishery enhancement alone?		Description of restoration, rehabilitation efforts	LGU
		14	To what extent do protected areas focus on single habitats (mangrove, seagrass, coral) alone?	Connectivity of habitats	Description of restoration, rehabilitation efforts	LGU
FISH AND FISHERIES		15	What is the contribution of fisheries to the per capita consumption of the area?	In relation to protein food intake	Municipal/ provincial poverty thresholds	LGU, NSCB
		16	What is the average fish catch (in kilograms) per day per person?		Catch rate	PCRA
		17	Are fishery resource management plans effective?		Evaluation of fishery management efforts	LGU
		18	What is the average fishing experience per fisher?	The longer the fishing experience, the harder for fishers to shift livelihood	Length of fishing experience	PCRA
		19	Is fishing the only source of livelihood?		Sources of income	PCRA, LGU
COASTAL INTEGRITY		20	How much has the land eroded in the last 30 years?		Long term shoreline trends	Anecdotal accounts; map analyses
HUMAN ACTIVITY	**Human settlements**	21	How much does the present land use pattern deviate from the land use plan?		CLUP evaluation	LGU
		22	To what extent do coastal modifications (pier, wharf, and seawall construction, reclamation, foreshore use) deviate from CLUP and similar regulations?		Evaluation of existing guidelines vis a vis location of coastal structures	LGU
	Economy	23	How extensive is the conversion of the coastal lands from rural-agricultural to residential to commercial and industrial use?		List of industries vis a vis location	LGU
	Education	24	How much of the adult population has less than 10 years of schooling?		Educational profile	LGU

ICSEA-C-CHANGE EXPOSURE | ASSESSMENT FORM

INSTRUCTIONS: Score each barangay for relevant Exposure criteria (Those not applicable to the site may be excluded). Scores are NOT to be averaged. Each Exposure score is integrated separately with the general means calculated for Sensitivity and lack of Adaptive Capacity, so users obtain the integrated vulnerability of a site to one stress factor at a time.

MUNICIPALITY: ___________________________________ **DATE:** _____________________

EXPOSURE CRITERIA Low (1-2) | Medium (3-4) | High (5)	**Barangays** (# of sites may vary; best to evaluate several at a time)		
	____________	____________	____________
Wave exposure and storm surge			
Sea-level rise			
Sea-surface temperature			
Extreme rainfall			

ICSEA-C-CHANGE SENSITIVITY RUBRIC | ASSESSMENT FORM

IMPORTANT NOTES:
1. All variables are to be scored
2. The average is calculated for each aspect, i.e. Coastal habitats, Fish and fisheries and Coastal integrity
3. The general mean is calculated using the computed averages

SUMMARY OF CRITERIA:
- Coastal habitat (6)
- Fish and fisheries (5)
- Coastal integrity (4)

MUNICIPALITY: ______________________ **DATE:** ______________

SENSITIVITY CRITERIA				LOW (1-2)	MEDIUM (3-4)	HIGH 5	BARANGAYS (# of sites may vary; best to evaluate several at a time) ________	________	________
COASTAL HABITAT	**Is there a coral reef in your area (with a defined profile)?**	1	How much of the coastline is lined by coral reefs/ communities?	More than 50% is lined by coral reefs/ communities	Between 25 to 50% is lined by coral reefs/ communities	Less than 25% is lined by coral reefs/ communities			
		2	What is the highest hard coral cover (%)?	over 50%	between 25 to 50%	less than 25%			
	Are there large seagrass meadows?	3	How much of the shallow areas are covered by seagrass?	seagrasses cover more than half of the reef flat	seagrasses cover more than 1/8 to 1/2 of of the reef flat	seagrasses cover less 1/8 of the reef flat			
		4	What is the maximum number of seagrass species?	mixed bed with over 5 species	2 to 4 species	monospecific bed			
	Are the mangrove areas widespread?	5	How much of the natural mangrove areas are left?	over 50% of the natural mangrove areas are left	between 25 to 50% of the natural mangrove areas are left	less than 25% of natural mangrove areas are left			
		6	What kind of mangrove forest is left?	riverine-basin-fringing type	riverine-fringing type	scrub-fringing type			
						Average for Coastal Habitats			

SENSITIVITY CRITERIA				LOW (1-2)	MEDIUM (3-4)	HIGH 5	BARANGAYS (# of sites may vary; best to evaluate several at a time) ________	________	________
FISH AND FISHERIES	**What kind of fishery operates in your barangay/area?**	7	Dominant catch	catch predominantly pelagics (tuna, mackerel, etc)	catch a mix of demersal and pelagic species	catch predominantly demersal fish e.g. groupers			
		8	Catch rate	>8kg per day (or equivalent CPUE)	3 to 8kg per day (or equivalent CPUE)	<3kg per day (or equivalent CPUE)			
		9	Are the fishing gears used restricted on shallow water (coral, mangrove, seagrass) habitats?	mostly mobile fishing gear	presence of both types	considerable number of habitat-associated gear (e.g. fixed gear on seagrass beds)			
	How important is the fisheries to the community?	10	Population density (Concentration of population)	200 persons or less per square kilometer (1 household per 2.5 ha)	between 200 to 500 persons per square kilometers (1 household per 1.25 ha)	more than 500 persons per square kilometer (1 household per 1 ha)			
		11	Fisheries ecosystem dependency	35% or less of the population are fishers	36% to 60% of the population are fishers	more than 60% of the population are fishers			
						Average for Fish and Fisheries			
COASTAL INTEGRITY	**Is the coastline prone to erosion and marine flooding?**	12	Has the beach changed much in the last 12 months?	land gain/ accreting	stable	eroding			
		13	Is the coastline prone to erosion?	Rocky, cliffed coast; bea ch rock	Low cliff (<5m high); cobble, gravel beaches; alluvial plains	Sandy beaches; delta; mud- or sandflat			
		14	Width of shore platform (m)	>100	[50, 100]	<50			
		15	Is the coast steep?	<1:50	1:50 to 1:200	>1:200			
						Average for Coastal Integrity			
						GENERAL MEAN			

