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Coastal Vulnerability Assessment of Rapu-Rapu and the West Coast of Albay Province, Philippines

Angelo P. Candelaria, Christian L. Baiño

Research and Development Management Division, Bicol University, Legaspi, Philippines
Email: apcandelaria@bicol-u.edu.ph

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Abstract

Coastal vulnerability assessment using the Integrated Sensitivity, Exposure, and Adaptive Capacity to Climate Change Vulnerability Assessment (ICSEA-C-Change) tool provides a deeper understanding of the potential impacts of climate change on coastal zones. Vulnerability ratings were obtained using rubrics that were presented to the stakeholders during focused group discussions. Derived scores were then averaged and consolidated to come up with the overall vulnerability rating. These ratings were based on the resource and status of coastal habitats' reliance on near-shore fishing and other quality measures like fisheries ecosystem dependency, population, and water quality of the coastal habitats in the barangays. Ratings resulted in identifying 12 barangays out of 23 that are highly vulnerable to climate change impacts such as waves, storm surges, sea level rise, increase in surface temperature, and extreme rainfall. These are Buenavista and Basicao (Pioduran), Catburawan (Ligao), Tapel, Nagas and Maramba (Oas), Talin-Talin, Pantao, Macabugos, and Tambo (Libon) and Buhatan and Villa Hermosa (Rapu-Rapu). Assessment results were highly influenced by the absence of three major marine habitats, i.e., coral reefs, seagrass/seaweeds, and mangroves in the coastal areas. Likewise, 11 barangays out of 23, which were Marigondon and Malidong (Pioduran), Maonon and Cabarian (Ligao), Badian and Cagmanaba (Oas), Apud and Rawis (Libon), and Galicia, Hamorawon, and Poblacion (Rapu-Rapu) obtained moderate vulnerability scores. This was attributed to the presence of marine habitats that although in poor state, may serve their ecological functioning when properly protected. Highly vulnerable barangays must be prioritized in coastal rehabilitation and disaster risk reduction management planning. Parameters encompassing the sensitivity and adaptive capacity of each barangay must be taken into consideration to reduce potential impacts brought by factors attributed to climate change. Vital information from the assessment will serve as basis for developing strategic plans for improving the climate change adaptation strategies of the local government units.

Keywords

Coastal Vulnerability, Climate Change, Sensitivity, Exposure, Adaptive Capacity

1. Introduction

Climate change is occurring, but its eventual extent and impacts are highly uncertain. It is a serious threat to the environment. Its effects are observed to be pervasive and particularly harmful to natural ecosystems and biodiversity. A deeper understanding of potential impacts and their consequences is needed. Also, appropriate programs need to be put in place to monitor variations due to climate change and other important coastal hazards. Strategies that result in appropriate responses to the dangers imposed by climate change and other coastal hazards need to be developed. Vulnerability assessment integrates these processes and assists in achieving appropriate outcomes.

The Philippines, being archipelagic is extremely vulnerable to the effects of climate variability as it ranked highest in the world in terms of vulnerability to incidence of typhoons and categorized third in terms of exposure to other weather disturbances (NCCAP, 1998). In the recent Climate Change Vulnerability Index (CCVI), a global ranking instrument which has calculated the vulnerability of around 170 nations to the effects of climate variability over the next 30 years, derived from the global risks advisory firm Maplecroft, which ranked 16 countries out of 170 to be extremely vulnerable to climate change. The Philippines has ranked sixth among the 16 countries documented (Maplecroft, 2010). This only shows that the country will not be spared from climate change impacts. Thus, coastal vulnerability assessment is essential to address the emergent need of improving developmental plans for strategic adaptation actions from the community up to the provincial, regional, and national levels. A more significant effort is needed to build adaptive capacity measures, especially for communities to mitigate said impacts.

Given the severity of this crisis towards human and marine biodiversity specifically in the West Coast of Albay Province and in the Municipality of Rapu-Rapu, it is critically important to strategically plan and act in order to increase socio-ecological resilience over the next few decades. This is really necessary so that the marine ecological habitats and closely associated environments and dependent communities can better adapt to the impacts of climate change. Reducing the negative effects of climate change can lessen the impact of global pressures and maintain the most diverse and productive coastal habitats for as long as possible. Minimizing these negative effects through a fully integrated ecosystem-based approach that considers the land and coastal-based drivers of abasement will support protecting biodiversity and maintain the essential provision of their ecological balance. Disregarding this fundamental action, the cumulative and synergistic effects of climate change and direct human impacts are likely to drive many marine ecosystems into a highly degraded state (SCSCCCR, 2012).

The main objective of the study is to apply the concept of vulnerability to coastal communities under climate change hazards in the coastal barangays of Pioduran, Ligao, Oas, Libon, and Rapu-Rapu of the Province of Albay. The overarching goal of these objectives is to assess the vulnerability of the coastal zones in the five municipalities to climate change and identify adaptive management interventions. The two specific objectives that encapsulate this goal are: to assess the vulnerability of the coastal zones in the five municipalities to climate change based on historical trends and sensitivity parameters and identify priority adaptive and mitigation management interventions; and quantify the adaptive capacity of the coastal habitats, fish and fisheries, coastal integrity, and human activity in the five municipalities to determine their ability to adapt to the impacts of climate change.

2. Materials and Methods

The coastal vulnerability assessment was carried out at two levels; the municipal and the barangay level. The municipal assessment reviewed existing documents at the local government unit, examined the climate change and current policies and utilized focus group discussions and key informant interviews with key coastal development stakeholders (Municipal Agriculture Office, MFARMC, Peoples' Organizations, Barangay Council Members, and Fisherfolks). It is used as reference for the recent weather forecasts of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) and other support studies by international organizations focusing on climate change. The assessment looked into the coastal barangays of the Municipalities of Pioduran, Oas, Libon, Rapu-Rapu, and the City of Ligao of the Province of Albay in the Bicol Region (**Figure 1**). The assessment has adopted the participatory adaptation and vulnerability method which focused on the sectors' sensitivity, exposure and adaptive capacity against the expected weather scenario, historical account of calamities and the communities' experience and observations of previous occurrences of disasters. This document presents the individual municipality and city-level assessments that were undertaken.

Preparatory activities were conducted to ensure that the vulnerability and adaptation assessment process will have strong support from both the officials and the technical staff of the local government units. These activities centered on laying the foundation of the assessment such that there will be clarity in the scope of the process that will be undertaken and to which end it will deliver—that is to contribute to the municipality and city sustainable development plans. The following activities/steps undertaken are presented in **Figure 2**.

The Integrated Sensitivity, Exposure and Adaptive Capacity to Climate Change Vulnerability Assessment Tool (ICSEA-C-Change, Licuanan et al., 2013) was used

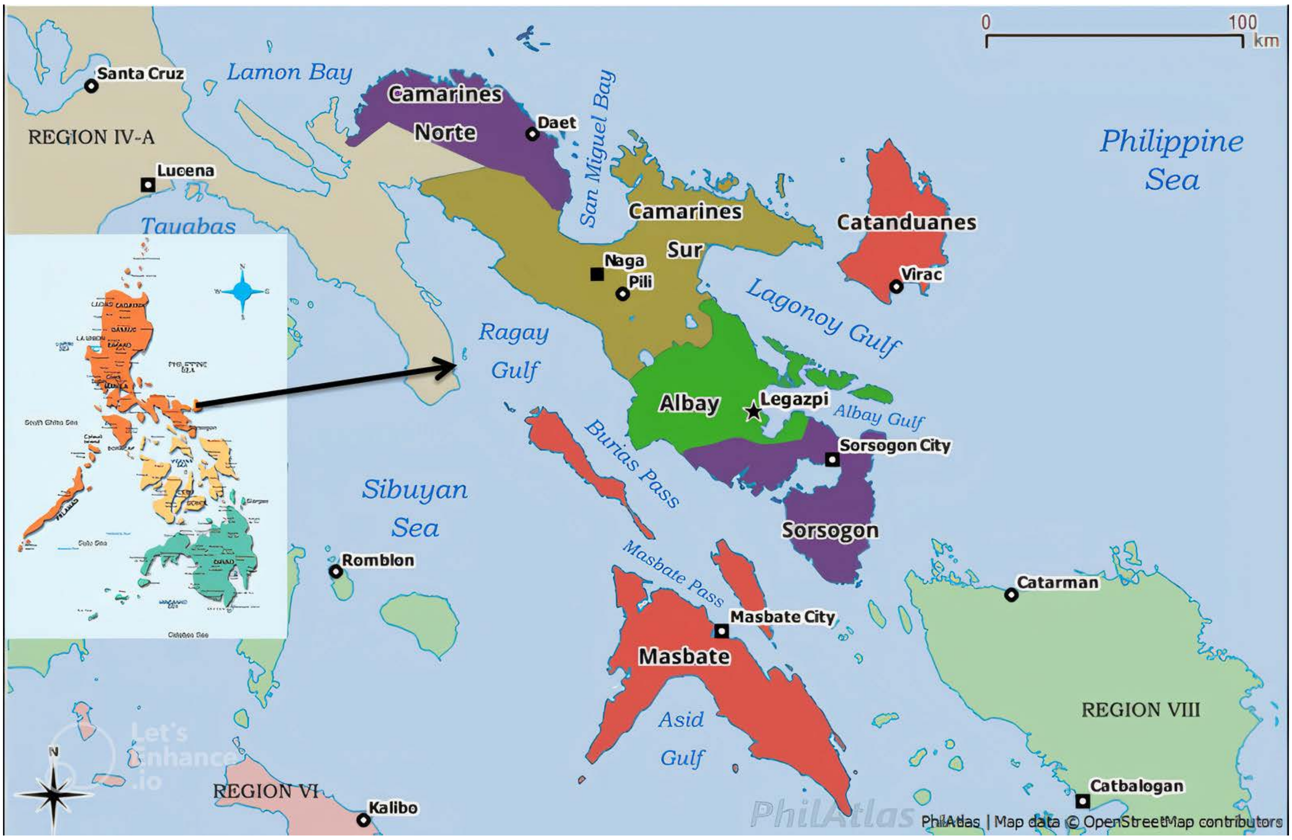
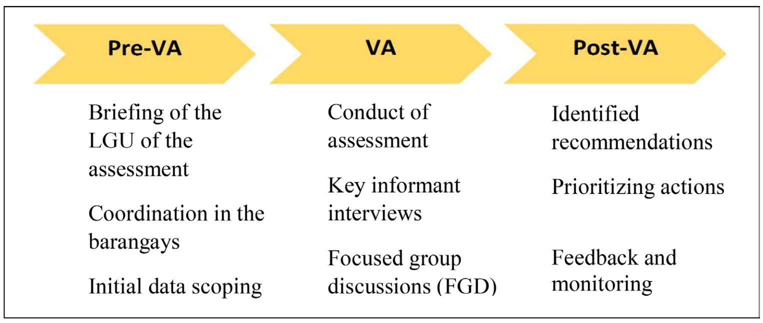


Figure 1. Map of the study areas (Source: PhilAtlas).



