# CLIMATE RISK AND VULNERABILITY ASSESSMENT FOR AGRICULTURE IN THE PROVINCES OF AKLAN, ANTIQUE, CAPIZ AND GUIMARAS, PHILIPPINES

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Western Visayas AMIA Team
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## ABSTRACT

*The study was conducted in the four provinces of Western Visayas, namely: Antique, Aklan, Capiz, and Guimaras from 2020-2021 with the main objective of assessing the provinces' risks and vulnerabilities to climate change. The evaluation followed the Climate Risk Vulnerability Assessment (CRVA) framework with three major components, namely: Exposure I (impact of climate change to change in temperature and precipitation), Exposure II (climate-related pressures/natural hazards), and adaptive capacity (adaptive capacity capitals) The sensitivity assessment (crop suitability), hazard and adaptive capacity were likewise determined and elucidated. The more important accomplishments and fundings of the study are as follows: 1) the agricultural vulnerabilities to climate change of the four provinces were objectively assessed; 2) GIS-guided visualization maps were generated; 3) the vulnerability of the four provinces studies determined in terms of sensitivity, hazard, and adaptive capacity index were attained and described; 4) the over-all vulnerability assessment, revealed that: a) in Aklan, the municipalities of Batan, Malinao, Makato, Tangalan were most vulnerable to climate change while Ibajay and Kalibo were the least vulnerable municipalities; in Antique, Anini-y, Hamtic, Belison, Laua-an, and Libertad were predicted to be most vulnerable while Patnongon was considered least vulnerable; in Capiz, Jamindan, Dao, and President Roxas were found most vulnerable while Panay and Ivisan, had the least vulnerability risk; and d) in Guimaras, Sibunag and San Lorenzo were found most vulnerable to climate change while Nueva Valencia was rated the least; 5) the results highlighted appropriate interventions needed by vulnerable communities; and 5) the results were able to prioritize needs for adaptive capacity of communities through designing and planning appropriate interventions and mitigation measures.*

*Keywords: Climate change, climatic risks, vulnerability, (add more)*

# INTRODUCTION

Western Visayas is composed of six provinces namely: Aklan, Antique, Capiz, Guimaras, Iloilo and Negros Occidental with total agricultural land area of 1,217,042.99 hectares. Priority commodities produced are rice, corn, coffee, cacao, coconut, banana, mango, sugarcane, abaca, watermelon. Palay production slightly declined to 2,077,790 MT during the year from 2,232,292.75 MT in CY 2019 due to losses brought by El Nino and Typhoon Ursula. Western Visayas is the third largest rice producing region in the country contributing 11.04% to the national production. Province of Iloilo is the major source of palay in the region accounting to 42% of the total regional rice production followed by the provinces of Negros Occidental and Capiz with 21% and 16% respectively.

In terms of corn production, the region ranked 6th among the top producing regions. Negros Occidental has the largest contribution to the regional production followed by Iloilo and Capiz. Crop production has the highest Gross Value Added (GVA) in its Agriculture according to PSA Report 2019.For the past 10 years, Western Visayas recorded information on extreme weather events that has significant effect especially in the agriculture and fishery sector of the region.

Around 12.9 Billion Pesos value of damage and Losses was recorded from CY 2010-2020. The information shows trend that at least every three years, extreme weather events recur that risks around Three Billion Pesos. Super Typhoon Yolanda that occurred last CY 2013 has recorded the highest value of damage and losses amounting to around Three Billion Pesos which resulted to decline on the agri-performance of the region.

Evidently, climate risks pose a major threat in sustaining productivity of the agri-fisheries sector for the attainment of food security in the country. To address this challenge, the Department of Agriculture (DA) launched the Adaptation and Mitigation Initiative in Agriculture (AMIA) to plan and implement strategies to help agri-fishery communities manage climate risks – from extreme weather events to long-term climatic shifts. AMIA Villages should be composed of two or more contiguous barangays, with sufficient number of accredited Farmers Association (FA), with at least total aggregate areas of Hundred hectares (100 ha) cultivated by AMIA farmer members within the AMIA Village. AMIA Villages were then piloted in every region to perform Climate Resilient Agriculture (CRA). To determine the strategic location for every AMIA Villages, Climate Risk Vulnerability Assessment (CRVA) must be done to determine highly vulnerable areas to climate risk. Vulnerability to climate risk was then considered as one factor to determine the pilot areas.