IMPORTANT NOTES:
1. All variables are to be scored
2. The average is calculated for each aspect, i.e. Coastal habitats, Fish and fisheries, Coastal integrity and Human activity
3. The general mean is calculated using the computed averages

SUMMARY OF CRITERIA:
- Coastal habitat (6)
- Fish and fisheries (5)
- Coastal integrity (4)

MUNICIPALITY: ____________________ **DATE:** ____________

ADAPTIVE CAPACITY CRITERIA				SCORING				BARANGAYS (# of sites may vary; best to evaluate several at a time)		
				2	3	4	5	________	________	________
COASTAL HABITAT	Health of coral communities	1	If there are corals, are there more massive corals compared to branching ones?	3 times more branching than massive corals	2 times more branching than massive corals	as many branching as massive corals	more massive than branching; or no corals			
		2	If there are corals, are there more large colonies compared to small colonies for the species?	number of adult and large colonies is 1/3 that of juvenile and small colonies of the species	number of adult and large colonies is 1/2 that of juvenile and small colonies of the same species	as many large colonies as small ones of the same species	more large adults than juveniles and small colonies of the same species; or no corals			
		3	Is the coral diversity much reduced?	more than 100 species remaining	between 75 to 100 species remaining	between 50 to 75 species remaining	less than 50 species remaining			
							Average/Corals			

ADAPTIVE CAPACITY CRITERIA				SCORING				BARANGAYS (# of sites may vary; best to evaluate several at a time)		
				2	3	4	5	________	________	________
	Health of seagrass meadows	4	If there are seagrasses, is *Enhalus acoroides* density highest among the seagrasses?	*Halophila - Halodule* dominated meadow	*Thalassia - Cymodocea- Halodule* dominated meadow	*Enhalus acoroides- Thalassia hemprichii* dominated meadow	*Enhalus acoroides dominated* meadow; or no seagrass			
		5	Are there more barren areas within the seagrass meadow?	Meadow is continuous and barren area is less than 20%	Barren area is between 20 to 40% of the meadow	Barren area is between 40 to 60% of the meadow	Barren area is more than 60% of the meadow; or there are no meadows			
							Average/Seagrass			
	Health of mangrove forests	6	Are the slow growing, slow colonizing species most common in the area?	presence of more than 5 mangrove species capable of colonizing newly available habitat at a rate that keeps pace with the rate of relative sea-level rise	presence of 3 to 4 mangrove species capable of colonizing newly available habitat at a rate that keeps pace with the rate of relative sea-level rise	presence of 1 to 2 mangrove species capable of colonizing newly available habitat at a rate that keeps pace with the rate of relative sea-level rise	Yes, all species are slow growing, slow colonizing			
		7	Are there more large trees than small propagules (in terms of density)?	seedlings and propagules observed between 8 to 12 months every year	seedlings and propagules observed between 4 to 8 months every year	seedlings and propagules observed between 1 to 4 months every year	Yes, all trees are large, seedlings and propagules are absent			
							Average/Mangroves			

ADAPTIVE CAPACITY CRITERIA				SCORING				BARANGAYS (# of sites may vary; best to evaluate several at a time)		
				2	3	4	5	____	____	____
	Water quality	8	Is the water murky/ silty in most of the year?	Water is clear all year round	Water is observed to be murky for 1 to 2 quarters a year	Water is observed to be murky/ silty for three quarters a year	Water is murky/ silty all year round			
		9	Does the area experience warm still water?	No	short periods of warm still water prevails and is related to tides	periods of warm still water prevails for several days or weeks at a time	periods of warm still water prevails for several months			
		10	Does solid waste accumulate in this coastal area?	No	solid waste are observed in this coastal area between 1 to 4 months every year	solid waste are observed in this coastal area between 4 to 8 months every year	solid waste accumulates in this coastal area all year round			
			Average/Water Quality							
Level of biodiversity management	Habitat restoration efforts	11	How much of the degraded area remain to be rehabilitated?	Less than 50% of the degraded habitats	Between 50 to 70% of the degraded habitats	Between 70 to 90% of the degraded habitats	More than 90% of the degraded habitats remain to be rehabilitated			
	Marine protected area	12	How much is the need to expand the MPA?	Almost none; MPAs are 15% or more of municipal waters	Total MPA areas is 7.5% to 15% of the municipal waters	Total MPA areas is between 1 to 7.5% of the municipal waters	Total MPA areas is less than 1% of the municipal waters			

ADAPTIVE CAPACITY CRITERIA				SCORING				BARANGAYS (# of sites may vary; best to evaluate several at a time)		
				2	3	4	5	____	____	____
		13	Was the MPA design and management focussed on fishery enhancement alone?	No, biodiversity and tourism aims also considered	Fisheries and tourism were considerations	Tourism was the only consideration	Yes			
		14	To what extent do protected areas focus on single habitats (mangrove, seagrass, coral) alone?	No; all habitats represented in the MPA	Only two habitats were included in the MPA	Only one habitat was included in the MPA	No habitats were included in the MPA			
			Average/Marine Protected Area							
			Average for Coastal Habitats							
FISH AND FISHERIES		**15**	What is the contribution of fisheries to the per capita consumption of the area?	less than 20%	between 20 to 40%	between 40 to 60%	more than 60%			
		16	What is the average fish catch (in kilograms) per day per person?	more than 5 kilos	between 2.5 to 5 kilos	between 1 to 2.5 kilos	less than 1 kilo			
		17	Are fishery resource management plans effective?	Yes			No; Or there are no management plans			