Source: Vulnerability Assessment Tools for Coral Ecosystems.

Figure 2. Steps undertaken during the coastal vulnerability assessment.

in conducting the vulnerability assessment in the five localities. It provided a rapid and synoptic assessment of the acute, immediate impacts of climate change on the coastal areas. The strategy adopted was participatory and relatively simple, and sought to provide coastal communities the means to understand their relative vulnerabilities to climate change impacts, including sea level rise, ocean warming, increased storminess, extreme rainfall events, and resulting sedimentation of coastal waters. The data-gathering procedure involved a review of secondary information available at the local government units, specifically with the Municipal/City Agriculture Office. Key informant interviews were undertaken with the key officials of the Municipality/City and likewise at the Barangay level to derive information on the profiles of communities and the various hazards that they have experienced. Focused group discussions were also undertaken in each of the coastal barangays to validate further the information generated and to obtain the scores for the ICSEA-C-Change rubrics taken from the participants. ICSEA-C-Change as the tool adopted evaluated the criteria relevant to biodiversity, coastal integrity, and fisheries concerns. The vulnerability assessment using the tool involved a set of rubrics that guided the assignment of scores for Sensitivity and Lack of Adaptive Capacity (LAC). Sensitivity rubrics used a five-point, three-level scoring that required a distinction for scores within "Low" (1 to 2 points), "Moderate" (2 to 4 points), and "High" (5 points) levels. For Lack of Adaptive Capacity, a four-point, four-level scoring was used. The data from the coastal habitat and fisheries assessment were made as a basis to come up with a comprehensive analysis and interpretation of the impacts of climate change across the study areas.

3. Results and Discussions

3.1. Historical Trends and Coastal Zone Sources of Climate Change Exposures

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

Scientific projections from climate models have been very useful for the coastal vulnerability assessment, however, in the absence of such information (as what the concerned local government units experienced at the start of the assessment process) that specifically focuses on the geographical area of Albay Province, local observations were very important. Such was critical to validate national and regional climate change data against the realm or experiences of the municipalities in order for the assessment to gather information on the likelihood or probabilities of future changes as basis to measure factors of their vulnerability as experienced on-ground. The "ground-truthing" exercises, by way of focused group discussions (FGDs) and key informant interviews (KIIs), provided a local dimension to the highly technical discourse of what lies ahead which seemed vague and "far off" in some sense especially to local communities.

The initial exposure analysis therefore solicited inputs from the communities themselves. Their observations, as evidenced by the changes they experience in their daily lives, were outlined based on how changes in climate are manifesting and affecting them. People who've been living in Pioduran, Ligao City, Oas, Libon, and Rapu-Rapu for more than 20 years were particularly asked to join and contribute their accounts on how they have observed climate (e.g. temperature, rainfall, and sea level) to have changed over the years. These accounts were gathered from the focus group discussions held in the coastal barangays from where the rubrics were applied to derive the scores for the vulnerability assessment.

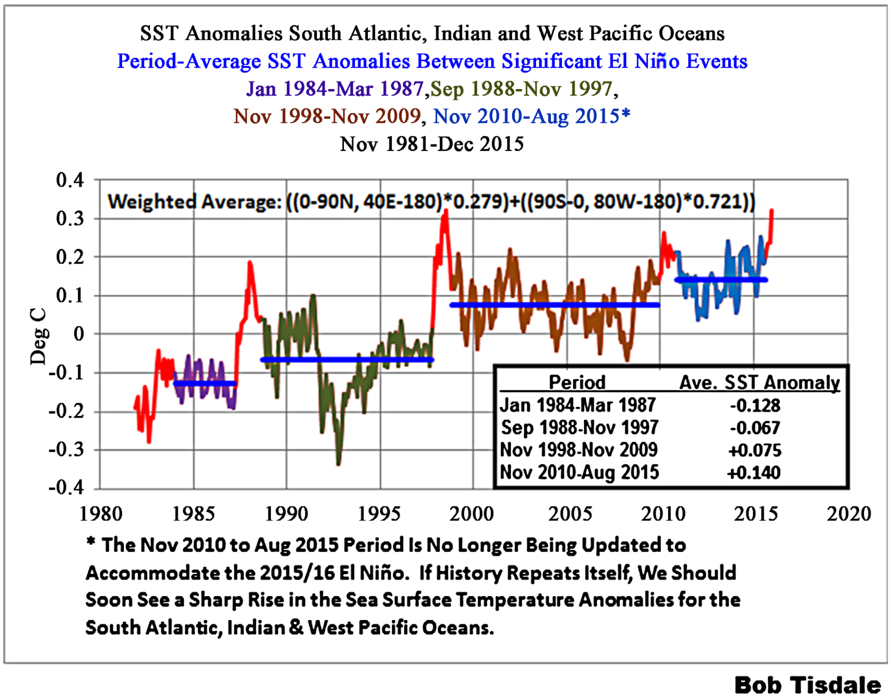
3.1.1. Sea Surface Temperature

Actual sea surface water temperatures close to shore at the coastal barangays of the four municipalities and one key city were observed to vary by several degrees compared with open water averages. This is especially true after heavy rains, close to river mouths, or after long periods of intense seaward breeze. The surface water which has been warmed by the sun is replaced by offshore breeze causing colder deep water. This may even vary specifically during low and high tides which fisherfolks and community stakeholders disclosed during the conduct of focus group discussions in the coastal barangays.

The research team used data and information from Climate Explorer even though there was no actual data on sea surface temperature recorded specifically in the coastal municipalities under assessment. The Royal Netherlands Meteorological Institute (KNMI) is in charge of managing Climate Explorer, a web-based tool for climatic study that includes a vast array of tools for analyzing climatic databases. A high-resolution paleoclimatology system, which is one of its application areas is used to explore and obtain weather data and acquired time series, to examine the climatic signal in uploaded high-resolution prevalent climate time series, and to explore the temporal and spatial characteristics of climate reconstructions (Trouet & van Oldenborgh, 2013).

It has been noted even by local scientists in the Philippines that the country's sea surface temperature (SST) has been rising over the past decades. During the past 20 to 30 years, the SST in the country's southern part increased by 0.20 degrees Celsius per decade. On the other hand, the SST in the country's northern part increased by 0.30 degrees Celsius per decade. These temperature fluctuations have a remarkable impact on the marine environment. In addition to the rise in SSTs, high sedimentation, and typhoon-influenced wave activity may lead to the corals' brittleness and increased sensitivity to siltation and as a result, seagrasses may die (David, 2010). Likewise, this ecosystem damage can result in the loss of nursery grounds for fish and support for endangered species.

Figure 3 presents and further validates the trend in the South Atlantic, Indian Ocean, and specifically the West Pacific Ocean, where the Philippines is situated from November 1981 to June 2015. The graph reveals that the observed warming of sea surface temperatures is remarkably shown in significant levels during 1986 to 1988 and 1997 to 1998 having onsets of La Niňa incidences. Anomalies for sea surface temperatures, however, have an upward trend due to El Niňo occurrences from 2009 to 2011. According to observations, there were no particularly exceptional shifts in sea surface temperatures during the first half of 2015. The rise in sea surface temperatures of the world's oceans during the months when there were substantial El Nio occurrences, especially from 1986 to 1988, 1997 to



Source: National Oceanic and Atmospheric Administration.

Figure 3. West Pacific SST: November 1981 to December 2015.

1998, and from 2009 to 2010, has been observed as the primary reason since 1982.

However, it could be noted that the tropics have more intense sunlight, which naturally results in higher sea surface temperatures. This is due to the fact that sunlight is less intense in the poles and the sea surface is frozen there due to cold sea surface temperatures at high latitudes. Given that these regions have warm sea surface temperatures, it nearly seems as though the climate models indicate a major warming in the tropical Pacific over the previous 31 years.

Based on people's accounts in almost all the coastal barangays assessed, these areas have become warmer and warmer as manifested in 1) the change in their fishing and farming yields and activity patterns; and 2) the electricity/energy consumption of households as they are now requiring more cooling appliance (e.g. electric fans and other cooling systems). Further, people account that summer months have proven to get hotter and hotter—thus the proliferation of resorts and swimming facilities in almost all the coastal barangays of the assessed areas. More pronounced (than temperature change) for the people is the change in the volume of rain they are getting over the years. Serious erosion and flooding events have been happening more frequently that affect economic activities like trading, fishing, farming, and vending.

3.1.2. Sea Level Rise

Due to the lack of sufficient data from the tide stations nearest the study areas, the Legaspi City, Albay tide station was evaluated using data derived from PSML, as shown in Figure 4. Tide gauge records were also obtained from the

Oceanography Division of the National Mapping and Resource Information Authority (NAMRIA). Since 1933, the Permanent Service for Mean Sea Level (PSMSL) has been responsible for the collection, publication, interpretation, and analysis of data on sea level rise derived from the global network of tide gauges. It is based at the Proudman Oceanographic Laboratory (POL), Bidston Observatory which is part of the UK Natural Environment Research Council (NERC). The PSML is an affiliate of the Federation of Astronomical and Geophysical Data Analysis Services (FAGS) established by the International Council of Scientific Unions (ICSU). PSML is being aided by FAGS, the Intergovernmental Oceanographic Commission (IOC) and NERC (AMST Legaspi, 2015).

The records downloaded cover the period from 1920 to 2020. Sea level rise observations presented revealed that an increasing trend in annual mean sea level occurred since the 1900s as observed by PSML and from the tidal gauge station of the Coast and Geodetic Survey Department (CGSD) of NAMRIA in Legaspi City, Albay. The city is flanked by the same body of water in the Pacific and in fact shares territory in Albay Gulf which includes the coastal waters of Rapu-Rapu. This data can be correlated likewise to the increasing trend in annual mean sea level trends for Pioduran, Ligao City, Oas, and Libon. Given this scenario for these areas or municipalities assume that sea level rise (SLR) is likewise a threat in their low-lying coastal areas. Minus an actual scientific observation, this was further substantiated and validated with community observations and personal accounts. Figure 4 presents the SLR observations gathered in the station for Legaspi City. No manual simulation and visualization of SLR impact was done as this was not available during the conduct of the study.