CRVA is now used as key step in targeting and planning for Climate Resilient Agriculture (CRA) communities to assess climate-risk vulnerability at the proposed AMIA sites. This would ensure that AMIA investments are cost-effectively channeled to support its overall goals and outcomes. This also addresses the inherent spatial and temporal variabilities within and across sites.

CRVA results are critical to AMIA's planning and designing of a multi-regional project for action research and development to build CRA communities. The resulting information would support AMIA strategic decisions in targeting key climate risks for specific communities in priority commodities / systems / landscapes in each region.

## Objectives of the Study:

Generally, the study aimed to conduct a climate risk vulnerability assessment for agriculture in the provinces of Aklan, Antique, Capiz and Guimaras in Western Visayas. Specifically, the study was undertaken to:

1. Assess the agricultural vulnerabilities to climate change of the provinces Aklan, Antique, Capiz and Guimaras in Region 6 employing the Climate Risk Vulnerability Assessment Framework;

2. Quantify impacts of climate change on crops studied using crop distribution models (baseline and future scenarios) which are important components of CRVA and also in preparing research interventions aimed at improving agricultural practices and crop management to cope with climate change;

3. Produce technical information essentially needed in the region in crafting strategic response to effectively address vulnerability-related problems arising from climate change;

4. Generate fresh information needed in the formulation of appropriate interventions and CRA options to address climate-related risks, and strengthen the adaptive capacities of communities concerned through designing suitable interventions and mitigation measures;

5. Generate outputs that can guide and assist decision-makers from government agencies, extension staff, and private sectors on geographic areas that badly demand interventions, and help them package these interventions needed in each geographical location;

6. Focus risk and vulnerability evaluation on priority crops such as rice, corn, coconut, banana, and mango as prime commodities in the region; and

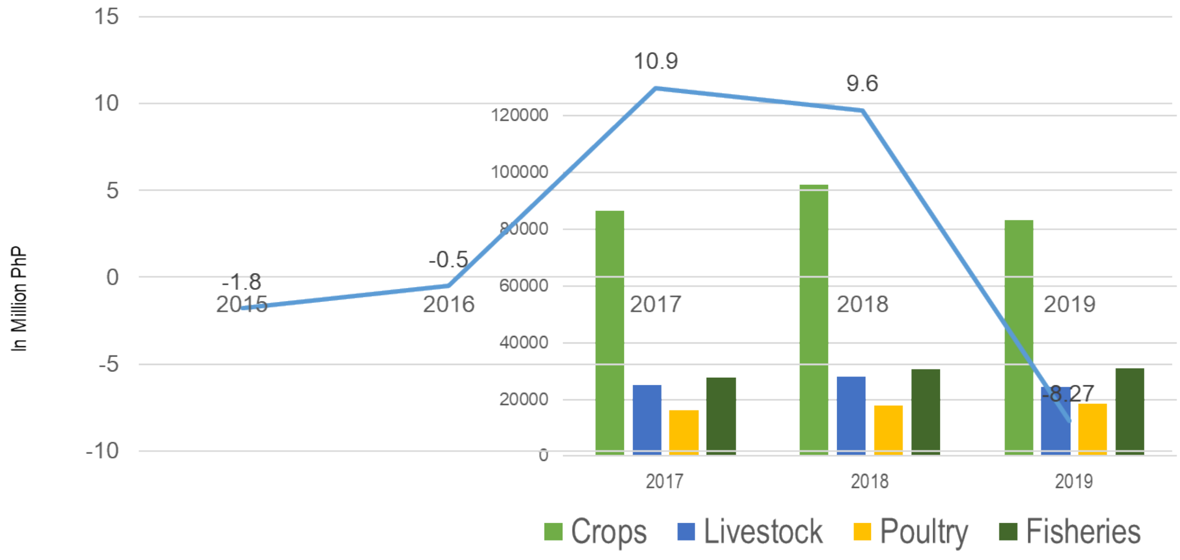
7. Produce strategic GIS-generated maps of rick-vulnerable areas in the provinces concerned that are prone to climatic hazards like drought, typhoons, floods, landslides, massive erosion, sea-level rise, and other risks caused by adverse weather conditions.

## REVIEW OF RELATED LITERATURES

Western Visayas is composed of six provinces namely: Aklan, Antique, Capiz, Guimaras, Iloilo and Negros Occidental with total agricultural land area of 1,217,042.99 hectares. Priority commodities produced are rice, corn, coffee, cacao, coconut, banana, mango, sugarcane, abaca, watermelon. Palay production slightly declined to 2,077,790 MT during the year from 2,232,292.75 MT in CY 2019 due to losses brought by El Nino and Typhoon Ursula. Western Visayas is the third largest rice producing region in the country contributing 11.04% to the national production. Province of Iloilo is the major source of palay in the region accounting to 42% of the total regional rice production followed by the provinces of Negros Occidental and Capiz with 21% and 16% respectively.