ADAPTIVE CAPACITY CRITERIA				SCORING				BARANGAYS (# of sites may vary; best to evaluate several at a time)		
				2	3	4	5	____	____	____
		18	What is the average fishing experience per fisher?	less than 5 years	between 5 to 10 years	between 10 to 20 years	more than 20 years			
		19	Is fishing the only source of livelihood?	No, more than 3 other sources of livelihood	Fishing plus two other sources of livelihood	Fishing plus another source of livelihood	Yes			
							Average for Fish and Fisheries			
COASTAL INTEGRITY		20	How much has the land eroded in the last 30 years?	0, accreting	between 0 to 15m land loss	between 15 to 30m land loss	more than 30m of land loss			
HUMAN ACTIVITY	Human settlements	21	How much does the present land use pattern deviate from the land use plan?	No deviation	Between 1 to 25%	Between 25 to 50%	More than 50%, or there is no use land use plan			
HUMAN ACTIVITY	Human settlements	22	To what extent do coastal modifications (pier, wharf, and seawall construction, reclamation, foreshore use) deviate from CLUP and similar regulations?	No deviation	Between 1 to 25%	Between 25 to 50%	More than 50%, or there is no land use plan			

ADAPTIVE CAPACITY CRITERIA				SCORING				BARANGAYS (# of sites may vary; best to evaluate several at a time)		
				2	3	4	5	____	____	____
	Economy	23	How extensive is the conversion of the coastal lands from rural-agricultural to residential to commercial and industrial use?	Industrial	Commercial	Residential	Rural agricultural			
	Education	24	How much of the adult population has less than 10 years of schooling?	Less than 20%	Between 20 to 40%	Between 40 to 60%	More than 60%			
							Average for Human Activity			
							GENERAL MEAN			

ICSEA-C-CHANGE INTEGRATION

INSTRUCTIONS: Follow the ICSEA-C-Change interpretation rules (listed below) to obtain a synoptic Vulnerability

Vulnerability is computed from the Sensitivity, Exposure, and lack of Adaptive Capacity component scores or subscores. The component scores are averaged and converted to a categorical (Low, Moderate, High) scale. These component scores are then combined, using the following rules: if at least one of the three components is a Moderate, the final Vulnerability rating for that given area is Moderate. On the other hand, if two components have a score of at least Moderate and the third component has a score of High, the final rating for that area will be High Vulnerability.

		Sensitivity					
		L (1-2)	M (3-4)	H (5)			
Exposure	L (1-2)	LLL	MLL	HLL	L (2)	LAC	
	M (3-4)	LMM	MMM	HMM	M (3-4)		
	H (5)	LHH	MHH	HHH	H (5)		
Sensitivity and Exposure subcore conversion:					Lack of Adaptive Capacity:		
- low is an average of 1.0 to 2.0					- low is an average of less than 3.0		
- moderate is an average of more than 2.0 up to 4.0					- moderate is 3.0 to 4.0		
- high is an average of more than 4.0					- high is more than 4.0		

BARANGAY	Exposure (Specify: ______________)	Sensitivity	Adaptive Capacity	Vulnerability
1.				
2.				
3.				

COASTAL INTEGRITY VULNERABILITY ASSESSMENT TOOL

CIVAT DATA CHECKLIST

Below is a checklist of potential data sources for vulnerability assessment with CIVAT. It is important for users to remember that they can consult their ICSEA-C-Change results for information that has already been scoped and consolidated. The shaded items necessitate field visits.

☐	1. Tide gauge data, e.g. from national mapping agency (NAMRIA predicted tide tables)
☐	2. Tide data (http://www.wxtide32.com/download.html)
☐	3. Sea-surface heights (http://www.aviso.oceanobs.com)
☐	4. Wave intensity (e.g. WEMo, See Chapter 3; maps, wind rose diagram)
☐	5. Topographic maps, e.g. from national mapping agency (NAMRIA in the Philippines)
☐	6. Bathymetric maps, e.g. from national mapping agency (NAMRIA in the Philippines)
☐	7. Geologic map, e.g. geological offices and institutions (MGB in the Philippines)
☐	8. Satellite images, e.g. from Google Earth
☐	9. Participatory Coastal Resource Assessment (PCRA)
☐	10. Comprehensive Land and Water Use Plan (CLUP/ CLWUP)
☐	11. Land use map, e.g. from national mapping agency (NAMRIA in the Philippines)
☐	12. Field observations (e.g. coastal characteristics, erosion, accretion)
☐	13. Anecdotal accounts (e.g. coastal characteristics, erosion, accretion)
☐	14. Habitat assessment (e.g. corals, mangroves, seagrasses)

POTENTIAL DATA SOURCES PER CIVAT CRITERION

Exposure

CRITERIA		DATA SOURCES
1	Relative sea level change (cm/yr)	Tide gauge data (NAMRIA) and sea-surface heights (AVISO Website)
2	Wave exposure during monsoons	▶ WEMo (Villanoy et al., See Chapter 3) ▶ Maps, wind rose diagram
3	Wave exposure during typhoons	
4	Tidal range	Predicted tide tables (NAMRIA)
	Proxy for wave exposure Orientation of the coast to predominant winds/ storms	Field observations, anecdotal accounts