Local observations highlighted by the people are the rise in tidal waters and sea levels. People from the coastal barangays, during the focus group discussions

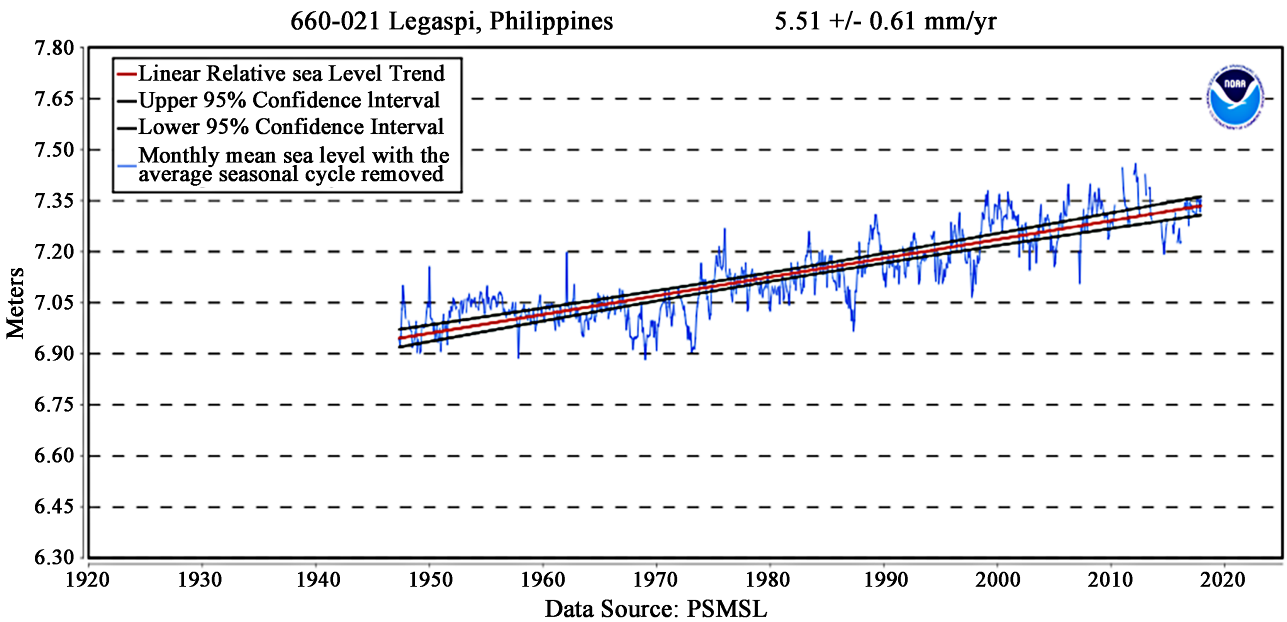


Figure 4. Annual mean sea level trend for Legaspi City, Albay.

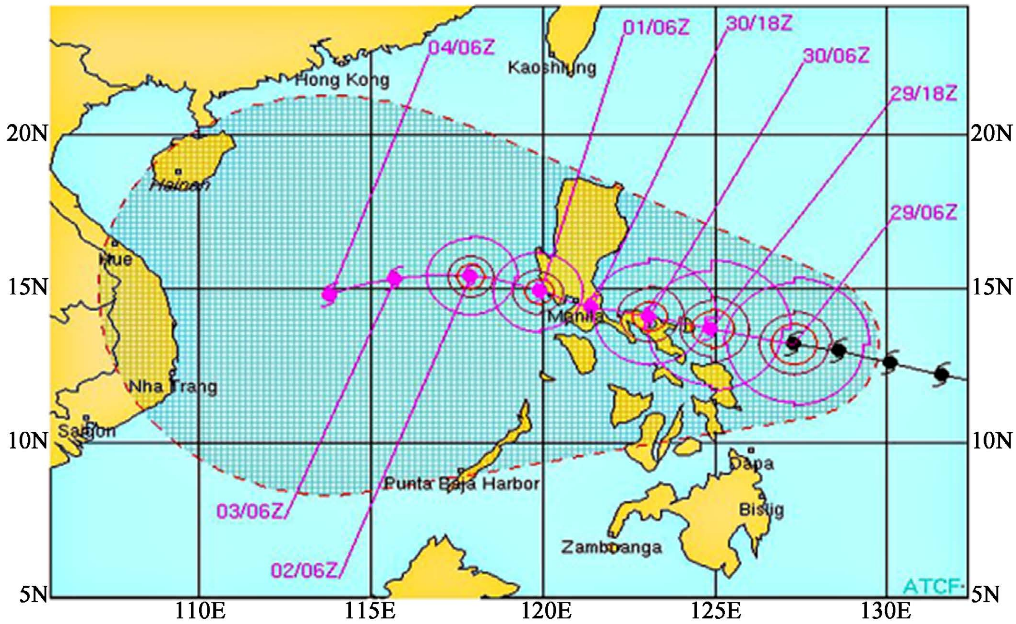
conducted, shared their actual observation of inundation in the beach areas and coastal shores, especially during typhoons and tropical storms in the Barangays of Malidong (Pioduran), Catburawan (Ligao City), Nagas, Tapel and Maramba (Oas), Pantao (Libon), and Villahermosa (Rapu-Rapu). These areas are the barangays that do not have substantial coral reefs, which serve as buffer during strong waves and storm surges. Older community members shared the estimation that about twenty (20) to thirty (30) meters of land in Barangay Catburawan and Cabarian of Ligao City and the shorelines of Nagas and Tapel of Oas, Albay have been inundated by sea waters. Some residents interviewed in these barangays recounted that during the 1970's the area where shorelines are now located had actual access roads then, and that it in fact served as their play area in those days and where even houses were situated before.

Sea level rise, as a major threat to the marine ecosystem, also affects the wavelength and amount of light that reaches sea grasses and corals. In the case of mangroves, establishing propagules (buds) becomes difficult when they are submerged owing to their incapacity to photosynthesize. The United Nations accordingly, estimates that by the year 2100, 30% of mangroves will be drowned. Typhoons and sea level rise may also lead to coastal erosion, causing the destruction of habitats of thousands of marine organisms. Through their life stages, living organisms that move to different habitats are the most vulnerable (David, 2010). While the direct consequences brought about by the impacts of sea level rise may not yet be fully experienced and apparently felt by the coastal residents, it is essential that there is an intensive information dissemination to all the community members and stakeholders so as to anticipate its ill effects in the near future.

3.1.3. Waves and Storm Surges

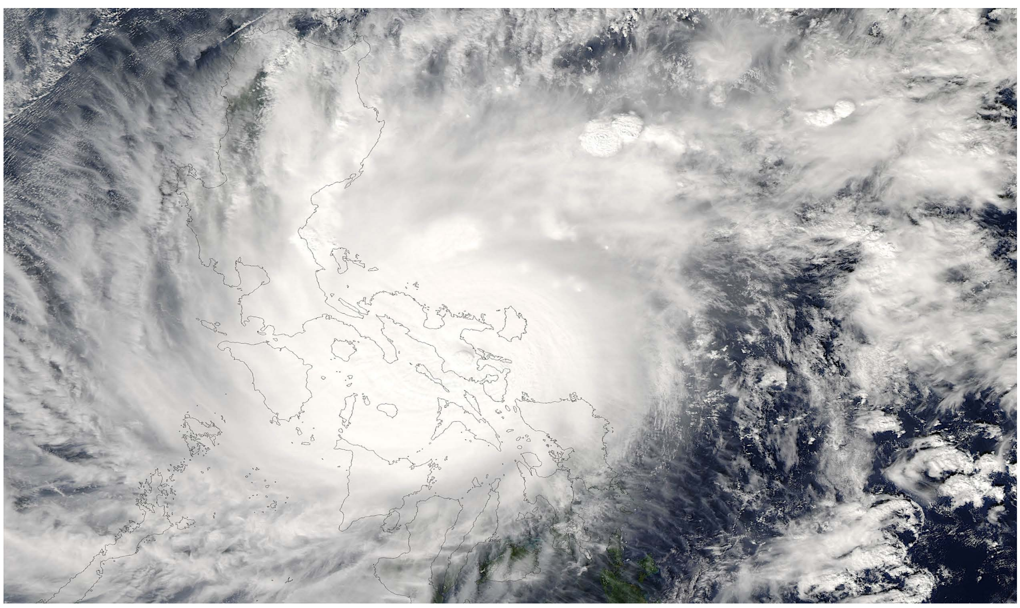
Storm surge happens when the sea level rises beyond the normal tide levels due to strong winds. Storm surge is the bulge of water that washes onto shore during a storm, measured as the difference between the predicted astronomical tide and the height of the storm tide. It is driven by wind and the inverse barometric effect of a moderate atmospheric pressure and is controlled by waves, tides, and uneven bathymetric and topographic surfaces. High water levels caused by storm surges and strong waves can engulf the coastal areas and damage properties. It is a violent natural force that can have a dreadful impact on life and properties. It is important for the community residents to understand it so that they can have a proactive stance when it happens.

The coastal flooding triggered by typhoons is as destructive as wind but can even be more deadly, and is by far the greatest threat that endangers the residents along the coastal zones. Tides, waves, and storm surges contribute greatly to coastal flooding, while rainfall and river flow likewise contribute during typhoons. Typhoon REMING (Durian) in November 2006 is a prime example of the ruin and devastation that can be triggered by storm surge, as shown in **Figure 5** and **Figure 6**, where at least 734 deaths up to an unofficial estimate of 1200 fatalities stemmed from "Reming" and many of those deaths occurred directly or indirectly, as a consequence of extreme flooding and storm surge. Lower atmospheric pressure (faster wind speeds) bigger storms generate a larger storm surge potential. Slower and larger but weaker storms cause much bigger storm surges and inundation (even to inshore areas) when compared to faster and small but more intense storms. Storms that form a perpendicular approach on the way to the coastline will also cause a greater storm surge, whereas those that cross side by side to the shoreline will have a lower storm surge.



Source: NASA.

Figure 5. Track of super typhoon REMING.



Source: NASA Observatory.

Figure 6. Satellite photo of typhoon REMING.