In terms of corn production, the region got a 3.94% share to the national corn production ranking 6th among regions. Negros Occidental has the largest contribution to the regional production with 49% followed by Iloilo and Capiz with 25% and 21% share respectively.

### Western Visayas' Gross Value Added in Agriculture, Forestry and Fishing




*Agri-Fishery GVA grew at an average annual rate of 1.99% from 2015 to 2019*
*Source: Philippine Statistics Authority*

The Gross Value Added (GVA) in Western Visayas over the 3-year period shows that the crops sector is the highest contributor to the total gross value added in AFFH, followed by fisheries sector. However, the livestock and poultry sectors combined account to a higher contribution than the fisheries sector. Growth rate of GVA on AFFH grew at an average annual rate of 1.99% from 2015 to 2019 due to a hefty decline on its GR during the period 2018-2019. Although increase in output of poultry and fisheries sectors were noted, decrease in outputs of crops and livestock sectors resulted in lower growth for the AFFH.

The region posted a 6.5% growth in its Gross Domestic Product (GDP) from 2018 to 2019 and remained the 5th largest economy outside of NCR. It posted a 915 Billion pesos at 2018 constant prices for 2019 while 916 Billion at current prices. The region's growth in 2018 approximates the national average GDP growth rate of 6.2 percent however, it has exceeded the national average growth in 2019 by posting an increase of 6.4 percent. The GRDP of Western Visayas for fiscal year 2019 was P915.3 billion compared to only P860.1 billion for fiscal year 2018.

The region's combined service sector still had the biggest contribution with 62.1 percent of the region's economy while the industry sector accounted for 21 percent of the region's economy. The agriculture, hunting, forestry, and fishing (AHFF) registered a share of 15.74 percent. The 2019 report on the economic performance of Western Visayas showed that agriculture, forestry, and fishing (AFF) rebounded to 0.5 percent from its -0.4 percent performance in 2018.

## Damage Report

For the past 10 years, Western Visayas recorded information on extreme weather events that has significant effect especially in the agriculture and fishery sector of the region. Around 12.9 Billion Pesos value of damage and Losses was recorded from C.Y. 2010-2020. The information shows trend that at least every three years, extreme weather events recur that risks around Three Billion Pesos. Super Typhoon Yolanda that occurred last CY 2013 has recorded the highest value of damage and losses amounting to around Three Billion Pesos which resulted to decline on the agri-performance of the region.

**Summary of Disaster Damage by Year and Value (cy 2010-2020)**

| Year | Value of Damage and Losses (PhP) | Significant Event |
|---|---|---|
| 2010 | 1,576,282,153.30 | *El Niño* |
| 2011 | 110,704,199.68 | |
| 2012 | 331,808,419.82 | |
| 2013 | 3,033,548,256.64 | *Super Typhoon Yolanda* |
| 2014 | 464,084,511.35 | |
| 2015 | 25,262,734.80 | |
| 2016 | 2,530,527,641.38 | *El Niño* |
| 2017 | 356,107,856.86 | |
| 2018 | 724,533,102.57 | *TD Agaton, TD Usman* |
| 2019 | 3,453,251,310.31 | *El Niño, TY Ursula* |
| 2020 | 392,060,467.03 | |
| **Total** | **12,998,170,653.74** | *(Significant events recur at least 3 years)* |

## Climate Risk Vulnerability Framework

Climate risks pose a major threat in sustaining the productivity of the agri-fisheries sector in the Philippines. To address this challenge, the Department of Agriculture (DA) launched the Adaptation and Mitigation Initiative in Agriculture (AMIA) to plan and implement strategies to help agri-fishery communities manage climate risks – from extreme weather events to long-term climatic shifts.

A key step in targeting and planning for Climate Resilient Agriculture (CRA) communities would be to assess climate-risk vulnerability at the proposed AMIA sites. This would ensure that AMIA investments are cost-effectively channeled to support its overall goals and outcomes. This also addresses the inherent spatial and temporal variabilities within and across sites.

Climate Risk Vulnerability Assessment (CRVA) results are critical to AMIA's planning and designing of a multi-regional project for action research and development to build CRA communities. The resulting information would support AMIA strategic decisions in targeting key climate risks for specific communities in priority commodities / systems / landscapes in each region.