Sensitivity

	SENSITIVITY CRITERIA		DATA SOURCES
INTRINSIC FACTORS	1.	Coastal landform and rock type	▶ Topographic map (NAMRIA) ▶ Google Earth ▶ Geologic map (MGB) ▶ Field observations
	2.	Seasonal beach recovery	▶ Field observations ▶ Anecdotal accounts
	3.	Slope from the shoreline to 20-m elevation (landward slope)	▶ Topographic and bathymetric maps (NAMRIA) ▶ Google Earth
	4.	Width of reef flat or shore platform	▶ Topographic map (NAMRIA) ▶ Google Earth
	5.	Beach forest/vegetation	▶ Google Earth ▶ Field observations
	6.	Lateral continuity of reef flat or shore platform	▶ Topographic map (NAMRIA) ▶ Google Earth
	7.	Coastal habitats, including the detailed habitat rubrics: ▶ Coral reef as sediment source ▶ Mangroves as sediment trap ▶ Seagrasses as sediment source and stabilizer ▶ Mangroves as wave buffer	▶ PCRA ▶ Habitat assessment/s
EXTRINSIC FACTORS	8.	Coastal and offshore mining (includes removal of fossilized corals on the fringing reef and beach)	▶ Field observations ▶ Anecdotal accounts
	9.	Structures on the foreshore	▶ Field observations ▶ Anecdotal accounts

Adaptive Capacity

ADAPTIVE CAPACITY CRITERIA		DATA SOURCES
1	Long-term shoreline trends (m/ year)	▶ Topographic maps ▶ Satellite images, Google Earth
2	Continuity of sediment supply	▶ Google Earth
3	Guidelines regarding the easement (setback zone)	
4	Guidelines on coastal structures	▶ CLUP/ CLWUP
5	Type of coastal development	▶ CLUP/ CLWUP ▶ LGU
6	Viability of coral reef as sediment source	▶ Land use maps (NAMRIA) ▶ Google Earth ▶ CLUP/ CLWUP
7	Viability of seagrasses as sediment source	▶ PCRA ▶ Habitat assessment
8	Viability of mangroves as sediment trap	
9	Viability of mangroves as wave buffer	

CIVAT EXPOSURE | ASSESSMENT FORM

INSTRUCTIONS: Evaluate each site for relevant Exposure factors. Criteria are scored based on the magnitude of their contribution to physical changes on the coast in relation to waves and sea level rise. Use the thresholds as the guide for scoring. When obtaining the ratings of Low, Medium or High, scores must be re-scaled according to the guidelines provided in the CIVAT chapter.

MUNICIPALITY: ______________________________ **DATE:** ____________________

EXPOSURE CRITERIA		Low	Medium	High	SITE SCORES (# of sites may vary)		
		(1-2)	(3-4)	(5)	________	________	________
1	Relative sea level change (cm/yr)	≤ 0.2	0.2-1.5	>1.5			
2	Wave exposure during monsoons*	Low	Medium	High			
3	Wave exposure during typhoons*	Low	Medium	High			
4	Tidal range (m)	≤ 1	1-2	≥ 2			
	Proxy for wave exposure: Orientation of the coast to predominant winds/storms	Relatively protected	Slightly exposed	Directly exposed			
				TOTAL			
				RATING (Low, Medium or High)			

IMPORTANT NOTES:

1. Criterion #7 (Coastal habitats) is to be used if there is no detailed habitat data. On the other hand, if such data is available for comprehensive assessment, Criteria 8.1 to 8.4 (Detailed habitat criteria; See Chapter 5) should be used INSTEAD of Criterion #7.

   1.1 Score all sub-criteria under items 8.1 to 8.4
   1.2 Average the scores of the sub-criteria per habitat function (e.g. Seagrass as sediment source, Mangrove as sediment trap). Use these averages when aggregating the scores within the main Sensitivity matrix.

2. Scores are to be aggregated.
3. The number of criteria will vary depending on what is applicable in the site, and if the detailed natural habitat assessment is conducted.
4. When obtaining the ratings of Low, Medium or High, scores must be re-scaled according to the guidelines provided in the CIVAT chapter.

SUMMARY OF CRITERIA:
This assessment form includes both the CIVAT Sensitivity rubric and that with the detailed criteria for natural habitats.

Without detailed habitat criteria (9 scores to aggregate)
- Intrinsic factors (7)
- Extrinsic factors (2)

With detailed habitat criteria (12 scores to aggregate)
- Intrinsic factors (6)
  + Detailed habitat criteria (4 habitat functions; 13 sub-criteria)
- Extrinsic factors (2)

MUNICIPALITY: ______________________ **DATE:** ______________

		SENSITIVITY CRITERIA	LOW (1-2)	MEDIUM (3-4)	HIGH (5)	SITE SCORES (# of sites may vary) ______	______	______
INTRINSIC FACTORS	1	Coastal landform and rock type	Rocky, cliffed coast; beach rock	Low cliff (<5m high); Cobble/ gravel beaches; alluvial plains; fringed by mangroves	Sandy beaches; deltas; mud/ sandflat			
	2	Seasonal beach recovery	Net Accretion	Stable	Net Erosion			
	3	Slope from the shoreline to 20-m elevation (landward slope; rise over run)	>1:50	1:50-1:200	<1:200			
	4	Width of reef flat or shore platform (m)	>100	[50, 100]	<50			

