Republic of the Philippines
Department of Environment and Natural Resources
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Website: http:/www.denr.gov.ph / E-mail: web@denrgov.ph

MEMORANDUM

FOR : The Assistant Secretary for Policy, Planning and Foreign- Assisted And Special Projects and Director, Forest Management Bureau In Concurrent Capacity

The OIC, Office of the Director and Assistant Director Biodiversity Management Bureau

The Directors

Environmental Management Bureau
Land Management Bureau
Mines and Geosciences Bureau

FROM : The OIC Director, Policy and Planning Service

SUBJECT : **ADOPTION RE: MANUAL ON STORM SURGE AND COASTAL EROSION VULNERABILITY ASSESSMENT**

DATE : 04 MAR 2021

This is in connection with the Manual on Storm Surge and Coastal Erosion Vulnerability Assessment and the draft DENR Memorandum Circular adopting it which was submitted by the ERDB for review and consideration of the DENR Policy Technical Working Group (PTWG).

The Manual aims to serve as a national guide in the conduct of coastal vulnerability assessment within priority watersheds across the country towards the development of integrated vulnerability models. Through integrated vulnerability assessment, science-based reduction of disaster intensity is possible by providing local context in the development of site-specific adaptation strategies.

In this regard, may we request for your comments/inputs on the Manual and we will highly appreciate receiving your inputs/comments on or before 16 March 2021 before we schedule it for PTWG deliberation on its possible adoption.

For your preferential action, please.

MELINDA C. CAPISTRANO

MEMO NO. 2021 - 205

Republic of the Philippines
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DENR MEMORANDUM CIRCULAR
No. 2021- ____________

SUBJECT : **ADOPTING THE MANUAL ON STORM SURGE AND COASTAL EROSION VULNERABILITY ASSESSMENT**

Pursuant to Executive Order No. 192, which mandates the Department of Environment and Natural Resources (DENR) as the primary government agency responsible for the sustainable development of the country's environment and natural resources, DENR Memorandum Circular No. 2008-05 entitled "Guidelines in the Preparation of Integrated Watershed Management Plan", and for the formulation of inputs to international and national frameworks and plans on climate change and disaster risk reduction through incorporation of criteria and approaches employed in existing vulnerability tools to arrive at a continuum (ridge to reef) vulnerability scenario, the hereto attached manual on "Storm Surge and Coastal Erosion Vulnerability Assessment" is hereby adopted for the guidance of all concerned.

The Manual shall serve as a national guide in the conduct of coastal vulnerability assessment within priority watersheds across the country towards the development of integrated vulnerability models.

The Ecosystems Research and Development Bureau (ERDB) shall conduct joint semi-annual monitoring and evaluation of integrated watershed management planning process of the watersheds to validate physical and financial accomplishments and to monitor compliance with the policies.

This Circular take effect immediately.

ROY A. CIMATU

Storm Surge and Coastal Erosion **Vulnerability Assessment Manual**

Please submit this accomplished form to:
Ecosystems Research and Development Bureau
Los Baños, Laguna

Climate change vulnerability assessment of coastal and marine areas

Recipient of Manual

Name: ____________________
Office: ____________________
Position: ____________________
Contact number: ____________________
Address: ____________________

Please help us improve this manual:

	1 Very Unsatisfied	2 Unsatisfied	3 Neutral	4 Satisfied	5 Very Satisfied
Content	☐	☐	☐	☐	☐
Map presentation	☐	☐	☐	☐	☐
Usefulness (field application)	☐	☐	☐	☐	☐
Usefulness (map generation)	☐	☐	☐	☐	☐
OVERALL	☐	☐	☐	☐	☐

Other suggestions

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Foreword

The Philippines is identified as the third most vulnerable country to climate change. Disaster can occur if climate-related hazards will reach the vulnerable sectors in the country. For instance, our location in the typhoon belt or at the West Pacific Basin makes as a path of an average of 20 tropical cyclones annually. Consequently, storms and floods are the principal hazards we face. With more than half of our local population situated in the highly exposed coastal areas and with the dependence of the community on the climate-sensitive resources for their livelihood, the incurred damages and loss of lives along the coastline due to impacts of natural hazards can be among the determining factor contributing to the country's identified level of risk to disasters.

Adaptation strategies or mitigations plans to these disasters require systematic vulnerability assessment. The output of vulnerability assessment enhances the awareness of planners, policymakers, leaders, and communities to climate change impacts and on the specific areas and assets that are most vulnerable.

The existing vulnerability assessment tool for priority watershed in the country was designed for upland ecosystems. The lack of a functional vulnerability assessment approach for the coastal areas and the given susceptibility of local coastal areas to climate change-induced natural hazards prompted the formulation of vulnerability assessment tool for coastal areas. From 2015-2019, ERDB carried out assessments at the level of coastal barangay or villages using a developed rubric tool to determine coastal vulnerability to coastal erosion and storm surge.

Through integrated vulnerability assessment, science-based reduction of disaster intensity is possible by providing local context in the development of site-specific adaptation strategies.

HENRY A. ADORNADO, *Ph.D.*
Director

Preface

The high exposure and sensitivity of our coastal areas to climate change impacts when coupled with low adaptive capacity translates into high level of vulnerability. To determine the vulnerability of coastal areas to climate change impacts, particularly to coastal erosion and storm surge, an integrative method covering the physical environment (exposure), present state of specific ecosystems (sensitivity), and ability to cope with climate change impacts (adaptive capacity) in coastal areas was developed and presented in this manual.

Exposure represents the physical aspect of vulnerability, particularly, those related to sea level rise exposure, wave exposure (tidal range and erosion and accretion). Sensitivity covers the characteristics of coastal areas relative to storm or typhoon frequency, proximity to river and other water bodies, vegetation cover, coastal landform or geomorphology, coastal slope, width of the reef flat and lateral extent of the reef relative to shoreline length. Adaptive capacity deals on the coastal community features that influence how the dwellers anticipate, responds, cope and recover from the climate change hazards. This vulnerability sub-factor focuses on the presence of man-made barriers, guideline on setback zones in CLUP, early warning system, evacuation system, beach or sand mining, coastal protection structures, land use pattern or coastal development, integrated and participatory coastal resources management program, environmental law enforcement, alternative or supplemental livelihood, information and education campaign, access to financial and technological resources, and resettlement sites.

A 5-point numerical scale was applied in the vulnerability matrix or rubric. Ascending values correspond to increasing contribution of indicators to the overall vulnerability. The average score was determined based on the number of indicators per sub-factor. The score for exposure, sensitivity, and adaptive capacity was factored in to compute for the overall vulnerability index. The index was computed using the equations of McLaughlin and Cooper (2010). The resulting coastal vulnerability sub-indices were tabulated scale to determine the degree of vulnerability (i.e. low to very high vulnerability) of the coastal area. The final vulnerability maps were generated through ArcGIS10.5.

Despite the data intensive process for GIS-based generation of vulnerability models, it is envisioned that more conservative models encompassing coastal areas will be generated with the guide of this manual. DENR hopes that generated vulnerability models will lead to less disaster in our coastal areas.

MAYUMI Q. NATIVIDAD
Assistant Director

Acknowledgement

This manual is a work in progress. It has started from consultative meetings with experts and stakeholders for the creation of coastal vulnerability assessment rubric tool, to field testing and refinement of the index tool and eventually generation of coastal vulnerability models and formulation of site-specific adaptive capacity measures. The changing nature of natural hazards and threats to coastal areas may pave way for the improvement of this manual.

Nonetheless, we give our utmost recognition and gratitude to the following for their contribution in the conceptualization and finalization of this first coastal VA manual:

Experts from MGB (Geologist Rey Villanueva and Dr. Yolanda Aguilar) and **DOST Project NOAH** (Dr. Alfredo Mahar Francisco Lagmay and Chief Science Research Specialist Oscar Lizardo) for sharing their expertise and data related to the tool creation and map generation;

The **Executive Committee of Ecosystems Research and Development Bureau** for the technical, financial and logistical support;

The **ERDB VA Research Team** (Dr. Jose Isidro Michael Padin, Ms. Mariche Bandibas, Mr. Alvin Gestiada, Ms. Annieraj Antong, Engr. Timothy John Dizon, Ms. Karen Rae Fortus, , For. Adrian Lansigan, For. John Rommel Manahan, Engr. Jay Velasco, Mr. Mark Angelo Bucay, Mr. Amiel dela Rosa, Ms. Jenilyn Regondola, Engr. Glady Mae Vijandre, For. Micah Marie Galapon, For. Lyndley De Torres, Ms. Regina Angeline Angeles and Mr. Randel Aragones) and **technical advisers** (Dr. Antonio Daño, Dr. Aurora Jose, Dr. Lynlei Pintor, Dr. Carmela Taguiam, Ms. Myline Aparente, and Ms. Jenneza Castro) for the commitment and efforts to contribute in this multidisciplinary assessment;

DENR field offices in Olongapo, Batangas, Quezon, Oriental Mindoro, Misamis Oriental, Zambales, Camarines Norte, Palawan, Aklan for allowing us to field test the manual and refine the field methodologies; and

The **local government units (LGUs) of** Kalaklan, Olongapo, Zambales, San Diego, Lian, Batangas and Bucana, Nasugbu, Batangas, Binahaan and Kanlurang Malicboy, Pagbilao, Quezon, Proper Bansud and Proper Tiguisan, Bansud, Oriental Mindoro, Poblacion 3, Villanueva, Misamis Oriental and Baluarte, Tagoloan, Misamis Oriental, San Andres, Pambisan, Pulantubig of Baco, Oriental Mindoro, Gama, Malabago, Poblacion North, Pagatpat of Santa Cruz, Zambales, San Roque, III, VI, VII of Mercedes, Camarines Norte, Tinagong Dagat and Malatgao, Narra, Palawan and Ondoy, Colong-colong, Naisud, San Isidro and Aslum of Ibajay, Aklan for sharing with the team the anecdotal accounts, geodata and expertise related to this VA.

Lastly, To Almighty God for the guidance, wisdom and perseverance given to the team.

CARMELITA I. VILLAMOR
Program Leader

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Definition of Key Terms

Coastal erosion is the landward displacement of the shoreline caused by the forces of waves and currents

Geographic Information System (GIS) is a computer-based tool for mapping and analyzing spatial data. It integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

Hazard is defined as a potentially damaging event or physical disturbance which can be categorized as natural

Map is a representation, usually on plane surface, of all or parts of the earth or some other body showing a group of features in terms of their relative size and position

Storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tide

Vulnerability is the extent to which a natural or social system is susceptible to sustaining damage from climate change, including climate variability and extremes

Acronyms

AC	Adaptive capacity
CAD	Computer Aided Design
CIV	Coastal Index of Vulnerability
CLUP	Comprehensive Land Use Plans
CRMP	Coastal Resources Management Program
DBH	Diameter at breast height
DENR	Department of Environment and Natural Resources
DOST	Department of Science and Technology
ERDB	Ecosystems Research and Development Bureau
GIS	Geographic Information Systems
GPS	Global Positioning System
IEC	Information, Education and Communication
IFSAR	Interferometric Synthetic Aperture Radar
IPCC	Intergovernmental Panel on Climate Change
IPCC-AR5	IPCC Fifth Assessment Report
LDRRMC	Local Disaster Risk Reduction and Management Council
LGU	Local Government Unit
LIT	Line-Intercept
MERF	Marine Environment Resources Foundation, Inc.
MGB	Mines and Geosciences Bureau
MPDO	Municipal Planning and Development Office
NAMRIA	National Mapping and Resource Information Authority
NOAA	National Oceanic Atmospheric Administration
NOAH	Nationwide Operational Assessment of Hazards
PA	Protected Area
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
SLR	Sea level rise
SPSS	Statistical Package for the Social Sciences
SSA	Storm Surge Advisory
TC	Tropical Cyclone
VA	Vulnerability Assessment

DENR-Costal Vulnerability Assessment in a Nutshell

Scale: Barangay
Hazard Type:

Storm surge

Storm surge is an **abnormal rise of water** generated by a **storm,** over and above the predicted astronomical tide (NOAA).

Coastal erosion

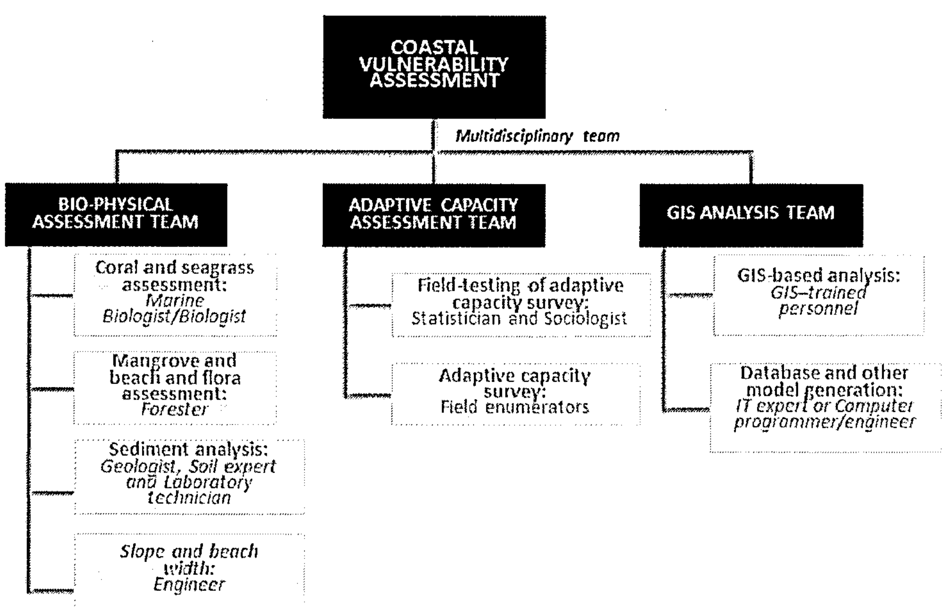
Coastal erosion is the **landward displacement** of the shoreline caused by the forces of waves and currents (Prasad and Kumar 2014).

Application:

This tool complements the ridge-to-reef vulnerability assessment approach by focusing on the impacts of climate change induced-hazards at the barangay or coastal village level. Apart from the climatic projections and habitat integrity conditions, the knowledge of coastal inhabitants on coastal resources management program, early warning systems, communication technology is considered as an important input in the generation vulnerability models.

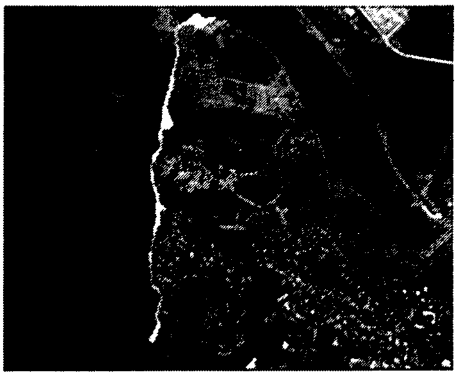
Requirements:

A. Multidisciplinary Team

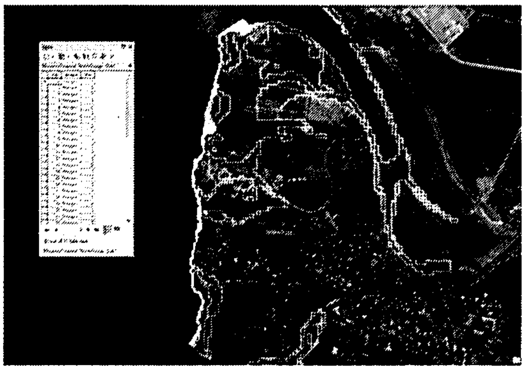


B. Datasets

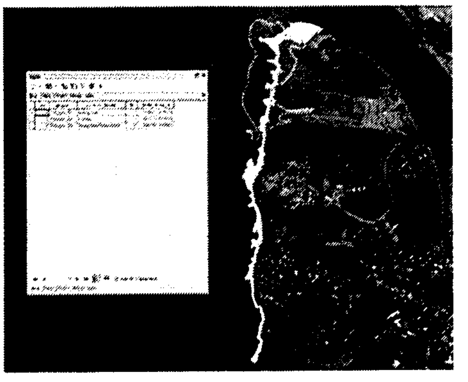
Slope



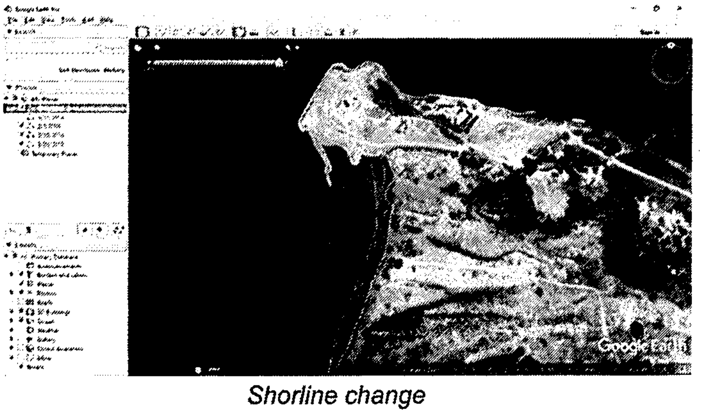
Rainfall



Storm surge exposure (SSA 1 by Project NOAH)



Mangrove cover (CRM, NAMRIA)



Shorline change

<u>Geodata</u>
<u>Field data</u>

- ✓ Beach width
- ✓ Habitat integrity (corals, seagrass and mangrove cover)
- ✓ Beach forest
- ✓ Coastal structures
- ✓ Adaptive capacity indicators
- ✓ Anecdotal accounts

Chapter 1

Introduction

Marine ecosystems support some of the most diverse, complex, and productive habitats such as coral reefs, seagrass beds, and mangroves. With global climate change, coral reefs will experience bleaching, susceptibility to pathogens and disease, and reduced calcification (McLean et al. 2001; Baker et al. 2008; Doney et al. 2012). The impact of accelerated sea-level rise will depend on vertical accretion rates and available space for horizontal migration that can be limited by the presence of infrastructure (McLean et al. 2001). Many mangrove forests are under stress from excessive exploitation, increased levels of inundation, and storm flooding (McCarthy et al. 2001). Coastal communities and properties are also vulnerable to various impacts associated with climate change. The effects of climate change in the coastal zone may be related to sea-level rise and other weather changes such as frequency and intensity of storms and associated storm surges (McLean et al. 2001). Besides inundation of low-lying coastal areas due to sea-level rise and increased flooding, other expected climate change impacts include increased beach erosion, degradation of coastal ecosystems, saltwater intrusion in freshwater systems, impacts on water trophic conditions, changes in biological communities and impacts on commercially important marine species (McCarthy et al. 2001; IPCC 2007). Adaptation and resilience to climate change may significantly constitute integrated management of marine ecosystems and a better understanding of their interaction with human development.

Vulnerability assessment is essential ***not only for adaptation strategy***, but also to ***enhance the awareness of planners***, ***policymakers***, ***leaders***, and ***communities to climate change impacts*** and on the ***specific areas*** and ***assets that are most vulnerable***.

The vulnerability methods developed by Ecosystems Research and Development Bureau (ERDB) for priority watersheds in the country have been a useful tool in the preparation of an updated integrated watershed plan. However, the existing assessment tool covers climate change-induced hazards in terrestrial areas such as forest fire, soil erosion, and flooding. This significantly leaves the vulnerability of coastal areas unknown to future sea-based hazards. Coastal vulnerability assessment determining the level of vulnerability within the identified priority watershed, particularly to coastal erosion and storm surge using a GIS-assisted approach is among the concerns of ERDB.

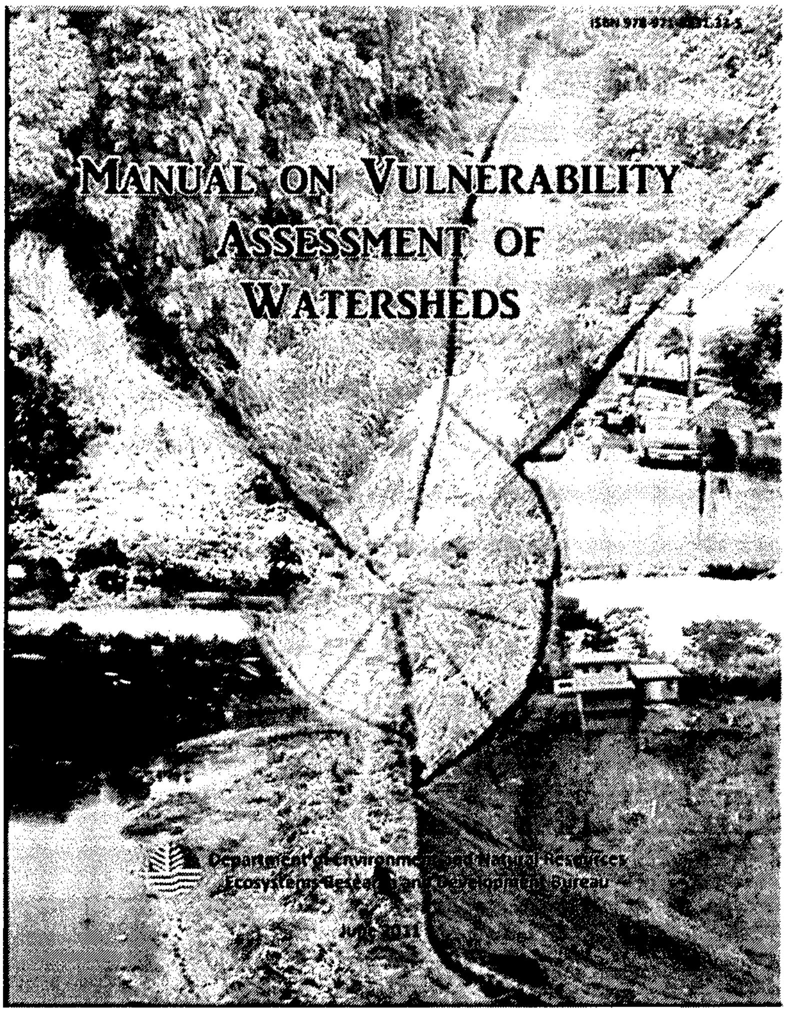


Fig.1 First manual on vulnerability assessment of watersheds (http://erdb.denr.gov.ph/wpcontent/uploads/2015/06/VA%20Manual.pdf).

Fig. 2 Climate change impacts on coastal areas within priority watershed: storm surge (left) and coastal erosion (right). (Photo source/credit: Philippine Central Info Negros and ACE CRC)

The new vulnerability assessment tool addresses the three main questions:

What is ***the level vulnerability of the coastal areas*** within watershed of interest to the impacts of climate change such as coastal erosion and storm surge?

What are the ***factors*** influencing the vulnerability of the coastal areas?

What are the ***programs or activities*** at the local level that could ***enhance adaptation*** to the impacts?

Coastal Vulnerability Assessment in the Philippines

Vulnerability is the extent to which a natural or social system is susceptible to sustaining damage from climate change, including climate variability and extremes (McCarthy et al. 2001; IPCC 2007). It is a function of the character, magnitude and rate of climate change and the variation to which a system is exposed, its sensitivity and its adaptive capacity (IPCC 2007). Exposure and sensitivity constitute the potential impact, which covers all impacts that may occur given a projected change in climate, without considering adaptation (McCarthy et al. 2001; Locatelli et al. 2008). Exposure refers to the nature and degree to which a system is exposed to significant climatic variations (McCarthy et al. 2001). Other literatures defined exposure as an inventory of the assets (e.g. people, property, systems, and functions) that could be lost, injured, or damaged due to an impact of climate change (NOAA 2010) or types and number of assets at risk (Tobey et al. 2011). Sensitivity is the degree to which a system will respond to a given change in climate, including beneficial and harmful effects, while adaptive capacity is the degree to which adjustments in practices, processes, or structures can moderate or offset the potential for damage or take advantage of opportunities created by a given change in climate (McCarthy et al. 2001; IPCC 2007). Under the vulnerability framework (Fig. 3), highly vulnerable system would be a system that is very sensitive to moderate changes in climate, where the sensitivity includes the potential for substantial harmful effects, and for which the ability to adapt is severely constrained (McCarthy et al. 2001). In other words a system with high exposure, high sensitivity and low adaptive capacity has the high vulnerability to the impacts associated with climate change.

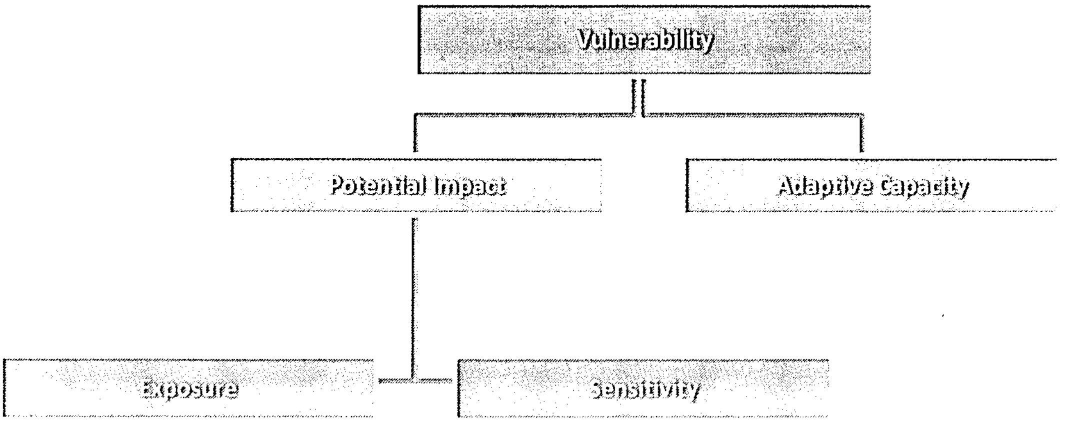


Fig. 3 The three main components of vulnerability: exposure, sensitivity and adaptive capacity (IPCC 2007). High exposure, high sensitivity and low adaptive capacity induce high vulnerability.

Increasing storm and typhoon intensity or frequency, changing precipitation patterns, increasing air and water temperature, ocean acidification, and sea-level rise are the effects of climate change observed not only in the coastal areas in the Philippines but across the world (NOAA 2010; MERF 2013). Sea-level rise due to thermal expansion and melting of land ice sheets and glaciers place coastal areas vulnerable to coastal erosion and storm surge (UNFCC 2007). Coastal erosion is the loss or displacement of land along the coastline due to the action of wind, waves, currents, tides, wind-driven water, runoff of surface water, storms and groundwater seepage (O'Neill 1985). The process provides terrestrial sediment to the coastal systems including beaches, dunes, reefs, mud flats, and marshes (European Commission 2004). On the other hand, storm surge is associated with water level oscillations, beyond the predicted astronomical tides, generated by wind forces of an atmospheric weather system such as tropical cyclones (Murty 1999; Lapidez et al. 2015). With the growing human interventions on the coastal zone, both natural processes can generate high economic, environmental, and social costs (European Commission 2004; UNFCC 2007).

The coastal areas of the Philippines are densely populated with more than 65 million of the population living within 822 coastal municipalities and cities (World Bank 2005). The Philippines is also one of ten countries most affected by extreme weather events (1993-2012) (Kreft and Eckstein 2013). Planning and implementing adaptation strategies in the coastal areas require understanding of the implications of climate of climate change, the specific assets that are most affected, and the associated impacts that cause the greatest damage. The basis for the adaptation strategy is a vulnerability assessment (NOAA 2010). Vulnerability assessment is a process for assessing, measuring, and/or characterizing the exposure, sensitivity, and adaptive capacity of a natural or human system to disturbance (Nelitz et al. 2013). The concept of vulnerability is defined differently in the various scientific areas and is closely related to other concepts, such as hazard, risk and resilience (Fig. 4); thus, coastal vulnerability assessment to climate change involves several concepts that must be clearly defined and to choose the scope and methods accordingly (Ramieri et al 2011).

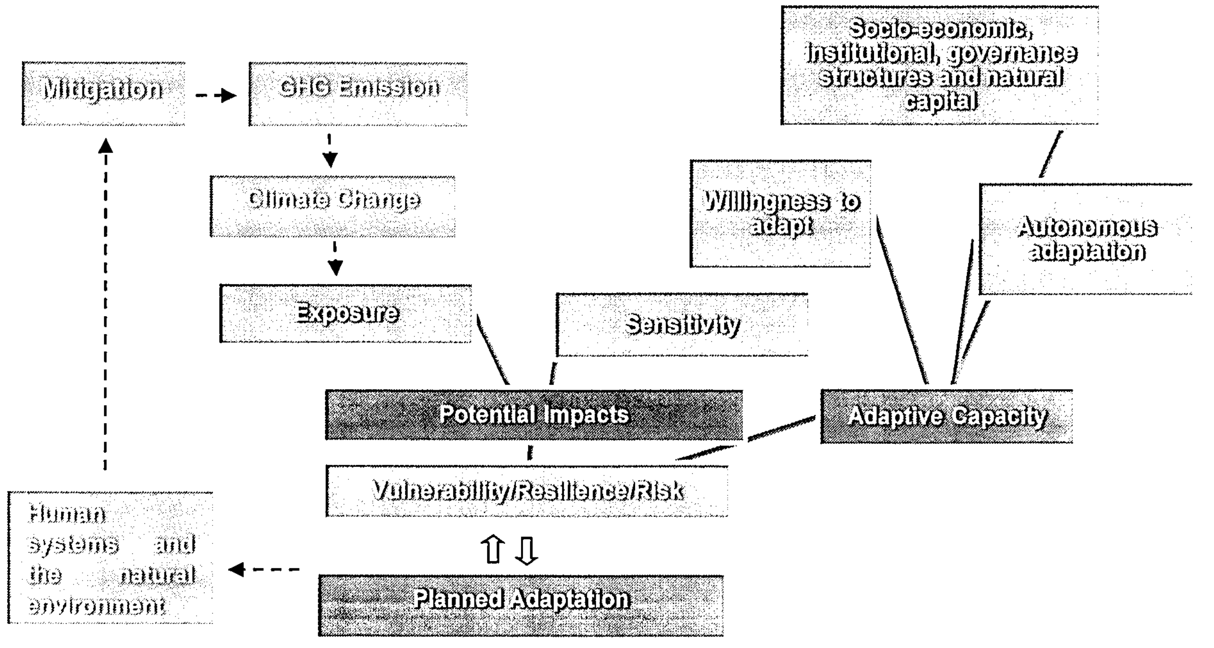


Fig. 4 Conceptual framework for climate change impacts, vulnerability, disaster risks and adaptation options (Ramieri et al., 2011).

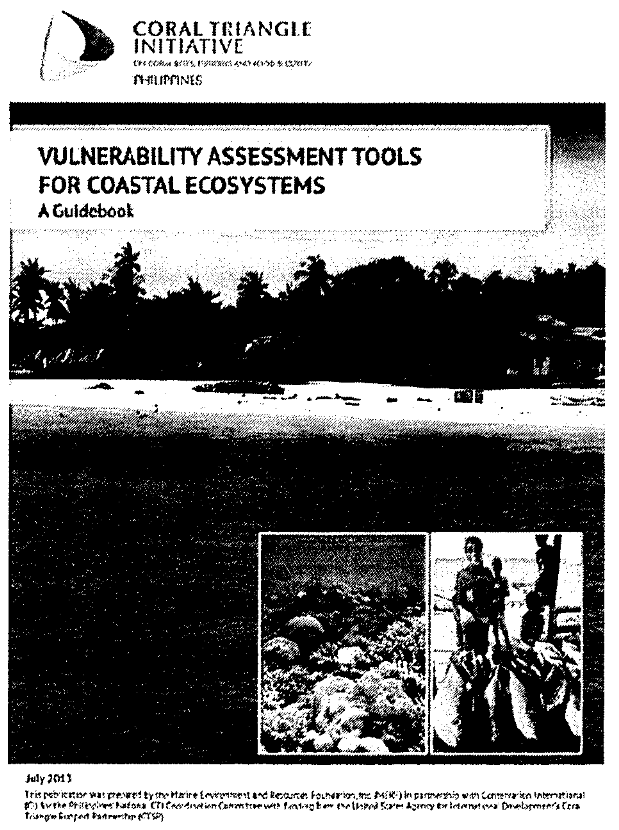


Fig. 5 Vulnerability assessment tools for coastal ecosystems (MERF 2013).