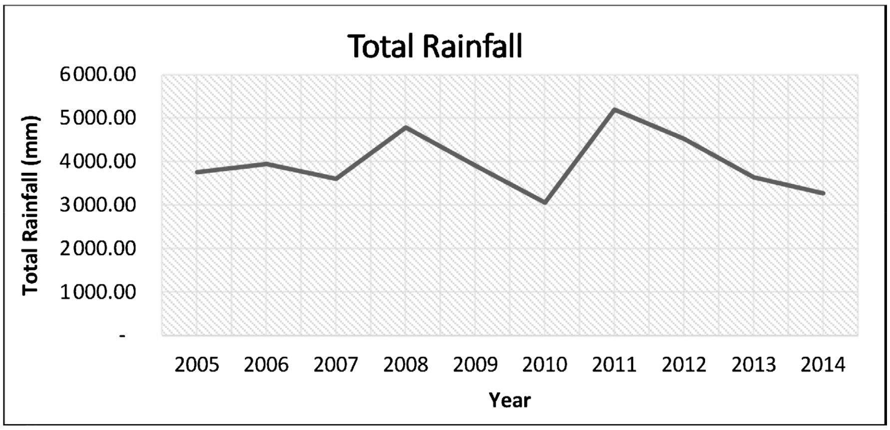
According to the participants in the focus groups held in the barangays examined, Typhoon "Reming" churned the Lagonoy Gulf in its wake of violent winds before making landfall in Camarines Sur. It stripped the coast of Rapu-Rapu and the Batan Islands, destroying 80% of all their homes and ramming nearly all the banca and other vessels aground. Using data from the NASA observatory, PAGASA's weather station in Virac, Catanduanes, malfunctioned after detecting a gust of 320 kph. It was the typhoon that had ever caused the most damage in the nation's history.

Legaspi City including the West Coast Municipalities, Ligao City, and the rest of Albay Province, which was under its intense southern eyewall, bore the brunt of the typhoon as houses lost their rooftops while building structures crumbled and bowed down. Everywhere, houses were literally blown off to pieces especially those near the shorelines. The areas near the shoreline of the barangays of Malidong (Pioduran), Catburawan (Ligao City), Nagas, Tapel and Maramba (Oas), Pantao (Libon), and Villahermosa (Rapu-Rapu) were the first ones to be inundated with seawater as this came rushing in, as revealed by the fisherfolks who have survived the ordeal. According to some women community members "Reming "came worse compared to Typhoon SISANG (Nina) of November 1987 which its impacts have exposed Rapu-Rapu and West Coast Municipalities to severe storm surge, and because there is no local terminology for storm surge, many people did not fully understand what was approaching. According to some Agricultural Technicians present during the FGDs, if areas potentially flooded by the storm surge have been mapped before it actually occurred, people could have been more prepared.

3.1.4. Extreme Rainfall

According to past and present studies, extreme and heavy rains are already occurring more frequently worldwide due to climate change brought on by man. Heat extremes that occurred once every 1000 days before due to century-long global warming now happen four to five times more frequently. It was discovered that the 0.85C global temperature rise since the industrial revolution and the ongoing emissions of greenhouse gases from power plants, factories, and automobiles are the causes of one in five instances of intense rain recorded worldwide. Up until today, there hasn't been a reliable accounting of just how much the world's temperatures and precipitation have increased. Previous studies show warming of the atmosphere increases the number of times temperatures reach extreme levels and evaporates more water from the oceans. It is from this sweltering, wetter background that extreme weather events emerge. Longer occurrences of prolonged rainy episodes and heat waves will also occur more often. The longer the period of precipitation or heat wave, the higher the fraction that is attributable to warming. Studies also found that the effects of warming will vary in other parts of the world. The weather outlook at the equator will become more extreme with 2C of warming. This means that tropical countries already dealing with frail infrastructure and poverty will experience more than 50 times as many extremely hot days and 2.5 times as many rainy ones (Fischer, 2015).

In the Albay West Coast and in the coastal barangays of Rapu-Rapu where assessments were conducted, the extreme weather is part of the chaotic nature of weather that emerges through a complex interplay of many factors. **Figure 7** presents the ten-year total rainfall data trend from 2005 to 2014 sourced out from the Southern Luzon PAGASA Regional Services Division in Legaspi City, which presented a low mean record in 2010 at 254.71 millimeters (mm) and recorded at its highest in 2011 at 433.36 mm. This was measured to reach a total of 3056.54 mm to 5200.30 mm in 2010 and 2011, respectively. The sudden rise in the total rainfall data generated was because of five (5) typhoons and tropical storms that became the most destructive for 2011 which brought in a lot of precipitation but very little wind. A lot of damage to property and deaths will be brought in caused by floods. However, there was no recorded casualty in the research areas as there have been initiatives taken by the Local Government Units in collaboration with the Provincial Government of Albay, which is internationally recognized to be at the forefront in terms of resiliency during calamities. These typhoons and tropical storms were BEBENG (Aere) in May, JUANING (Nock-Ten) in July, MINA (Nanmadol) in August, PEDRING (Nesat) in September, and SENDONG (Washi) in December 2011. Participants during the focused group discussions have confirmed that though the province was not directly hit by these typhoons and tropical storms, the southwest monsoon (Habagat) contributed to intensifying the heavy precipitation before it dissipated. Residents have also disclosed that it was Typhoon BEBENG (Aere) in May 2011, which inundated the shorelines and even caused some landslides. The findings by PAGASA still imply a potential intensification and increase in the occurrence of exceeding rainfall into the time ahead as the worldwide mean temperature continues to rise, and such trends should be considered in adaptation plans to minimize the hazards caused by extreme rainfall events in the province and in the country in general.



Source: Southern Luzon PAGASA Regional Services Division.

Figure 7. Total Rainfall Generated in Legaspi, Albay from 2005-2014.

Table 1 summarizes the biophysical effects and their impact on the socio-economic conditions represented by the different sectors in the coastal barangays of each municipality/city. This was determined through the information derived by the study from the various climate change exposures and local risk affects the coastal zones experience. Generally, the effects of extreme rainfall

Table 1. Biophysical exposures and critical impacts by sector.

Climate-Driven Phenomena	Biophysical/Risk Effects *(Evidence from previous Events)*	Data Source/s	Critical Impact Barangay/Sector
Increase in Temperature	• Projected 2˚C - 3˚C change in temperature in the Bicol Region with 2× CO_2 Scenario (Canadian Climate Change Model) • Recorded episodes of ENSO (El Nino and La Nina) that affected the Province of Albay	• Philippine Initial National Communication on Climate Change (PINCCC)	• Agriculture, • Livelihoods • Water sector • - Health
Sea Level Rise	• Inundation of land and changes in tides in the coastal barangays of Malidong (Pioduran), Catburawan (Ligao City), Nagas, Tapel and Maramba (Oas), Pantao (Libon), and Villahermosa (Rapu-Rapu). • Observed a slight SLR on the West Coast and on the Pacific side in Rapu-Rapu.	• Barangay visual accounts and observations • PSML • PINCC (Coast and Geodetic Survey Department or CGSD of NAMRIA in Legaspi, Albay)	• Agriculture, • Livelihoods • Water sector • Health • Settlements, Land • Use
Waves and Storm Surges	• Passing of more typhoons (exceeding the area average of 3 typhoons within 2 years) • More rain volume from Typhoons surpassing the average (2009) • Stronger winds (between 150 to 260 km/hr.) • Increasing incidence of evacuation of household members from their residence along coastal areas especially those living very near the shorelines • Occurrence of Storm Surge	• PAGASA data and local observations • Case of Tropical Depression Dante (2009) • Super Typhoons Sisang (1987) and Milenyo and Reming in 2006 • Provincial Disaster Profile from Albay-PDCC • 1970 and 1983 as noted in the official records from NRDB-PAGASA	• Housing • Livelihood/ • Economy • Water drains, settlements • All sectors • Schools, • Women, and Children • Settlements, Livelihoods, basic infrastructure • Lifelines (water, power, electricity communications)
Extreme Rainfall and Riverine Floods	• Flashflood events • Riverbank erosion • Areas identified as land slide and erosion prone • Projected 1.0 - 1.5 change in rainfall ratio in the Bicol Region with 2× CO_2 Scenario (Canadian Climate Change Model)	• PDCC data • PDCC data • - Local Geo-hazard map (MGB-DENR)	• Agriculture, • Livelihoods • Health • Land Use

Source: UN-Habitat (Fukuoka).

and intensified precipitation expected in the coastal zones are flooding, flash-floods, soil erosion, landslides, owing to water tributary overflow, and disruptions in both agricultural and fisheries economic activities. The table presents impact areas, like agriculture, health, land use, water sector, and settlements being exposed to flooding, combined risks from storm surges, sea level rise, and landslides. It can be gleaned from **Table 1** that the areas which are most affected by climate-driven phenomena are agriculture, livelihood, water, and health sectors from across the various biophysical exposures that the coastal communities experience.

3.2. Climate Change Impact Sensitivity Parameters

The sensitivity of an area to climate change impacts mainly depends on the status of coastal habitats (corals, seagrass, and mangroves), the importance of fisheries in the community, and coastline status from marine flooding and erosion (Licuanan et al., 2013). It is important to have a comprehensive understanding of these factors that contributes to the sensitivity of a community to climate change impacts.

The extent of coastal habitats in the study area was derived from the results of the comprehensive habitat assessment conducted. Important data in fisheries (fisher population, gear types used and distribution, and catch rates) and socio-economic data (barangay profiles, total population size, income, other sources of income or livelihood, household size, and education) were also collected. Other information pertaining to the VA, including issues and concerns related to fisheries and its governance, were obtained through focused group discussions (FGD) and key informant interviews (KII).