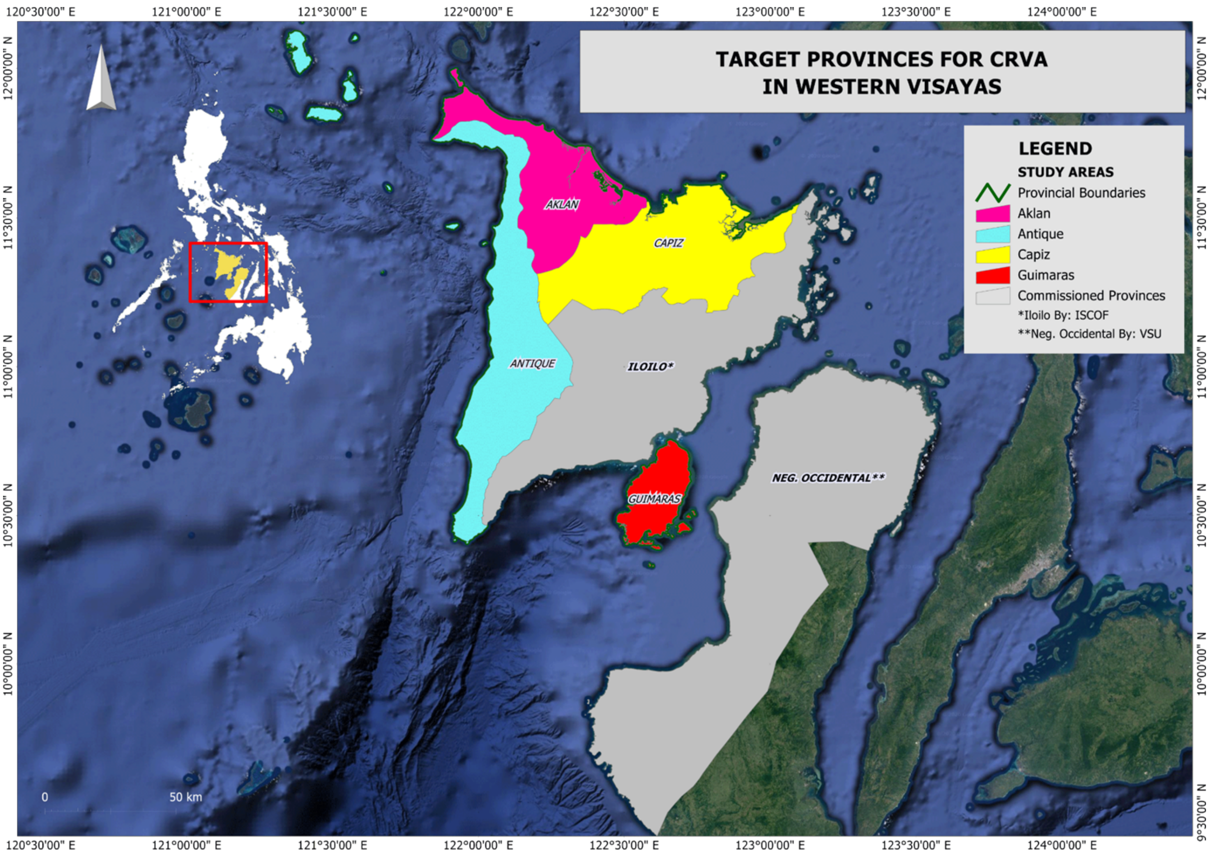



**Figure 1.** AMIA Villages in Region VI, Philippines

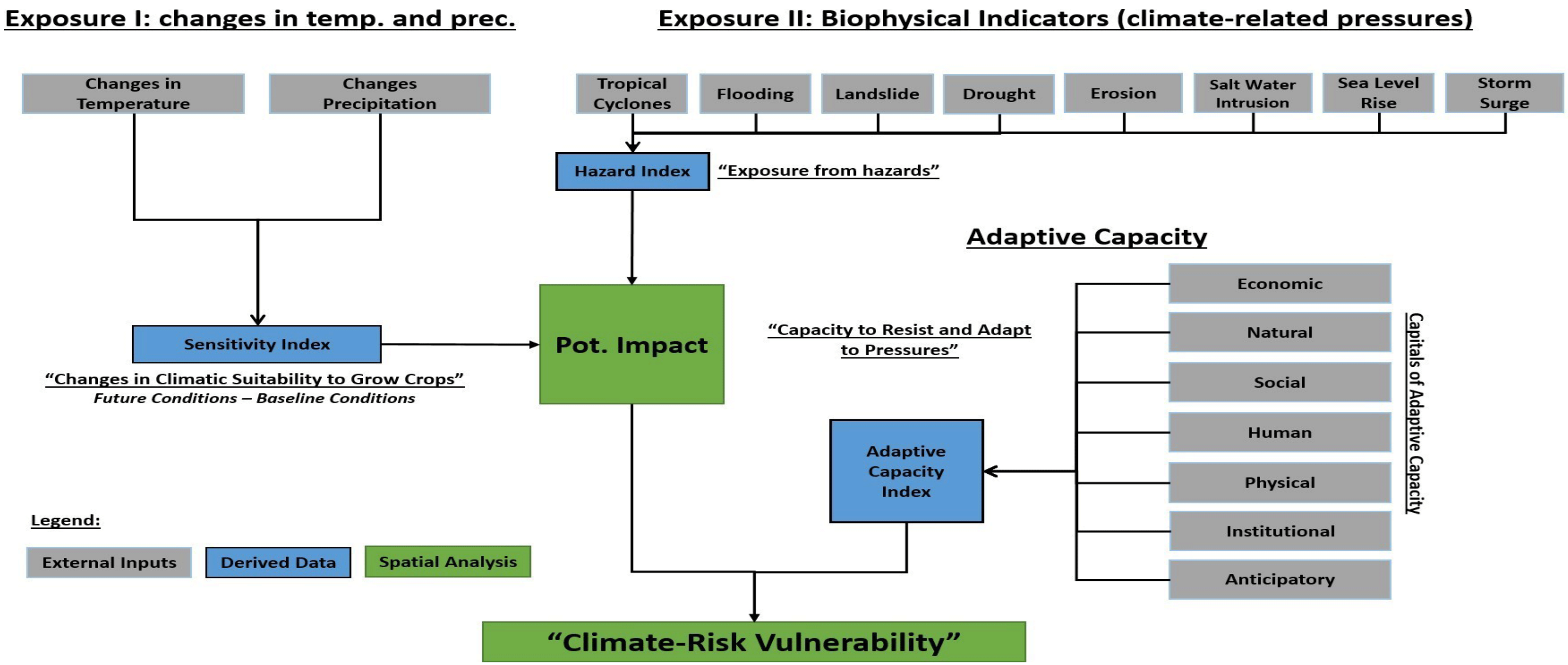
The Framework presents three key dimensions of vulnerability for the agricultural sector: To determine the vulnerability of the area, A Climate Risk Vulnerability Assessment Framework is utilized (Figure 2). This framework includes the following aspects:

**Exposure:** The nature and degree to which a system is exposed to significant climate variations (IPCC, 2014).

**Adaptive Capacity**: The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2014).

**Sensitivity:** The increase or decrease of climatic suitability of selected crops to changes in temperature and precipitation (Parker et al., 2019). The sensitivity analysis is based on the assumption of a high emission scenario (RCP 8.5) by 2050, whereas the adaptive capacity component is derived from the up-to-date and validated socio-economic and bio-physical data at the municipality-level of the provinces covered by the study. The 2050-time slice was selected to allow for medium term planning for agriculture. Selection of later time slices (2070 and 2090) also present higher climate uncertainty.

The resulting vulnerability assessment enables science- based spatial targeting of agricultural extension and financial investment in areas most at risk or tailored to a specific hazard, crop or lack of adaptive capacity. The framework is anchored on the approach of Intergovernmental Panel on Climate Change (IPCC) that defines climate change vulnerability in terms of exposure to climate change-induced shocks (e.g. increased typhoons, floods, drought, landslides, gradual warming and changes in precipitation patterns); the sensitivity of ecological systems to such shocks; and the adaptive capacity of livelihoods to respond to the climate shocks.




$$f(Haz, Sens, AC) = \sum_{n=i}^{n} (Haz_{(w_h)} + Sens_{(w_s)}) + (1 - AC_{(w_a)}) \quad \textbf{Eq. 1}$$

Where: *Haz* = hazard index, *Sens* = sensitivity index ($i$ = crop), and *AC* = adaptive capacity index. $W_h$ = weight given for hazard, $W_s$ = weight given for sensitivity, and $W_a$ = weight given for adaptive capacity.