Various methods or tools had been developed for vulnerability assessments. These are categorized into four categories, which include index-based methods, indicator-based approach, GIS-based decision support systems, and methods based on dynamic computer models (Ramieri et al. 2011). Each method has its own advantage and constraint depending on the scope, criteria, and issues to be evaluated. In the Philippines, vulnerability assessment tools for coastal ecosystems that consider the local context, availability of data, and participative approach are recently introduced (MERF 2013). These tools focus on the vulnerability of integrated ecosystem services, physical coast, and fisheries. The Ecosystems Research and Development Bureau have been implementing vulnerability assessment in Philippines watersheds with emphasis on flooding, landslide, and soil erosion (ERDB 2011). According to the International Federation of Red Cross and Red Crescent Societies (IFRC) that a disaster occurs when a hazard impacts on vulnerable people. As such, there is a need to develop an integrative method, or tool that centers on the population, properties, and infrastructure as exposed assets in the coastal area, while taking into account the vulnerability of the ecosystems to the identified climate change impacts, changes in adaptive capacity, and generation of vulnerability maps at local scale. It is also essential to incorporate criteria and approaches employed in the existing vulnerability assessment tools to arrive at a continuum (ridge to reef) vulnerability scenario.

Table 1. Comparison of coastal vulnerability assessment tool.

Project	Component	CC impacts considered	Scope	Methodology		Unique features of vulnerability components			Output	
				Scoring	Vulnerability indices computation	E	S	AC	Vulnerability rating	Other information
Climate change vulnerability assessment toolkit for coastal ecosystems/ Vulnerability assessment tools for coastal ecosystems	Integrated Coastal, Sensitivity, Exposure, and Adaptive Capacity to Climate Change (ICSEA Change)	Sea level rise, waves, storm surge, sea surface temperature and rainfall	Biodiversity, coastal integrity, fisheries	Rubric scoring (1-2: Low, 3-4: Moderate, 5: High)	Average of scores	Wave Exposure (generated using Model WEMo)	Coastal habitat and fish and fisheries conditions as indicators	Coastal habitat, human settlement and coastal integrity as indicators	Categorical (Low, Moderate, High)	Exposure index maps and technical information for conduct of CIVAT or TURF in coastal barangay
	Coastal Integrity Vulnerability Assessment (CIVAT)	Sea level rise and waves	Coastal integrity and bio-physical	Rubric scoring (1-2: Low, 3-4: Moderate, 5: High)	Cross tabulation (Samson 2011)	Wave exposure and tidal range as indicators	Habitat conditions as indicators	Coastal habitat conditions as indicators	Categorical (Low, Moderate, High)	Recommended adaptation strategies
	Tool for Understanding Resilience of Fisheries (TURF)	Waves, storm surges and surface temperature	Fisheries, bio-physical and socio-economic component	Rubric scoring (1-2: Low, 3-4: Moderate, 5: High)	Cross tabulation (Samson 2011)	Oceanographic data as indicators	Indicators on fisheries, reef ecosystem features and socio-economic attributes	Indicators on fisheries, reef ecosystem features and socio-economic attributes	Categorical (Low, Moderate, High)	Recommended adaptation strategies

Climate change vulnerability assessment of coastal and marine areas within priority watersheds	Storm surge and coastal erosion	Biophysical and coastal communities	Rubric scoring (1: Very low, 2: Low, 3: Moderate, 4: High and 5:Very High	Coastal index computation based on McLaughlin and Cooper (2010) and Ellison (2009)	Shoreline change (generated from ArcGIS) and storm surge inundation	Habitat conditions as indicators and inclusion of IFSAR data for slope generation	Community knowledge/participation on CRMP, environmental laws, communication technology, early warning system and alternative livelihood as indicators	Coastal vulnerability index (0-20: Very low; 20-40: Low; Moderate: 40-60; High:60-80; and Very High: 80-100)	VA map generated using ArcGIS; Recommended adaptation strategies

Chapter 2

Methodology

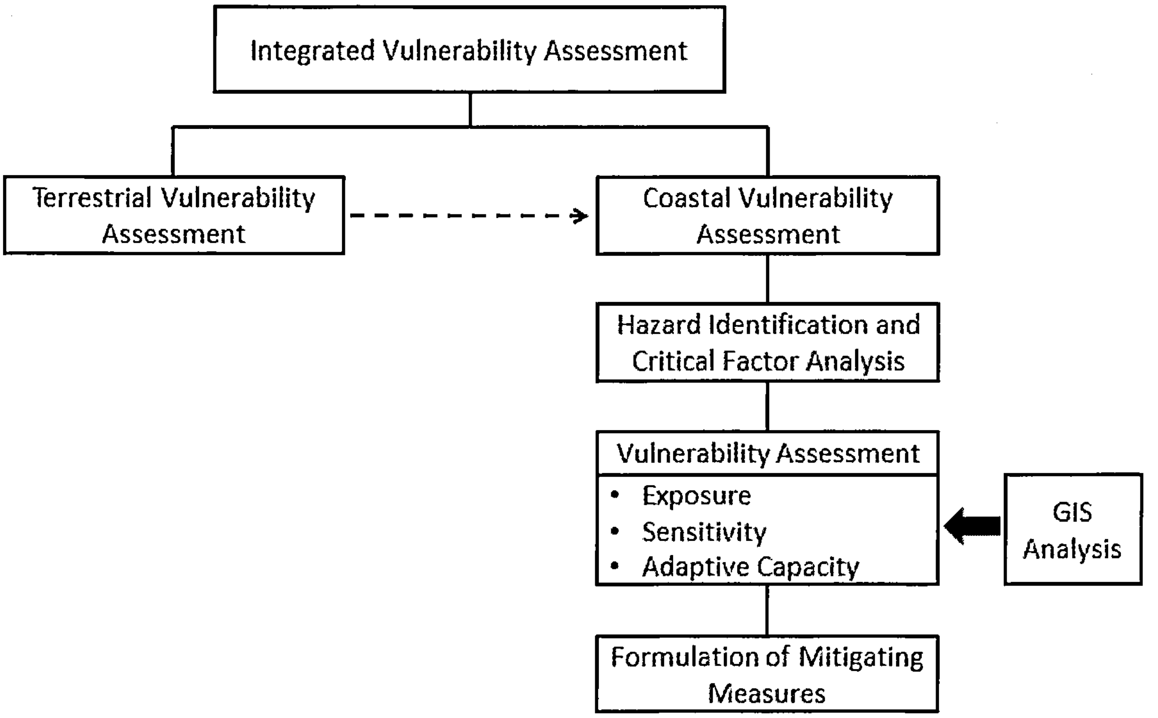


Fig. 6 Process flow for integrated vulnerability assessment.

Step 1.Formulation of multidisciplinary team

Conduct of vulnerability assessment requires a ***multidisciplinary team***. The assessment is a data intensive processing requiring personnel with experience or field specialization in sociology, economics, governance/policy, botany or forestry, biology, zoology, marine biology, geology, oceanography, hydrology, engineering, and GIS.

Consultative meetings with other experts (MGB and DOST) may also be done to discuss important parameters affecting the susceptibility of a particular site to coastal erosion and storm surge.

Step 2. Review of the rubric assessment tool

The coastal vulnerability assessment is anchored on its rubric tool. A rubric tool contains the dimensions of vulnerability-exposure, sensitivity and adaptive capacity. The rubric describes the corresponding levels of one dimension with respect to site conditions. For instance, the levels of exposure may be classified as very low, low, moderate, high or very high or as numerical scores respectively as 1, 2, 3, 4, and 5. Organized the criteria for respective dimensions in a matrix to facilitate the factor analysis. Scoring and analysis are discussed in the succeeding part of this manual. The review of the rubric tool simply aims to familiarize the personnel on the ***factors categorized under the exposure, sensitivity and adaptive capacity*** for a particular hazard. Note that not all exposure or sensitivity factors for coastal erosion were used for storm surge assessment or vice versa. The factors are selected based on the published drivers and other factors influencing the susceptibility to coastal erosion and storm surge.

Exposure

This indicator is comprised of four sub-indicators. Scale the factors for rates of sea level rise, sea level rise exposure, tidal range and erosion/accretion rates. . These four indicators are also used for storm surge. Storm surge exposure at advisory 1 is added to determine the inundated area at 2m surge height.

Rates of sea level rise

Global sea level rise is affected by the thermal expansion of sea water and melting of land ice (Church et al. 2013 as reviewed by Kahana in 2016). Calculations from satellite observations revealed that global sea level rise rate is about 1.7mm/yr. A higher estimated value at 2.8 to 3.6 mm/yr was cited from the IPCC AR5 assessment with consideration of 90% probability of increase between 1993 and 2010. Average global sea level change is expected to rise 3.1 cm every ten years. A higher rising rate for water levels around the Philippines was reported with increase in values between 7.6 to 10.2 cm each decade (three times of the global average) (IDRC 2015). Local sea level is influenced by groundwater depletion (Konikow 2011), decreasing ocean salinity (Ishii et al. 2006; Antonov et al. 2002); subsidence of coastal areas (Anderson et al. 2010), strength of ocean currents (Ezer et al. 2013; Sallenger et al. 2012), among others.

Sea level rise exposure by 2050 [cm]

Based on the assumption of Clavano (2012), the rate of sea level around the Philippines is expected to rise by at least 20 cm in the next 40 years. This absolute rise is influenced by spatial variation, regional ocean-atmosphere dynamics, inland tides, climate patterns and weather effects.

Tidal range (m)

Tidal range is the vertical distance between consecutive high and low water level over a tidal cycle (Surge Watch 2014). This parameter determines energy distribution within the intertidal zone. Wave energy are more concentrated in the intertidal zone and more frequent at micro-tidal environments (<2 m) (Trenhaile 2016; Stormsurge Watch 2014). Tidal environment has shown to contribute a significant role in sediment transport (Allen et al. 1980). The developed rubric scoring for coastal erosion and storm surge used levels of tide within the micro-tidal (<2m), meso-tidal (2-4 m) and macro-tidal (>4m). Large tidal scale coinciding with the timing of surge relative to high water is critical in vulnerability assessment (Flather 2001).

Erosion/accretion rate (m yr-1)

Coastal areas are very dynamic. The significant changes on these portions undergo significant changes due to natural and anthropogenic impacts (Neelamani 2017). Apart from field examination of coastal erosion evidences, satellite images and existing maps were also reviewed to determine the progressive change in the coastline. Polylines were demarcated in selected Google earth imagery files for the computation of accretion-erosion in MBA.

Storm surge exposure at 1-m wave height (%)

Analysis for storm surge exposure of coastal areas was based from the storm surge assessment and mitigation of then DOST-Project NOAH (Nationwide Operational Assessment of Hazards). NOAH conducts advanced disaster science research, comprehensive and multi-disciplinary assessment of hazards (Cadiz 2018). The sensitivity inputs on this coastal vulnerability assessment were based on NOAH's Storm Surge Advisory (SSA) 1: 2m storm surge height. Level of inundation were from low (<0.5 m) to high (1.5 m).

Table 2. List of exposure parameters for coastal erosion and storm surge vulnerability assessment.

Variable	Hazard Coastal erosion	 Storm surge	References
Rates of relative sea level change (mm year^{-1})	✓	✓	NOAA 2018
Sea level rise exposure by 2050 (cm)	✓	✓	Clavano 2012
Tidal range (m)	✓	✓	Tide forecast NAMRIA DGS Tides/WXTide32
Erosion/accretion rate (m yr^{-1})	✓	✓	Historical satellite images (Google Earth)
Storm surge exposure (%)		✓	DOST-Project NOAH

Sensitivity

Coastal erosion sensitivity indicators comprised of 11 sub-indicators, which include information on storm frequency, rainfall amount, beach width, coastal geomorphology, coastal slope, proximity to river mouth, width of the reef flat, beach and forest vegetation, coastal habitats and structures on the foreshore). Storm surge vulnerability indicators require datasets on storm frequency, beach width, coastal geomorphology, width of the reef flat, coastal habitat and man-made buffers.

Storm/typhoon frequency (no.)

Tropical cyclone (TC) frequency was based from the 1951-2013 record of TC in the Philippines. Tropical cyclone is a low-pressure system with strong winds in a counter-clockwise direction in the Northern Hemisphere. Tropical cyclones have a wind speed range of 40-300 kilometers per hour and a diameter from 300 to 100 km wide (Terry 2007; Cinco 2016). Tropical cyclone activity is deemed necessary for coastal erosion and storm surge assessment as local coastal communities are situated in typhoon-prone archipelago.

Rainfall amount (mm)

The vulnerability inputs for rainfall amount were based on the climate projections in 2020 and 2050 for the Philippines. The projected rainfall change was under the emission scenarios in the Fourth Assessment Report (A4) of the Intergovernmental Panel on Climate Change (IPCC). Seasonal rainfall change was computed with respect to the observed baseline rainfall data from (1971-2000).

Beach morphology (Beach width, coastal geomorphology and coastal slope)

Beach morphology determines how the coast responds to processes such as wave action and tidal currents, as well as to climate change hazards. Coastal slope also indicates the susceptibility of the coast to flooding and erosion. It is expected that low-lying coastal plains more likely to experience rapid erosion. Coastal slopes were derived from the IFSAR (Interferometric Synthetic Aperture Radar) data. The type of sediment was also noted during the survey. Finer sediments typically provide less inclination than larger grains (Asplund and Malmstrom 2018).

Proximity to river mouth (m)

Proximity to river mouth is part of sensitivity analysis for coastal erosion. River supplies the coastal area with sediment load which may consist of fine, cohesive or non-cohesive sediments (Mangor et al. 2017.)

Reef flat

Coral reefs reduce wave energy by an average of 97% (Ferrario et al. 2014). This wave attenuation benefits comes from the reef crest and reef flat of the coral reef environment. The reef crest extends from the seaward edge and the shallowest part of the reef while reef flat is the shallow part of the reef that reaches the shallowest part of the reef. The former dissipates 86% of wave energy while the latter attenuates approximately half of the remaining wave energy. The Coastal Resources Map of NAMRIA (2015) and primary data from underwater surveys are needed to generate the sensitivity sub-indices ratings.

Beach forest and vegetation

Beach forest and vegetation are important for improving slope stability, consolidating sediments and providing shoreline protection (Prasetya 2006).

Coastal habitats

The condition of the coral reefs, seagrass, mangrove and other beach forest vegetation were also determined as input to the sensitivity analysis of the coastal communities. These coastal habitats reduce the impacts of climate change driven hazards into the coasts (Licuanan et al. 2015). For instance, the presence of mangrove species colonizing newly available habitat (relative with the rate of relative sea level rise) indicates the recovery of an area after a disturbance (McLeod and Salm 2006 in Licuanan et al. 2015). Presence of climax seagrass (*Enhalus acoroides, Thalasassia hemprichii* and *Cymodocea serrulata*) indicates a relatively stable environment. The coral community patterns, size patterns and diversity can influence the tolerance of areas to wave action and sedimentation (Licuanan 2002 and Licuanan et al. 2015).

Structures on the foreshore

Foreshore structures such groins and seawalls were also considered as sensitivity factors. The presence of such structures equated to high sensitivity rating because of the assumption that these structures are often constructed to address chronic erosion in the area (MERF 2013).

Table 3. List of sensitivity parameters for coastal erosion and storm surge vulnerability assessment.

Variable	Hazard		References
	Coastal erosion	Storm surge	
Storm/typhoon frequency (no.)	✓	✓	Cinco et al. 2016
Rainfall amount (mm)	✓		PAGASA 2011
Beach width (m)	✓	✓	Field data (based on methodology of Emery (1960) Historical satellite images (Google Earth)
Coastal geomorphology	✓	✓	Grain-size analysis
Coastal slope (%)	✓	✓	IFSAR-slope derived data
Proximity to river mouth (m)	✓		Satellite image (Google Earth)
Width of the reef flat (m)	✓	✓	Coastal Resources Map (NAMRIA 2015) Satellite image (Google Earth)
Lateral extent of the reel flat (% length of the shoreline)	✓	✓	CLUP, Coastal Resources Map (NAMRIA 2015) Satellite image (Google Earth)
Beach forest and vegetation	✓	✓	Land cover (NAMRIA 2015) Satellite image (Google Earth)
Coastal habitats	✓	✓	CLUP Coastal Resources Map (NAMRIA 2015) Field data
Structures on the foreshore	✓		CLUP
Man-made buffers		✓	CLUP

Adaptive capacity

A semi-structured questionnaire is used on the adaptive capacity assessment of coastal communities situated within the outlet of priority watersheds. Nineteen parameters to be ranked from 1 to 5 corresponding to very low to very high AC levels were used to determine the ability of the communities to deal with coastal hazards. These parameters are the number of ordinances relative to beach/sand mining law, proximity of settlement to coastline, coastal protection structure, land use pattern/ coastal development, integration and implementation of coastal zoning plan in the CLUP, awareness of community on the guidelines of setback zone, presence of coastal resources management program (CRMP), community participation to CRMP, presence of environmental laws, knowledge of the community on the presence of environmental laws, enforcement of environmental laws, dissemination of information and education campaign materials, early warning device PA system, communication technology, evacuation center, resettlement areas, LGU knowledge and application of geo-hazard map, community knowledge on geo-hazard map and alternative or supplemental livelihood.

Households within the target coastal barangays are interviewed (minimum of 30 respondents). Results are encoded in the SPSS software for descriptive analysis and computation of AC values needed for the model generation. The detailed adaptive capacity assessment is presented on the Field assessment part of this manual.

Step 3. Desk study

Review the data needs and availability prior to the conduct of the field assessment. The geodata such as **administrative**, **historical, slope, coastal resources or storm surge map** are among the commonly acquired information prior to actual field assessment.

Coastal polygon

The coastal polygon represents the target area for the assessment. This unit of interest is demarcated from Google Earth. The demarcation covers the exposed area of the coastline and must be within the recognized 3km coastal area boundary. This allows data assembly on common scales across the target coastal strip.

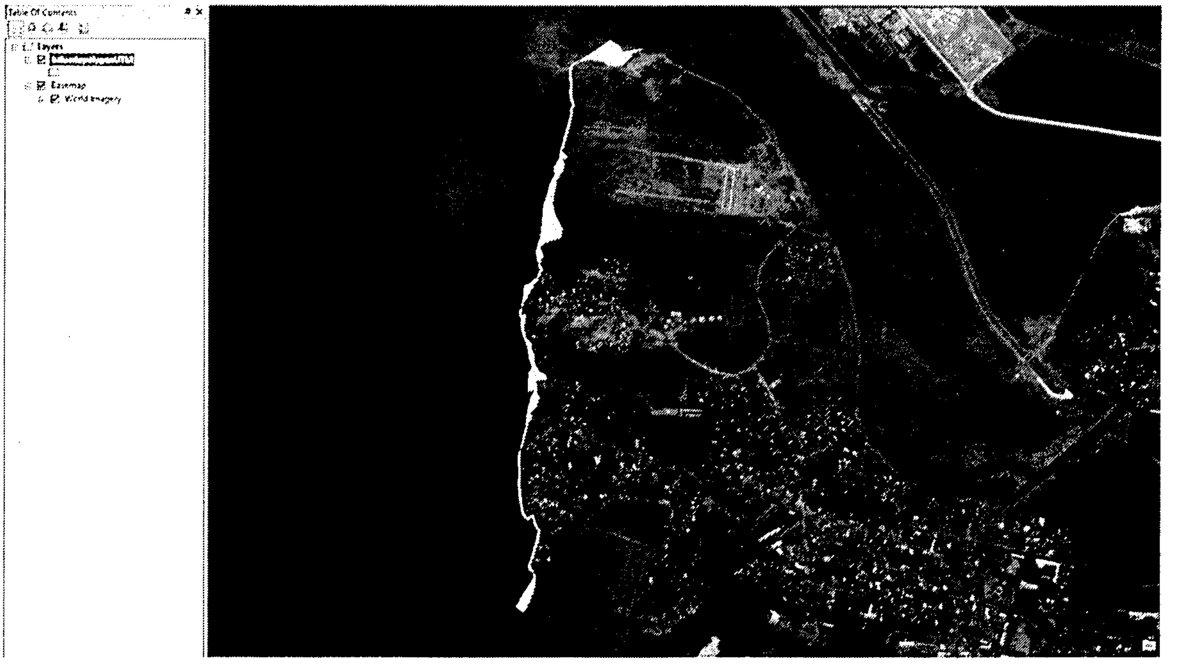


Fig. 7 Sample coastal polygon.

Historical map

Available **historical maps** can be obtained from Google Earth. The collected **data must be validated** on the field to account for recent events or phenomenon resulting to the discrepancy between retrieved historical maps and existing field conditions. As an example, the coastline of Barangay Baluarte in Tagoloan, Misamis Oriental in the following years was retrieved: 2004, 2009, 2016 and 2019. These temporal references are basis for examination of shoreline changes. Observation points in these shorelines are assigned for the computation shoreline change rate.

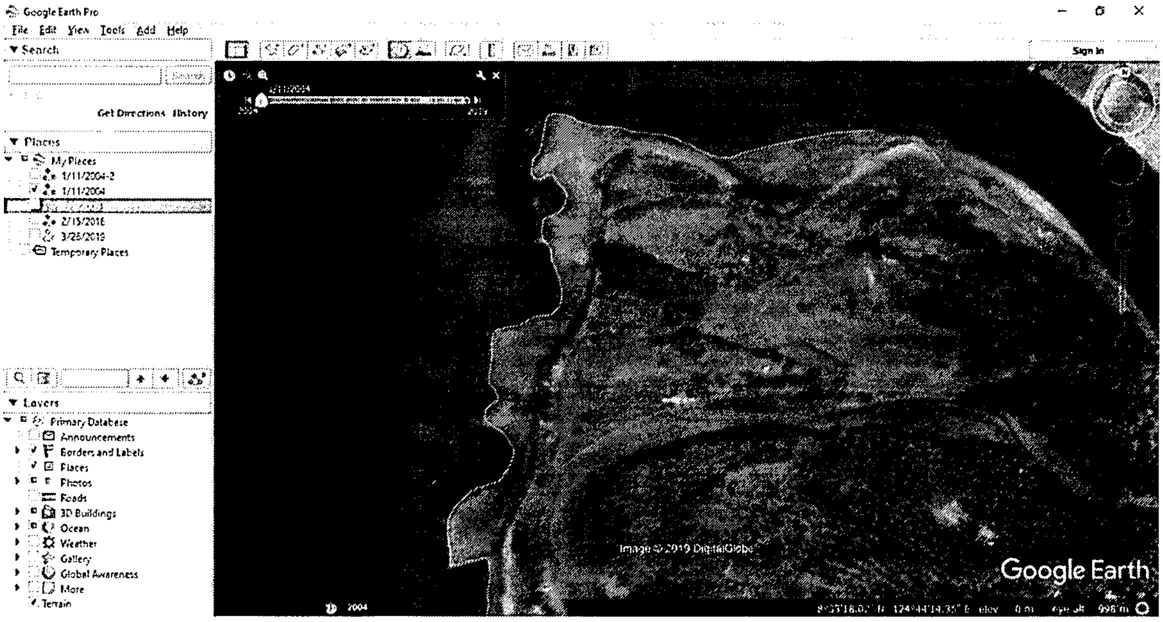


Fig. 8 Digitized shoreline polyline in the 2004 imagery of Baluarte, Tagaloan, Misamis Oriental.

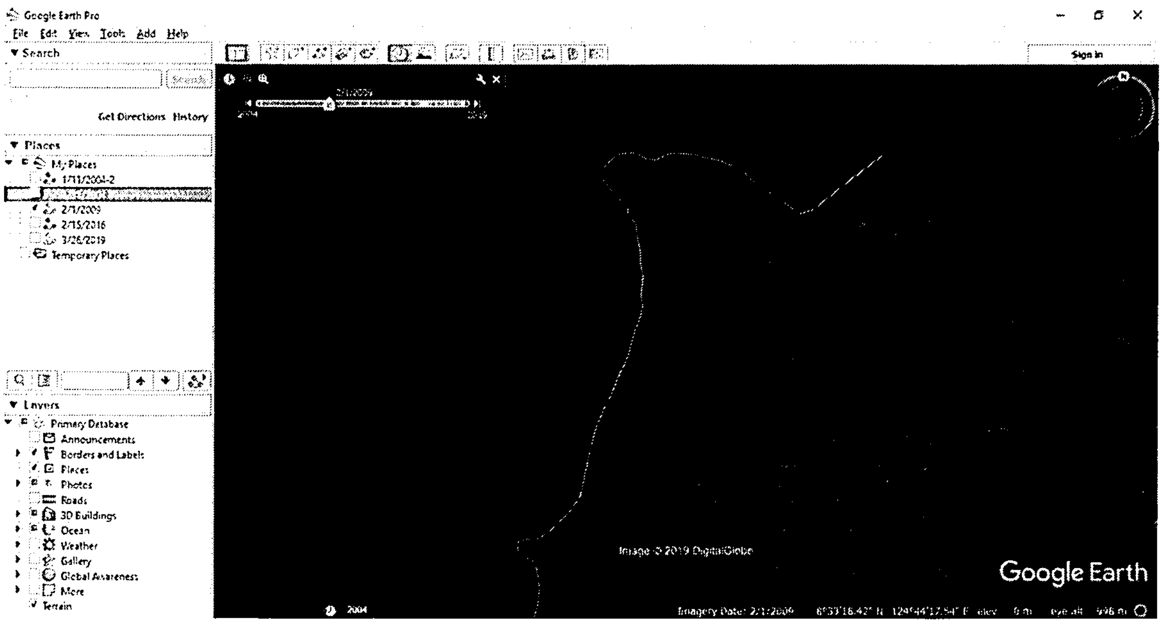


Fig. 9 Digitized shoreline polyline in the 2009 imagery of Baluarte, Tagaloan, Misamis Oriental.

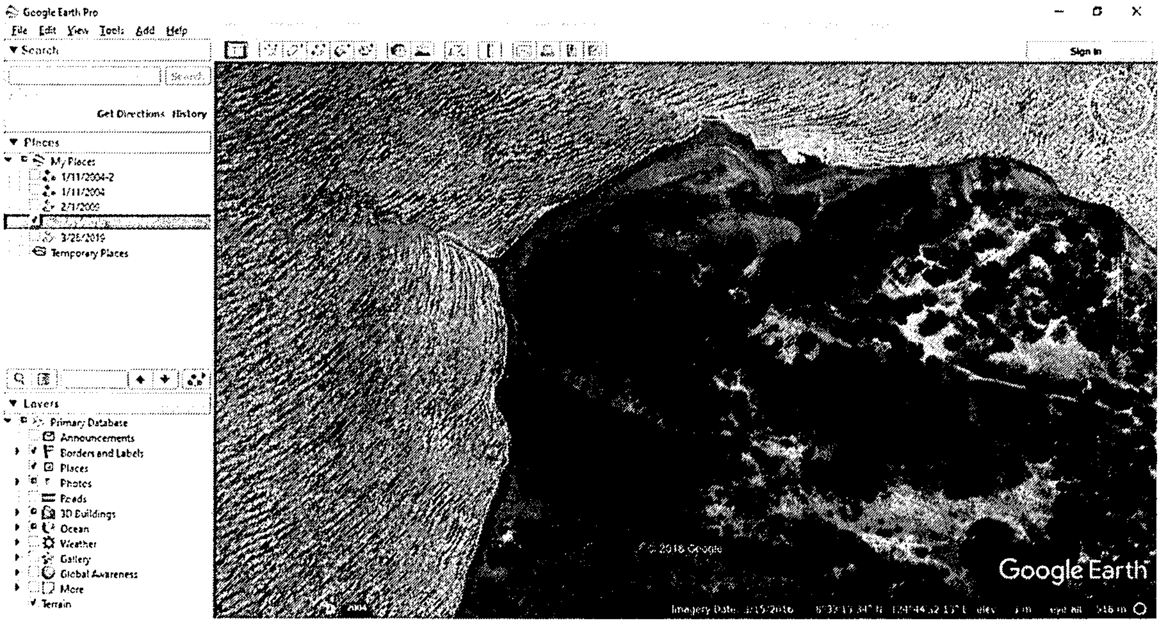


Fig. 10 Digitized shoreline polyline in the 2018 imagery of Baluarte, Tagaloan, Misamis Oriental.

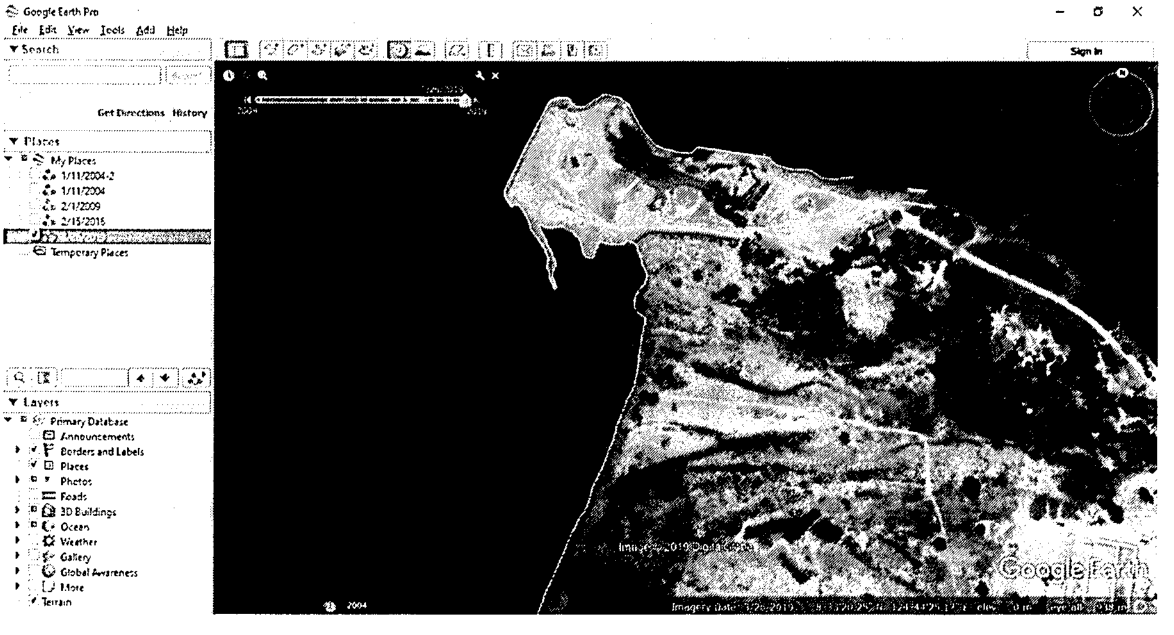


Fig. 11 Digitized shoreline polyline in the 2019 imagery of Baluarte, Tagaloan, Misamis Oriental.

Fig. 12 Consolidated demarcated shorelines of Baluarte, Tagaloan, Misamis Oriental.

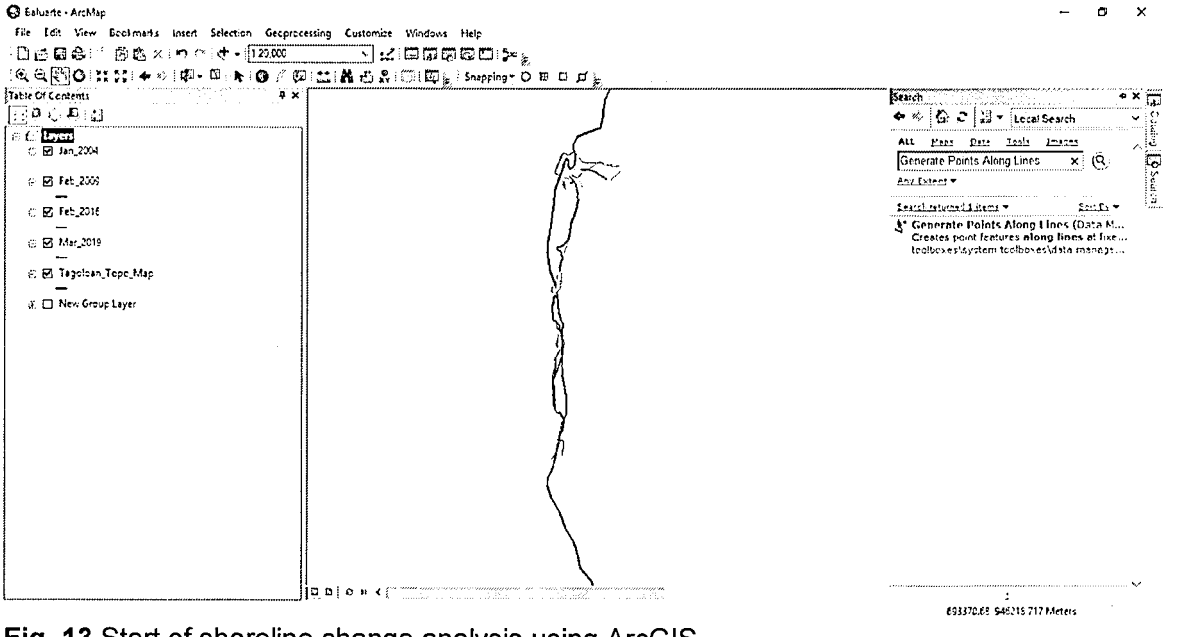


Fig. 13 Start of shoreline change analysis using ArcGIS.