3.2.1. Coastal Habitats

Extent of Coral Reefs. The extent of the coral reefs is one of the indicators measured in identifying the sensitivity of an area to the impacts of climate change. Hard coral cover is considered in measuring the extent of reefs. The higher the percentage of hard coral cover, the lower the sensitivity of the barangay to the effect brought about by climate alterations. Four (4) barangays were assessed in Pioduran namely Basicao, Marigondon, Malidong, and Buenavista. Malidong had high sensitivity due to the coral reef absence. Basicao and Buenavista have also high sensitivity due to the poor status of the reefs having 16.0% and 11.0% cover, respectively (Mendoza Jr. et al., 2105). Marigondon has moderate sensitivity because of the fair status of coral reefs with 26.0% cover. Vulnerability assessment for Ligao City comprised the three (3) barangays namely, Maonon, Cabarian, and Catburawan with 14.0%, 38.0%, and 25.0% hard coral cover, respectively (Mendoza Jr. et al., 2015). Maonon had high sensitivity due to the poor status of coral cover compared to Cabarian and Catburawan which have moderate sensitivity because of the fair status of coral cover. The absence of coral reefs in Maramba, Nagas, and Tapel contributed to the high sensitivity of these barangays to the impacts of climate change. Granting that Cagmanaba and

Badian are the only barangays with coral reefs within the municipality, Cagmanaba had still high sensitivity due to the poor condition of hard coral cover assessed in the area. Conversely, the fair status of coral reefs in Badian contributed to the moderate sensitivity of the community to the adverse effects of climate change. Three (3) coastal barangays in Libon namely, Tambo, Macabugos, and Pantao have high sensitivity to the impacts caused by climate change. This was mainly because of the absence of coral reef areas in the barangay. Apud, Rawis, and Talin-Talin have moderate sensitivity due to the fair condition of the assessed reef assemblage. Study sites in Rapu-Rapu have less sensitivity due to the good condition of the assessed coral reefs. Good status was greatly attributed to a good percentage of hard coral cover.

It can be gleaned from the data and information derived through the habitat assessment and FGDs conducted that the coral reefs in the study areas are extremely exposed to high levels of local stress and may turn into a highly degraded state if and when they remain poorly managed. Given the dependence of human communities on coral reefs, as they are sources of food and income, these changes are likely to have serious long-term consequences for people and the livelihood of communities. The stressful situation may aggravate as the population of people living along the coastal areas is expected to double in the years to come. The number of fishers will likewise increase as the population grows putting in more stress and threat to these ecosystems.

Extent of Seagrass Meadows. The number of identified seagrass species is one of the important factors to measure the extent of seagrass meadows in the area. This is also essential to determine the sensitivity of a community to the impacts derived from climate change. A community is said to have less sensitivity if it has an abundant number of seagrass species. The higher the number of seagrass species in the area, the lower its sensitivity to the effects brought by climate change. Out of four (4) barangays assessed in Pioduran, only Malidong had medium sensitivity because it has four (4) identified species. Basicao, Maigondon, and Buenavista had high sensitivity due to the absence of seagrass beds in the community. Barangay Catburawan in Ligao had high sensitivity because of the absence of seagrass beds. Maonon and Cabarian have less sensitivity because of abundant seagrass beds in the area with five (5) and six (6) identified species, respectively (Dioneda et al., 2015a). Three (3) barangays in Oas namely, Maramba, Nagas, and Tapel poised a high sensitivity rating due to the absence of seagrass assemblage. Badian and Cagamanaba have less sensitivity to the impacts brought by climate change because of abundant seagrass species. Rampant use of beach seines within the coastal barangays of Libon contributed to the poor state of seagrass beds which contributed to the high sensitivity to climate change impacts. Abundant seagrass beds in Galicia, Hamorawon, and Poblacion contributed to less sensitivity of the area to the impacts brought by climate change.

Seagrass serves as a unique habitat. The meadows provide canopy cover that protects small living things such as invertebrates and juvenile fish, including some commercial fish species. This has been observed based on the remarks of the community and fishers of the coastal barangays of Oas and Rapu-Rapu, Albay, as these areas are still more abundant in seagrass compared to Libon and Pioduran areas, which possess only about one to two species of seagrasses. Based on the FGDs conducted, fishers cited advantages of seagrass such as it helps to diminish the surge of currents along the bottom of coastlines. They have added that seagrasses help stabilize the ocean floor in a manner related to the process of land grasses that prevent soil erosion. Most fishers they say are now aware that seagrass communities are vital to the survival of fishery and fishery industries.

Extent of Mangrove Forests. Derived scores for this parameter were taken from the FGD conducted. During the interaction, participants cited an estimation of the percentage of the remaining mangroves left in their community based on their physical observation. They also added that degradation of the mangroves was due to observed perturbations such as rampant illegal cutting and wood extractions, conversion of mangrove area into fish ponds, and the uncontrollable environmental factors such as typhoon which significantly leads to the devastation of the mangrove forests. The type of mangrove forest is essential in measuring the sensitivity of the area to climate change impacts. A mangrove forest with a basin-riverine-fringing type is less sensitive. Hence, it is the best type to reduce the drifts caused by climate change. Based on the comprehensive habitat assessment conducted, Cabarian and Hamorawon poised these best types of forest (Malvar et al., 2015), hence, these barangays have less sensitivity to the possible impacts of climate change. The assessment resulted that the mangrove forest in Marigondon had the largest area which indicates less sensitivity of the barangay to the impacts of climate change. Conversely, barangay Badian had the smallest area calculated which indicates that this barangay had a high sensitivity to the effects of climate alterations.

The remarkable mangrove ecosystems which are just localized in some key areas of the coasts are of great importance to coastal communities, providing not only a source of food and resources but also protecting coastlines from erosion and regulating the climate. Hence, areas that have mangroves are deemed to be 100% sensitive to climate change impacts. However, mangroves are also one of the most threatened ecosystems if continued to be cleared at an alarming rate. In contrast, the mangrove forests present in the community, if properly managed, will serve as a potential source of recreation and tourism.

3.2.2. Fish and Fisheries

Dominant catch. Fish catches whether demersal or pelagic are becoming more affected by the impacts of climate change. Based on the result of capture fisheries of the exploited fishes in Albay West Coast (Pioduran, Ligao, Oas, and Libon) and the East Coast (Rapu-Rapu), the coastal barangays in Pioduran catches both pelagics and demersal species of fish, thus, these barangays have medium sensitivity to the impacts of climate change. Capture fisheries reported that there are 13 small pelagics and 11 demersal that are predominantly caught within the municipality. Catches in the barangays of Ligao City are highly dominated by demersal species represented by groupers, goatfishes, snapper, slipmouth, and emperors. This implies that the coastal barangays in this municipality have high sensitivity to the effects brought by climate alterations. There were 11 demersal species and eight pelagics reported during the capture fisheries survey. Small pelagics such as sardines, mackerel, anchovies, and scads dominated the species caught within the coast of Oas and Libon. Thus, coastal barangays within these municipalities are less sensitive to the impacts caused by climate alterations. There were 13 species of pelagic fishes identified in Oas while 10 pelagic fishes in Libon. Demersals dominated the catches in the Municipality of Rapu-Rapu numbering to about 19 species. Catch composition in this municipality is highly sensitive to climate change impacts (Dioneda et al., 2015b).

Catch Rates. High catch rates indicate less sensitivity to climate change impacts. The lower the catch rate, the higher the possibility of high sensitivity of an area to the effects brought by climate change. Sensitivity is high if the catch rate is 3 kg per trip per day, medium if the catch rate is 3 kg to 8 kg per trip per day, and low if the catch rate is greater than 8 kg per trip day. Out of the 17 barangays assessed in the west coast, only Rawis in Libon resulted to have less than a 3 kg catch rate. This implies a high sensitivity of the community to climate change impacts. Conversely, Maramba in Oas showed the highest catch rate. This infers a low sensitivity of the barangay to the effects of climate change. Catch rates in the assessed sites of Rapu-Rapu showed moderate sensitivity to the possible impacts caused by climate change. The high catch rates were greatly attributed to the good condition of the coastal habitats within the municipality (Dioneda et al., 2015b).

Fishing Gears. Fishing gear used also plays an important role to lessen the sensitivity impacts of climate change in coastal areas. Using passive or stationary gears can contribute to higher sensitivity of a certain area than to those using active or mobile gears to the impacts brought by climate change. Active or mobile fishing gears are commonly used in the five municipalities. These include Handlines (*Binwit*), Seines (*Sinsuro*), and Traps (*Palakaya and Kalansisi*). Passive or fixed gears used include Gill nets (*Barangay*, *Patitig*, *Pakitang*, *Palubog*, *and Lambat*), Scoopnet with light, Spear guns, Fish pots, and Fish corrals. Although active fishing gears are most commonly used in Rapu-Rapu, it has also the highest number of fixed gears used compared to the municipalities in the east coast.

3.2.3. Fisheries Ecosystem Dependency

These attributes provide vital information on the importance of fisheries to the welfare of the community. The number of fisher folks relative to the total population indicates the significance of the fishers in an area. The more fishers present in the community, the higher the dependency on fishing. Many coastal populations of developing regions in the tropics rely largely on fishery resources for food and livelihood. Based on the FGD conducted, most of the barangays in the study sites reported that aside from fishing, there are one to two other sources of livelihood. Farming is the main source of livelihood aside from fishing. Some residents were involved in handicrafts and managing mini-stores in their houses.

3.2.4. Population Density

The number of people living in the coastal communities are important indicator for determining sensitivity to any perturbation including that of climate change. An area living with more than 500 persons per square kilometer is more sensitive to climate change impacts. Out of seventeen (17) barangays in the west coast, three (3) barangays are said to be high in sensitivity. Badian in Oas has a population density of $1233/km^2$ while Nagas has $816/km^2$. Apud in Libon has a computed population density of $872/km^2$. Coastal vulnerability assessment in Rapu-Rapu consisted of five barangays namely Galicia, Villa Hermosa, Hamorawon, Buhatan, and Poblacion. Out of these barangays, Buhatan is reported to have a high sensitivity in terms of population density. It has a computed population density of $738/km^2$ making it more sensitive to climate change impacts.

3.3. Adaptive Capacity Parameters

IPCC defines adaptive capacity as the ability or potential of a system to adjust to climate change, to potential damages, to take advantages and opportunities, or to cope up with the consequences. Identifying factors that contribute to the adaptive capacity of an area is necessary for the design and implementation of effective adaptation strategies so as to reduce the likelihood and the magnitude of harmful outcomes resulting from climate change. Adaptive capacity also enables sectors and institutions to take advantage of opportunities or benefits from climate change, such as a longer growing season or increased potential for tourism.

3.3.1. Health of Corals

The health of corals is vital to determine the capacity of an area to adapt to the impacts caused largely by climate change. Poor health of coral reefs in the area indicates the lacking capacity of the coastal barangays to adapt to the changes brought by climate alterations.

Assessment of reef areas in Basicao and Buenavista derived poor condition results in terms of the percentage of live cover (**Table 2**). Live cover is categorized into hard and soft corals, nutrient indicator algae, sponges, and others (sessile organisms including anemones, tunicates, and gorgonians). This indicates that these barangays have minimal ability to cope with the changes that are brought about by climate alterations (Mendoza Jr. et al., 2015).