			SENSITIVITY CRITERIA	LOW (1-2)	MEDIUM (3-4)	HIGH (5)	SITE SCORES (# of sites may vary) ______	______	______
	5		Beach forest/vegetation	Continuous and thick with many creeping variety	Continuous and thin with few creeping variety	Very patchy to none			
	6		Lateral continuity of reef flat or shore platform	>50%	[10-50]	<10%			
	7		Coastal habitats	Coral reef, mangroves and seagrasses or coral reef and mangroves are present	Either coral reef or mangrove is present	None			
	DETAILED NATURAL HABITAT CRITERIA	*8.1*	*Coral as sediment source*	**Average for items 8.1.1 to 8.1.2**					
		8.1.1	Living coral cover	Over 50%	Between 25 to 50%	Less than 25%			
		8.1.2	Coral community growth form in the shallow reef	At least half of the corals are hemispherical/ massive and encrusting	At least half of the corals are tabulate	At least half of the corals are branching and foliose			
		8.2	*Seagrass bed as sediment source and stabilizer*	**Average for items 8.2.1 to 8.2.3**					
		8.2.1	Areal extent relative to reef flat	Seagrasses cover more than half of the reef flat	Seagrasses cover more than 1/8 to 1/2 of the reef flat	Seagrasses cover less 1/8 of the reef flat			
		8.2.2	Capacity to withstand storm removal and wave impacts	Root system extensive; *Enhalus acoroides* and *Thalassia hemprichii* dominated	*Thalassia - Cymodocea-Halodule* beds	Small sized species, i.e. *Halophila - Halodule* meadows			
		8.2.3	Seagrass meadow type	Mixed bed with over 5 species	2 to 4 species	Monospecific bed			
		8.3	*Mangroves as sediment trap*	**Average for items 8.3.1 to 8.3.3**					

		SENSITIVITY CRITERIA	LOW (1-2)	MEDIUM (3-4)	HIGH (5)	SITE SCORES (# of sites may vary)		
DETAILED NATURAL HABITAT CRITERIA	8.3.1	Forest type	Riverine-basin-fringing type; basin-fringing type	Riverine-fringing type; fringing	No mangrove; scrub type			
	8.3.2	Mangrove zonation	3 to 4 mangrove zones (*Avicennia-Sonneratia; Rhizophora; Ceriops-Bruguiera-Xylocarpus; Nypa* zones)	2 mangrove zones	Only 1 mangrove zone present			
	8.3.3	Capacity to trap sediments	At least half of the mangrove area are *Avicennia-Sonneratia* dominated	At least half of the mangrove area are dominated by species with pneumatophore (*Avicennia, Sonneratia*) and knee root (*Bruguiera, Ceriops tagal*) system	Area is dominated by species with prop (*Rhizophora*) or buttress/ plank (*Xylocarpus granatum, Heritiera littoralis*) type of root system			
	8.4	*Mangrove as wave buffer*	**Average for items 8.4.1 to 8.4.5**					
	8.4.1	Forest type	Riverine-basin-fringing type	Riverine-fringing type	Scrub-fringing type			
	8.4.2	Present vs historical mangrove extent	0 to 25% of original mangrove area loss; at least 75% of seaward zone remaining	26 to 50% of original mangrove area loss	over 50% of original mangrove area loss			
	8.4.3	Mangrove zonation	3 to 4 mangrove zones (*Avicennia-Sonneratia; Rhizophora; Ceriops-Bruguiera-Xylocarpus; Nypa* zones)	2 mangrove zones	Only 1 mangrove zone present			

		SENSITIVITY CRITERIA	LOW (1-2)	MEDIUM (3-4)	HIGH (5)	SITE SCORES (# of sites may vary)		
	8.4.4	Mangrove canopy cover	Mangrove area with over 50% canopy cover	Mangrove area with canopy cover that is between 25% to 50%	Mangrove area with less than 25% canopy cover			
	8.4.5	Mangrove basal area	More than 50 m2 per ha	Between 25 to 50 m2 per ha	Less than 25 m2 per ha			
EXTRINSIC FACTORS	9	Coastal and offshore mining (includes removal of fossilized corals on the fringing reef and beach)	None to negligible amount of sediments being removed (i.e., sand and pebbles as souvenir items)	Consumption for HH use	Commercial scale			
	10	Structures on the foreshore	None; one or two short groins (i.e., <5m long) and/ or few properties on the easement with no apparent shoreline modification	Short groins & short solid-based pier (5 to 10m long); seawalls and properties with aggregate length of less than 10% of the shoreline length of the barangay	Groins and solid-based pier > 10m long; seawalls and other properties with aggregate length of more than 10% of the shoreline length of the barangay			
TOTAL								
RATING (Low, Medium or High)								

IMPORTANT NOTES:

1. Criteria that highlight the role of natural habitats (i.e. coral reefs, mangroves and seagrasses) as sediment source/ trap should be included if the assessment is being conducted on a relatively homogeneous system where such habitats are present. These criteria are found in this assessment form as items 6 to 9.

   Note: The score for item 9 ("Viability of mangroves as wave buffer") should be the computed average for items 9.1 and 9.2.

2. Scores are to be aggregated.
3. The number of criteria will vary depending on what is applicable in the site.
4. When obtaining the ratings of Low, Medium or High, scores must be re-scaled according to the guidelines provided in the CIVAT chapter.

SUMMARY OF CRITERIA: This assessment form includes both the CIVAT Adaptive Capacity rubric and that with the detailed criteria for natural habitats.

Adaptive Capacity (9)
- ► Physical coast characteristics (5)
- ► Natural habitat processes (4, according to habitat function)

MUNICIPALITY: ______________________ **DATE:** ______________

	ADAPTIVE CAPACITY CRITERIA	LOW (1-2)	MEDIUM (3-4)	HIGH (5)	SITE SCORES (# of sites may vary) ____	____	____
1	Long-term shoreline trends (m/ year)	≤ -1 (eroding)	(-1,0)	>0 (accreting)			
2	Continuity of sediment supply	if interruption in sediment supply is regional	if interruption in sediment supply is localized	If sediment supply is uninterrupted			
3	Guidelines regarding the easement (setback zone)	No provision for easement (setback zone) in the CLUP and zoning guidelines	Setback policy is clearly stated in the CLUP and zoning guidelines; with <50% implementation	Implementation of setback policy is at least 50%			
4	Guidelines on coastal structures	CLUP and zoning guidelines promotes the construction of permanent and solid-based structures along the coast	Clearly states the preference for semi-permanent or temporary structures to be built along the coast(e.g., made of light materials and on stilts) is in the CLUP and zoning guidelines	Prohibits construction of solid-based structures; For those already erected, CLUP/zoning guidelines has provision to remove or modify any structure causing obstruction and coastal modification			