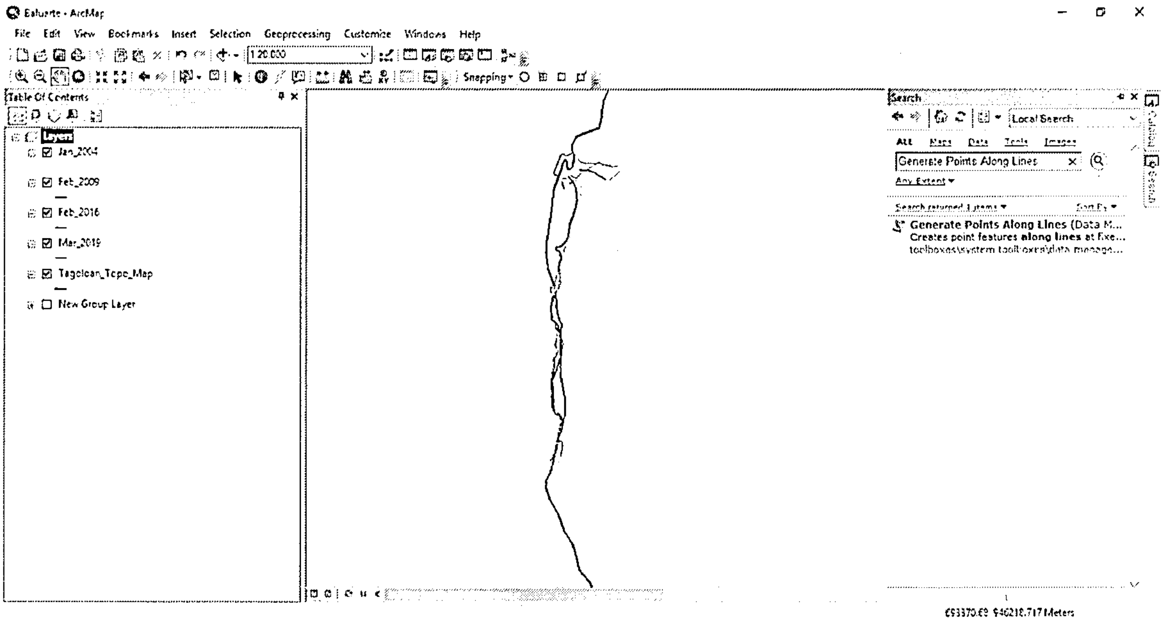


Fig. 14 Generation of calculation points along the polylines.

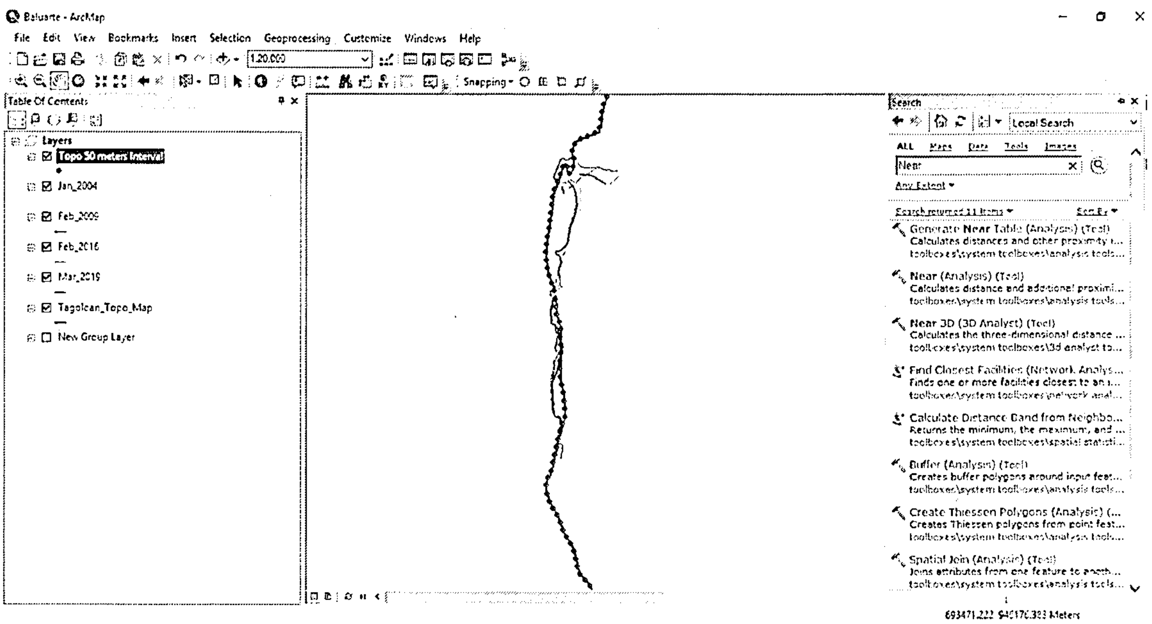


Fig. 15 Near analysis of polylines in ArcGIS.

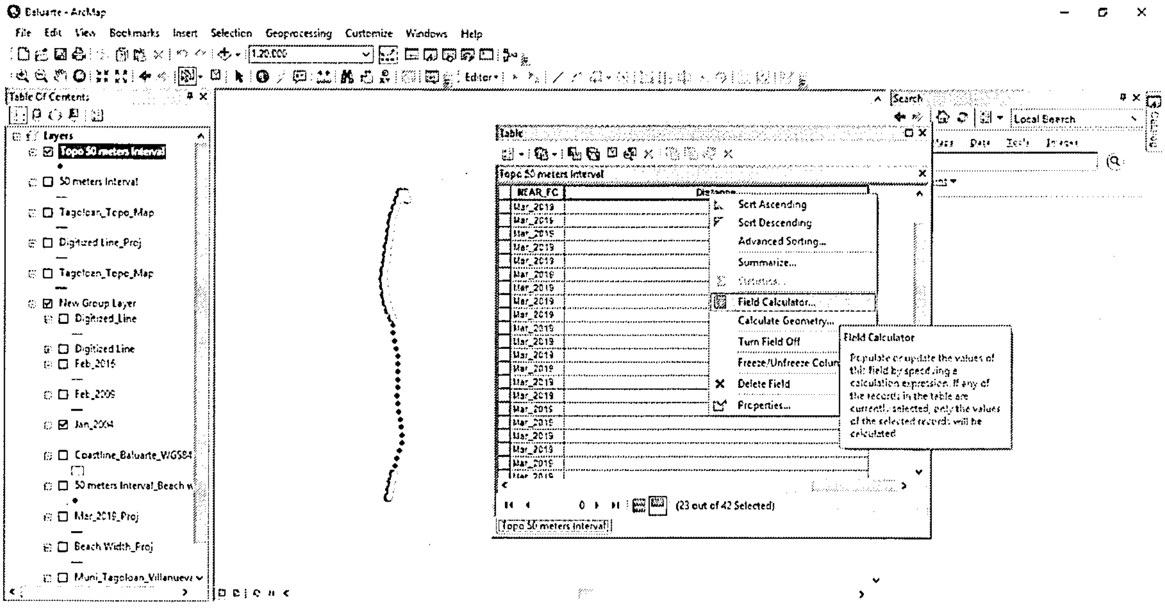


Fig. 16 Computations of shoreline change. Repeat the procedure for other reference shorelines.

$$Shoreline\ change = \frac{Difference\ of\ shoreline}{Year\ difference}$$

In this case, the computed shoreline change rate was -0.40 m/yr. Note this value as input in the critical factor analysis. During the field assessment, shoreline change may be validated through **anecdotal accounts** and **evidences of field erosion**. Examples are given in the field assessment part of this manual.

Slope

Slope map is generated using the Interferometric Synthetic Aperture Radar (IFSAR) data. The result will be verified in the field as part of coastal geomorphology analysis using the Emery method (1961). The generated slope maps along the shoreline of Barangay Baluarte, Tagaloan, Misamis, Oriental and Baragay Ondoy in Ibajay, Aklan are presented as examples. Based on this set of geodata, the slope of Baluarte ranged from 0.0051 to 8.6042. Ondoy on the other hand displayed slope values from 0-3.55. These slope values are among the sensitivity inputs for coastal erosion and storm surge.

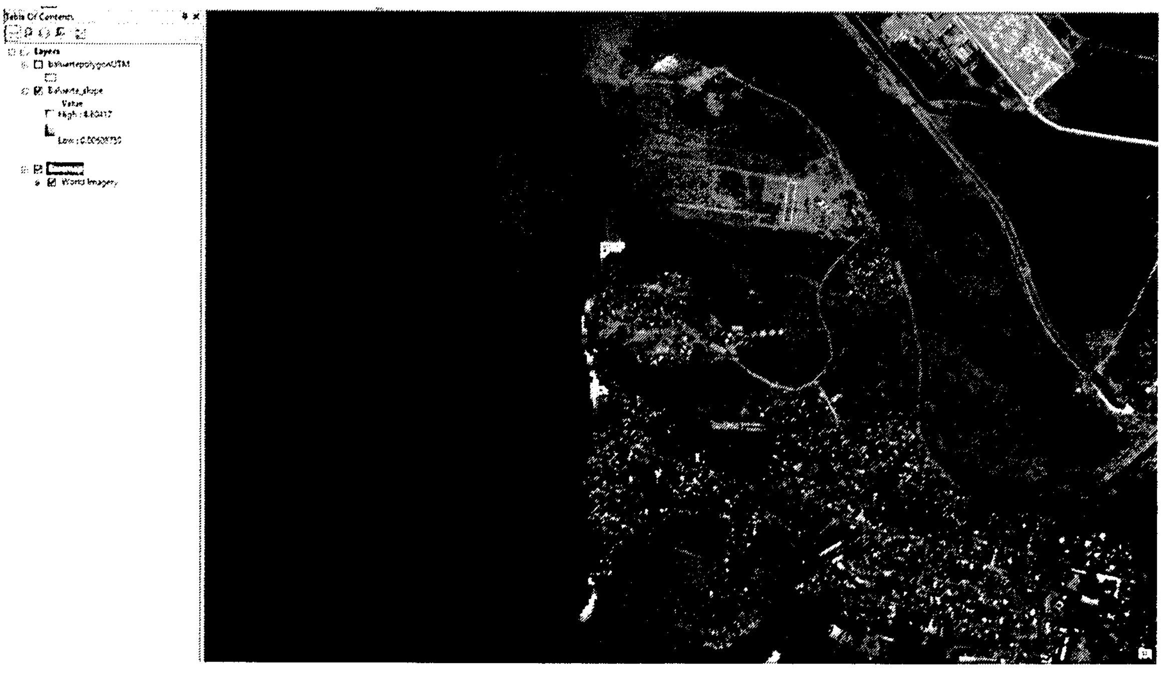


Fig. 17 Slope of Baluarte, Tagaloan, Misamis Oriental.

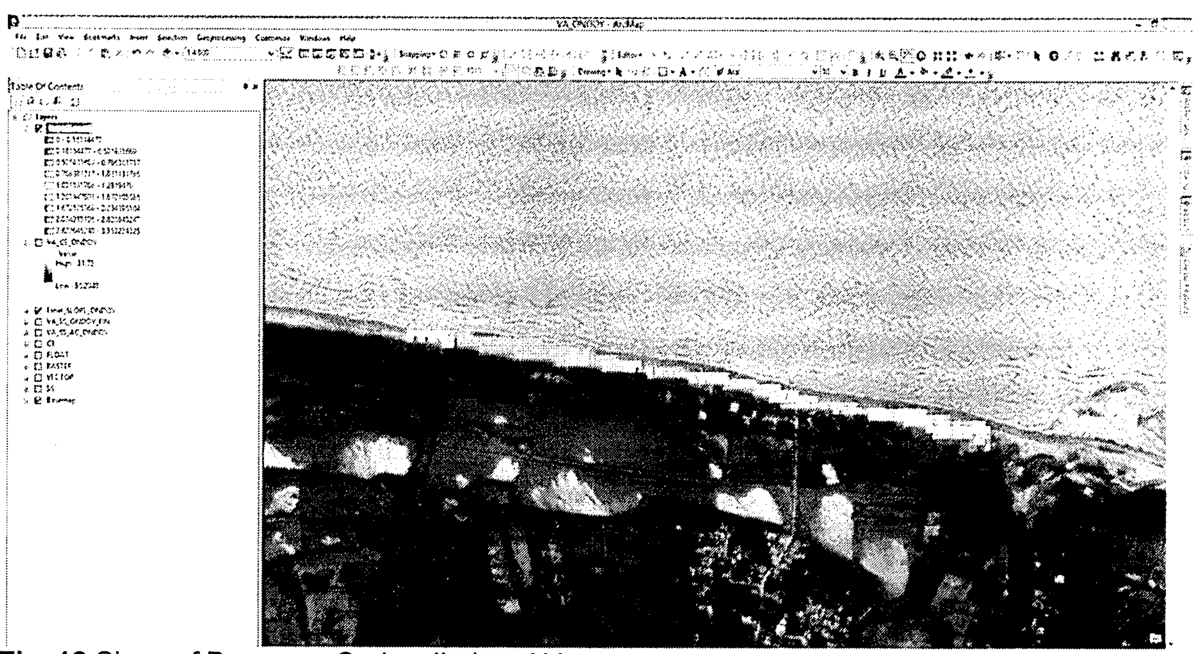


Fig. 18 Slope of Barangay Ondoy, Ibajay, Aklan.

Beach width

Pre-determined transect and preliminary measurements for beach width examination are generated using Google Earth. As shown in the coastal area of Barangay Upper Kalaklan, Olongapo, Zambales, perpendicular transects are demarcated along its coasts. The starting point of each transect is placed on the lowest water line mark and ends on the coastline. The corresponding waypoints of the first and last points of transect must be recorded as basis during the field validation.

Using the ruler tool, measure the distance form the first to the last point, the obtained values corresponds to beach width. Record the values using meters (m) as the unit of measure.

Table 4. Pre-determined stations and measurements for beach width assessment.

Station	Easting		Northing		Beach width (m)
	deg	min	deg	min	
S1-S	120	16.052	14	50.294	24.55
S1-E	120	16.062	14	50.303	
S2-S	120	16.021	14	50.341	18.16
S2-E	120	16.029	14	50.347	
S3-S	120	16.000	14	50.416	21.54
S3-E	120	16.012	14	50.417	

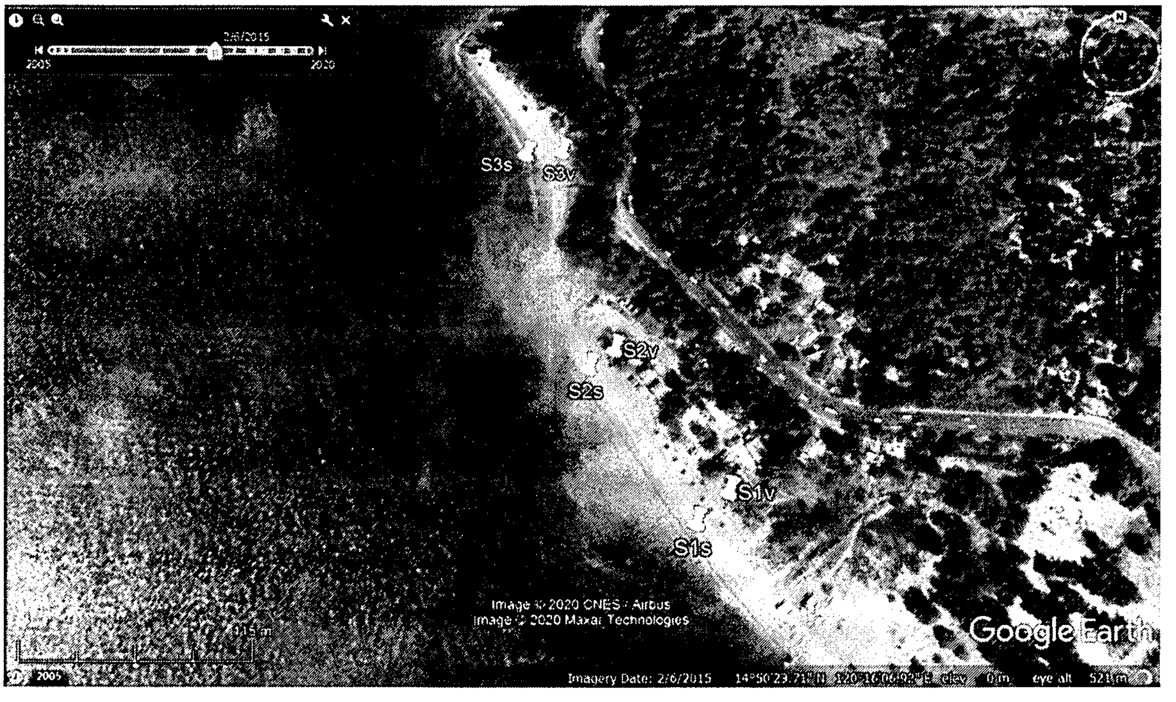


Fig. 19 Generation of pre-determined transect using Google Earth.

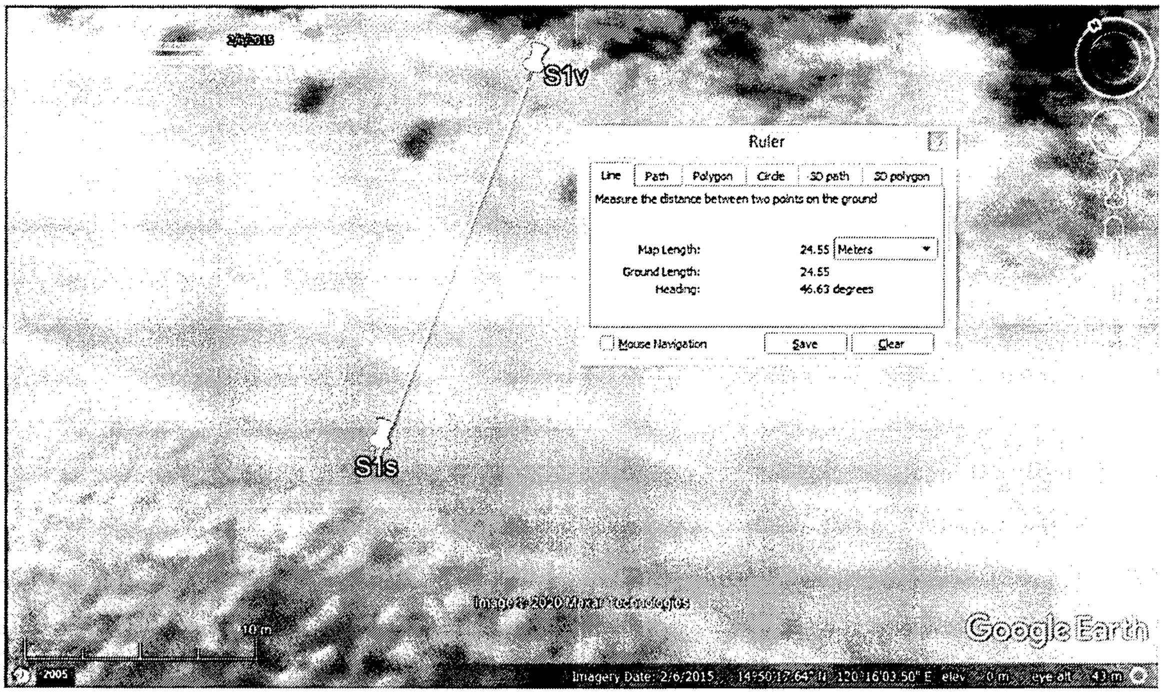


Fig. 20 Beach width measurement using the ruler tool in Google Earth (Station 1).

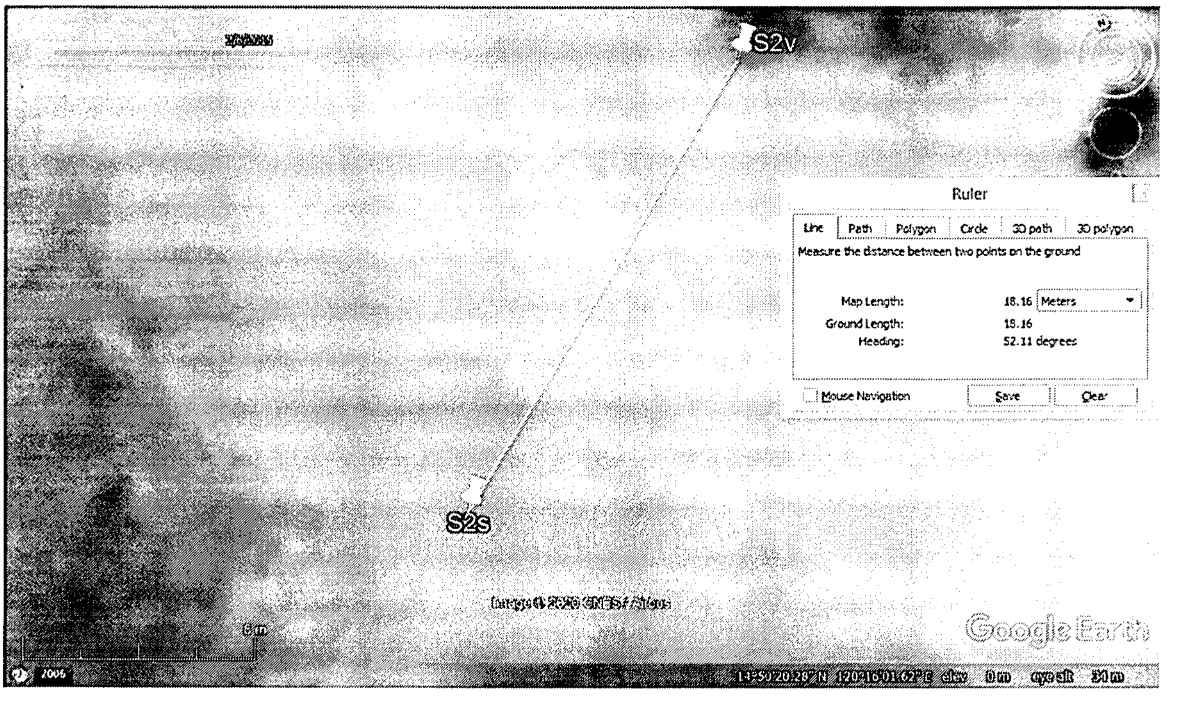


Fig. 21 Beach width measurement using the ruler tool in Google Earth (Station 2).

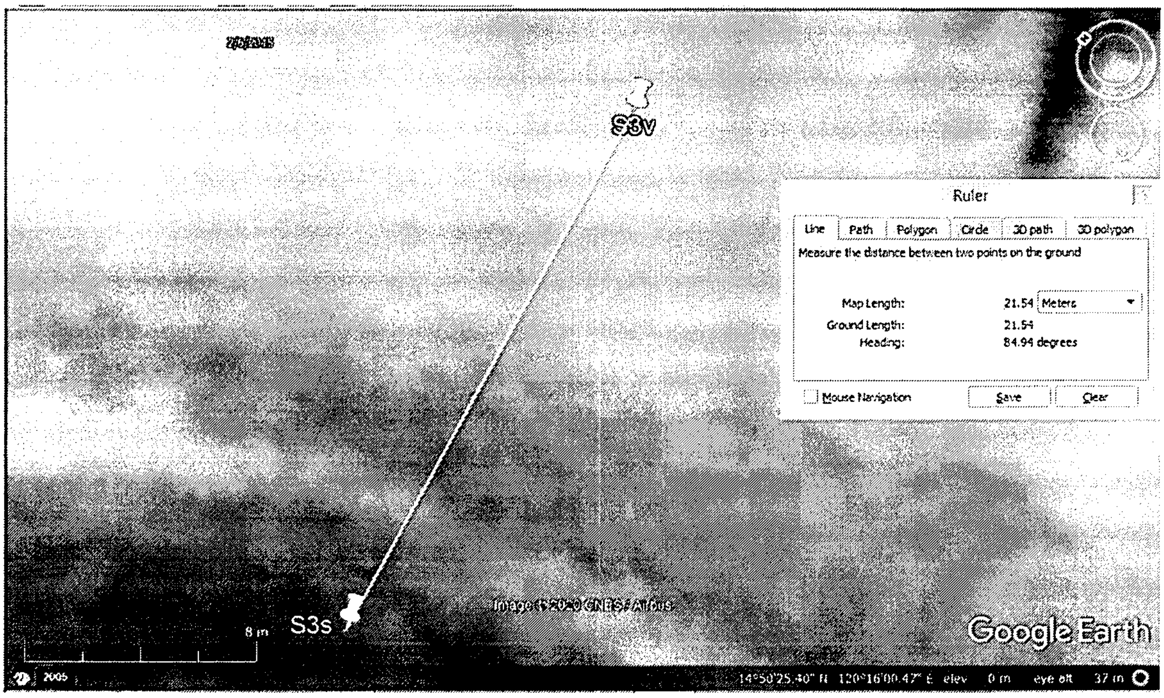


Fig. 22 Beach width measurement using the ruler tool in Google Earth (Station 3).

Coastal resources

The presence and extent of cover of coral reef, seagrass and mangrove areas also important sensitivity parameters as these natural habitats protect protection from natural hazards. These coastal features can generally attenuate the surge impacts from the coasts to inland communities (Wamsley et al. 2010). Ferrario (2014) revealed that the entire reef can reduce wave energy and height. The reef flats alone were able to dissipate the remaining wave energy (65%) and wave height (43%) from the reef crest. As for mangrove, the reported reduction surge rate through this ecosystem was between 5-15 cm/km, even up to 50 cm/km (McIvor et al. 2012; Krauss et al. 2009; Zhang et al. 2012). These natural habitats can dissipate the wave energy via breaking and frictional dissipation (Lowe et al. 2009; Guannel 2016).

Numerical simulations have also shown that coastal wetlands have the potential to attenuate storm surges and waves depending on the coastal landscape and the strength and duration of the storm (Wamsley et al. 2010). A wide vegetation belt (300 m) on a mild slope (1:500) was proven to increase the reduction of water depth and velocity. The reported maximum decrease in surge and velocity was 1.37 m and 1.07 m/s, respectively, compared to the values on landward areas without vegetation (Das et al. 2011). Sparse vegetation offers limited protection to the community once surges propagate into inland areas.

As shown in the next two figures, the geodata on coastal resources from NAMRIA indicated the presence of mangrove in Baluarte, Tagaloan, Misamis Oriental while all three important coastal habitats were recorded in San Diego, Lian, Batangas. Such data will be validated in the field through underwater surveys. The validated onsite status and health of these ecosystems translates into the quality of the protection services rendered into the coastal communities. This will be later shown in the scaling of factors on different vulnerability dimensions.

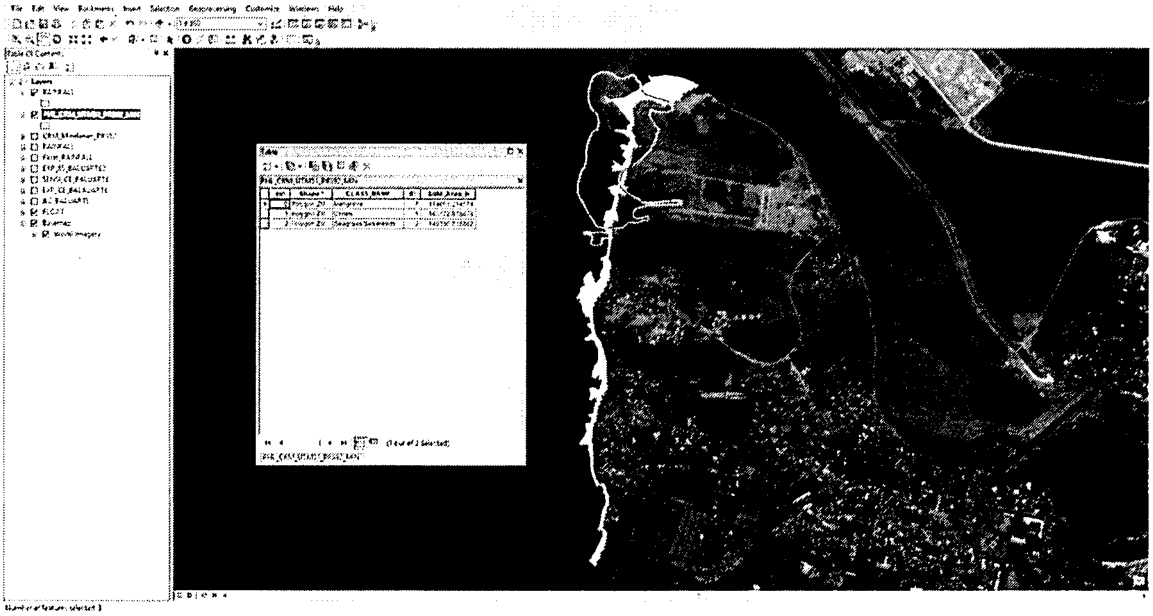


Fig. 23 Example of using geodata on of mangrove cover in Baluarte, Tagaloan, Misamis Orinetal.

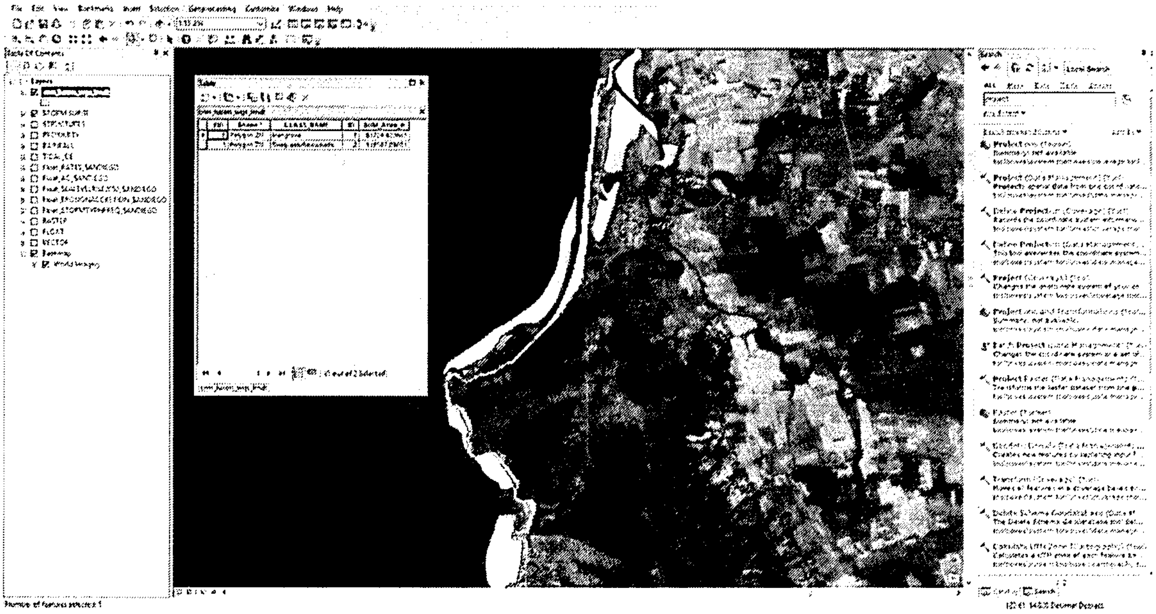


Fig. 24 Example of using geodata on mangrove and seagrass cover in San Diego, Lian, Batangas.