Reef communities with fair and good conditions are said to have a moderate capacity in coping with the changes caused by climate change. Reef status contributes to the ability of these barangays to reconfigure from the destructions brought by climate disturbances.

Table 2. Percentage live cover of the reef area in Ligao, Pioduran, Oas, Libon and Rapu-Rapu, Albay.

Barangay	Live Cover (%)	Status
Pioduran		
Marigondon	40.0	Fair
Basicao	25.0	Poor
Buenavista	20.0	Poor
Ligao		
Maonon	30.0	Fair
Cabarian	39.0	Fair
Catburawan	26.0	Fair
Oas		
Badian	35.0	Fair
Cagmanaba	28.0	Fair
Libon		
Rawis	55.0	Good
Talin-Talin	39.0	Fair
Rapu-Rapu		
Galicia	54.0	Good
Gaba	57.0	Good
Pagol Island	69.0	Good

3.3.2. Health of Seagrass

The health of seagrass is measured through the identification of what species highly dominate the area in terms of density as well as the percentage cover of the species identified. Seagrass beds in Pioduran are only found in Sitio Lagaan, in Barangay Malidong. This area is situated near the mangrove forest of Marigondon. Based on the computed density, the seagrass bed is inhabited by *Halodule-Cymodocea-Halophila* mixed meadows. This was highly dominated by *Halodule uninervis* in terms of density having 94.89 shoots/m^2 (Table 3).

Both Barangay Maonon and Barangay Cabarian in Ligao are generally classified to have *Cymodocea-Thalassia-Halodule* mixed meadows. Seagrass beds in Sitio Tambak in Maonon is dominated by *Thalassia hemprichii, Cymodocea rotundata,and Halodule pinifolia* in terms of density of 101.5 shoots/m^2, 77.5 shoots/m^2, 52.5 shoots/m^2, respectively. Speciesthat dominate the seagrass beds in Cabarian *are Cymodocea rotundata* with 250.13 shoots/m^2, *Halodule pinifolia* with 137.83 shoots/m^2, and *Thalassia hemprichii* with 153.62 shoots/m^2.

Seagrass found in Barangay Badian in Oas is characterized as *Halodule-Cymodocea-Halophila* mixed meadows. *Halodule uninervis* dominates the seagrass area having a density of 133.33 shoots/m^2. Seagrass assemblage found in Cagamanaba

Table 3. Density of seagrass species identified in the west and pacific seaboards of Albay.

Municipality/ Barangay	Species	Density (shoot/m^2	Municipality/ Barangay	Species	Density (shoot/m^2
Pioduran			**Libon**		
Malidong	*Halodule uninervis*	94.89	Rawis	*Halodule uninervis*	177.00
(Sitio Lagaan)	*Cymodocea serrulata*	51.28		*Halodule pinifolia*	44.67
	Halophila ovalis	12.83	Talin-Talin	*Halodule uninervis*	191.67
	Enhalus acoroides	4.67			
Ligao			**Rapu-Rapu**		
Maonon	*Cymodocea rotundata*	101.50	Galicia	*Cymodocea serrulata*	79.23
	Thalassia hemprichii	77.50		*Enhalus acoroides*	50.39
	Halodule pinifolia	52.50		*Halodule uninervis*	44.37
	Halodule uninervis	4.50		*Halophila ovalis*	30.07
	Enhalus acoroides	2.50		*Thalassia hemprichii*	11.33
Cabarian	*Cymodocea rotundata*	250.13		*Cymodocea rotundata*	5.20
	Thalassia hemprichii	153.62		*Thalassodendron*	1.78
	Halodule pinifolia	137.83	Hamorawon	*Halodule pinifolia*	97.52
	Syringodium isoetifolium	28.24	(Gaba Bay)	*Cymodocea serrulata*	80.38
	Enhalus acoroides	22.55		*Syringodium isoetifolium*	60.57
	Halophila ovalis	3.37		*Cymodocea rotundata*	60.18
Oas				*Halodule uninervis*	58.18
Badian	*Halodule uninervis*	133.33		*Thalassia hemprichii*	38.11
	Cymodocea serrulata	113.33		*Enhalus acoroides*	25.93
	Halophila ovalis	56.33		*Halophila ovalis*	18.99
	Cymodocea rotundata	54.67	Poblacion	*Halodule ununervis*	79.60
	Halodule pinifolia	26.67		*Thalassia hemprichii*	59.10
	Thalassia hemprichii	21.33		*Enhalus acoroides*	43.99
Cagmanaba	*Halodule pinifolia*	157.20		*Halophila ovalis*	4.4
	Thalassia hemprichii	70.49		*Cymodocea rotundata*	3.27
	Cymodocea rotundata	52.95		*Syringodium isoetifolium*	2.67
	Enhalus acoroides	23.04		*Cymodocea serrulata*	0.97
	Halophila ovalis	20.59		*Cymodocea serrulata*	0.97
	Halodule uninervis	13.91			
	Halophila minor	1.87			

Source: Assessment of Seagrass and Seaweed Communities, 2015 Project Report.

is classified as *Halodule-Thalassia-Cymodocea* mixed meadows. These seagrass beds are located near Trinity Island. An assemblage of seagrass found in this area is highly dominated by *Halodule pinifolia* with 157.20 shoots/m^2 computed density.

Also, as presented in **Table 3**, two barangays in Libon, which are Rawis and Talin-Talin were reported to have poor condition of seagrass beds as regards their health status. These areas were dominated by *Halodule uninervis* in terms of density which are 177.00 shoots/m^2 and 191.67 shoots/m^2, respectively (Dioneda et al., 2015a).

Seagrass in Galicia in Batan Island is generally classified as *Cymodocea-Enhalus-Halodule* mixed meadows. Species found in this area is dominated by *Cymodocea serrulata* with a density of 79.23 shoots/m^2. Hamorawon (Gaba Bay) also located in Batan Island is characterized by *Halodule-Cymodocea-Syringodium* mixed meadows and is dominated by *Halodule pinifolia* with 97.52 shoots/m^2 density. Seagrass beds in Barangay Poblacion in Rapu-Rapu Island are dominated by *Halodule uninervis* with a density of 79.60 shoots/m^2. Seagrass species found in this area are greatly inhabited by *Halodule-Thalassia-Enhalus* mixed meadows.

3.3.3. Health of Mangroves

The health of mangroves is determined based on the number of species found in the mangrove forest and its capacity to regenerate. Based on the comprehensive mangrove assessment conducted, Pioduran has three (3) mangrove forests located in Marigondon, Malidong (Sitio Lagaan), and Buenavista. Reports showed that Malidong (Sitio Lagaan) has the highest number of species identified which is twelve (12) and is dominated by *A. marina* and *C. decandra* in terms of number of stands. Buenavista has eleven (11) species identified which is dominated by *C. decandra* in terms of count, while Marigondon has nine (9) species identified and is dominated by *Rhizophora* species wherein *R. apiculata* has the highest number of stands. More mangrove saplings and seedlings species for Marigondon also have a greater regenerative capacity to withstand climate change alterations, as gleaned from **Table 4**.

There are also three (3) mangrove forests assessed in the coastal community of Ligao City. These are situated in Maonon (Sitio Sabang), Cabarian, and Catburawan. The mangrove forest of Catburawan is reported to have the highest number of species identified within the municipality. This barangay has eleven (11) species identified which are dominated by *A. rumphiana* and *C. decandra*. Barangay Maonon has seven (7) species identified and is highly dominated in terms of the number of stands by *C. decandra* and *E. agallocha*. Cabarian has the least number of species identified within the municipality in terms of the number of stands. There were six (6) species identified and dominated by *A. marina* (Malvar et al., 2015).

Mangrove forests assessed in Badian and Cagmanaba are dominated by *A. marina* and *S. alba* in terms of the number of stands recorded. Six (6) species were identified within the mangrove community in Badian while nine (9) species

Table 4. Number of mangrove species identified, density count of saplings and seedlings and regenerative capacity in Pioduran, Ligao, Oas, Libon and Rapu-Rapu.

Municipality/ Barangay	Number of Trees	Number of Species	Density		Percentage
			Saplings	Seedlings	
Pioduran					
Marigondon	1225	9	71	158	18.69
Sitio Lagaan	646	12	47	147	30.03
Buenavista	269	11	9	79	32.71
Ligao					
Maonon	48	7	12	32	91.67
Cabarian	342	6	27	167	56.73
Catburawan	1060	11	25	51	7.17
Oas					
Badian	67	6	11	23	50.75
Cagmanaba	491	9	28	55	16.90
Libon					
Apud/Rawis	739	13	23	121	19.49
Pantao	512	10	28	82	21.48
Tambo	64	8	11	25	56.25
Rapu-Rapu					
Poblacion	1047	7	328	224	52.72
Hamorawon	947	7	41	98	14.68
San Ramon	640	6	64	50	17.81

Source: Assessment of Mangroves, 2015 Project Report.

were identified in the mangrove forest of Cagmanaba.

Mangrove communities assessed in Libon were in Rawis, Pantao, and Tambo. Thirteen (13) species were identified in Rawis and is dominated by *C. decandra* and *A. marina* in terms of count per stand. The mangrove forest in Pantao has ten (10) identified species dominated by *A. marina* and *A. rumphiana*. Tambo has eight (8) enumerated species and is dominated by *A. marina* and *S. alba* in terms of the number of stands.

Table 4 also presents the mangrove forest assessment in Rapu-Rapu, which was done in Hamorawon (Gaba Bay) and San Ramon in Batan Island, and Poblacion in Rapu-Rapu Island. The mangrove community in Hamorawon is dominated by *Rhizophora* species. It has seven (7) identified species where *R.mucronata* and *R. apiculata* has the highest number of stands recorded. Six (6) species of mangroves were identified in San Ramon. Mangrove forest in this area is dominated by *A. marina*, *S. alba,* and *R. apiculata* in terms of the number of counted stands. The mangrove community in Poblacion is dominated by *Rhizophora* species. This community of mangroves has seven (7) identified species where *R. sylosa* and *R. apiculate dominate* in terms of the number of stands (Malvar et al., 2015).