	ADAPTIVE CAPACITY CRITERIA	LOW (1-2)	MEDIUM (3-4)	HIGH (5)	SITE SCORES (# of sites may vary) ____	____	____
5	Type of coastal development	Industrial, commercial, highways, large institutional facility	Residential	Agricultural, open space, greenbelt			
6	*Viability of coral reef as sediment source* Living coral cover	less than 25%	between 25 to 50%	over 50%			
7	*Viability of seagrasses as sediment source* Capacity to recover from storm blow-outs	*Enhalus-Thalassia* dominated	*Thalassia - Cymodocea- Halodule* dominated	*Halophila - Halodule* dominated			
8	*Viability of mangroves as sediment trap* Capacity to trap sediments	area is dominated by species with prop (*Rhizophora*) or buttress/ plank (*Xylocarpus granatum, Heritiera littoralis*) type of root system	at least half of the mangrove area are dominated by species with pneumatophore (*Avicennia, Sonneratia*)and knee root (*Bruguiera, Ceriops tagal*) system	at least half of the mangrove area are *Avicennia-Sonneratia* dominated			
9	*Viability of mangroves as wave buffer*			*(Average of items 9.1 and 9.2)*			
9.1	Mangrove canopy cover	mangrove area with less than 25% canopy cover	mangrove area with canopy cover that is between 25% to 50%	mangrove area with over 50% canopy cover			
9.2	Mangrove basal area	less than 25 m2 per ha	between 25 to 50 m2 per ha	more than 50 m2 per ha			
				TOTAL			
				RATING (Low, Medium or High)			

CIVAT INTEGRATION

INSTRUCTIONS: Consolidate the ratings for Exposure, Sensitivity and Adaptive Capacity into the table below and obtain the measurement for Vulnerability

BARANGAY	EXPOSURE	SENSITIVITY	POTENTIAL IMPACT*	ADAPTIVE CAPACITY	VULNERABILITY*
1.					
2.					
3.					

Use the corresponding cross-table to obtain measurements for Potential Impact and Vulnerability

Sensitivity (columns) / Exposure (rows)

PI	L	M	H
L	L	L	M
M	L	M	H
H	M	H	H

Adaptive Capacity (columns) / PI (rows)

V	L	M	H
L	M	L	L
M	H	M	L
H	H	H	M

*RULES FOR RE-SCALING SCORES (CIVAT)

If the no. of criteria = 2	
Maximum score	(2 x 5) = 10
Minimum score	(2 x 1) = 2
Total range	[max - min] = 8
Intervals	8 ÷ 3 = 2.7 or 3
Interval	8/3
	2.7
Rating	Range
Low	2-4
Medium	5-7
High	8-10

If the no. of criteria = 3	
Maximum score	(3 x 5) = 15
Minimum score	(3 x 1) = 3
Total range	[max - min] = 12
Intervals	12 ÷ 3 = 4
Interval	12/3
	4.0
Rating	Range
Low	3-7
Medium	8-11
High	12-15

If the no. of criteria = 4	
Maximum score	(4 x 5) = 20
Minimum score	(4 x 1) = 4
Total range	[max - min] = 16
Intervals	16 ÷ 3 = 5.3 or 5
Interval	16/3
	5.1
Rating	Range
Low	4-9
Medium	10-15
High	16-20

If the no. of criteria = 5	
Maximum score	(5 x 5) = 25
Minimum score	(5 x 1) = 5
Total range	[max - min] = 20
Intervals	20 ÷ 3 = 6.7 or 7
Interval	20/3
	6.7
Rating	Range
Low	5-11
Medium	12-18
High	19-25

If the no. of criteria = 6	
Maximum score	(6 x 5) = 30
Minimum score	(6 x 1) = 6
Total range	[max - min] = 24
Intervals	24 ÷ 3 = 8
Interval	24/3
	8.0
Rating	Range
Low	6-14
Medium	15-22
High	23-30

If the no. of criteria = 7	
Maximum score	(7 x 5) = 35
Minimum score	(7 x 1) = 7
Total range	[max - min] = 28
Intervals	28 ÷ 3 = 9.3 or 9
Interval	28/3
	9.3
Rating	Range
Low	7-16
Medium	17-26
High	27-35

If the no. of criteria = 8	
Maximum score	(8 x 5) = 40
Minimum score	(8 x 1) = 8
Total range	[max - min] = 32
Intervals	32 ÷ 3 = 10.7 or 11
Interval	32/3
	10.7
Rating	Range
Low	8-18
Medium	19-29
High	30-40

If the no. of criteria = 9	
Maximum score	(9 x 5) = 45
Minimum score	(9 x 1) = 9
Total range	[max - min] = 36
Intervals	36 ÷ 3 = 12
Interval	36/3
	12.0
Rating	Range
Low	9-21
Medium	22-33
High	34-45

If the no. of criteria = 10	
Maximum score	(10 x 5) = 50
Minimum score	(10 x 1) = 10
Total range	[max - min] = 40
Intervals	40 ÷ 3 = 13.3 or 13
Interval	40/3
	13.3
Rating	Range
Low	10-23
Medium	24-37
High	38-50

If the no. of criteria = 11	
Maximum score	(11 x 5) = 55
Minimum score	(11 x 1) = 11
Total range	[max - min] = 44
Intervals	44 ÷ 3 = 14.7 or 15
Interval	44/3
	14.7
Rating	Range
Low	11-26
Medium	27-41
High	42-55