Storm surge

Project NOAH storm surge advisory is intended to give forecast with 24-hour lead time before the passage of a tropical cyclone in the country. Each forecast is based on Storm Surge Advisory (SSA) which was based on the combination of storm surges and maximum tide levels: SSA 1 (0.01m to 2m); SSA 2 (2.01 to 3m), SSA3 (3.01m to 4m) and SSA (4m and above). These advisories provide the extent, depth and hazard level of storm.

For this vulnerability assessment, the percentage of affected area in the demarcated polygon is determined through the **overlay analysis of SSA 1 shapefiles in ArcGIS**. If about 80% of the polygon is inundated at the lowest level of advisory, the area is considered to be very sensitive to storm surge. Overlay of SSA 1 in Baluarte, Tagaloan, Misamis Oriental is shown in the image. The result showed that 75% of the area is inundated at lowest level of advisory. Result of such overlay analysis can be a **guide question** in determining the present site condition in terms of its existing adaptation strategies to storm surge and provide pointers on possible interventions in case higher SSA will be applicable in their area.

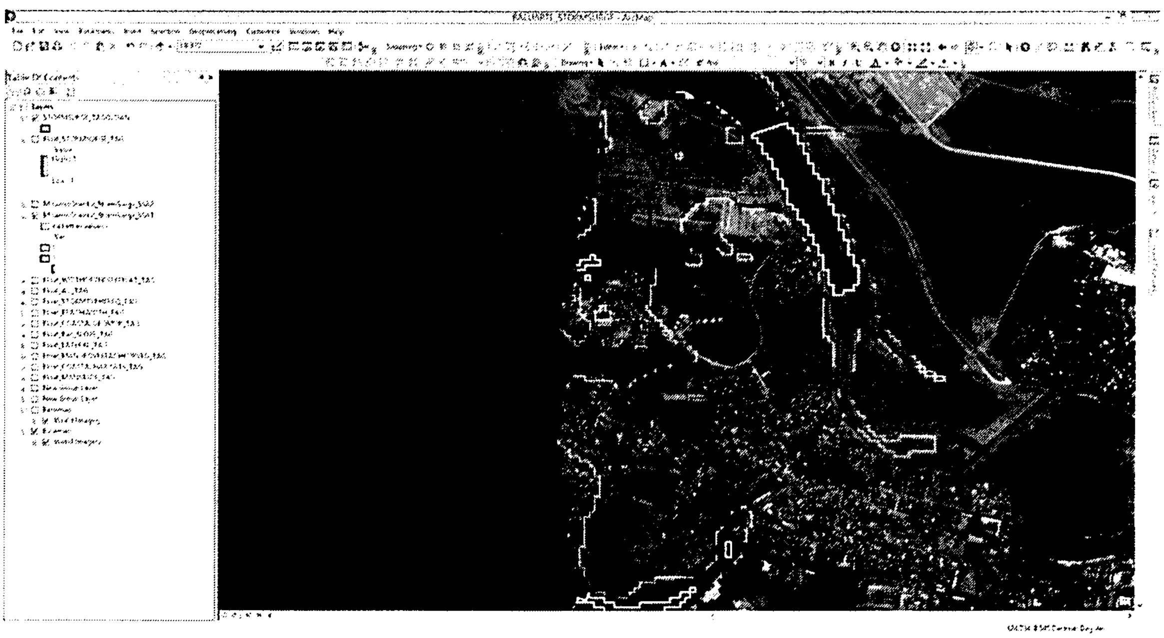


Fig. 25 Example of using geodata on storm surge advisory in Tagaloan, Baluarte, Misamis Oriental.

Step 4. Field Assessment

Field assessment starts with the reconnaissance survey followed by quantitative survey and lastly field validation.

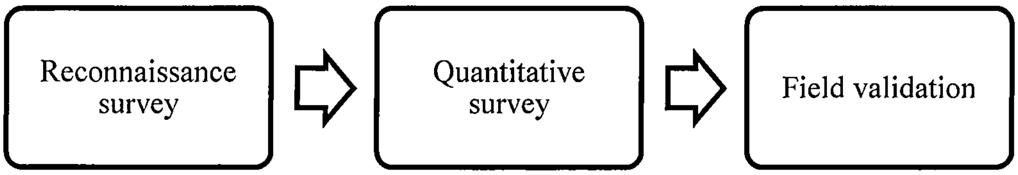


Fig. 26 Phases of field assessment.

The first phase is about coordination and validation of recognized administrative boundary. It is possible that the local government unit implements a different administrative boundary compared to the retrieved national boundary from NAMRIA. In this situation, it is suggested that the boundary recognized by the LGU will be prioritized because they are considered as the primary recipient of vulnerability models and such models is deemed appropriate to be based on the boundary recognized by the stakeholders on coastal communities.

Do not forget to cite the reference for the boundary used in the assessment (e.g. *NAMRIA Topographic Map, DENR Public Land Survey Maps, LGU Municipal Base Maps and MPDO 2000*). Disclaimer in the administrative boundaries is among the prescribed mapping procedure and map elements (*Disclaimer: Administrative boundary is not authoritative*).

3a. Bio-physical assessment

Coastal and marine habitat assessment

The next phase of field assessment is the quantitative survey. Quantitative survey will also cover the **ground truthing** of the available geodata on coastal resources. In this assessment, coral communities are assessed using the Line Intercept Transect (LIT), which is used to determine the percentage cover of benthic communities. Percentage cover of benthic communities such as hard coral, soft coral, sponges, algae, rock, dead coral was estimated.

Fig. 27 Underwater survey in Ibajay, Aklan.

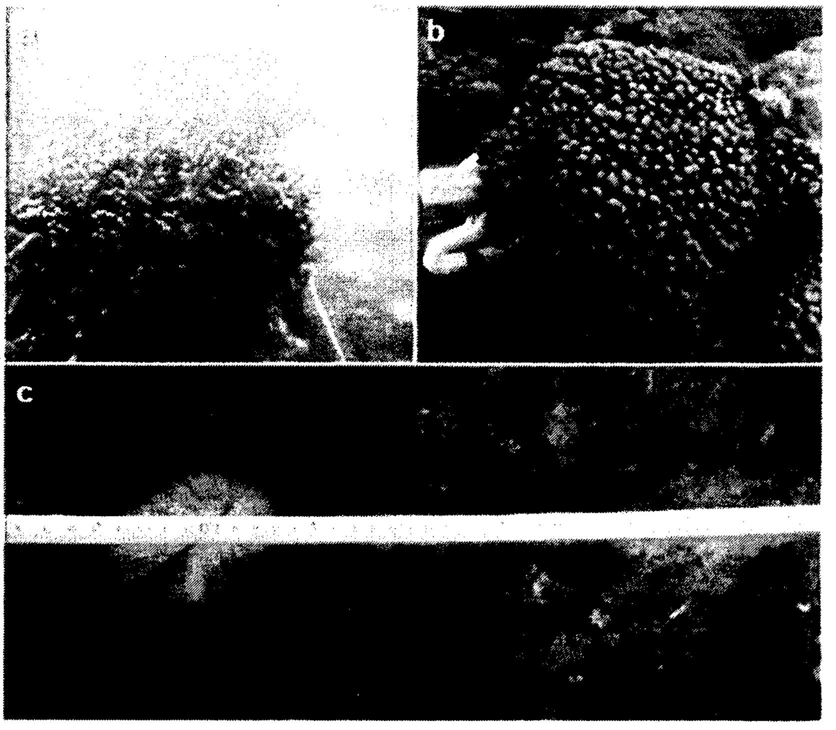


Fig. 28 Example of benthic lifeforms observed at the sampling stations: a. colonies of branching *Porites* on the reef near the pier structures, b. submassive colonies of *Porites* at the marine sanctuary, c. benthic attributes intercepted by the transect at the sampling site.

Quantitative survey of seagrasses is undertaken using the methods in English et al. (1997). A transect is laid perpendicular to the shoreline heading seaward until seagrasses are no longer found. A 0.5 x 0.5 m quadrat will be pressed along the transect at every 5-m interval. Seagrass within the quadrat is identified to species level and counted. Substrate cover of components or parameters within the quadrat is also estimated. Associated flora and fauna is noted. Data is recorded in a plastic slate. Geographic locations of the quadrats is marked using a handheld GPS.

Nested quadrat method (English et al. 1997) is employed to describe the mangrove and/or beach vegetation. A 10 m x 10 m plot was established within the vegetation. The distance of each plot is estimated about 100 meters apart or less depending on the vegetation structure. In each plot, plants larger than 5 cm in diameter were measured and recorded per plot for total height, and diameter-at-breast height (DBH), while small plants are identified and counted.

Fig. 29 Field assessment and validation of mangrove area in Tagaloan, Baluarte, Misamis Oriental.

The integrity of the marine habitats in the area is examined to determine if prevailing conditions can provide protection from coastal erosion and storm surge. Coral reefs serve as submerged offshore breakwaters. Apart from the composition and cover, underwater surveys reveal ***threats to these ecosystems*** from poor visibility, collapsed reef formations, among others. The unsustainable fishing practices and sediment pollution can generally threaten the existing coral reefs. The existing local conditions of the coral reefs limit their provision of protection against coastal erosion impacts to coastal communities. Sparse seagrass cover, converted mangrove areas into fishponds and lack of beach forest vegetation translate into high sensitivity into coastal hazards. Coastal vegetation can influence sediment dynamics in response to coastal erosion drivers such as sea-level rise and tidal forces (Feagin et al. 2009). The dominance of seagrass and mangrove cover, vis-a-vis the factors affecting wave attenuation in a particular locality, may further limit the sedimentation transport to offshore portions (Pinsky et al. 2013). These findings will serve as an important input into the formulation of site-specific and relevant adaptation strategies.

Beach morphology

In field shoreline morphology assessment, beach width measurements are taken along the coastline. Obtained values from the actual assessment will be compared with the measurements taken using the recent satellite imagery of the coastline. Deviations between results are determined and factors resulting to such are identified through available information, documentation of coastal erosion evidences in the area or anecdotal accounts. The conduct of shoreline morphology assessment was based on Emery method (1961). The tool used is two graduated poles separated by a definite distance (in this case 2m). The alignment and reading of the intersection between the two poles determines the change in elevation and beach width along the profile. The reading will start from the mark of the lowest shoreline until the exposed portion of beach or coastline. Remember to follow a straight path from the starting point of measurement until the last point. A transect may also be laid to serve as guide by the observers. Two individuals hold the poles, maintains its level and before reading the elevation change in the observation points. A third person is assigned to record the measurements and document the data gathering.

Obtained measurements are used to generate shoreline models using MS Excel and AutoCAD. This serve as additional visual reference in determining vulnerability levels along the coastal strip. Moreover, this could also serve as identification of priority areas in coastal erosion management as this supplies the information on which areas of the coast have diminishing beach area.

Fig. 30 Beach morphology assessment.

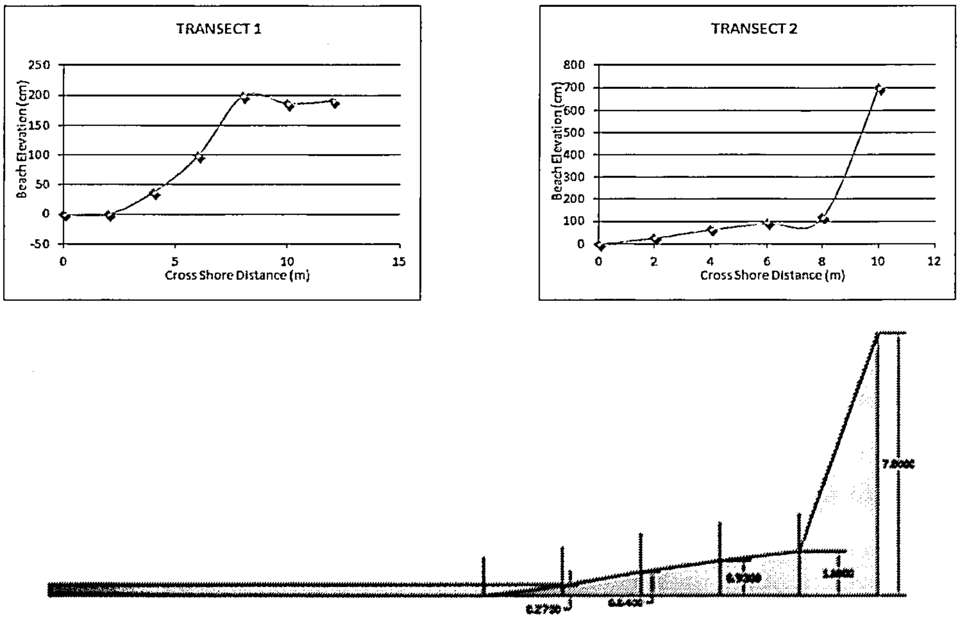


Fig. 31 Generated models based on elevation change and beach width measurements.

Fig. 32 Example of documented coastal erosion evidence in Narra, Palawan (exposed roots of beach flora).

Soil type

Comprising sediment is considered as among the key physical parameters for identifying erosion in coastal areas (Prasetya 2006). Sediment samples are collected along the coastline. Samples are collected in marked three stations. These samples are brought to the laboratory for grain-size analysis. The results will not serve as reference in the critical factor analysis but will serve as important considerations for future beach nourishment project.

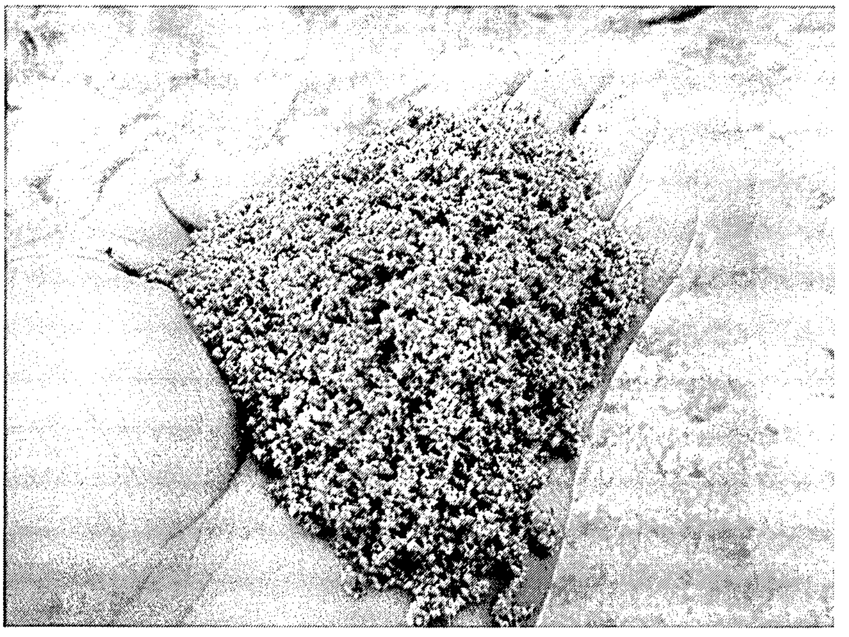


Fig. 33 Macro-documentation of sediment in the site.

Table 5. Grain-size anlaysis in San Diego, Lian, Batangas.

Station	Sieve number	Opening (mm)	Mass of soil retrieved (g)	Percent retained	Percent passing
1	35	0.5	22.8	22.8 %	77.20 %
	40	0.42	6.9	6.9 %	93.10 %
	60	0.25	50.8	50.8 %	49.20 %
	100	0.149	15.2	15.2 %	84.80 %
	140	0.105	1.00	1.00 %	99.00 %
	>140		3.30	3.30 %	96.7%
			100.00		
2	35	0.5	14.00	14.00 %	86.00 %
	40	0.42	5.40	5. 40 %	94.60 %
	60	0.25	62.60	62.60 %	37.40 %
	100	0.149	13.60	13.60 %	86.40 %
	140	0.105	1.40	1.40 %	98.60 %
	>140		3.00	3.00 %	97.00 %
			100.00		
3	35	0.5	14.80	14.80 %	85.20 %
	40	0.42	5.90	5.90 %	94.10 %
	60	0.25	56.70	56.70 %	43.30 %
	100	0.149	15.20	15.20 %	84.80 %
	140	0.105	3.80	3.80 %	96.20 %
	>140		3.60	3.60 %	96.40 %
			100.00		

Table 6. Soil composition in in San Diego, Lian, Batangas.

Station	Soil texture			Textural Grade
	% Sand	% Clay	% Silt	
1	96	0	4	Sand
2	96	0	4	Sand
3	100	0	0	Sand

3b. Adaptive capacity assessment

Adaptive capacity assessment is carried-out at the household level of the target community. Coastal dwellers in the first line of hazard exposure are the major respondents. Barangay officials usually participated as local guides or enumerators. Ratings on existing coastal protection structures from sandbags to boulders; extent of setback zone implementation; number of activities under coastal resources management (e.g. mangrove planting, coastal clean-up, maintenance of mangrove nursery; declaration of marine protected areas; observance of illegal fishing, among others); number of early warning systems (radio, television, internet); capacity of evacuation and resettlement areas; access and level of knowledge on geohazard maps among the local leaders; and duration of considered alternative livelihood are discussed during the survey. The adaptive capacity form is presented in the annex of this manual.

After the survey, photo-documentation is taken to support the given ratings of the respondents. These include documentation of water-level markers, signs for storm surge advisories, evacuation centers, early warning communication devices such as megaphone, siren and bells, coastal protection structures and existing alternative livelihood for the community. Examples of adaptation strategies for documentation are presented from **Fig.34-Fig.38**.

Fig. 34 Layers of rubber tires placed filled with rocks were seen in front of the houses in coastal areas of Misamis Oriental.

Fig. 35 Abandoned stilt house in Misamis Oriental. Elevated houses offer protection from inundation in the area.

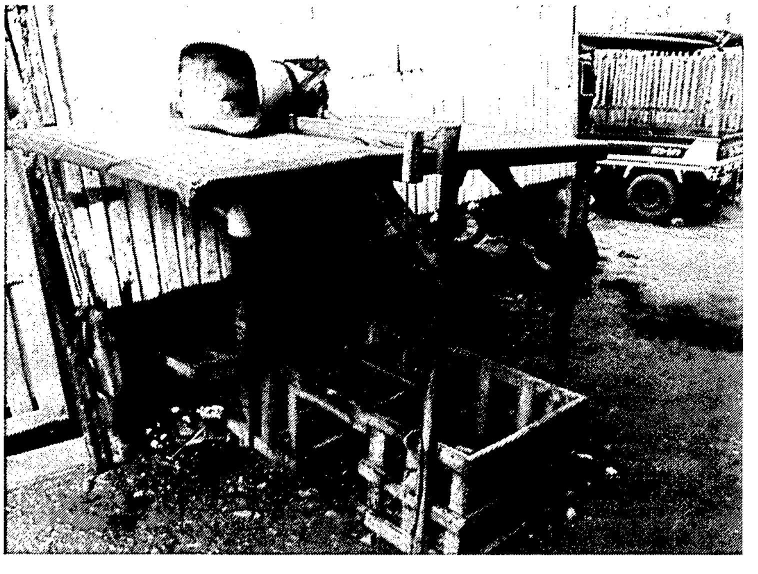


Fig. 36 A common early warning communication device in coastal barangay is megaphone. Designated *purok* leaders give updates or instructions to their constituents regarding water level rising and mode of evacuation during the passage of typhoon.

Fig. 37 Information materials on evacuation posted in hazard prone area are also documented.

Fig. 38 Alternative livelihood options are also covered in the documentation. Alternative livelihood provides additional support to coastal households to be able to take protective measures on impacts of coastal hazards.

Step 5. Critical factor analysis

Scaling of factors for the sub-indices components is used for a standard scoring system. Numeral scale of 1 pertained to factors with very low contribution to exposure, sensitivity or adaptive capacity while the maximum value of 5 represented factors with very high contribution on the same parameters (**Table 6** and **Table 7**). Weighing of the respective components is not done due to the diverse number of value of judgement on combined weights (Cendrero and Fisher 1997 cited in in McLaughlin and Copper 2007).

Table 7 Guide in scaling of exposure and sensitivity factors affecting the vulnerability of coastal areas to coastal erosion and storm surge (adapted from Gornitz 1990 as reviewed by McLaughlin and Copper 2010; ERDB 2017).

Scale	Description
1	Factor contributes to **very low** exposure/sensitivity/adaptive capacity
2	Factor contributes to **low** exposure/sensitivity/adaptive capacity
3	Factor contributes to **moderate** exposure/sensitivity/adaptive capacity
4	Factor contributes to **high** exposure/sensitivity/adaptive capacity
5	Factor contributes to **very high** exposure/sensitivity/adaptive capacity

Table 8. Scale of factors for coastal vulnerability assessment.

Vulnerability sub-indicators	CE	SS	Description	Scale	Rate
Exposure factors					
Relative sea level rise (mm/yr)	✓	✓			
(Ozyurt 2007 and Ramieri et al. 2011)			<1	1	Very low
			1-2	2	Low
			3-5	3	Moderate
			6-7	4	High
			>7	5	Very high
Sea level rise exposure by 2050 (cm)	✓	✓			
(Clavano 2012)			0	1	Very low
			10-20	2	Low
			21-30	3	Moderate
			31-40	4	High
			>40	5	Very high
Tidal range (m)	✓				
			<1	1	Very low
			1-1.4	2	Low
			1.5-1.8	3	Moderate
			1.9-2	4	High
			>2	5	Very high
Tidal range (m)		✓			
			>2	1	Very low
			1.9-2	2	Low
			1.5-1.8	3	Moderate
			1-1.4	4	High
			<1	5	Very high
Erosion/Accretion rates (m yr^{-1})	✓	✓			
			2.1	1	Very low
			1.1-2.0	2	Low

Vulnerability sub-indicators	CE	SS	Description	Scale	Rate
			-1-1	3	Moderate
			-1.1--2	4	High
			<-2.1	5	Very high
Storm surge exposure (%) at SSA 1		✓			
(Project NOAH)			<20	1	Very low
			20 - 40	2	Low
			40 - 60	3	Moderate
			60 - 80	4	High
			>80	5	Very high
Sensitivity factors					
Storm/Typhoon frequency	✓	✓			
(Cinco et al. 2016)			<10	1	Very low
			11-40	2	Low
			41-60	3	Moderate
			61-80	4	High
			>80	5	Very high
Rainfall amount (mm)	✓				
			<500	1	Very low
			501 - 1,000	2	Low
			1,001 -1,500	3	Moderate
			1,501 - 2,000	4	High
			>2,000	5	Very high
Beach width (m)	✓	✓			
			>150	1	Very low
			110 - 130	2	Low
			90 – 110	3	Moderate
			70 – 90	4	High
			<70	5	Very high
Coastal geomorphology	✓	✓			
			Rocky cliff	1	Very low
			Cliff	2	Low
			Low cliff (<5 m high)	3	Moderate
			Cobble/gravel beaches	4	High
			Sandy beaches, mudflats	5	Very high
Coastal slope (%)	✓	✓			
			>10	1	Very low
			6-10	2	Low
			3.6 – 5	3	Moderate
			2 - 3.5	4	High
			<2	5	Very high
Proximity to river mouth (m)	✓				
			<500	1	Very low
			501 - 800	2	Low
			801 - 1100	3	Moderate
			1101 - 1400	4	High
			>1400	5	Very high

Vulnerability sub-indicators	CE	SS	Description	Scale	Rate
Width of the reef flat (m)	✓	✓			
			>90	1	Very low
			81 - 90	2	Low
			71 - 80	3	Moderate
			61 - 70	4	High
			<60	5	Very high
Lateral extent reef flat	✓	✓			
(% length of the shoreline)			>90	1	Very low
			71- 90	2	Low
			51-70	3	Moderate
			31-50	4	High
			<30	5	Very high
Beach forest and vegetation	✓	✓			
			>50% forest or canopy cover	1	Very low
			<50% forest or canopy cover	2	Low
			Brushland	3	Moderate
			Grassland	4	High
			Sparsely vegetated	5	Very high
Coastal habitat	✓	✓			
			>50% coral, seagrass, and mangrove cover	1	Very low
			<50 % coral, seagrass, and mangrove cover	2	Low
			>50% coral-seagrass or seagrass-mangrove cover	3	Moderate
			<50% coral-seagrass or seagrass-mangrove cover	4	High
			<50% coral or seagrass or mangrove cover	5	Very high
Structures on the foreshore	✓				
			<2 short groins (5 m long) and/or few properties on the easement with no shoreline modification	1	Very low
			-		
			Short groins & solid-based pier (5 to 10 m long), seawalls and structures with aggregate length of <10 % of the shoreline length	3	Moderate
			-		

Vulnerability sub-indicators	CE	SS	Description	Scale	Rate
			Groins and solid-based pier (>10 m long) seawalls and other properties with aggregate length >10% of the shoreline length	5	Very high
Man-made buffer		✓			
			Seawalls and other structures with an aggregate length of >75% of the shoreline length and >1-m height	1	Very low
			-		
			Seawalls and other structures with an aggregate length of 50%-70% of the shoreline length and > 1-m height	3	Moderate
			-		
			Seawalls and other structures with aggregate length of <50% of the shoreline length and >=1-m height	5	Very high
Adaptive capacity					
No. of ordinances relative to beach/sand mining law	✓	✓			
			Absent	1	Very low
			1	2	Low
			2	3	Moderate
			3	4	High
			4	5	Very high
Proximity of settlement to coastline (m)	✓	✓			
			<100	1	Very low
			100 to 400	2	Low
			401 to 700	3	Moderate
			701 to 1000	4	High
			>1000	5	Very high
Coastal protection structure	✓	✓			
			No structure	1	Very low
			Temporary structure (sandbag/ light materials)	2	Low

Vulnerability sub-indicators	CE	SS	Description	Scale	Rate
			Concrete breakwater	3	Moderate
			Concrete armors and boulders	4	High
			Seawall	5	Very high
Land use pattern/ coastal development	✓	✓			
			Commercial/ industrial	1	Very low
			Unclaimed	2	Low
			Agricultural/open space	3	Moderate
			Settlement/residential	4	High
			Protected	5	Very high
Integration and implementation of Coastal Zoning Plan in the CLUP	✓	✓			
			Not integrated and implemented (presence of settlements in seawater)	1	Very low
			Integrated but not implemented (presence of settlements within 3m zone)	2	Low
			Limited implementation (presence of settlements within 20m zone)	3	Moderate
			Partially implemented (presence of settlements within 40 m zone)	4	High
			Fully implemented (no presence of settlements within the setback zone)	5	Very high
Awareness of community on the guidelines in setback zone	✓	✓			
			Not aware	1	Very low
			Low level of awareness	2	Low
			Average level of awareness	3	Moderate
			High level of awareness	4	High
			Very high level of awareness	5	Very high
Presence of CRMP	✓	✓			
				1	Very low
			None		
				2	Low
			1		
			2	3	Moderate

Vulnerability sub-indicators	CE	SS	Description	Scale	Rate
			3	4	High
			>4	5	Very high
Community participation to CRMP (mangrove planting, beach forest rehabilitation, coastal clean-up)	✓	✓			
			No participation	1	Very low
			Low level of participation	2	Low
			Average level of participation	3	Moderate
			High level of participation	4	High
			Very high level of participation	5	Very high
Presence of environmental laws	✓	✓			
			None	1	Very low
			1	2	Low
			2	3	Moderate
			3	4	High
			>4	5	Very high
Knowledge of the community on the presence of environmental laws	✓	✓			
			No knowledge	1	Very low
			Low level of knowledge	2	Low
			Average level of knowledge	3	Moderate
			High level of knowledge	4	High
			Very high level of knowledge	5	Very high
Enforcement of environmental laws (given that the community is knowledgeable on the presence of environmental laws	✓	✓			
			at least 76% of the total ordinances violated	1	Very low
			51%-75% of the total ordinances violated	2	Low
			26%-50% of the total; ordinances violated	3	Moderate
			<=25% of the total ordinances violated	4	High

Vulnerability sub-indicators	CE	SS	Description	Scale	Rate
			no reported apprehension/ violation	5	Very high
Information and education campaign materials	✓	✓			
			No IEC materials seen nor read	1	Very low
			Dissemination of IEC materials only after the occurrence of storm surge and coastal erosion	2	Low
			Dissemination of IEC materials before and after the occurrence of storm surge and coastal erosion	3	Moderate
			Occasional dissemination of IEC materials	4	High
			Regular dissemination of IEC materials	5	Very high
Number of early warning device PA system (batingaw, bandillo, staff gauge, rain gauge)	✓	✓			
			No available	1	Very low
			1	2	Low
			2	3	Moderate
			3	4	High
			>4	5	Very high
Number of communication Technology (mobile, 2-way radio, TV, radio)	✓	✓			
			No available	1	Very low
			1	2	Low
			2	3	Moderate
			3	4	High
			>4	5	Very high
Evacuation centers	✓	✓			
			No evacuation centers	1	Very low
			<=30% of potential affected households could be accommodated	2	Low
			31%-65% of potential affected household could be accommodated	3	Moderate
			66%-99% of coastal households could be	4	High

Vulnerability sub-indicators	CE	SS	Description	Scale	Rate
			accommodated		
			100% of potential coastal households could be accommodated	5	Very high
Resettlement areas	✓	✓			
			No resettlement area	1	Very low
			<=30% of potential affected households could be resettled	2	Low
			31%-65% of potential affected household could be resettled	3	Moderate
			66%-99% of coastal households could be resettled	4	High
			100% of potential coastal households could be resettled	5	Very high
LGU knowledge and application of geo-hazard maps	✓	✓			
			No knowledge	1	Very low
			<=25% of members of LDRRMC are knowledgeable and understand geohazard maps	2	Low
			26%-50% of members of LDRRMC are knowledgeable and understand geohazard maps	3	Moderate
			51%-75% of members of LDRRMC are knowledgeable and understand geohazard maps	4	High
			100% of members of LDRRMC are knowledgeable and understand geohazard maps	5	Very high
Community knowledge on geo-hazard maps	✓	✓			
			No knowledge on the presence of geohazard maps	1	Very low
			<=25% of the total respondents have knowledge of geohazard maps	2	Low

Vulnerability sub-indicators	CE	SS	Description	Scale	Rate
			26%-50% of the total respondents have knowledge of geohazard maps	3	Moderate
			51%-75% of the total respondents have knowledge of geohazard maps	4	High
			No knowledge on the presence of geo-hazard maps	5	Very high
Alternative or supplemental livelihood	✓	✓			
			not available all throughout the year	1	Very low
			available only for 1 to 3 months	2	Low
			available for 4-6 months	3	Moderate
			available for 7 to 11 months	4	High
			available all throughout the year	5	Very high

Step 6. GIS analysis and mapping

Geographic Information Systems (GIS) allow generation of models or maps based on the available geodata. The results are as reliable as its data sources. After the labor-intensive gathering and validation these data, the corresponding scores from the critical factor analysis are configured in command lines of GIS software (ArcGIS 10.5 or higher) to generate thematic maps for exposure, sensitivity, adaptive capacity, and vulnerability per unit/location (barangay or municipality level). Data assembly and analyses for exposure, sensitivity and adaptive capacity indices were done following the methods in McLaughlin and Copper (2010).

Adding the assigned variables of exposure
The equations used for the calculation of coastal vulnerability index:

1. **Coastal erosion sub-indices**

Exposure index={[(sum of exposure variables)-4]/16}X100
Sensitivity index={[(sum of sensitivity variables)-11]/44}X100
Adaptive capacity index={[(sum of adaptive capacity variables)-19]/76}X100

2. **Storm surge sub-indices**

Exposure index={[(sum of exposure variables)-5]/20}X100

Sensitivity index={[(sum of sensitivity variables)-9]/36}X100

Adaptive capacity index={[(sum of adaptive capacity variables)-19]/76}X100

A. Coastal Index of Vulnerability (CIV)

CIV=(Exposure index + Sensitivity index + Adaptive capacity index)/3

Chapter 3
Application

Conversion of vector file (polygon) to raster file

Prepare the polygon of the parameter to process and open its attribute table.