Regenerative Capacity. If the total number of saplings and seedlings is more than 50% of mature trees, the probability of the forest sustaining its existence is high. If the density is low, it can indicate a high impact on the area (Participatory Methods in Community-based Coastal Resource Management Vol. 3, 1998). Maonon, Cabarian, Badian, Tambo, and Poblacion have recorded greater numbers of saplings and seedlings which can be attributed to the rehabilitation and reforestation being implemented in these areas (Malvar et al., 2015). This indicates that these barangays have the highest adaptive capacity. On the contrary, barangay Catburawan has the least adaptive capacity considering that it has the lowest density of seedlings and saplings recorded (Malvar et al., 2015).

3.3.4. Water Quality

Water samples were collected from each municipal water with a meter depth from the surface. Total Suspended Solid (TSS) was analyzed at the DOST-Regional Standards and Testing Laboratories (RSTL). TSS is the substance that can be filtered in the water sample which came from silt, industrial and household waste discharge, decaying matter, and sewage. Increasing TSS makes water silty which asserts a low adaptive capacity in changes in environmental conditions.

The observed TSS in the municipality of Oas, Ligao City, Libon, Pioduran, and Rapu-rapu ranges from 2 ppm to 29 ppm, as shown in **Figure 8**. The result shows a baseline for evaluating the TSS conditions in the various areas observed. In contrast with the DAO acceptable standard of >30% mg/L of TSS the baseline result for Rapu-Rapu and Pioduran offshoots the tolerable limit of TSS in marine waters. TSS Baseline for Oas, Ligao, and Libon is within the acceptable standard. However, a series of water sampling should be conducted to further justify the results. RSTL describes waters from the sampling site as clear water except for the water samples collected from Rapu-Rapu (RP), GL1, and SR3

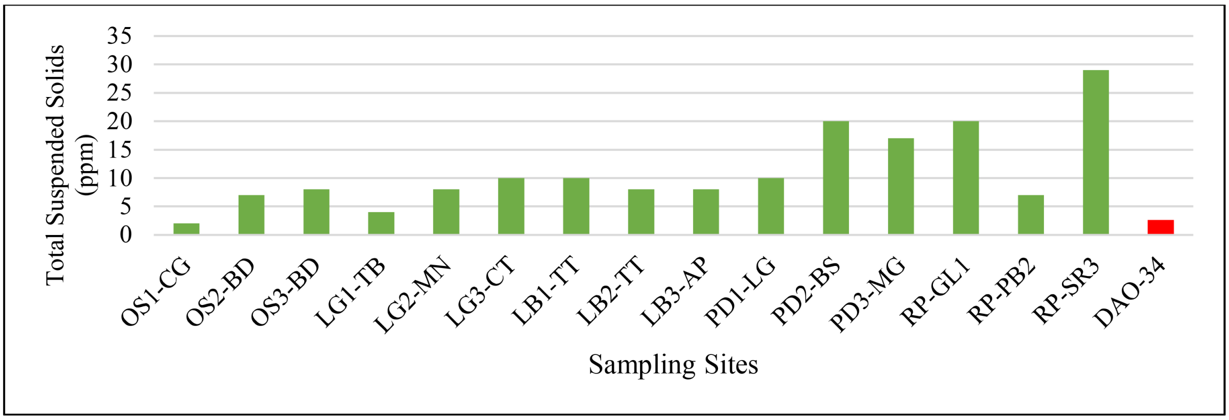


Figure 8. Total suspended solid baseline in Albay West Coast and Rapu-Rapu (OS—*Oas*, LG—*Ligao City*, LB—*Libon*, PD—*Pioduran*, RP—*Rapu-Rapu*).

which are clear water with few sediments, and slightly turbid water from Pioduran (PD) 2BS and Libon (LB) 3AP (with white specs). All the water samples were classified under the Class SB/SC based on DAO 34. This water level classification avow that the municipal waters are being used for recreational services such as bathing, skin diving, boating, swimming, etc. It also further identified that the waters are used for fisheries, and for commercial and sustenance purposes like fishing, spawning, and for mangroves areas.

3.4. Coastal Vulnerability Rating

The sensitivity rubrics used a five-point, three-level scoring that required a distinction for scores within "Low" (1 to 2 points), "Moderate" (2 to 4 points), and "High" (5 points) levels. For Lack of Adaptive Capacity, a four-point, four-level scoring was used (ICSEA-C-Change, Licuanan et al., 2013).

Computed vulnerability ratings were summarized in **Table 5**. The Sensitivity and Exposure are categorized as High if the average is more than 4.0, Moderate if the average is more than 2.0 to 4.0 and Low if the average is from 1.0 to 2.0. Lack of Adaptive Capacity (LAC) is categorized as High if the average is more than 4.0, Moderate if the average is between 3.0 to 4.0, and Low if the average is less than 3.0. Scores for Exposure were derived from the perception of the stakeholders during the focused group discussions. Likewise, with the support data from reliable sources such as PAGASA-DOST and NOOA. Participants have given their ratings ranging from 1 to 5 depending on their experiences regarding typhoons and extreme rainfall. Sensitivity and Adaptive Capacity scores were derived from the assessment conducted on coastal habitats (corals, seagrass, and mangroves), fish and fisheries, coastal integrity, and from the socioeconomic data gathered. Scores were categorized into three: Low (1-2), Medium (3 - 4), and High (5).

Ratings are integrated using the following rules: 1) if at least one of the components is Moderate, the final rating is Moderate; 2) if two components have scores of Moderate, and the third component is high, the final rating is High Vulnerability; and 3) Low Vulnerability rating is achieved if all components derived Low average scores.

Basicao Coastal, Marigondon, Malidong (Sitio Lagaan), and Buenavista were the coastal barangays assessed in Pioduran. Among these four barangays, Basicao Coastal, Malidong, and Buenavista have a high vulnerability rating. This indicates that these barangays are the most vulnerable to the negative impacts brought by climate change. High ratings for these areas were attributed to their being highly exposed to tidal waves and typhoons due to the lack of coastal habitats within the coastal area. Also, a high sensitivity rating was derived from each barangay. High sensitivity was due to the poor extent of coastal habitats (corals, seagrass, and mangroves), the dependency of the community on fisheries, and the observed eroding coastal shores. Marigondon had a moderate vulnerability rating which indicated that this area is less vulnerable to climate

Table 5. ICSEA-C-Change vulnerability rating summary in the west and east coast of Albay.

Municipality/Barangay	Parameters			Remarks
	Exposure	Sensitivity	Lack of Adaptive Capacity	
PIODURAN				
Buenavista	4.00	4.17	3.84	High
Malidong (Sitio Lagaan)	4.50	4.17	3.97	High
Marigondon	3.00	3.99	3.60	Moderate
Basicao	4.50	3.78	3.96	High
LIGAO				
Maonon	4.00	3.89	3.12	Moderate
Cabarian	3.00	3.23	3.26	Moderate
Catburawan	4.00	4.17	3.78	High
OAS				
Badian	3.00	3.14	3.28	Moderate
Cagmanaba	3.00	2.98	3.49	Moderate
Tapel	5.00	4.30	4.18	High
Nagas	5.00	4.00	4.14	High
Maramba	5.00	4.17	4.03	High
LIBON				
Apud	4.00	3.91	3.71	Moderate
Rawis	4.00	3.69	3.59	Moderate
Talin-Talin	4.50	3.49	3.91	High
Macabugos	4.50	3.71	4.26	High
Pantao	4.50	4.16	3.91	High
Tambo	4.50	4.00	4.00	High
RAPU-RAPU				
Galicia	3.00	3.49	3.73	Moderate
Villa Hermosa	4.50	4.24	4.00	High
Hamorawon	3.00	3.31	3.80	Moderate
Buhatan	4.50	4.62	4.20	High
Poblacion	4.00	3.98	3.82	Moderate

alterations. The low exposure rating is highly attributed to the good condition of the marine habitats in the area.

Catburawan obtained a high vulnerability rating among the three coastal barangays in Ligao City. This contributed to a high sensitivity rating brought by the low extent of habitats and reliance of fishers on demersal fishes. Moderate sensitivity and adaptive capacity rating brought Maonon and Cabarian to be moderately vulnerable to impacts caused by climate change. The moderate sensitivity of these barangays was caused by eroding coastlines as well as the dependency of the community on the fisheries ecosystem as their source of livelihood.

As shown in Figure 9, Maramba, Nagas, and Tapel derived a high overall vulnerability because of their high sensitivity and lack of adaptive capacity rating. This was mainly influenced by their lack of coastal habitats (coral, seagrass, and mangroves). This implies that these areas are more exposed to strong winds brought by typhoons and increase in sea level. Badian and Cagmanaba were the least vulnerable mainly because of the low sensitivity rating and high adaptive capacity rating. This is greatly influenced by the good condition of its coastal habitats.