If the no. of criteria = 12	
Maximum score	(12 x 5) = 60
Minimum score	(12 x 1) = 12
Total range	[max - min] = 48
Intervals	12 ÷ 3 = 16
Interval	48/3
	16.0
Rating	Range
Low	12-28
Medium	29-44
High	45-60

If the no. of criteria = 13	
Maximum score	(13 x 5) = 65
Minimum score	(13 x 1) = 13
Total range	[max - min] = 52
Intervals	52 ÷ 3 = 17.3 or 17
Interval	52/3
	17.3
Rating	Range
Low	13-30
Medium	31-48
High	49-65

TOOL FOR UNDERSTANDING RESILIENCE OF FISHERIES
TURF DATA CHECKLIST

A great advantage of TURF is it makes use of commonly collected fisheries and socio-economic information in coastal municipalities. Although there is data that must be gathered in the field, it can be accomplished through primary interviews and focus-group discussions. Also, users would do well to consult the results of their preliminary assessment with ICSEA-C-Change for already scoped and consolidated information. Nonetheless, below is a checklist of potential data sources for vulnerability assessment with TURF. Shaded items are methods that require site work.

☐	1. Participatory Coastal Resource Assessment (PCRA)
☐	2. Municipal fisheries profile
☐	3. Provincial/ municipal development plan
☐	4. Fish landing survey
☐	5. Focus-group discussions (FGD; e.g. on catch, gears, fisheries income, etc.)
☐	6. Interviews (e.g. on catch, gears, fisheries income, etc.)
☐	7. Habitat assessment (e.g. Fish visual census, LIT)

DATA NEEDS PER TURF COMPONENT

I. FISHERIES	II. ECOSYSTEM	III. SOCIO-ECONOMIC
✓FGD ✓Interviews ✓Fish landing survey	✓Fish visual census ✓LIT	✓FGD ✓Interviews ✓Municipal fisheries profile; other related LGU documents

IMPORTANT NOTES:

1. Three components are assessed: Fisheries, Ecosystem and Socio-economic.
2. Scores are to be aggregated.
3. When obtaining the ratings of Low, Medium or High, scores must be re-scaled according to the guidelines provided in the TURF chapter.

SUMMARY OF VARIABLES:

- ▶ Fisheries (3)
- ▶ Ecosystem (3)
- ▶ Socio-economic (2)

MUNICIPALITY: ______________________ **DATE:** ______________

	VARIABLE	LOW (1-2)	MEDIUM (3-4)	HIGH (5)	SITE SCORES (# of sites may vary)		
					______	______	______
	I. FISHERIES						
1	Dominant catch composition	Catch composition of gears is predominantly of pelagic types (e.g. tuna, mackerel, roundscad). *These fish taxa are highly mobile and migratory in the pelagic realm that it would be less likely that they will be affected by wave impacts.*	Catch composition is a mixture of pelagic and demersal fishes. *While pelagic fishes are less impacted by waves the demersal species are more vulnerable.*	Catch is largely comprised of demersal fishes that are mostly associated with nearshore habitats (e.g. coral reefs, seagrass beds and mangrove areas). *These habitats are highly vulnerable to wave impacts.*			
2	Catch rate	Average catch rate is greater than 8 kg/ fisher/ day	Average catch rate is greater than 3 but less than 8 kg/ fisher/ day	Average catch rate is less than 3 kg/ fisher/ day			
3	Gear dependence on habitats	Fishing gears are mostly of mobile type such as variants of small-sized and large-sized gill nets, and lines used at offshore waters	Presence of both mobile and stationary type of gears	Predominance of habitat-dependent or stationary gears (e.g., fyke nets, traps, fish corrals)			
				Fisheries | TOTAL			
				RATING (Low, Medium or High)			

	VARIABLE	LOW (1-2)	MEDIUM (3-4)	HIGH (5)	SITE SCORES (# of sites may vary)		
					______	______	______
	II. ECOSYSTEM						
1	Abundance of exposure (wave) tolerant reef fish species relative to total abundance of the community structure	High abundance of wave-tolerant reef fish species such as wrasses, fusiliers, and some butterflyfish relative to the total species abundance	Mix of mobile, wave-tolerant and site-attached reef fish species	Low abundance of wave-tolerant species and preponderance of other site-attached fish families (Chaetodontids, Pomacentrids, Pomacanthids) not adapted to high wave energy environments			
2	Density of coral dependent species	Density of coral-dependent species is less than 5% relative to the total fish density	Coral-dependent fish density is between 5% and 10% to the total fish density	Density of coral-dependent species is greater than 10% to the total fish density			
3	Reef habitat quality	Coral cover is greater than 50% (e.g. Gomez et al. 1981) or a long stretch of the coast is lined with fringing reefs	Coral cover of the site is between 25% and 50%. There are gaps and channels along the stretch of the reef front	Coral cover is less than 25%. There are more gaps relative to the total area of the reef			
				Ecosystem | TOTAL			
				RATING (Low, Medium or High)			
	II. ECOSYSTEM						
1	Population density	Population of less than 200 per square kilometer in a fishing village/town; not crowded	200-400 persons per square kilometer	Greater than 500 persons per square kilometre; very crowded			
2	Fisheries ecosystem dependency	Around one-fourth (25%) or less of the adult population are full-time fishers	Greater than 25% up to 50% of the adult population are full-time fishers	Majority in the adult population (> 50%) are full-time fishers			
				Socio-economic | TOTAL			
				RATING (Low, Medium or High)			

IMPORTANT NOTES:

1. Three components are assessed: Fisheries, Ecosystem and Socio-economic.
2. Scores are to be aggregated.
3. When obtaining the ratings of Low, Medium or High, scores must be re-scaled according to the guidelines provided in the TURF chapter.