**Figure 2:** Climate Risk Vulnerability Assessment Framework

## Recent Studies on Climate Change Vulnerability Assessment in the Philippines

Several vulnerability assessments[1] have already been conducted in the Philippines. The climate change vulnerability assessments in the Philippines is characterized by: 1) wide range of indicators used for each component of vulnerability; 2) coverage is very sparse; 3) coverage was broad (Asia) but resolution was too coarse (regional); 4) some study refers climate vulnerability as a single weather event (typhoon); 5) context – some are context specific (agriculture, watersheds) while others are general; 6) limited use of climate projections to forecast climate impacts to species and crops. The studies can be useful for different objectives and institutions, but the variables and analyses are of limited use if impacts of climate change will be understood for the agricultural sector that can be used by the Department of Agriculture in planning and designing Climate Resilient Agriculture (CRA). This shows that there is limited initiative that uses a scalable framework to map in high resolution (municipality level) the risks and vulnerability for long term agricultural resilience targeting and prioritization in the Philippines.

## Climate Projections in the Philippines

Figure 3 shows the projected precipitation and temperature changes in the Philippines across four time periods (KNMI, 2019). Most of the GCMs suggest that an increasing temperature minimum of ~2°C (with an uncertainty of ± 1°C) is expected in most parts of the country under RCP 8.5 scenario. Temperature minimum is one of the highest climatic factor that affects yields for rice (Peng et al., 2004) *"Rice grain yield declined by 10% for each 1 degrees C increase in annual mean minimum temperature"* and maize (Tongson et al., 2017) "*Projected rainfall patterns showed wet months becoming wetter and dry months becoming drier. Crop simulations showed 7% to 13% reductions in growing cycles and 17% to 41% reductions in mean yields. Reductions in mean yields were due to the larger influence of water stress on dry yields. The 11% to 13% reductions in wet yields were due to effects of rising temperatures rather than CO2 fertilization impacts"*. On the other hand, while the majority of the GCMs estimate that precipitation will increase, a few GCMs ($25^{th}$ percentile) suggest that there will be a decrease in precipitation in the Philippines by 2050 until the end of the century.

The uncertainty of temperature and precipitation shows that a wide range or an ensemble of GCMs should be used in assessing climate change impacts.

[1] Based on limited search over the internet for available articles and reports on VA.