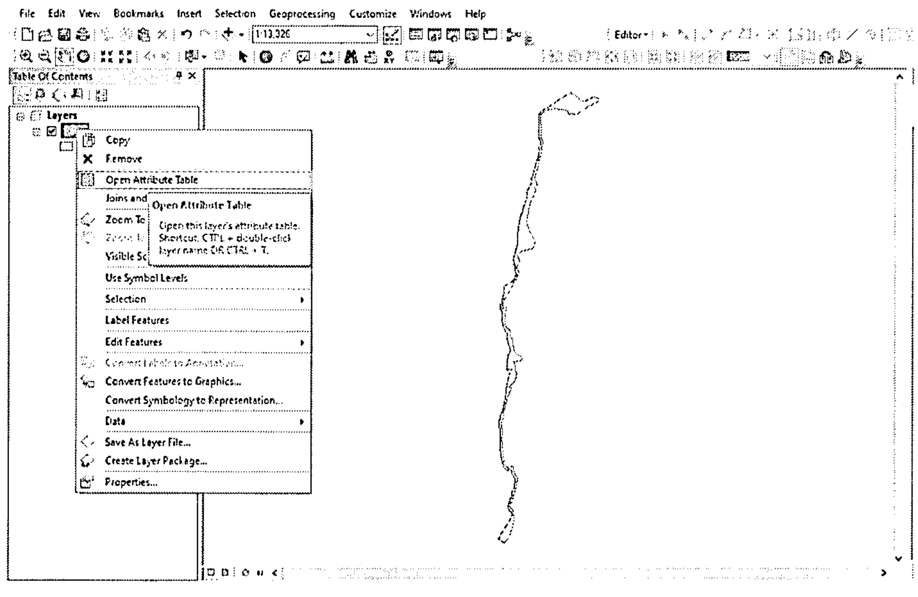


Fig. 39 Conversion of vector to raster file.

In the **Table options**, click the drop-down button and select **Add field**.

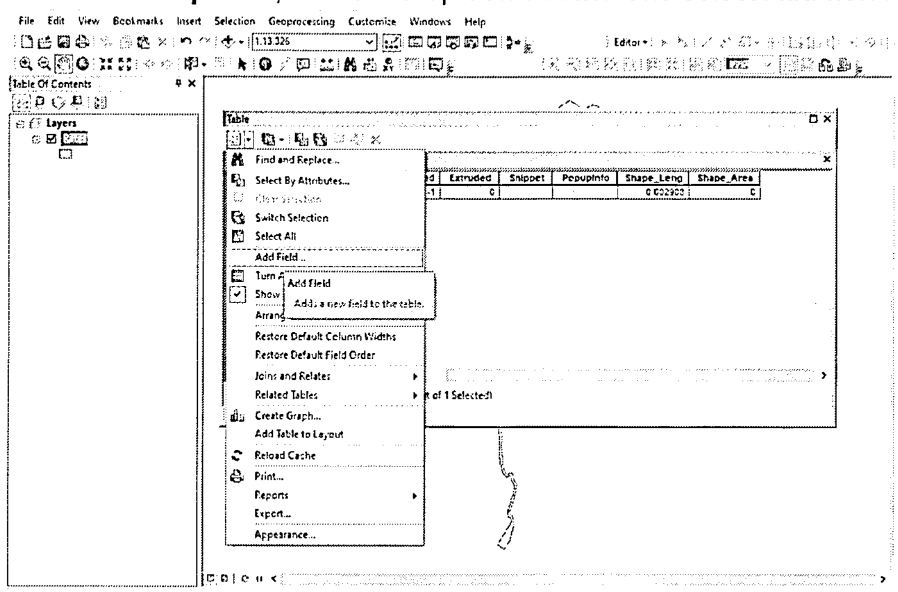


Fig. 40 Creation of additional attribute input.

Add '**Rating**' field and choose '**Double**' as its type. Then click OK.

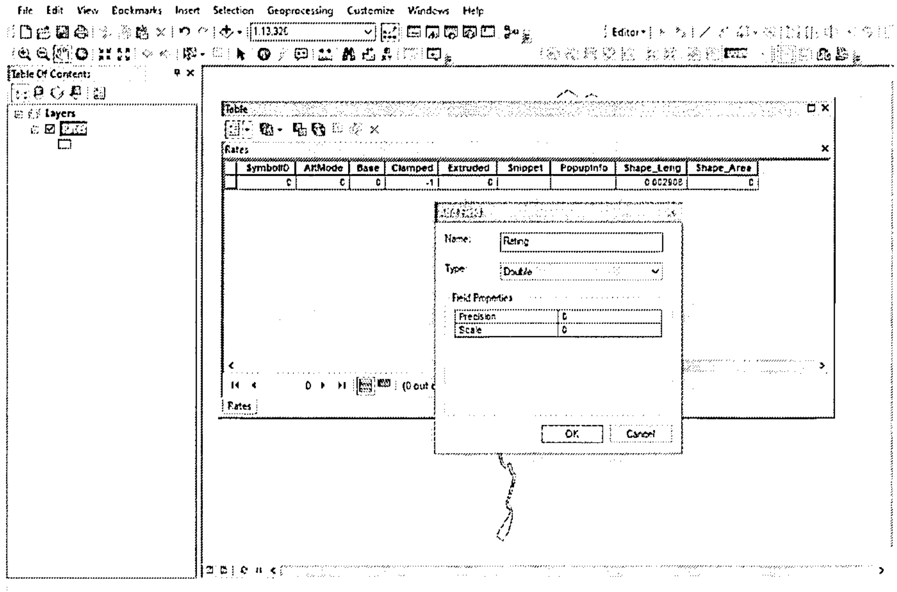


Fig. 41 Creation of rating field.

Add another field and name it '**Description**' and choose '**Text**'. Then, OK.

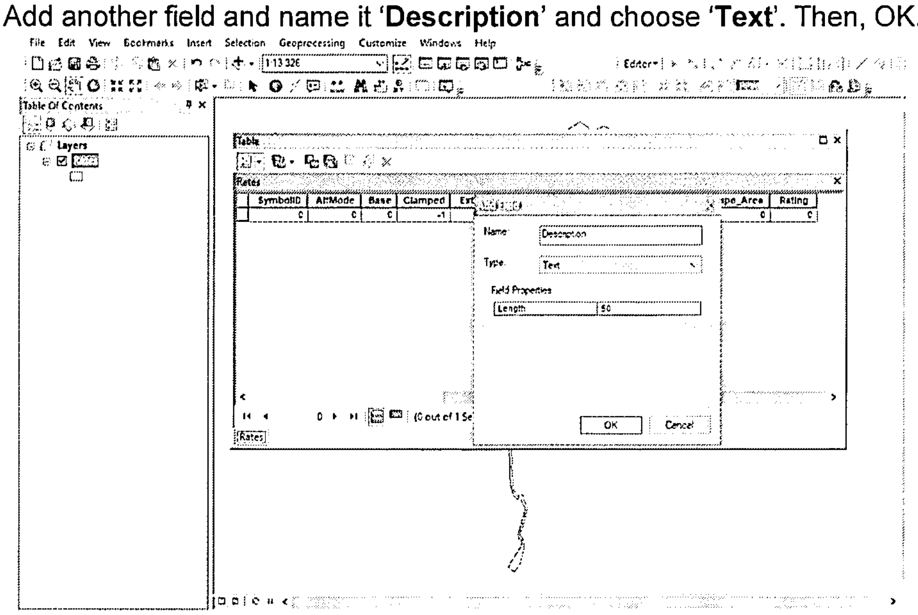


Fig. 42 Preparation of description field.

Next, right-click the parameter on Table content then click Start Editing to input the values for Ratings and Description on its Attribute Table.

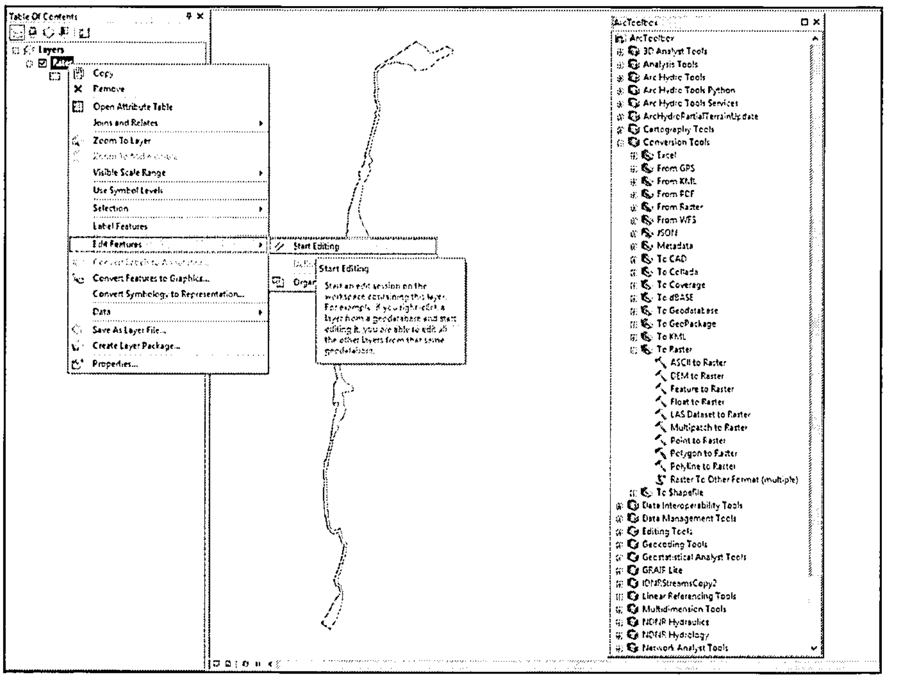


Fig. 43 Start of editing for rating and description values.

Edit the values for Ratings and Description (based on critical factor result).

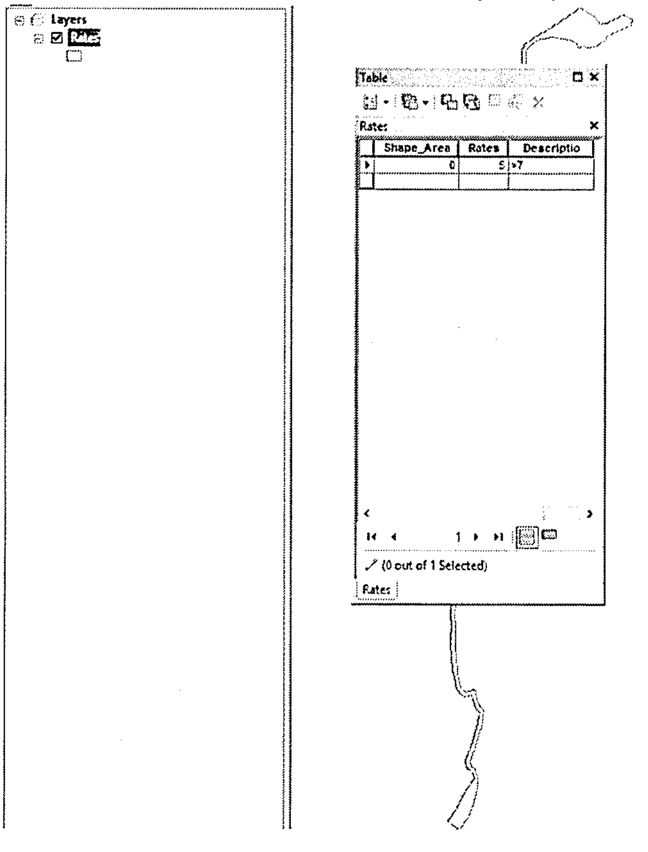


Fig. 44 Use of critical factor analysis results in ArcGIS.

After editing, navigate to Editor Toolbar then select Stop Editing and save edits.

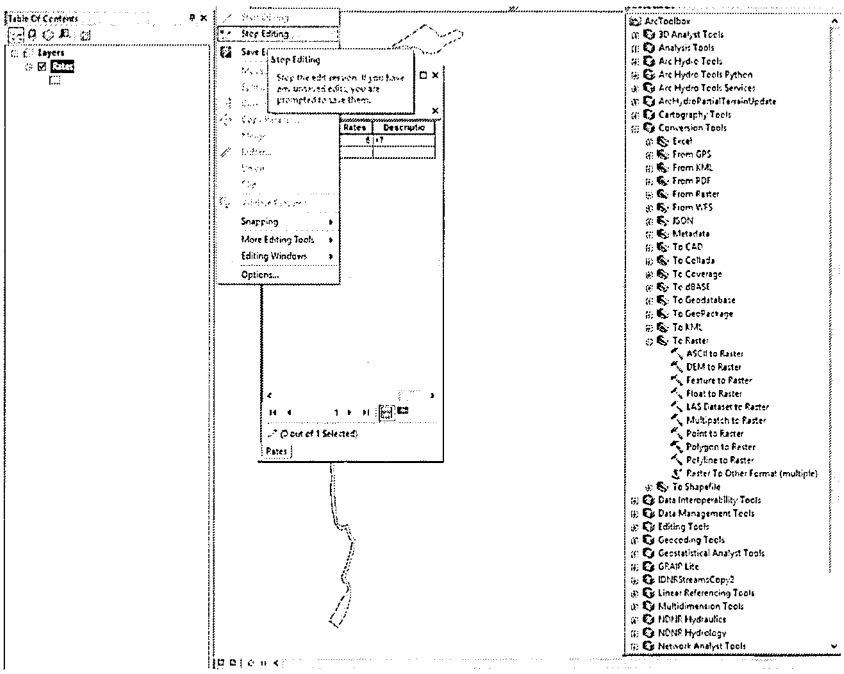


Fig. 45 Stop and save edit for the target parameter.

Now, proceed to Arc toolbox > Conversion Tools > To Raster > Polygon to Raster.

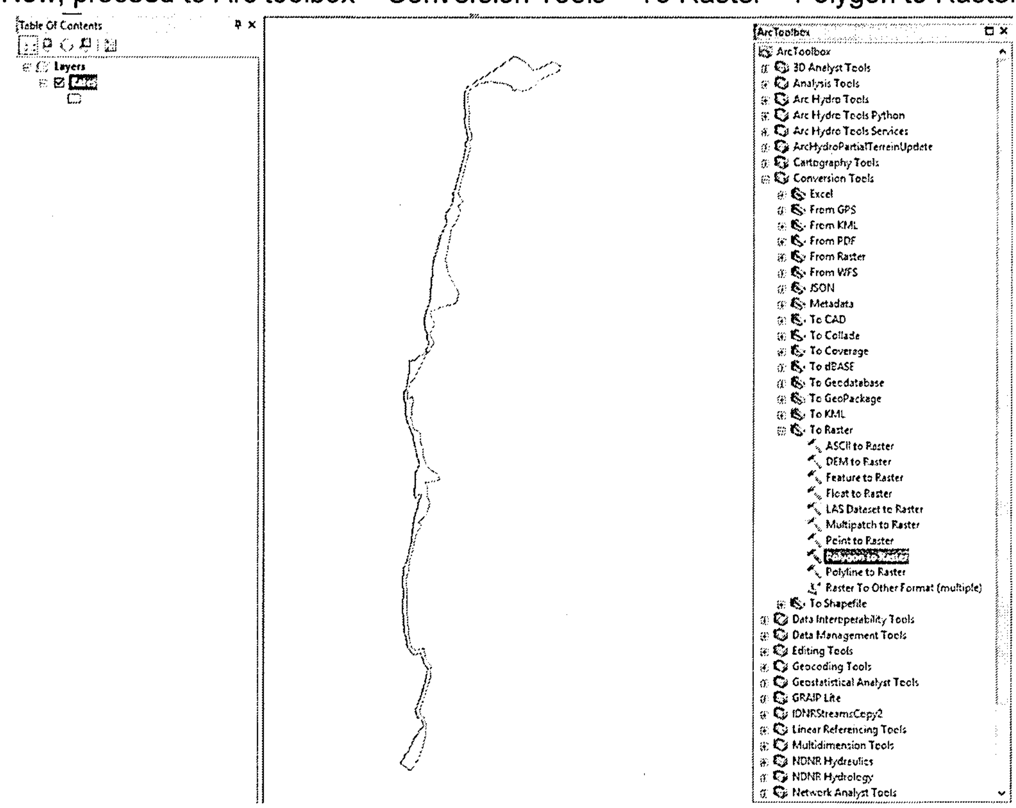


Fig. 46 Conversion of file.

Drag/Select 'Rates' vector for Input features, select 'Rating' for Value Field, create filename and locate your folder path on Output Raster Dataset, and type '10' on Cellsize then click OK to run.

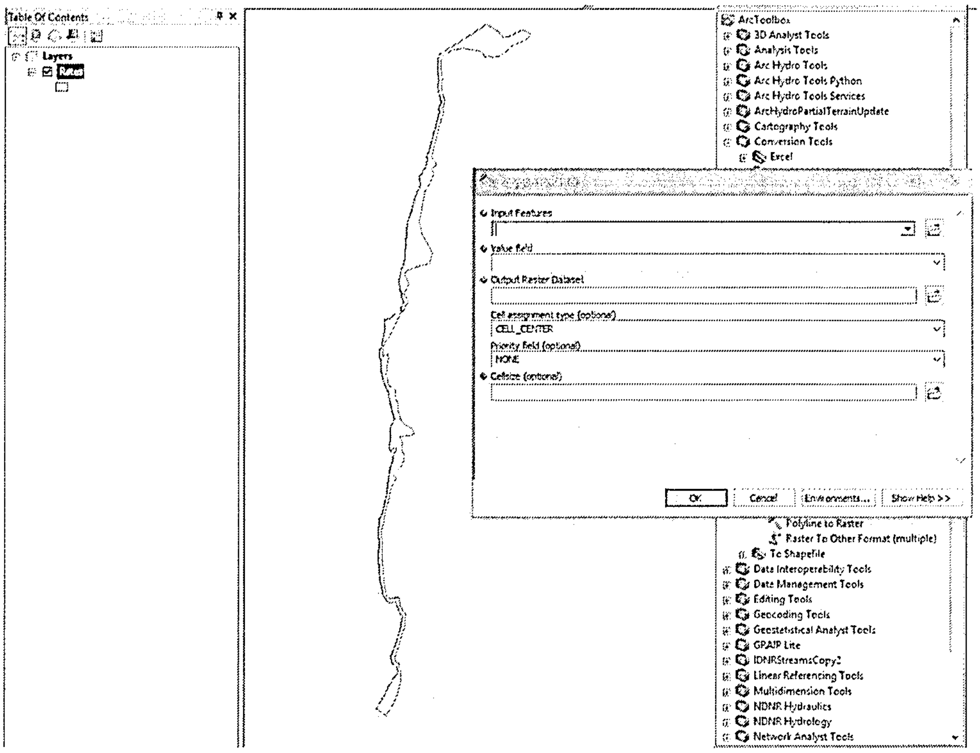


Fig. 47 Details of file conversion.

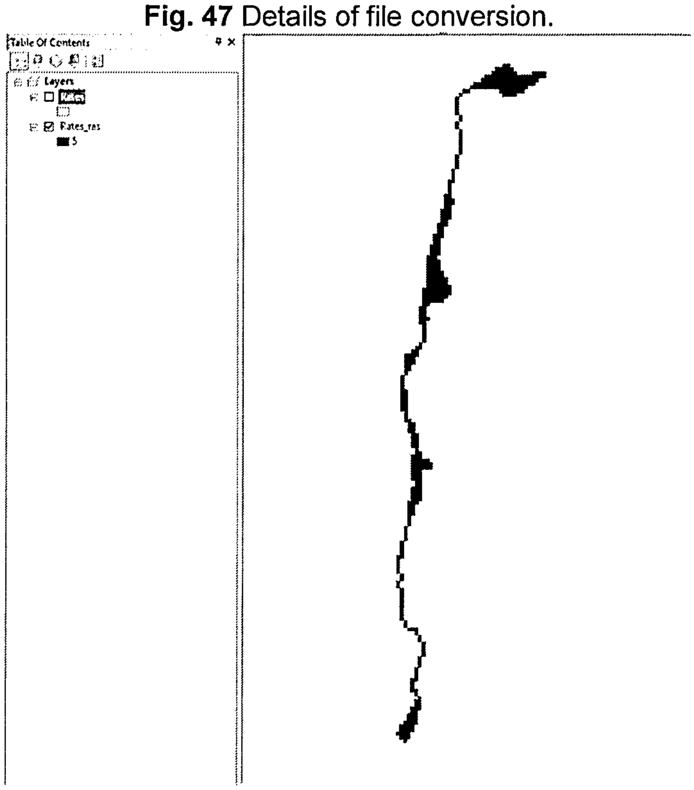


Fig. 48 Result of Polygon to Raster conversion of Rates parameter.

Conversion of raster file to float file and generation of thematic maps

Float

This converts each cell value of a raster into a floating point representation. Basically, the values you get from converting a polygon to raster is represented by float values which will then be used in computing the CIV using raster calculator.

Navigate to Arctoolbox > Spatial Analysis > Math > Float

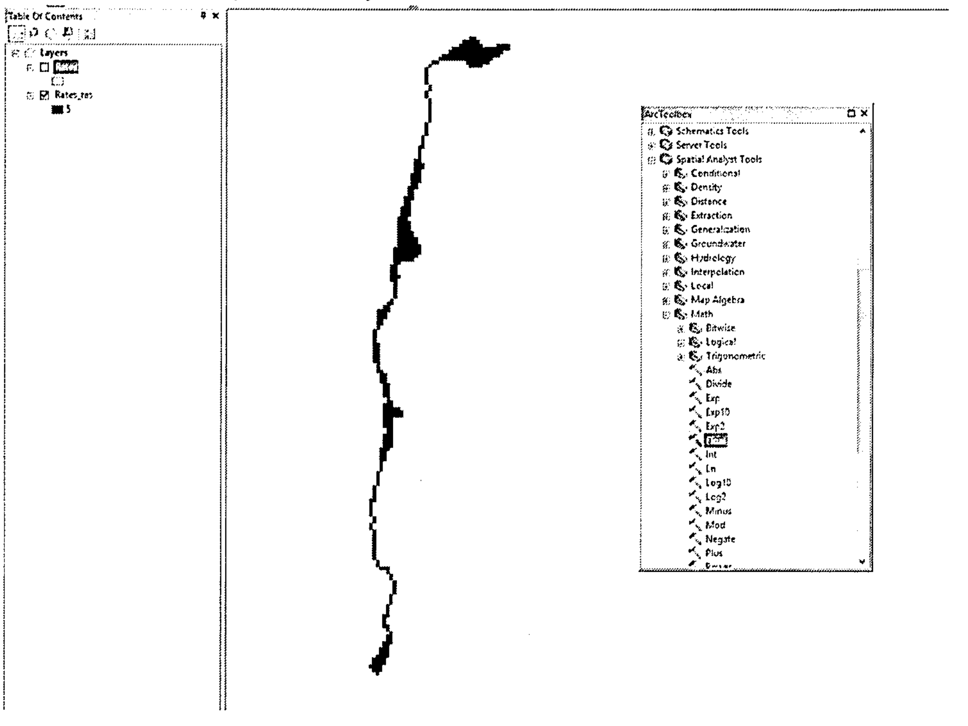


Fig. 49 Start of conversion from raster to float.

Drag/Select 'Rates_ras' on Input raster, and create your filename and locate your folder path, then click OK to run.

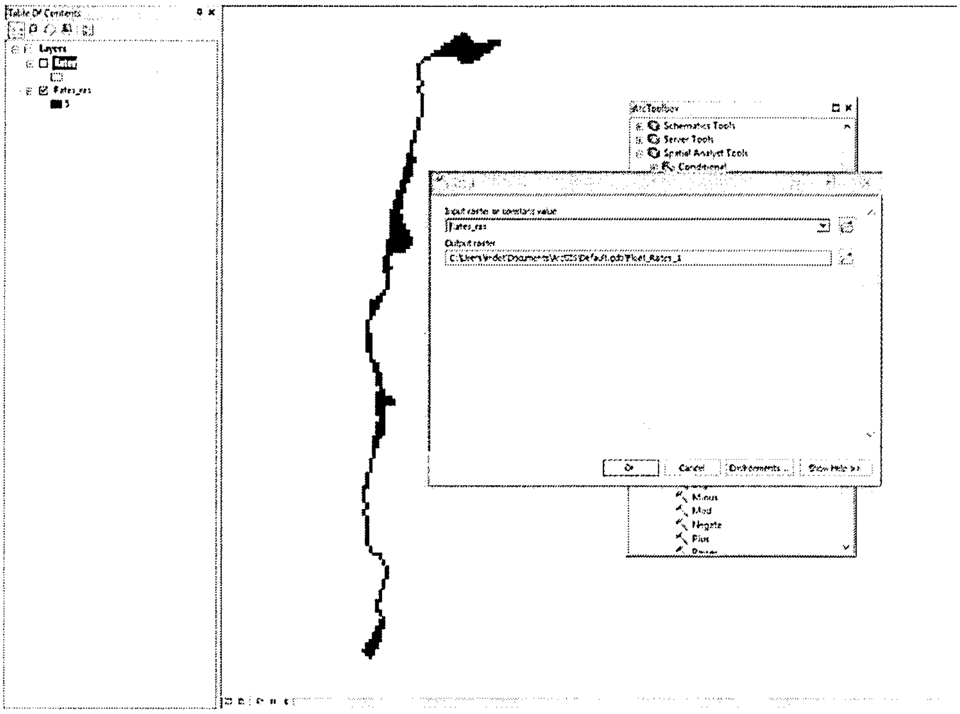


Fig. 50 Creation of geodatabase for float layer.

The generated float layers will be used in the generation of thematic maps for each parameter in the critical factor analysis under the hazard of interest.

Table 9. Color scheme for critical factor analysis.

Degree	Score
Very high susceptibility	5
High susceptibility	4
[illegible]	3
Low susceptibility	2
Very low susceptibility	1

Exposure

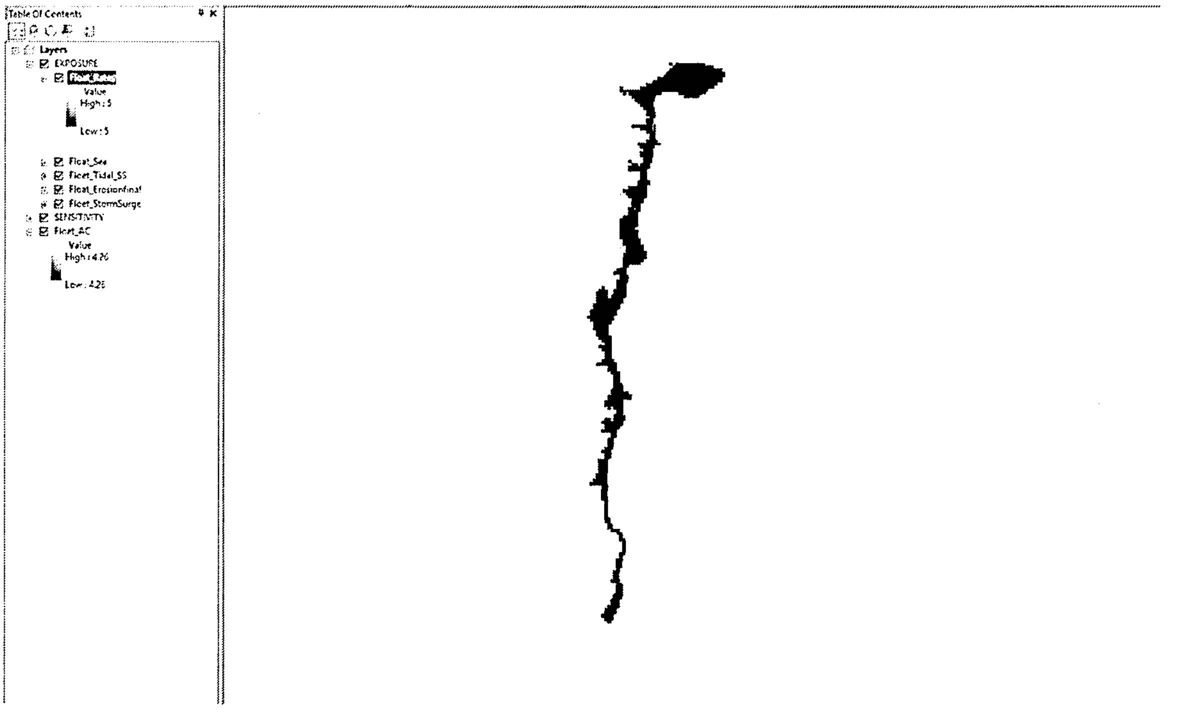


Fig. 51 Preparation of thematic map based on rates of sea level rise.

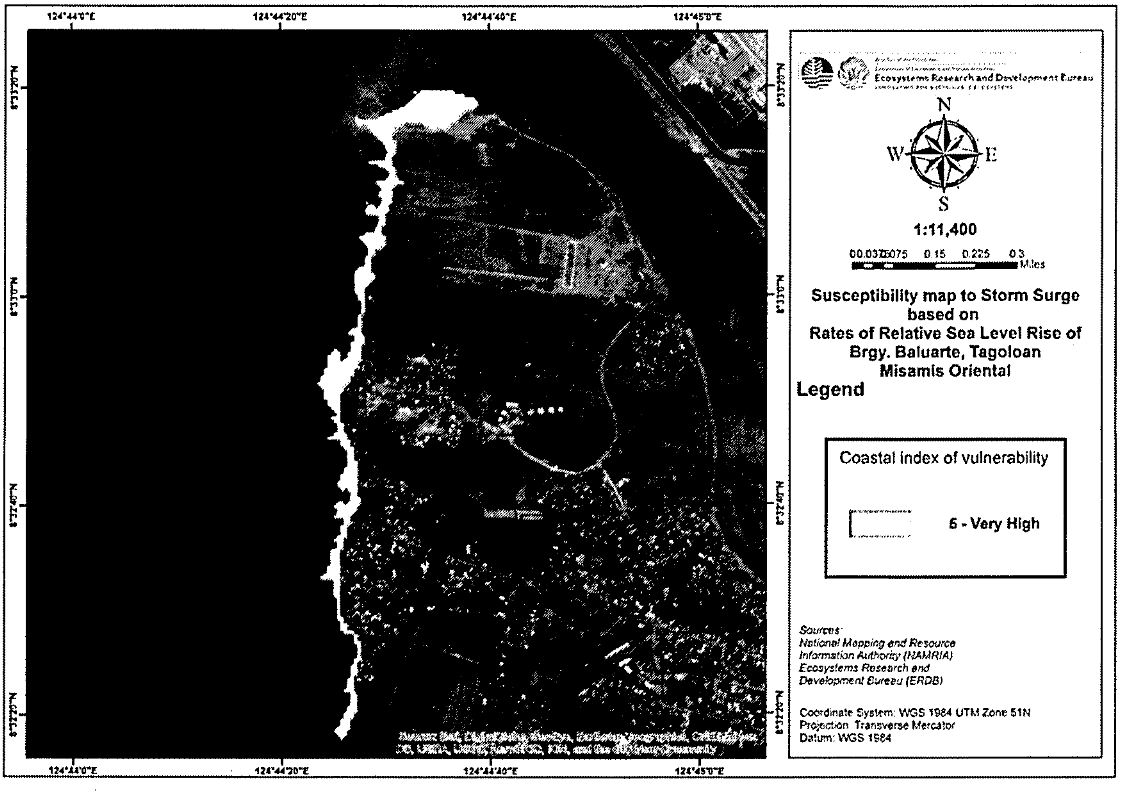


Fig. 52 Susceptibility map to storm surge based on rates of SLR.