SUMMARY OF VARIABLES:

- Fisheries (4)
- Ecosystem (2)
- Socio-economic (3)

MUNICIPALITY: ______________________ **DATE:** ______________

	VARIABLE	LOW (1-2)	MEDIUM (3-4)	HIGH (5)	SITE SCORES (# of sites may vary)		
					______	______	______
	I. FISHERIES						
1	Change in catch composition	Considerable change in the last two decades (e.g., dominant catch replaced; loss of previously common fishes; etc.)	Few changes in the last two decades	Very minimal change in the last two decades			
2	Size and amount of fish caught	Small, immature fishes are abundant; few large spawners caught	Mix of small and large fishes	Most catches are large, mature fishes			
3	Peak occurrence of juveniles or presence of fry fisheries	Absence of peak recruitment or minimal occurrence of juveniles through time; no fry fisheries	Observed seasonality but no large pulses of recruitment; minimal catch in fry fisheries	Large pulses of juvenile abundance during peak recruitment period; fry fisheries is prominent			
4	Habitat (for fishing) condition and extent	Small, fragmented habitats for fishing	Patchy but large habitats for fishing	Large contiguous habitats for fishing such as long fringing reefs relative to coastline			
				Fisheries | TOTAL			

	VARIABLE	LOW (1-2)	MEDIUM (3-4)	HIGH (5)	SITE SCORES (# of sites may vary)		
					______	______	______
	II. ECOSYSTEM						
1	Extent of reef habitats	Small, fragmented reef habitats	Patchy but relatively large reef habitats	Large contiguous reef habitats such as long fringing reefs relative to coastline			
2	Presence of adjacent habitats	Absence of adjacent habitats or extreme degradation of adjacent habitats (e.g. coral reefs, seagrass beds, mangroves)	Presence of one adjacent habitat (e.g., coral reef, seagrass bed, or mangrove forest) in good condition	Presence of 2 more adjacent habitats (e.g., coral reefs, seagrass bed, or mangrove forest) in good condition			
				Ecosystem | TOTAL			
				RATING (Low, Medium or High)			
	II. ECOSYSTEM						
1	Annual livelihood income from fishing	Per capita income is below the provincial poverty threshold	Income is higher than the provincial poverty threshold up to 60%	Income is higher than 60% of the provincial poverty threshold			
2	Proportion or percentage of fishers with other sources of income	Less than 40% of the fishers have other sources of income	40-60% of the fishers have other sources of income	Greater than 60% of the fishers have other sources of income			
3	Annual cumulative income from other sources relative to the provincial poverty threshold	Annual cumulative per capita income is below provincial poverty threshold	Cumulative income is higher than poverty threshold up to 60%	Cumulative income is greater than 60% of the poverty threshold			
				Socio-economic | TOTAL			
				RATING (Low, Medium or High)			

TURF INTEGRATION

1. Once scores have been rescaled and translated to Low, Medium or High, consolidate the ratings for each component into the table below.

COMPONENT	EXPOSURE	SENSITIVITY	POTENTIAL IMPACT*	ADAPTIVE CAPACITY	COMPONENT VULNERABILITY*
Barangay/ site: ____________					
I. FISHERIES					
II. ECOSYSTEM					
III. SOCIO-ECONOMIC					
Barangay/ site: ____________					
I. FISHERIES					
II. ECOSYSTEM					
III. SOCIO-ECONOMIC					
Barangay/ site: ____________					
I. FISHERIES					
II. ECOSYSTEM					
III. SOCIO-ECONOMIC					

*Use the corresponding cross-table to obtain measurements for Potential Impact and Vulnerability

Sensitivity (columns) / Exposure (rows)

PI	L	M	H
L	L	L	M
M	L	M	H
H	M	H	H

Adaptive Capacity (columns) / PI (rows)

V	L	M	H
L	M	L	L
M	H	M	L
H	H	H	M

2. Obtain the overall TURF Fisheries vulnerability.

BARANGAY	Fisheries Vulnerability	Ecosystem Vulnerability	Socio-economic Vulnerability	OVERALL TURF VULNERABILITY*
1.				
2.				
3.				

*Use the guide table to get the Overall TURF Vulnerability

Reef ecosystem (columns) / Fisheries (left) / Socioeconomic (right)

Fisheries	H	M	L	Socioeconomic
H	HHH	HMH	HLH	H
H	HHM	HMM	HLM	M
H	HHL	HML	HLL	L
M	MHH	MMH	MLH	H
M	MHM	MMM	MLM	M
M	MHL	MML	MLL	L
L	LHH	LMH	LLH	H
L	LHM	LMM	LLM	M
L	LHL	LML	LLL	L

* RULES FOR RE-SCALING SCORES (TURF)

If the no. of criteria = 2

Maximum score	(2 x 5) = 10
Minimum score	(2 x 1) = 2
Total range	[max - min] = 8
Intervals	8 ÷ 3 = 2.7 or 3
Interval	8/3
	2.7

Rating	Range
Low	2-4
Medium	5-7
High	8-10

If the no. of criteria = 3

Maximum score	(3 x 5) = 15
Minimum score	(3 x 1) = 3
Total range	[max - min] = 12
Intervals	12 ÷ 3 = 4
Interval	12/3
	4.0

Rating	Range
Low	3-7
Medium	8-11
High	12-15

If the no. of criteria = 4

Maximum score	(4 x 5) = 20
Minimum score	(4 x 1) = 4
Total range	[max - min] = 16
Intervals	16 ÷ 3 = 5.3 or 5
Interval	16/3
	5.1

Rating	Range
Low	4-9
Medium	10-15
High	16-20

Photo Credits:
Main cover photo: Riovie Ramos
Inset photos: Miledel Christine Quibilan
Wilfredo Licuanan

CORAL TRIANGLE INITIATIVE
ON CORAL REEFS, FISHERIES AND FOOD SECURITY
PHILIPPINES