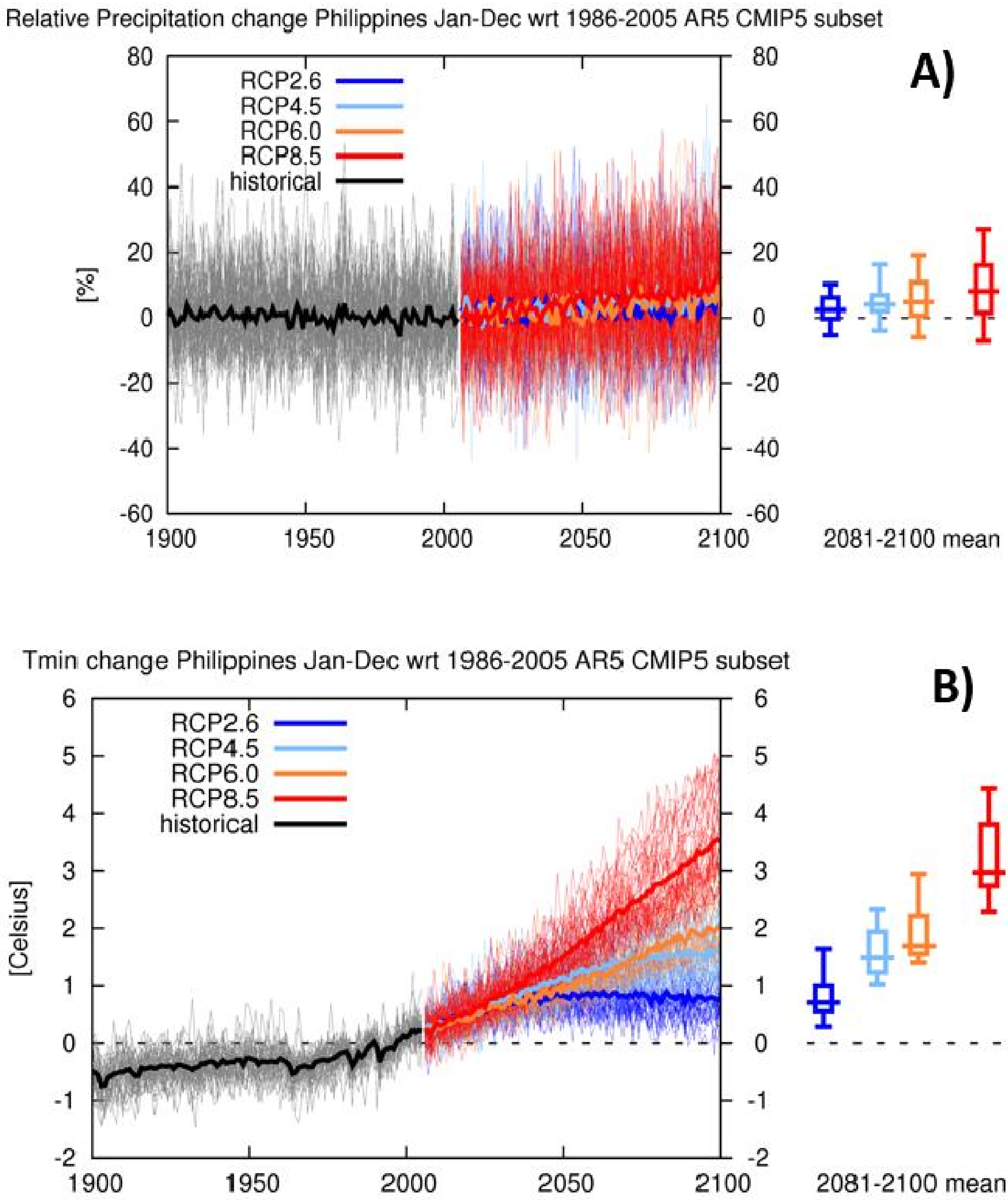



***Figure 3.*** *Projected changes in A) precipitation and B) temperature minimum in the Philippines by 2030, 2050, 2070, and 2090.*

## Background on Philippines’ Exposure to Natural Hazards

**Typhoons** are projected to globally increase its intensity due to progressive climate change over the coming decades (Webster et al. 2005, Emanuel et al. 2008). The vast majority (57%) of global typhoons occur in the Pacific Ocean basin (NOAA 2013): The Philippines is considered the second most exposed country in the world to typhoons after China (NOAA 2010), receiving at least 15 typhoons (aggregate of tropical storms and typhoons) a year (PSA, 2014). Northern Luzon, Southeastern Luzon, and Eastern Visayas are the geographical regions with high incidence of typhoons and tropical storms (Figure 4). With months of higher incidence of typhoons which fall on the major cropping season in the Philippines, farmers are at high risk in terms of crop losses. The economic vulnerability of the agricultural sector to typhoons being the most damaging geophysical hazard was highlighted by FAO (2015) in their recent disaster analysis for the Philippines: “Most of the production damage and losses [are] caused by typhoons/storms, amounting to USD 3.5 billion or 93 percent [for the agricultural sector]. The majority of the damage and losses in the agriculture sector were in the crop sub sector with USD 3.1 billion [for the period 2006-2013]”.

Agricultural production in the Philippines, particularly rice and maize, are exposed to the impact of typhoons since the growing period of these crops coincides when typhoon events are high (Figure 4A). A single typhoon event can cause billions of pesos in terms of damage to agriculture alone (Figure 4B). In 2013, Super Typhoon Yolanda hit Western Visayas and caused extensive damage to agriculture estimated to reach PhP 2,972,956,167.64 in the region alone. Data source from Department of Agriculture Region 6. The department has recorded an estimated amount PhP 6,970,914,854.44 of damage from typhoons for the year 2010 to 2020 that hit Western Visayas.