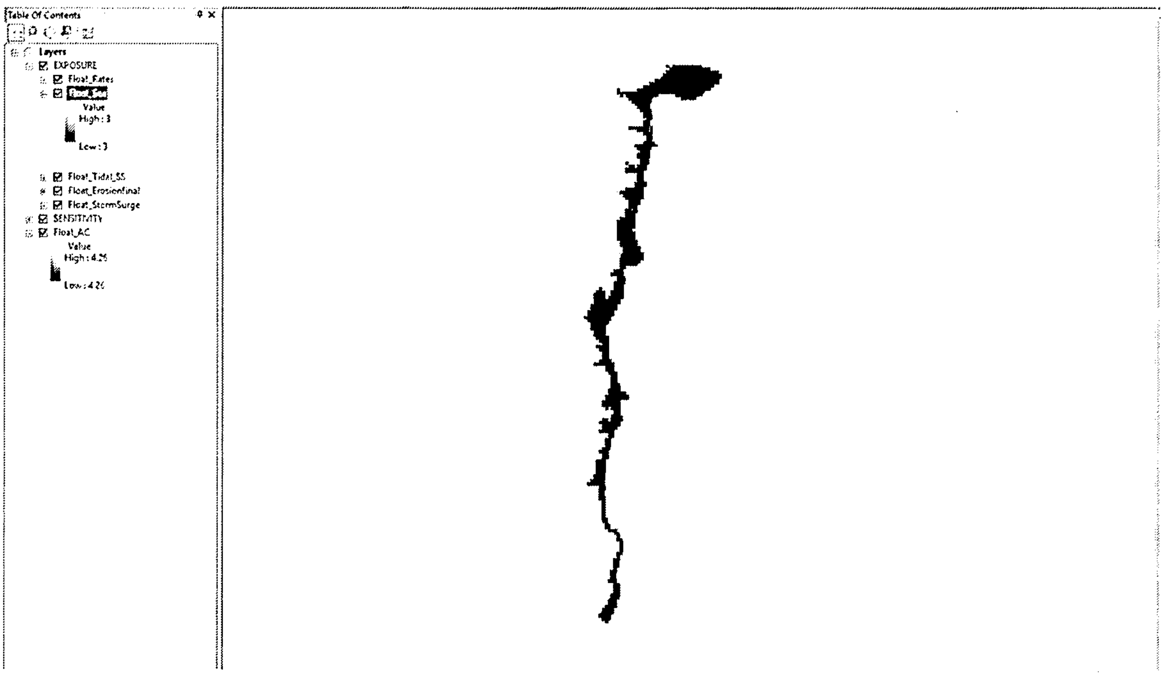


Fig. 53 Preparation of thematic map based on SLR exposure.

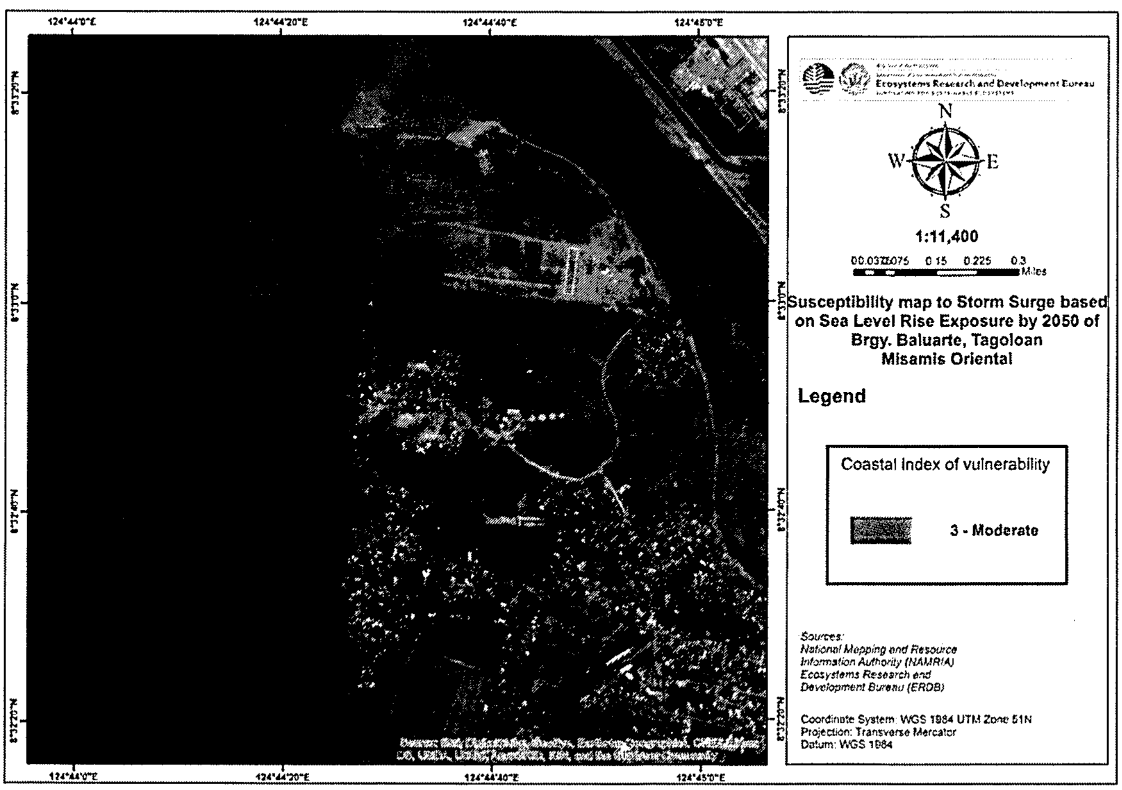


Fig. 54 Susceptibility map to storm surge based on sea level rise exposure (2050).

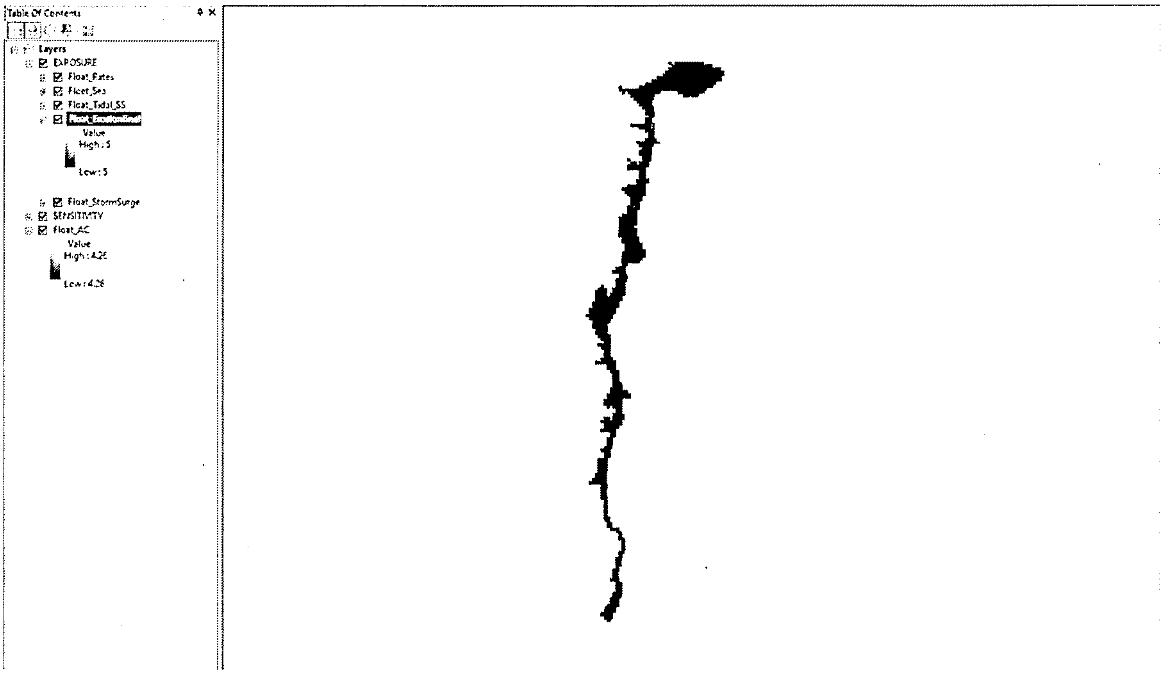


Fig. 55 Preparation of thematic map based on erosion or accretion rates.

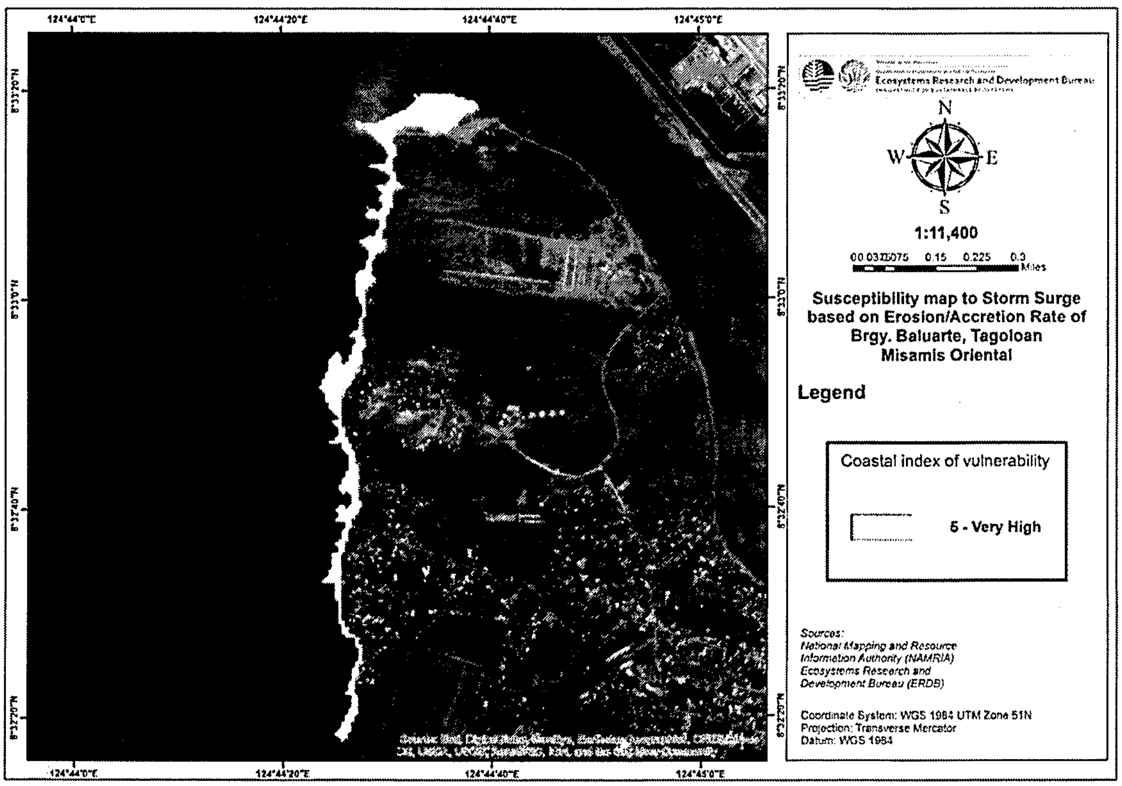


Fig. 56 Susceptibility map to storm surge based on shoreline change pattern.

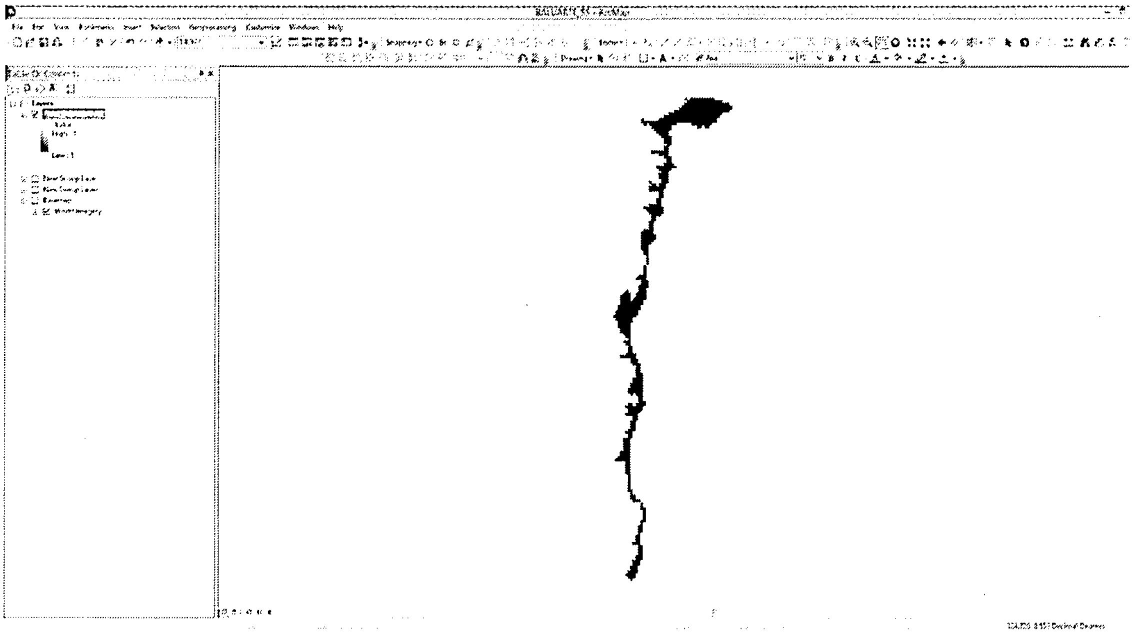


Fig. 57 Preparation of thematic map based on tidal range.

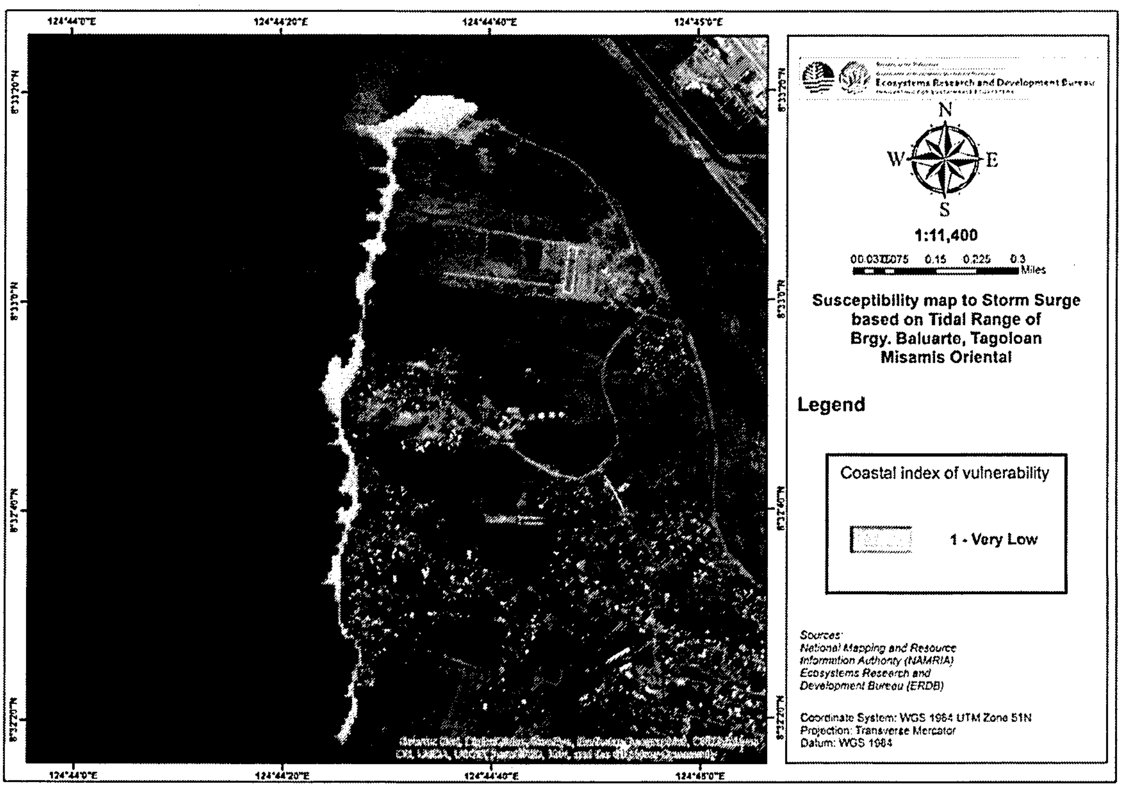


Fig. 58 Susceptibility map to storm surge based on tidal range.

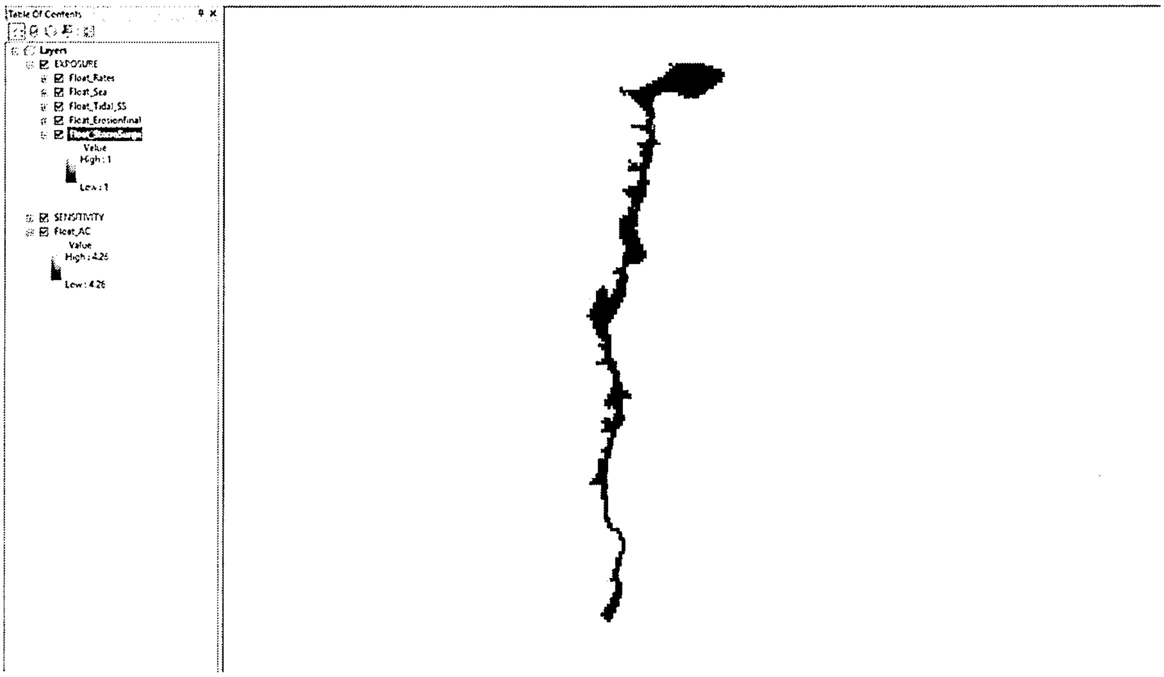


Fig. 59 Preparation of thematic map based on storm surge inundation at SSA1.

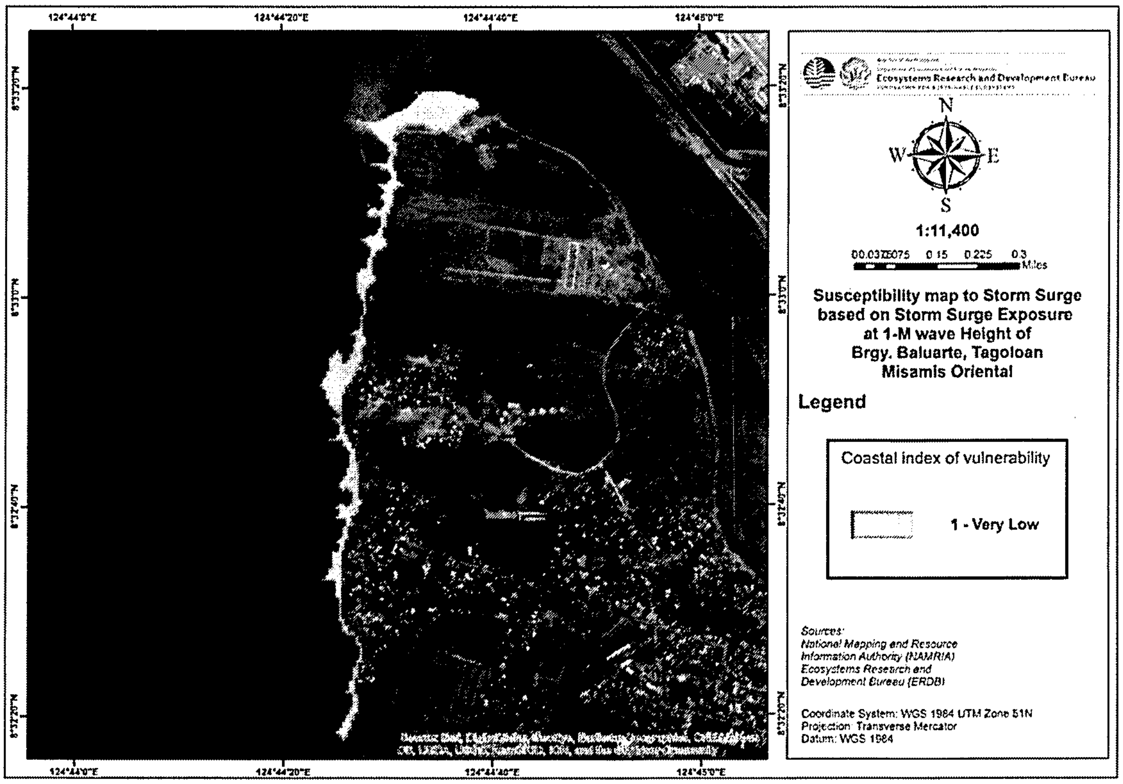


Fig. 60 Susceptibility map to storm surge based on storm surge exposure at SSA 1.

Sensitivity

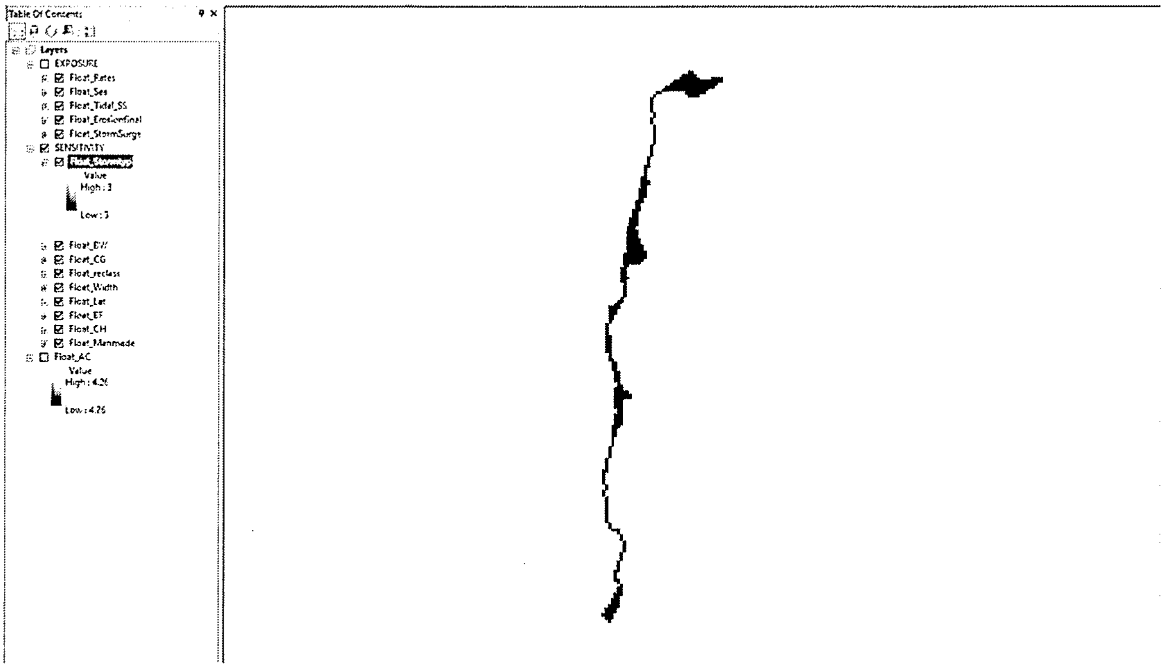


Fig. 61 Preparation of thematic map based on storm frequency.

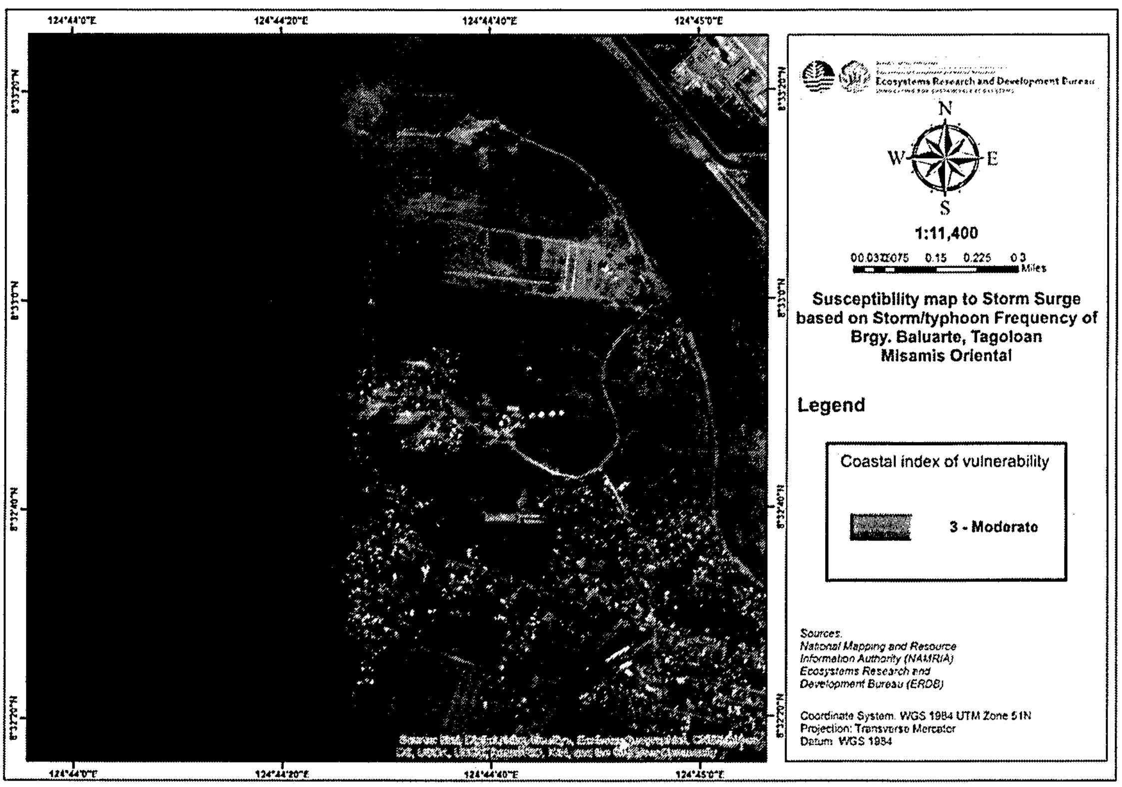


Fig. 62 Susceptibility map to storm surge based on typhoon frequency.

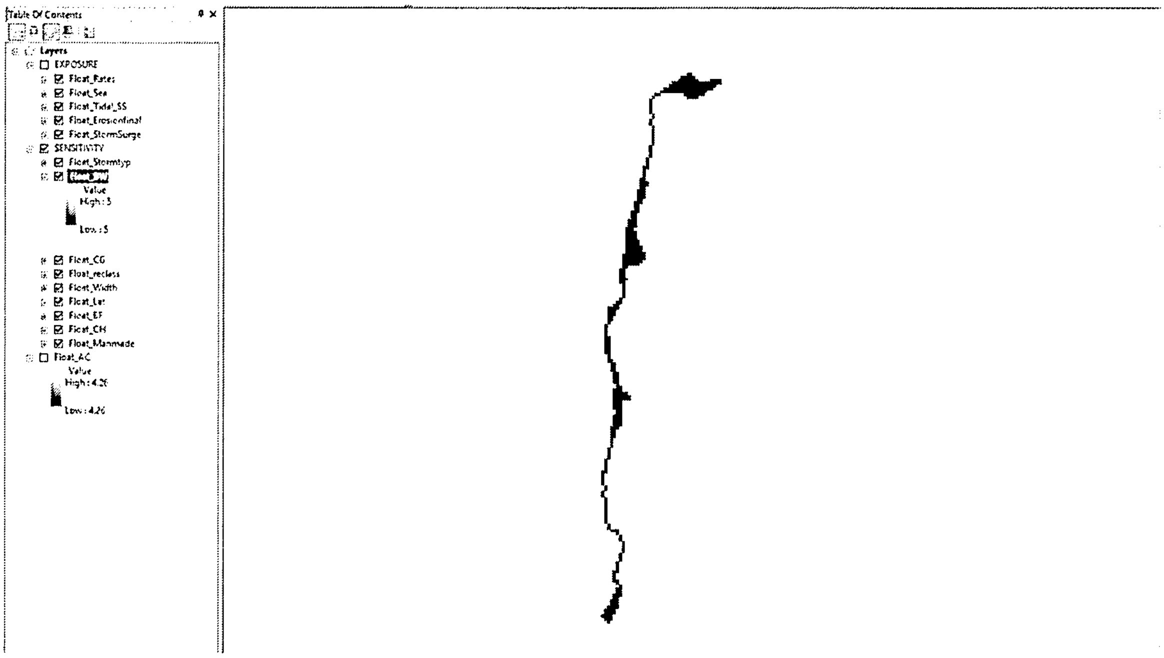


Fig. 63 Preparation of thematic map based on beach width.

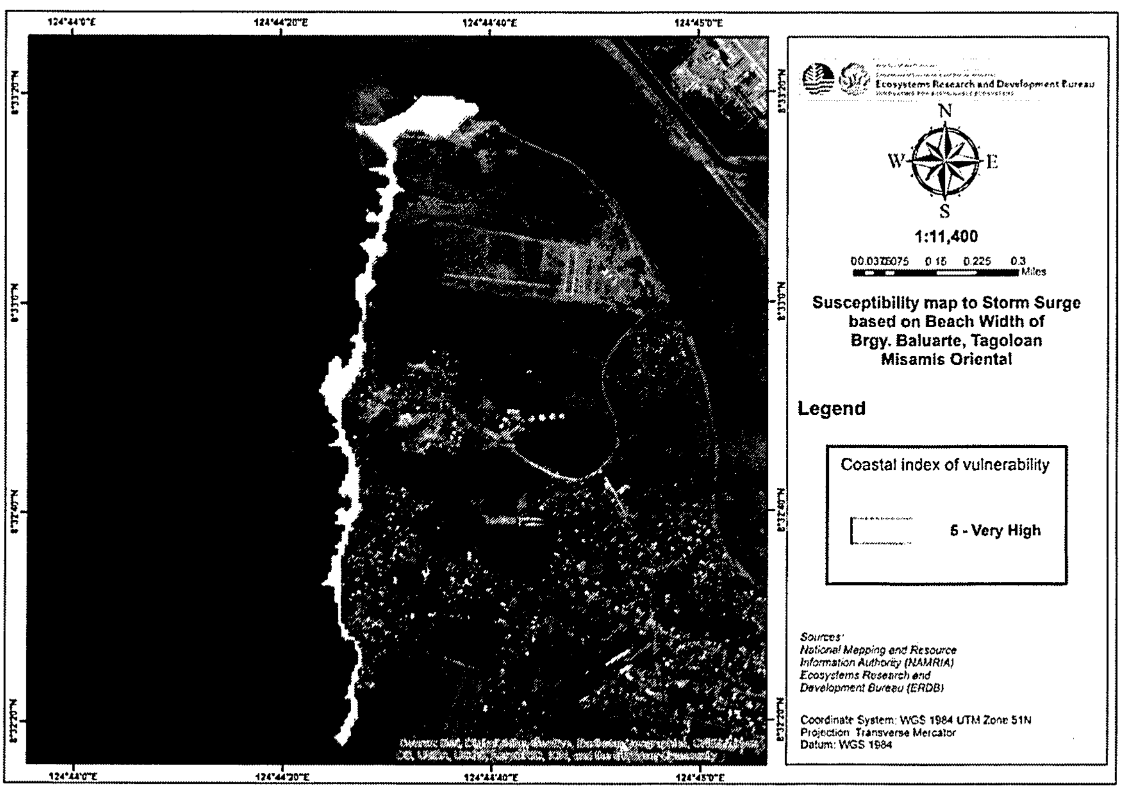


Fig. 64 Susceptibility map to storm surge based on beach width.