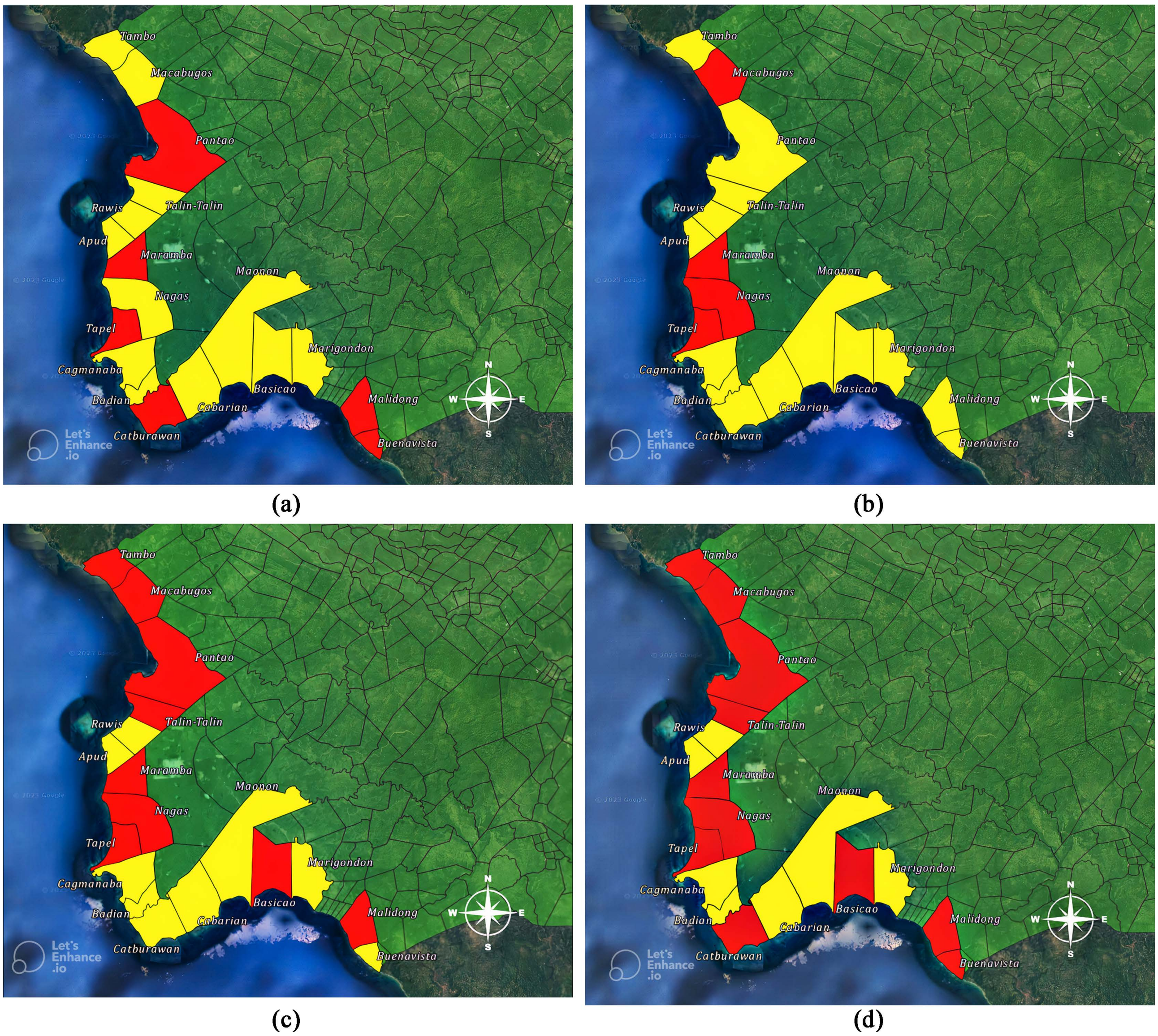


Figure 9. Exposure (a), Sensitivity (b), Lack of adaptive capacity (c), and Overall vulnerability map (d) of Albay West Coast. (*Yellow for Moderate and Red for High Vulnerability*).

Four out of the six coastal barangays in Libon derived a high vulnerability rating namely Talin-Talin, Macabugos, Pantao, and Tambo (Figure 9). The high exposure, sensitivity, and lack of adaptive capacity ratings contributed to the high vulnerability score of these barangays. Exposure to sea level rise and storm surges were implications of the lack of coral reefs and seagrass in the area, which serve as tidal wave buffers. Likewise, exposure to the impacts of typhoons and strong winds is likely imminent because of the absence of mangrove forests as observed in the area. Because of the absence of these marine habitats were results of high scores for sensitivity and lack of adaptive capacity. Contributing to this effect are the various human activities manifested by the unrestrained conversion of the coastal zones into residential areas due to the growing population of coastal communities. Barangays Apud and Rawis obtained moderate sensitivity and lack of adaptive capacity ratings as an effect on the perceived presence of different marine habitats in these barangays.

Out of five barangays assessed, as shown in Figure 10, in the municipality of

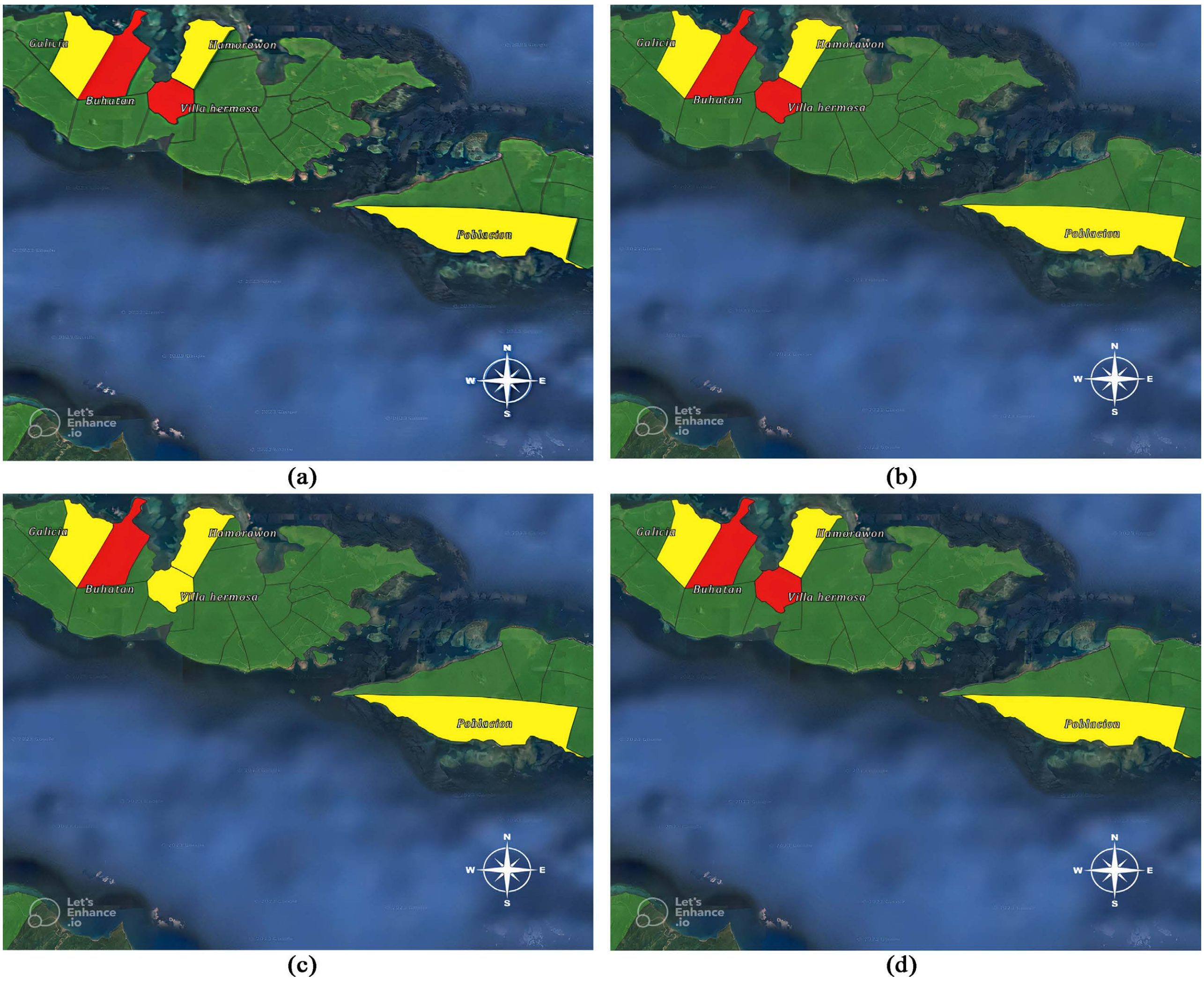


Figure 10. Exposure (a), Sensitivity (b), Lack of adaptive capacity (c), and Overall vulnerability map (d) of Rapu-Rapu. (1—Galicia, 2—Buhatan, 3—Villa Hermosa, 4—Hamorawon and 5—Poblacion).

Rapu-Rapu, two barangays resulted to have high vulnerability ratings (Buhatan and Villa Hermosa) mainly because of their high exposure and high sensitivity ratings. Sensitivity was the result of the poor growth of coastal habitats. Poblacion, Galicia, and Hamorawon have moderate vulnerability ratings due to moderate sensitivity and adaptive capacity. This was due to the good health condition of habitats in the area and the abundance of fish catch.

4. Conclusion

Vulnerability assessment using the ICSEA-C-Change tool provided relevant and responsive information to demonstrate vulnerabilities of the coastal barangays from impacts of disturbances attributed to climate change. The assessment activities and results became an awareness-building tool for the stakeholders of varying sectors including government agencies and civil society organizations to respond and share information and resources to achieve a common goal for the benefit of the local communities affected. The output opens an opportunity for the municipal, provincial, and national levels of governance to devote to prioritizing initiatives for the implementation of climate change adaptation and mitigation programs and projects. Highly vulnerable barangays (Buenavista, Basicao, Catburawan, Tapel, Nagas, Maramba, Talin-Talin, Pantao, Macabugos, and Tambo) are the areas to be prioritized in the disaster risk reduction and climate change adaption management planning. The study showcased the areas that need development initiatives in reducing the impacts of climate change and improving the adaptive capacity to provide coping mechanism strategies brought by climate change. The study's methodology drew from already-existing sources of data. Although strong levels of collaboration were anticipated, it was often difficult to find responses to queries. However, it turned out that enhanced information coordination for the application of risk assessment to coastal management would benefit from expanded use and accessibility of databases. Further monitoring of these activities is necessary because human-induced hazards may be a greater threat to the study areas than climate change.

5. Recommendations

While the direct consequences brought about by the impacts of the various coastal vulnerabilities investigated (sea level rise, waves, storm surge, extreme rainfall, and the rise in sea surface temperature) may not yet be fully experienced and apparently felt by the coastal residents, it is essential that there is an intensive information dissemination program implementation undertaken to all the community members and stakeholders so as to anticipate its ill effects in the near future. A serious and in-depth promotion of a multi-level information, education, and communication (IEC) system concerning the result of human activities posing threats to the diversity of coastal habitats should be undertaken and given priority. The program for IEC should be intended to change the knowledge and practices of fisherfolks towards a greater appreciation of the true economic and ecological value of its marine habitats.

Policy regulations on the part of the Local Government Units (LGUs) concerned need to be strengthened. The fisherfolks, though how organized cannot totally resolve various internal and external issues and concerns affecting them, like quarrying, the incriminate cutting of mangroves, and the use of beach seines which contribute to coastal degradation. The need for a collaborative effort on the part of the people's organizations and LGUs will play a vital role in addressing these factors. Reducing the climate change impacts on coastal ecosystems may involve on exploring a climate-ready mariculture system for fisheries. The correct implementation of the policies in place is vital to its realization.

The issue on the growing population in the coastal barangays should also be given focus as this affects the carrying capacity of the marine ecosystems. Subsequent studies should consider the disaster risk reduction and climate change adaptation capacities of coastal communities. An assessment of the impact of the increasing population in the coastal communities should likewise be studied together with the demand and supply of fish and fishery products of the municipalities and the province in general.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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