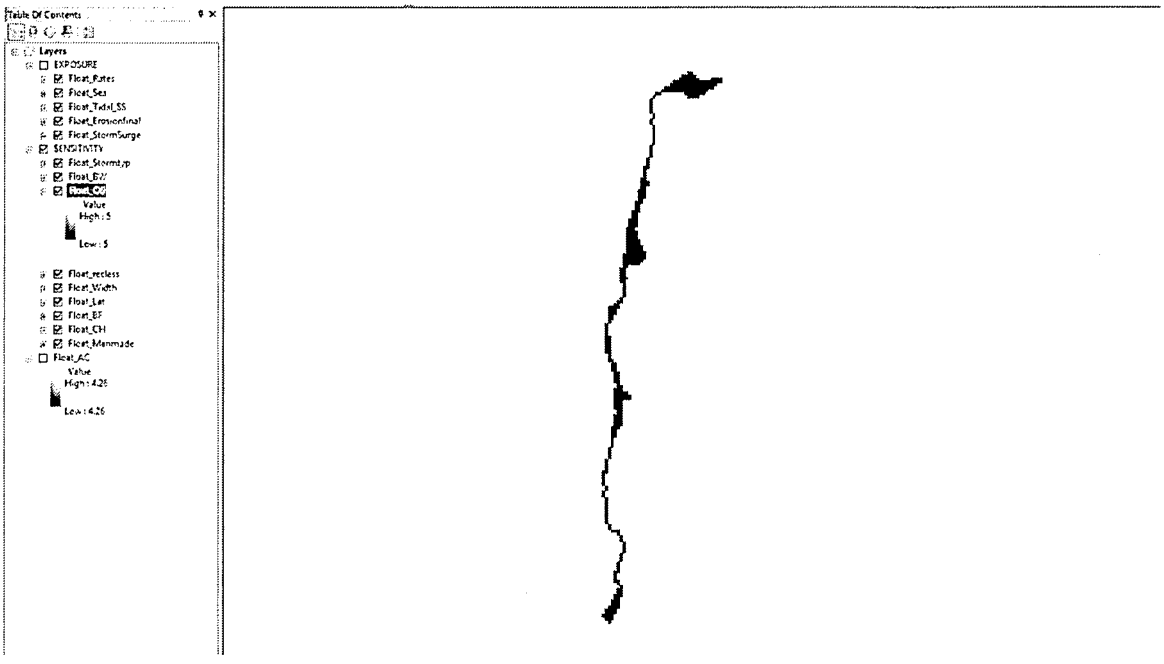


Fig. 65 Preparation of thematic map based on geomorphology.

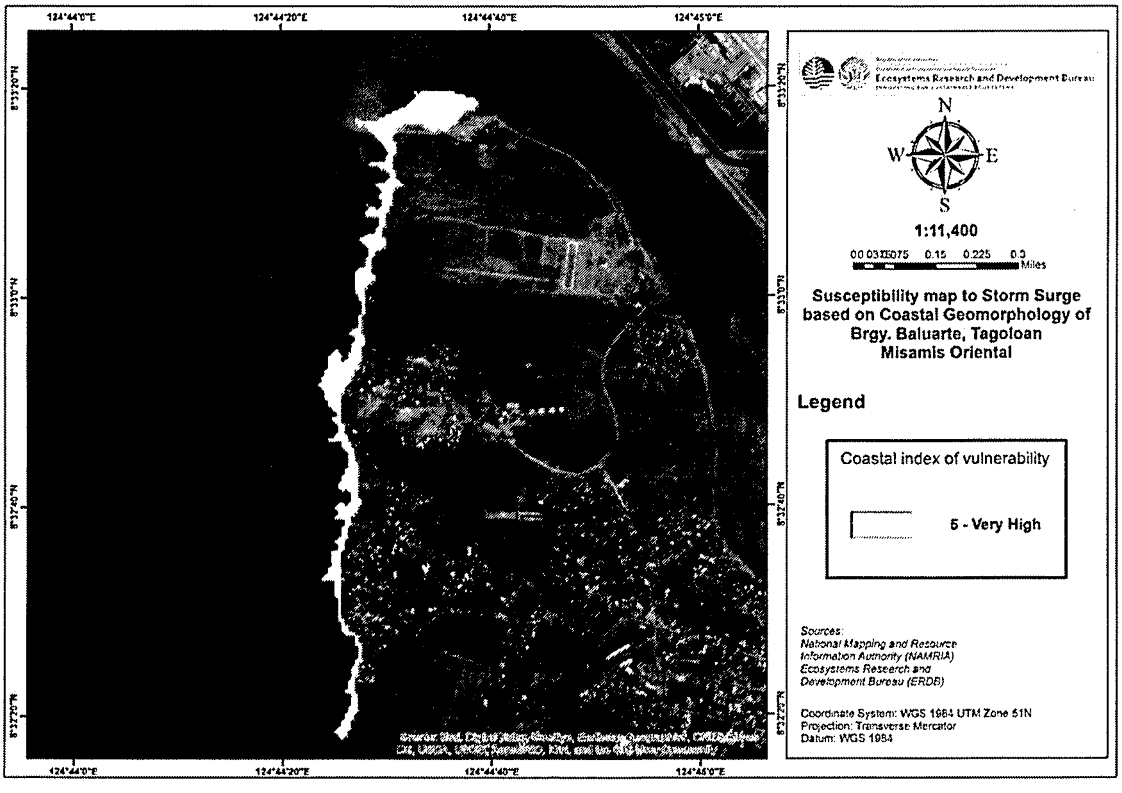


Fig. 66 Susceptibility map to storm surge based on coastal geomorphology feature.

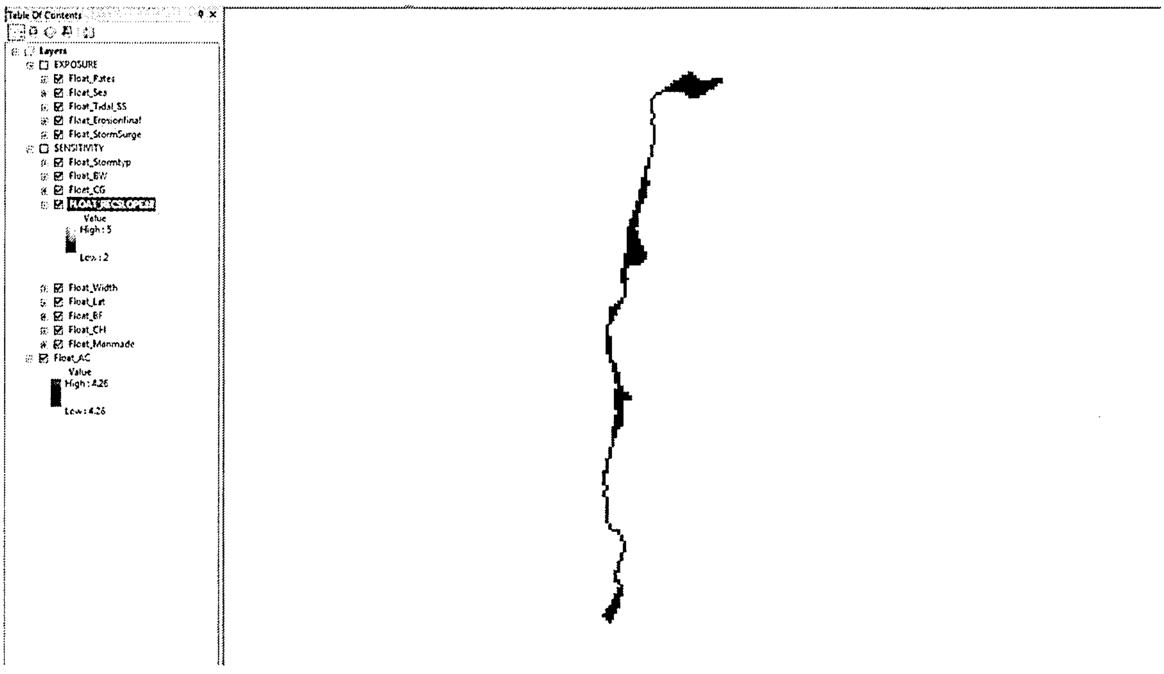


Fig. 67 Preparation of thematic map based on slope.

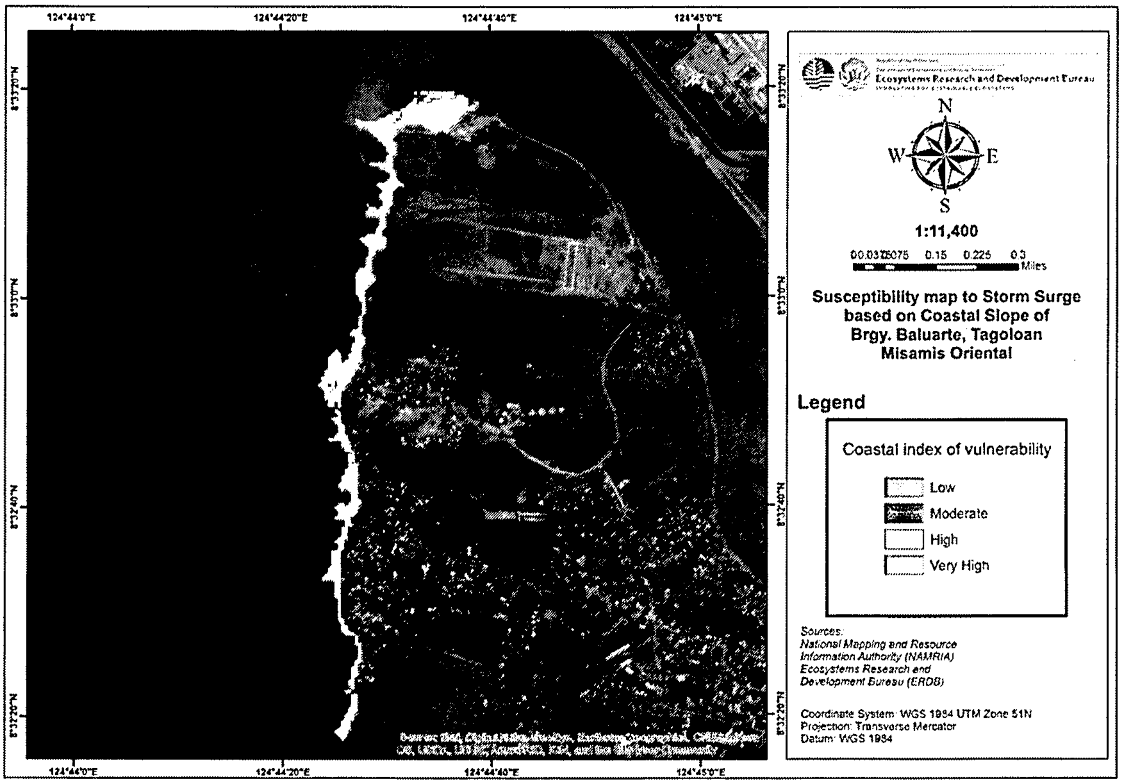


Fig. 68 Susceptibility map to storm surge based on slope.

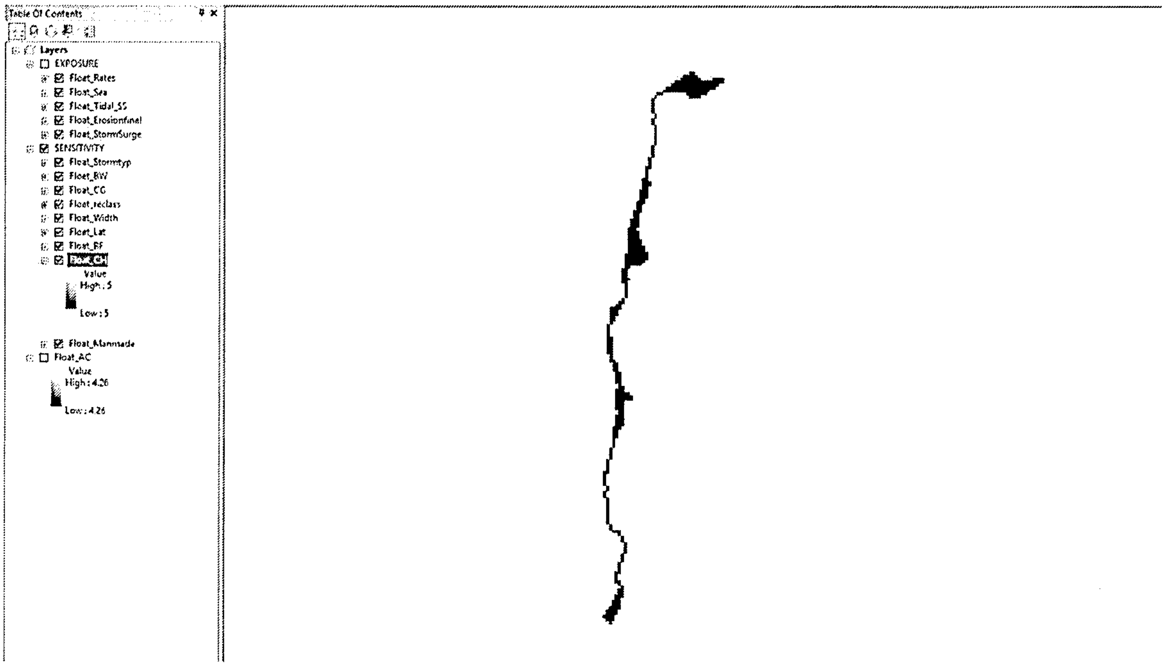


Fig. 69 Preparation of thematic map based on coastal habitat.

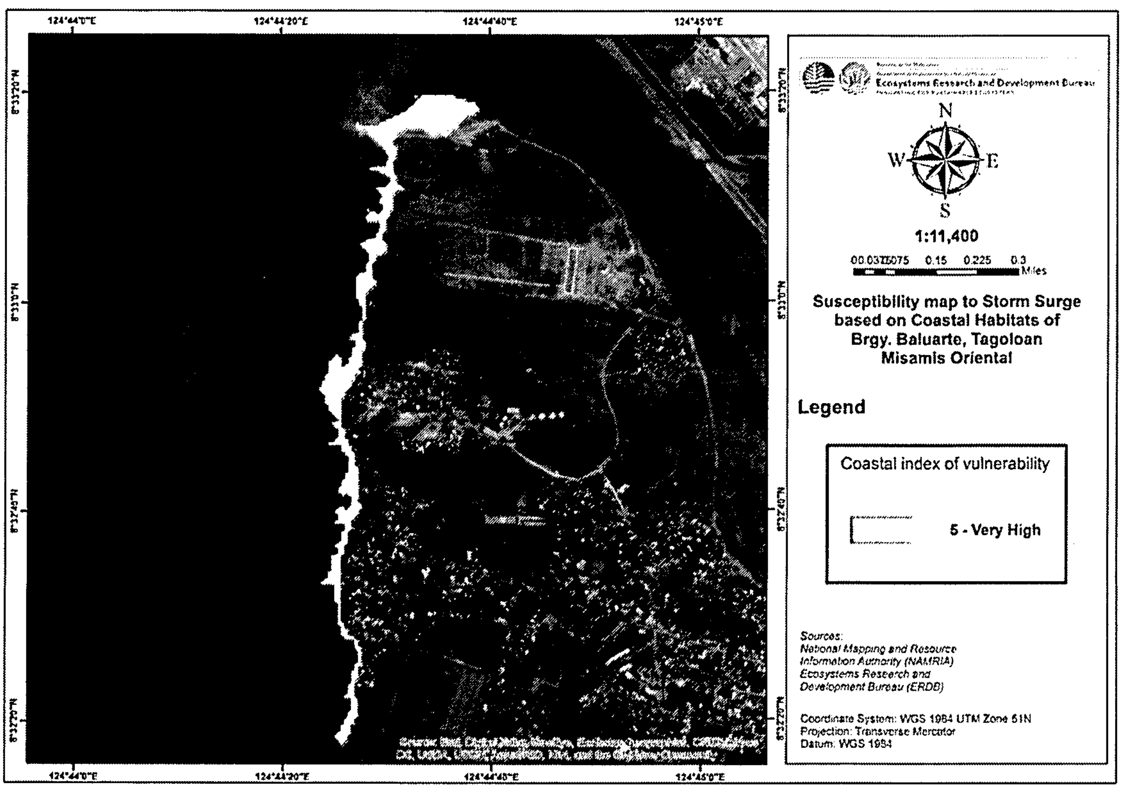


Fig. 70 Susceptibility map to storm surge based on existing coastal habitat.

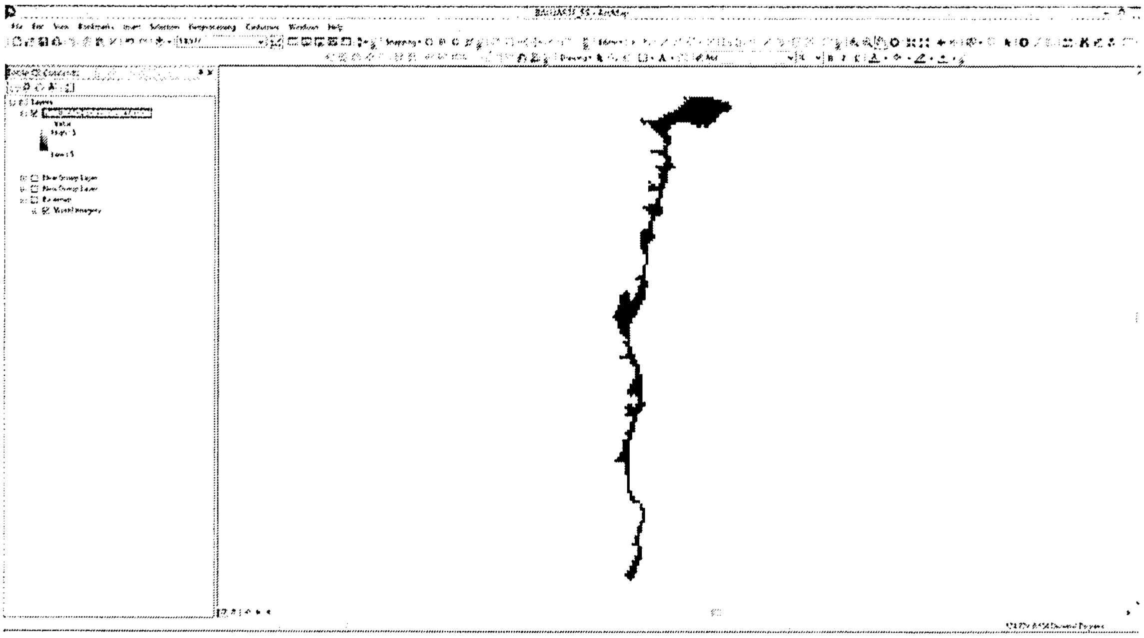


Fig. 71 Preparation of thematic map based on vegetation.

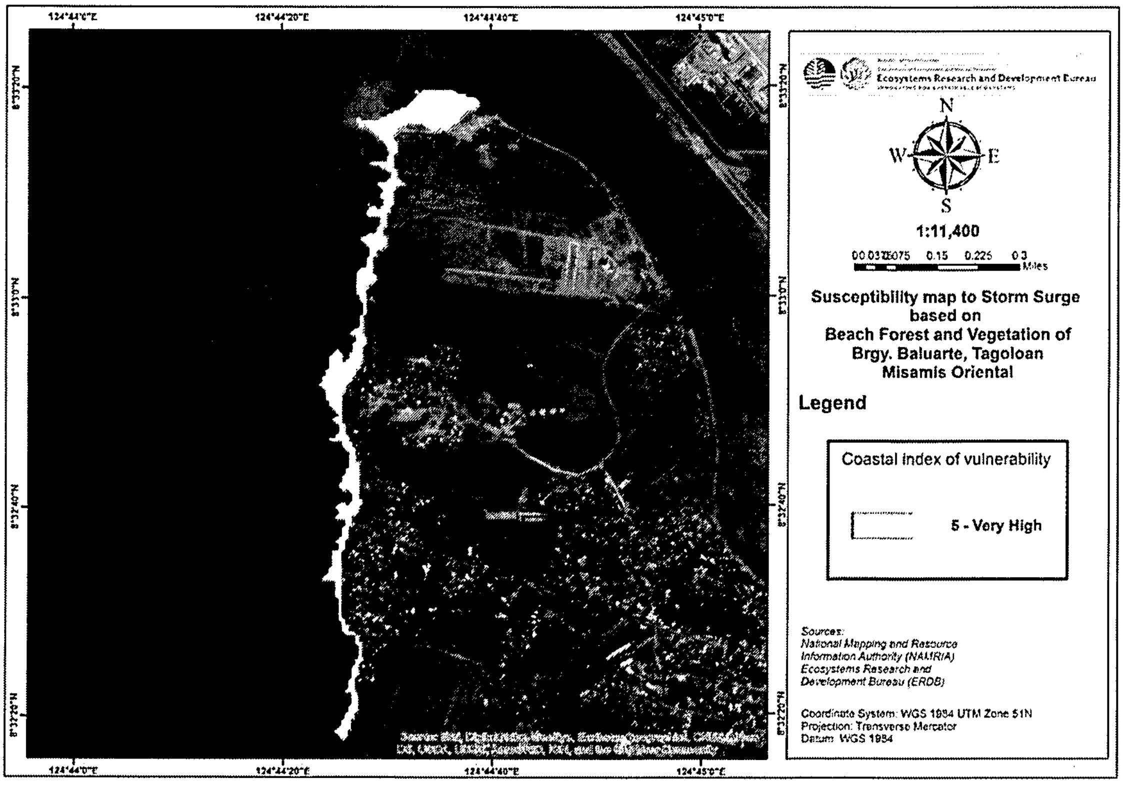


Fig. 72 Susceptibility map to storm surge based on beach forest and vegetation.

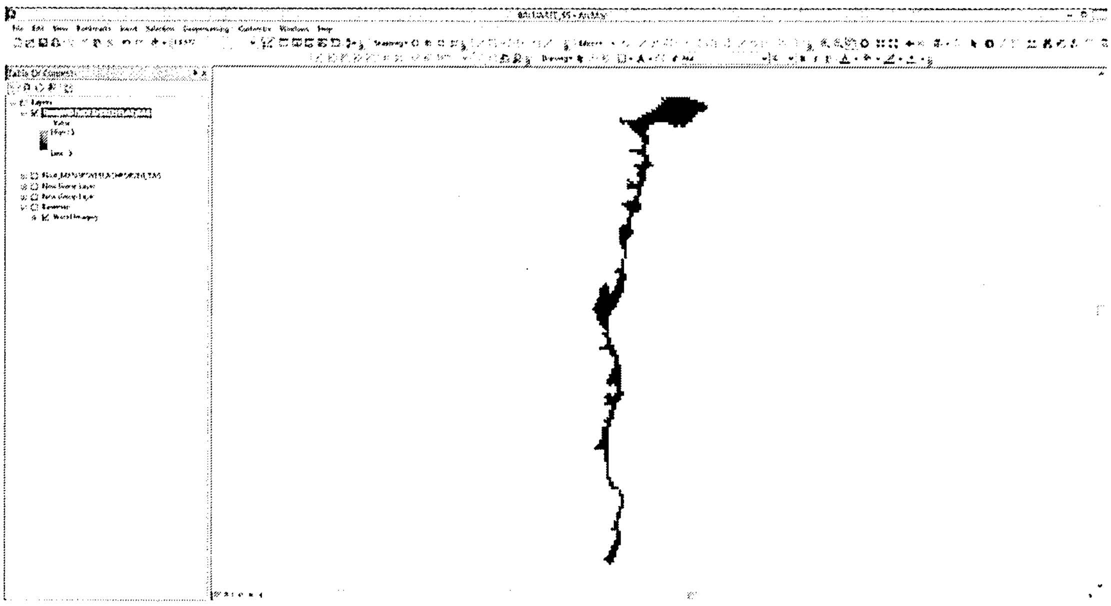


Fig. 73 Preparation of thematic map based on width of the reef flat.

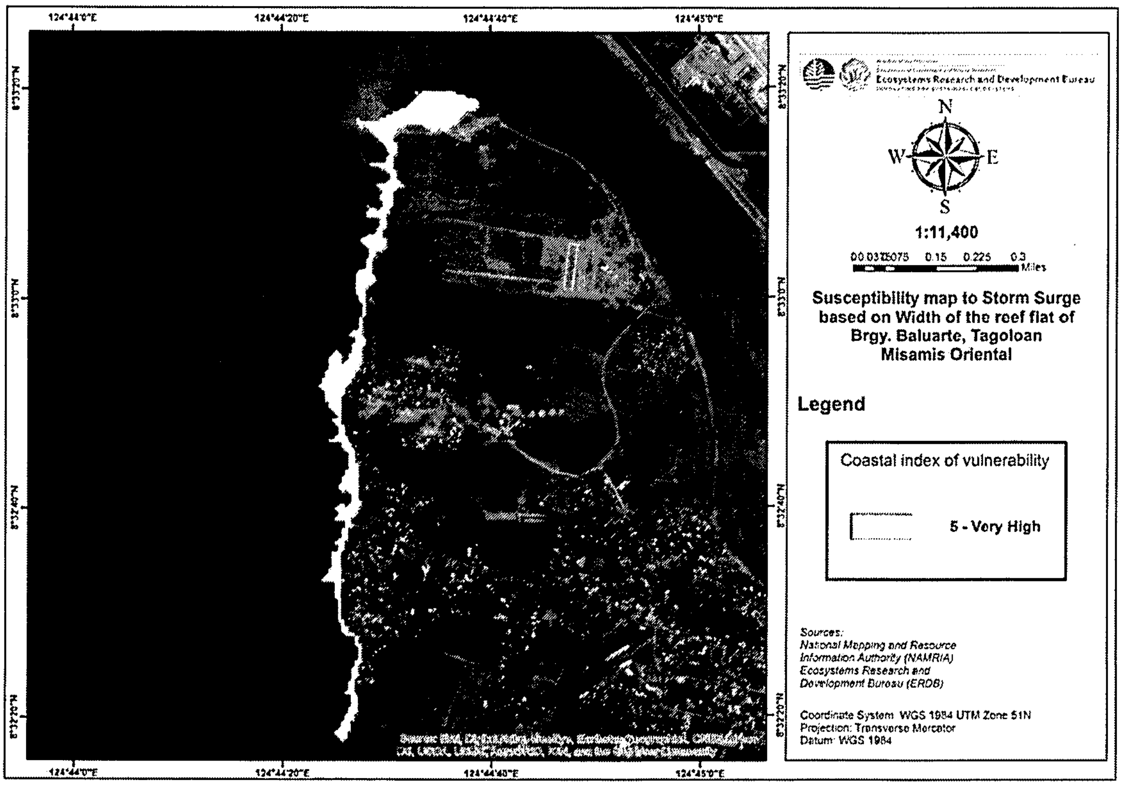


Fig. 74 Susceptibility map to storm surge based on width of the reef flat.

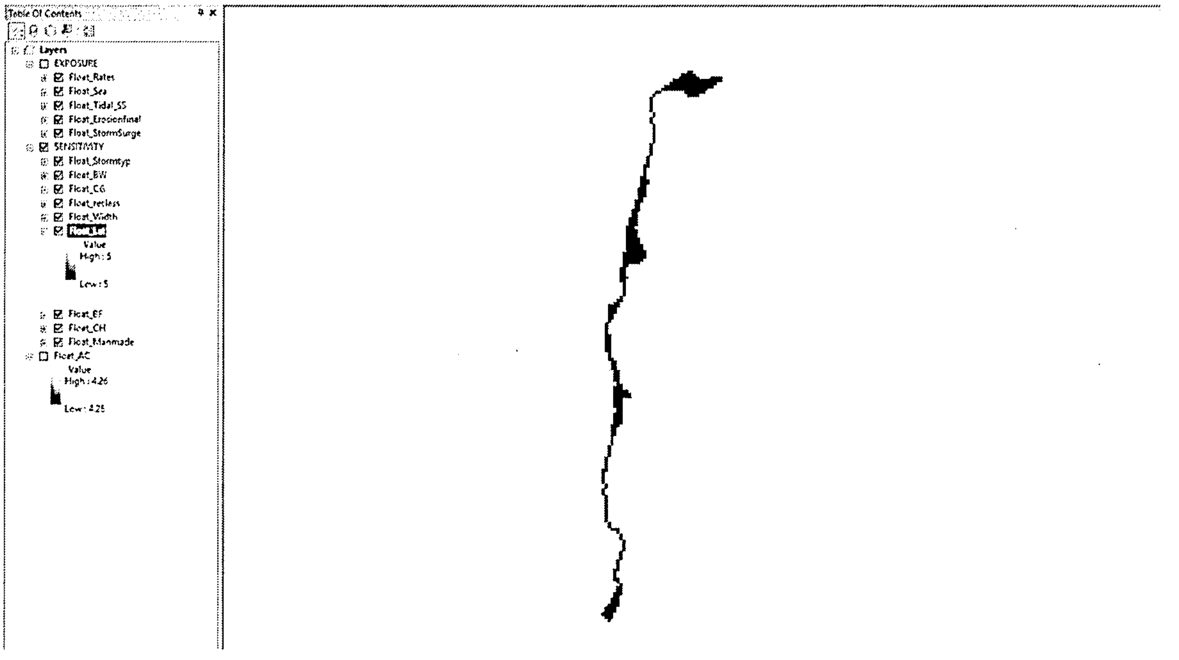


Fig. 75 Preparation of thematic map based on lateral extent of the reef.

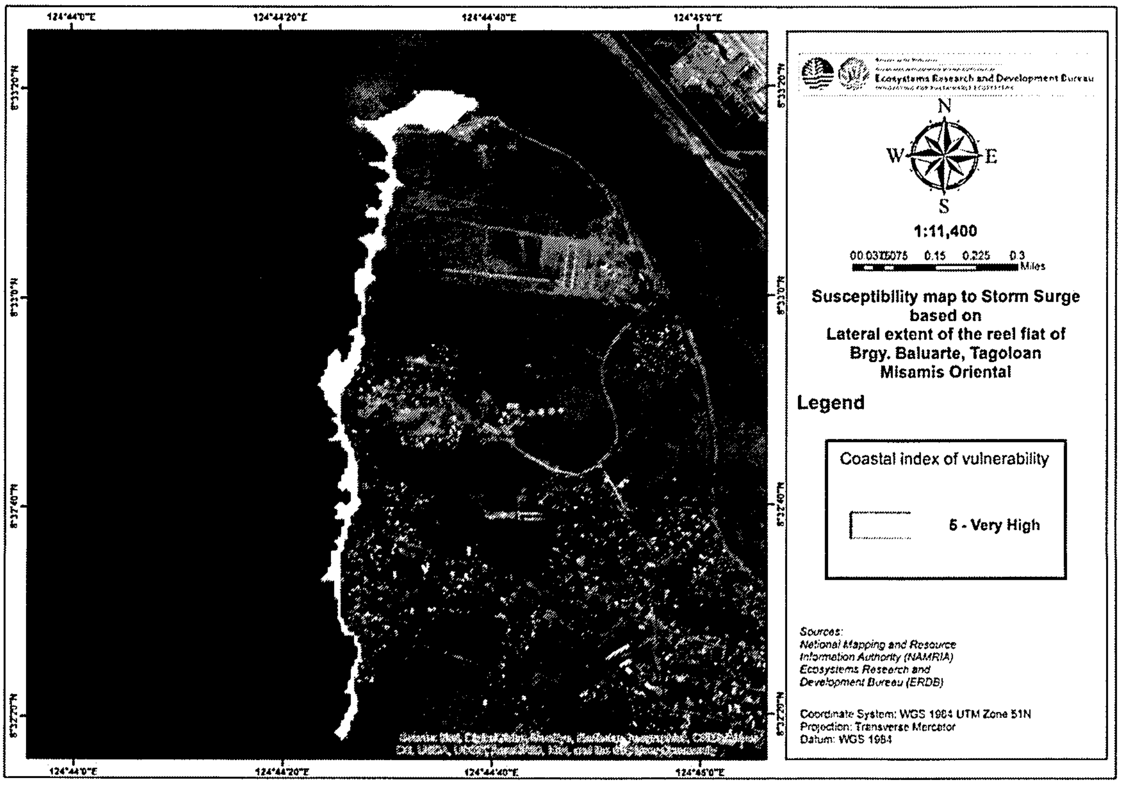


Fig. 76 Susceptibility map to storm surge based on lateral extent of reef flat.

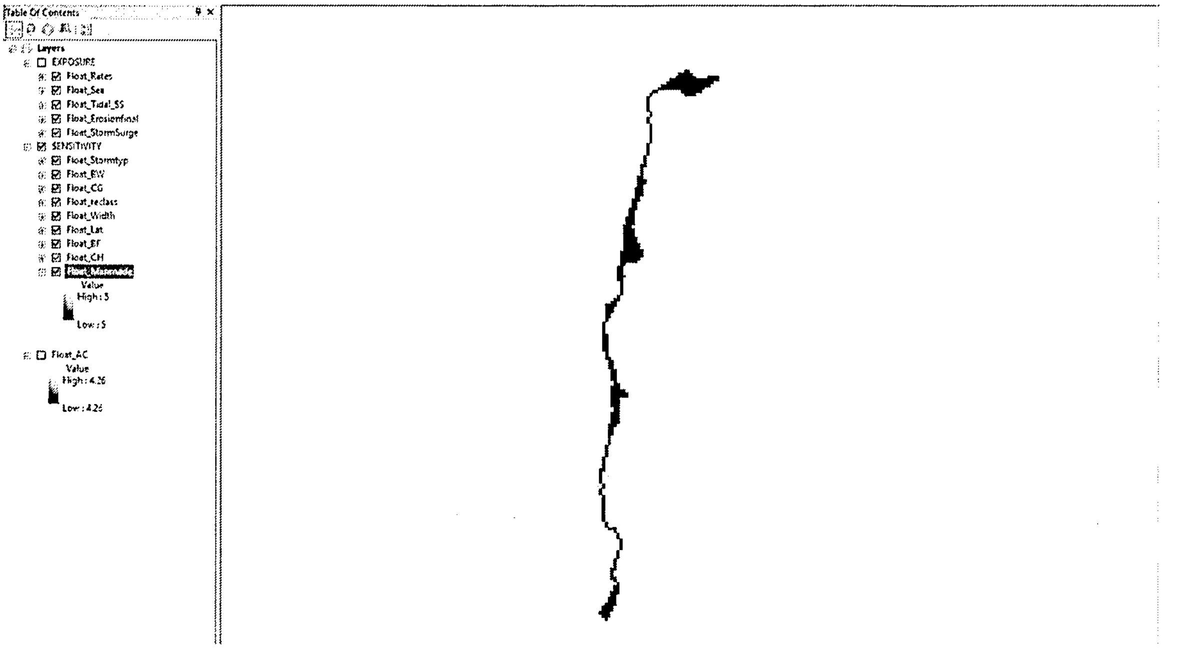


Fig. 77 Preparation of thematic map based on manmade structures.

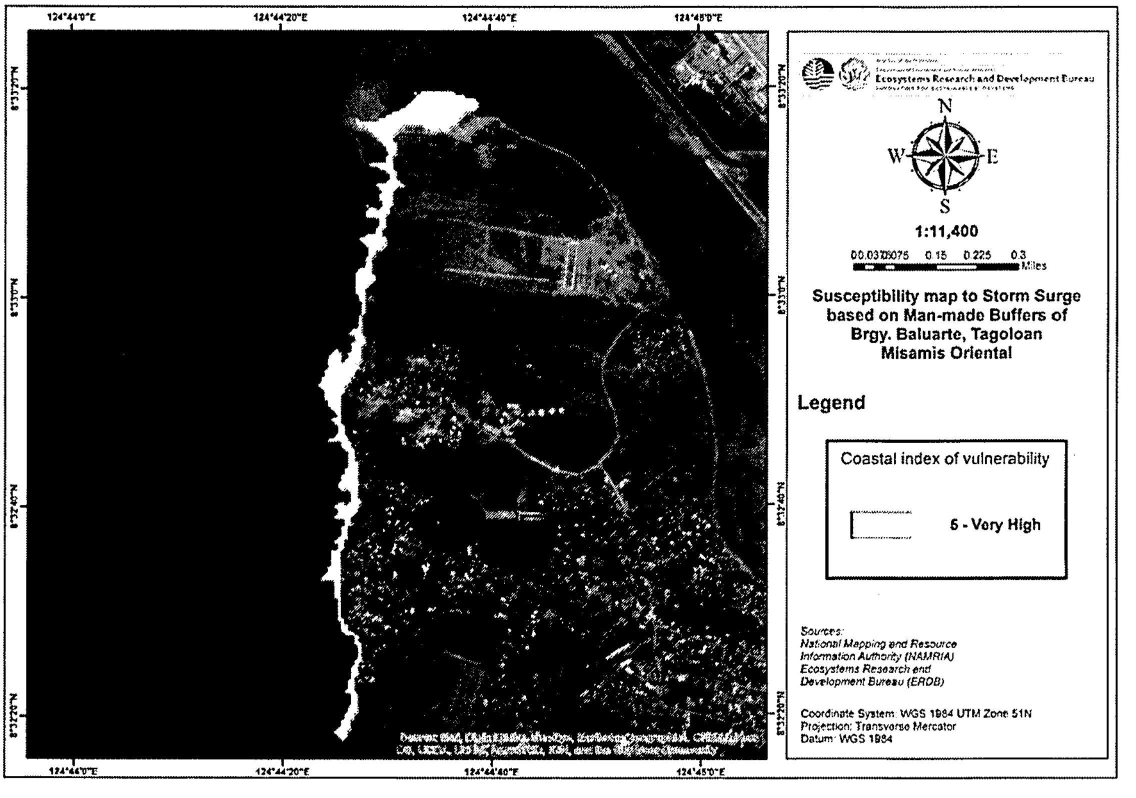


Fig. 78 Susceptibility map to storm surge based on man-made buffers.

Adaptive capacity

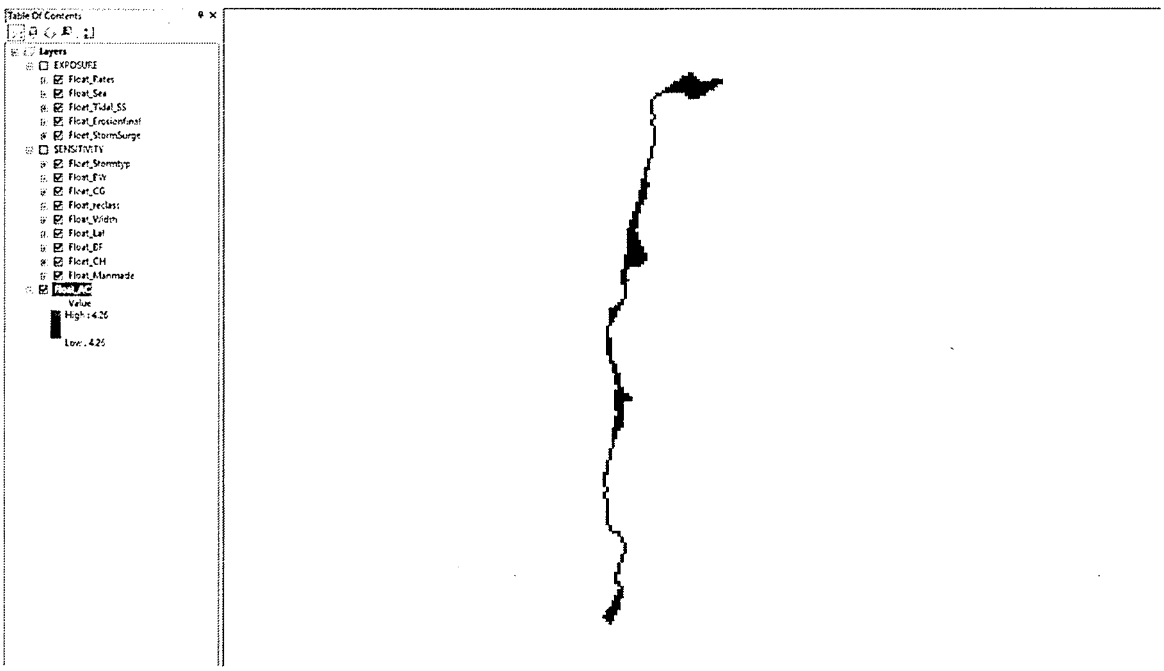


Fig. 79 Preparation of thematic map based on adaptive capacity.

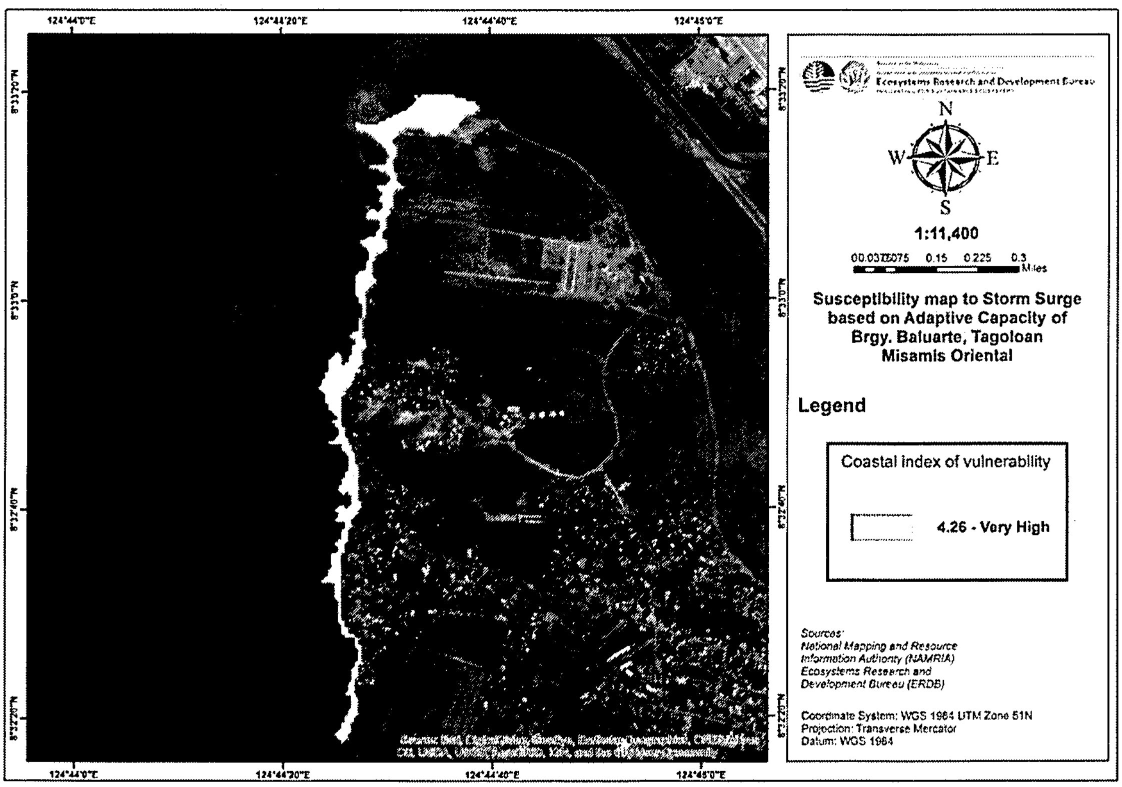


Fig. 80 Susceptibility map to storm surge based on adaptive capacity of the community.

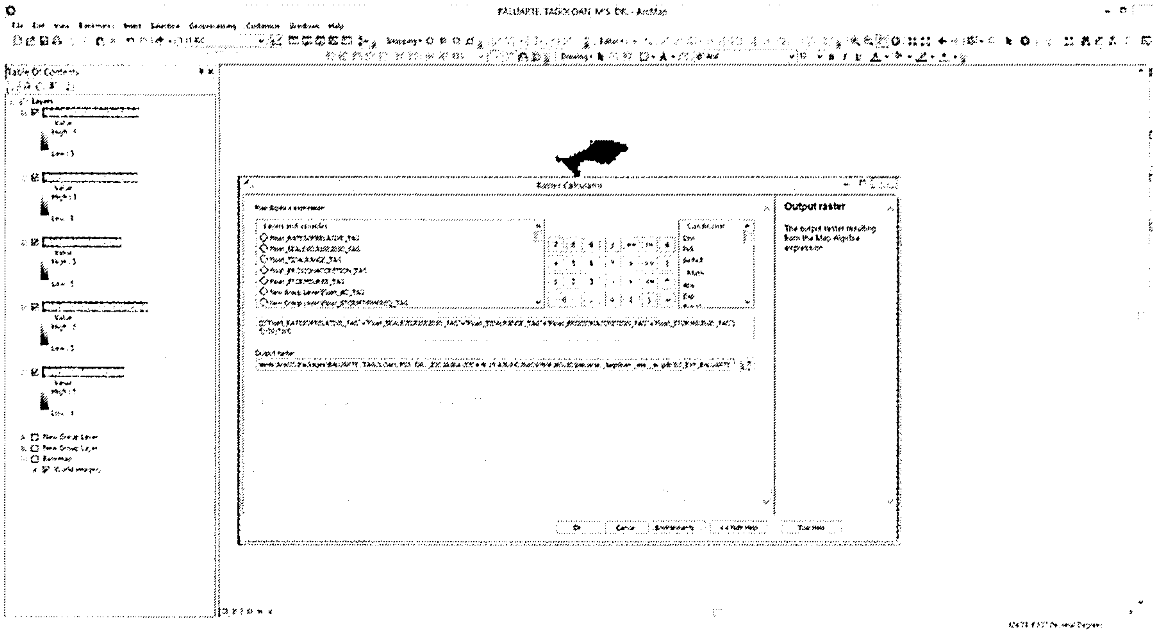


Fig. 81 Computation of exposure index.

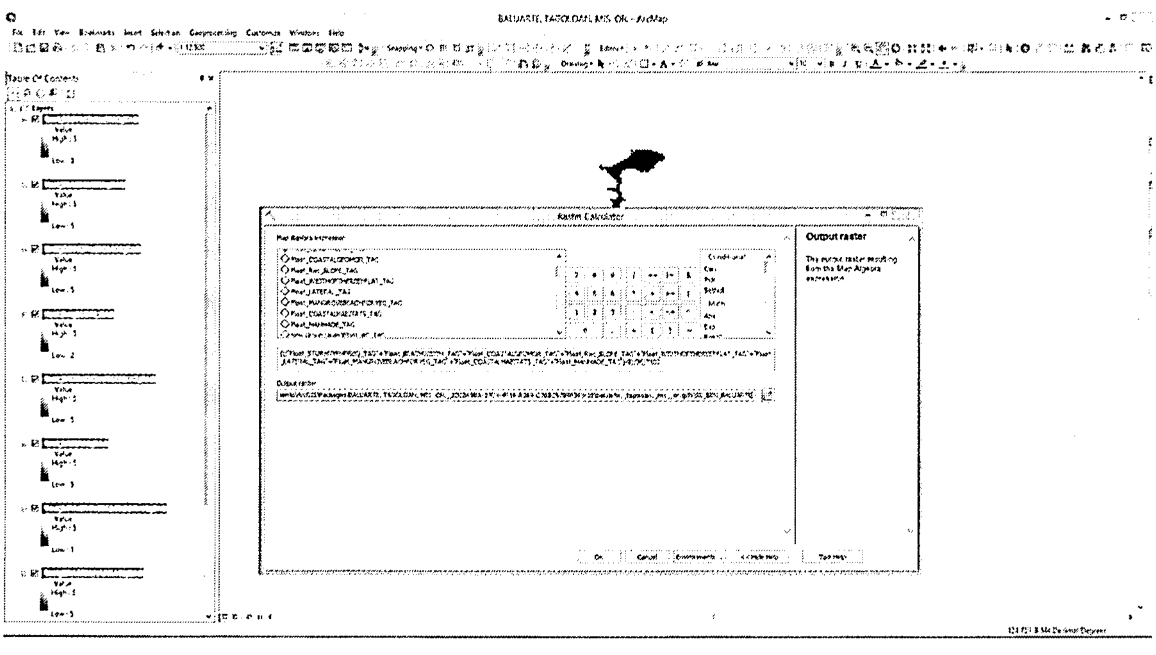


Fig. 82 Computation of sensitivity index.

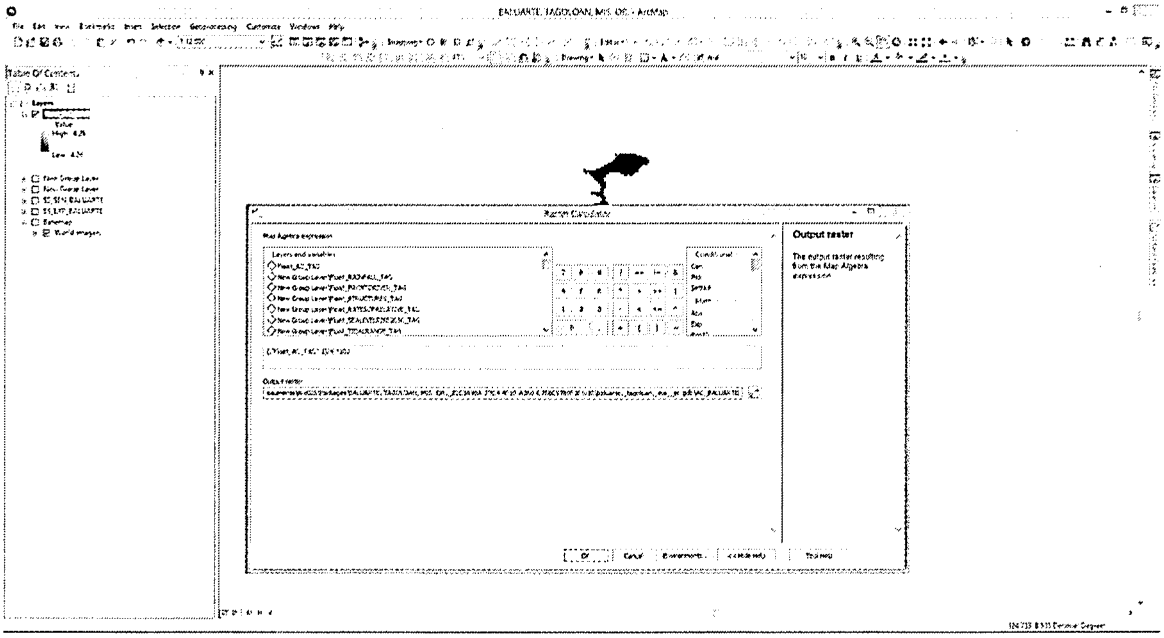


Fig. 83 Computation of adaptive capacity index.

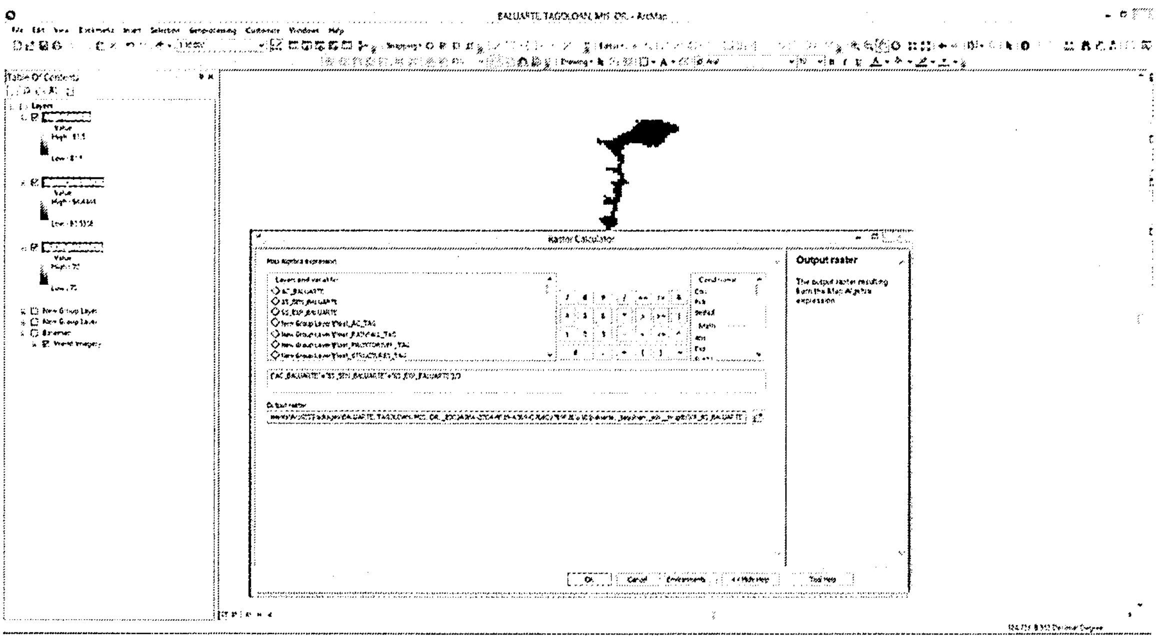


Fig. 84 Computation of vulnerability index.

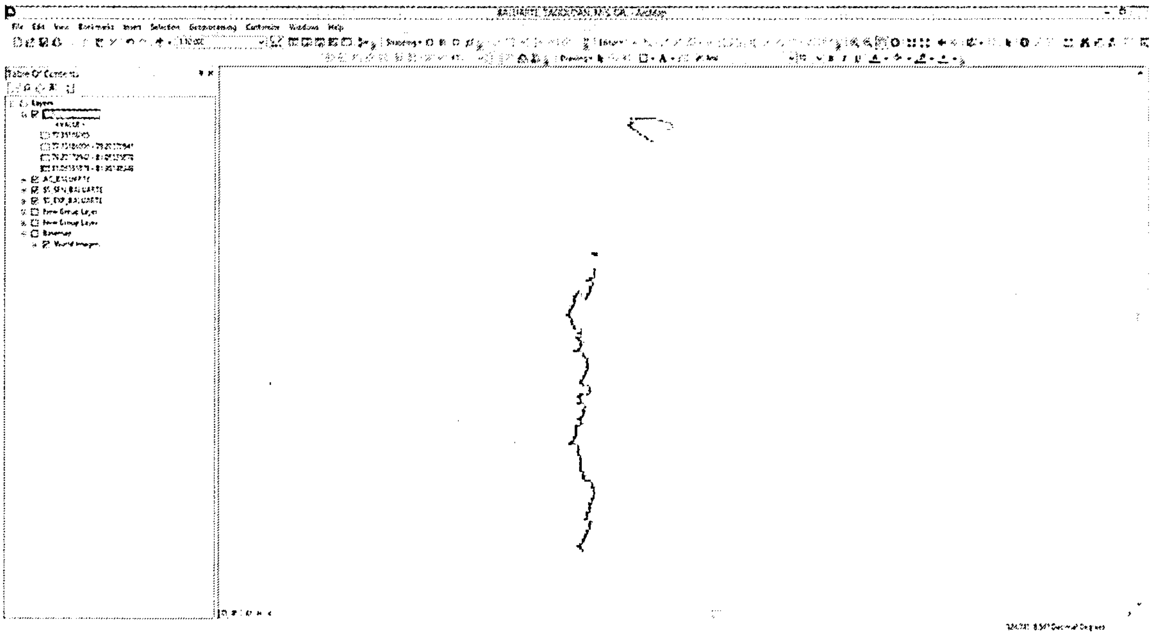


Fig. 85 Generated vulnerability model on storm surge.

Table 10. Color scheme for vulnerability map generation.

Degree	CIV Index
Very high vulnerability	80-100
High vulnerability	60-80
[illegible]	40-60
Low vulnerability	20-40
Very low vulnerability	0-20

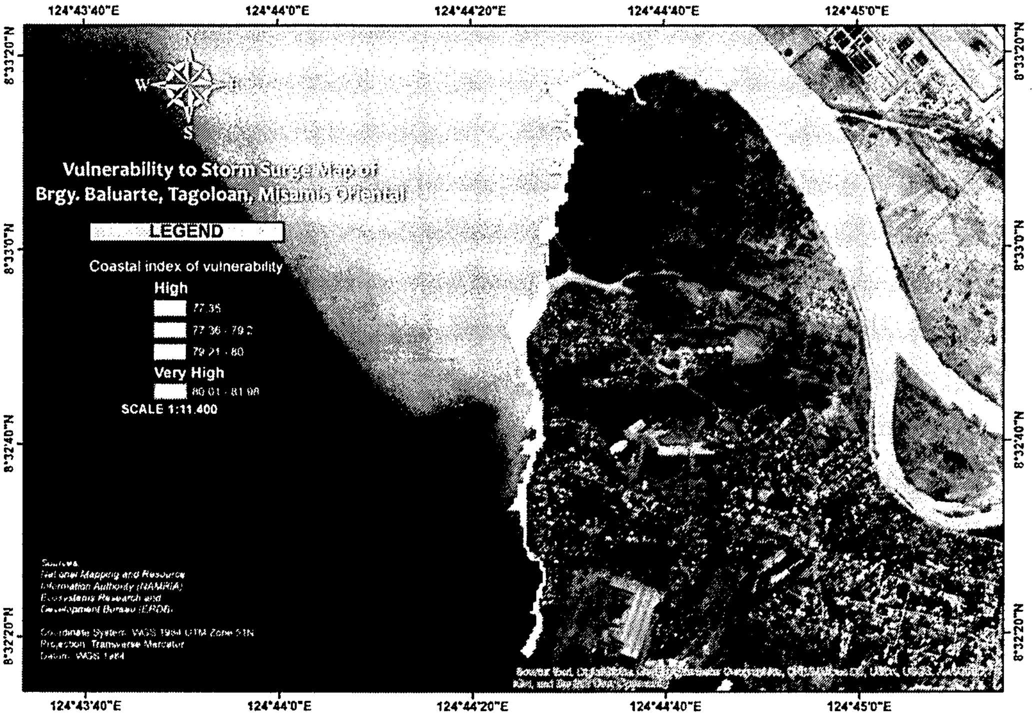


Fig. 86 Vulnerability to storm surge map.

CLIMATE CHANGE VULNERABILITY ASSESSMENT FOR COASTAL AND MARINE ENVIRONMENT

Name:____________________
Sex/Civil Status/Age:____________
Length of stay in the area:__________
Educational attainment:__________

Indicator/Variable			Rating		
1. No. of ordinaces relative to beach/sand mining law	☐ Absent 1(Very Low)	☐ 1 2 (Low)	☐ 2 3(Moderate)	☐ 3 4(High)	☐ 4 5 (Very High)
2. Proximity of settlement to coastline	☐ <100 1(Very Low)	☐ 100 to 400 2 (Low)	☐ 401 to 700 3(Moderate)	☐ 701 to 1000 4(High)	☐ >1000 5 (Very High)
3. Coastal protection structure	☐ No structure 1(Very Low)	☐ Temporary structure (sandbag/ light materials) 2 (Low)	☐ Concrete breakwater 3(Moderate)	☐ Concrete armors and boulders 4(High)	☐ Seawall 5 (Very High)
4. Land use pattern/coastal development	☐ Commercial/ industrial 1(Very Low)	☐ Unclaimed 2 (Low)	☐ Agricultural/open space 3(Moderate)	☐ Settlement/residential 4(High)	☐ Protected 5 (Very High)
5. Guidelines on setback zones in CLUP 5.a. Integration and Implementation of Coastal Zoning Plan in the CLUP	☐ Not integrated and implemented (presence of settlements in seawater) 1(Very Low)	☐ Integrated but not implemented (presence of settlements within 3m zone) 2 (Low)	☐ Limited implementation (presence of settlements within 20m zone) 3(Moderate)	☐ Partially implemented (presence of settlements within 40 m zone) 4(High)	☐ Fully implemented (no presence of settlements within the set back zone) 5 (Very High)
5.b. Awareness of community on the guidelines in setback zone	☐ Not aware 1(Very Low)	☐ Low level of awareness 2 (Low)	☐ Average level of awareness 3(Moderate)	☐ High level of awareness 4(High)	☐ Very high level of awareness 5 (Very High)

Indicator/Variable	Rating				
6. Coastal resources management program (CRMP)					
6.a. Presence of CRMP	☐ None 1(Very Low)	☐ 1 2 (Low)	☐ 2 3(Moderate)	☐ 3 4(High)	☐ >4 5 (Very High)
6.b. Community participation to CRMP (mangrove planting, beach forest rehabilitation, coastal clean up, et al.)	☐ No participation 1(Very Low)	☐ Low level of participation 2 (Low)	☐ Average level of participation 3(Moderate)	☐ High level of participation 4(High)	☐ Very high level of participation 5 (Very High)
7. Environmental law enforcement (national, municipal and barangay ordinances) 7.a. Presence of environmental laws	☐ None 1(Very Low)	☐ 1 2 (Low)	☐ 2 3(Moderate)	☐ 3 4(High)	☐ >4 5 (Very High)
7.b. Knowledge of the community on the presence of environmental laws	☐ No knowledge 1(Very Low)	☐ Low level of knowledge 2 (Low)	☐ Average level of knowledge 3(Moderate)	☐ High level of knowledge 4(High)	☐ Very high level of knowledge 5 (Very High)
7.c. Enforcement of environmental laws (given that the community is knowledgeable on the presence of environmental laws	☐ at least 76% of the total ordinances violated 1(Very Low)	☐ 51%-75% of the total ordinances violated 2 (Low)	☐ 26%-50% of the total; ordinaces violated 3(Moderate)	☐ <=25% of the total ordinances violated 4(High)	☐ no reported apprehension/ violation 5 (Very High)
8. Functional Communication Facilities 8.a. Information and education campaign materials	☐ No IEC materails seen nor read 1(Very Low)	☐ Dissemination of IEC materials only after the occurrence of storm surge and coastal erosion 2 (Low)	☐ Dissemination of IEC materials before and after the occurrence of storm surge and coastal erosion 3(Moderate)	☐ Occasional dissemination of IEC materials 4(High)	☐ Regular dissemination of IEC materials 5 (Very High)

Indicator/Variable	Rating				
8.b. Early warning device PA system(batingaw, bandillo, staff gauge, rain gauge)	▭ No available 1(Very Low)	▭ 1 2 (Low)	▭ 2 3(Moderate)	▭ 3 4(High)	▭ >4 5 (Very High)
8.c. Communication Technology (mobile, 2-way radio, TV, radio)	▭ No available 1(Very Low)	▭ 1 2 (Low)	▭ 2 3(Moderate)	▭ 3 4(High)	▭ >4 5 (Very High)
9. Evacuation centers	▭ No evacuation centers 1(Very Low)	▭ <=30% of potential affected households could be accommodated 2 (Low)	▭ 31%-65% of potential affected household could be accommodated 3(Moderate)	▭ 66%-99% of coastal households could be accommodated 4(High)	▭ 100% of potential coastal housholds could be accommodated 5 (Very High)
10. Resettlement areas	▭ No resettlement area 1(Very Low)	▭ <=30% of potential affected households could be resettled 2 (Low)	▭ 31%-65% of potential affected household could be resettled 3(Moderate)	▭ 66%-99% of coastal households could be resettled 4(High)	▭ 100% of potential coastal housholds could be resettled 5 (Very High)
11. Local Dissater Risk Reduction and Management Council 11.a. LGU knowledge and application of geohazard maps	▭ No knowledge 1(Very Low)	▭ <=25% of members of LDRRMC are knowledgeable and understand geohazard maps 2 (Low)	▭ 26%-50% of members of LDRRMC are knowledgeable and understand geohazard maps 3(Moderate)	▭ 51%-75% of members of LDRRMC are knowledgeable and understand geohazard maps 4(High)	▭ 100% of members of LDRRMC are knowledgeable and understand geohazard maps 5 (Very High)

Indicator/Variable			Rating		
11.b. Community knowledge on geohazard maps	☐ No knowledge on the presence of geohazard maps 1(Very Low)	☐ <=25% of the total respondents have knowledge of geohazard maps 2 (Low)	☐ 26%-50% of the total respondents have knowledge of geohazard maps 3(Moderate)	☐ 51%-75% of the total respondents have knowledge of geohazard maps 4(High)	☐ at least 76% of the total respondents have knowledge of geohazard maps 5 (Very High)
11. c. Alternative or supplemental livelihood	☐ not available all throughout the year 1(Very Low)	☐ available only for 1 to 3 months 2 (Low)	☐ available for 4-6 months 3(Moderate)	☐ available for 7 to 11 months 4(High)	☐ available all throughout the year 5 (Very High)

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