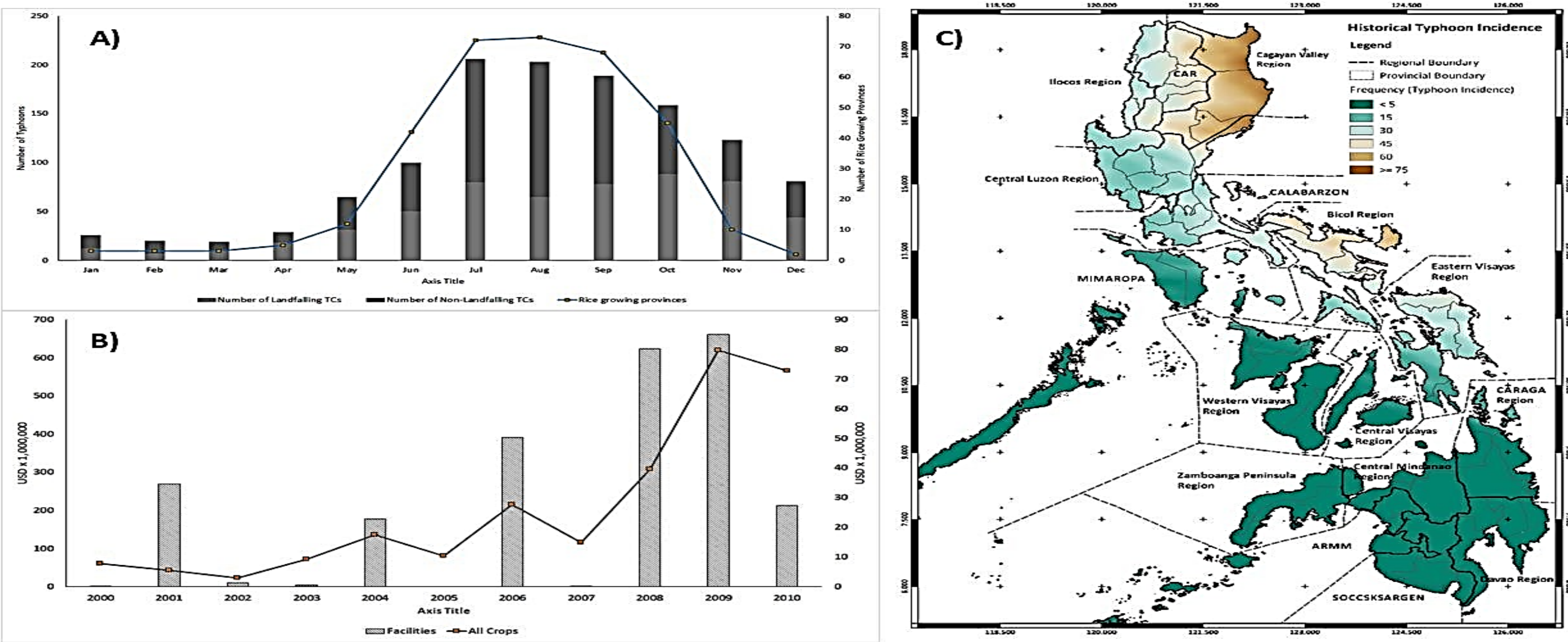



***Figure 4.*** *Temporal and spatial risk of typhoon in the Philippines showing A) monthly frequency of tropical cyclones entering the Philippine Area of Responsibility (PAR), B) Crop damage trend, and C) Areas that are most frequently visited by typhoons.*

The damage to crops, property, and livelihoods brought about by typhoons, flood, and drought are increasingly becoming greater and costly. As reported by Israel and Briones (2013), the total economic damage of typhoons, flood, and drought from 2000 to 2010 is estimated to be USD 2,234.21 million. The rice sector suffered the most and the damage has an estimated value of USD 1.2 billion, followed by maize (USD 461.50 million) and high value crops (HVC) (USD 244.82 million). Damage to agricultural facilities was found out to be related to crop damage during typhoon, flood, and drought events (Israel and Briones, 2013). The eight climate-related hazards that were considered in this study are briefly described below with an emphasis on its impact within the Western Visayas context.

**Flooding** is a scenario occurring when there is an abnormal progressive rise in the water level of a stream that may result in the overflowing by the water of the normal confines of the stream with the subsequent inundation of areas which are not normally submerged. There are two kinds of flood, the Minor flooding and Major flooding, while floods take some time, usually from 12 to 24 hours or even longer, to develop after the occurrence of intense rainfall, there is a particular type known as flash floods which develops after no more than six hours and, frequently, after an even less time. The Department of Agriculture Western Visayas reported an accumulated cost of damage of Php12,694,006,993.08 for CY 2010-2020 due to flooding. Flood dataset was acquired from the multi-hazard AMIA dataset in shape file format also with the other 7 remaining hazards under the study.

**Drought** is a prolonged dry period in the natural climate cycle that can occur anywhere. It is a creeping phenomenon brought by deficiency of precipitation over an extended period of time where agriculture is the most affected sector. The impacts of drought usually include damage to crops and reductions in crop yields, death of livestock and wildlife, increased fire hazard, reduced freshwater availability and damage to wildlife fish habitats. These impacts might greatly affect the economic and social consequences including reduced income for the agriculture and broader economic sectors, higher food prices, unemployment and migration, and even death induced by starvation and armed conflicts.

Drought is usually categorized into five main types: Meteorological drought, Hydrological drought, Agricultural drought, Socio-economic drought and Ecological drought. The Department of Agriculture in Western Visayas has recorded a total amount of damage of Php 5,350,011,169.28 due to drought from CY 2010 to 2020.

**Erosion** is the geological process in which earthen materials are worn away and transported by natural forces such as wind or water. This scenario is usually caused by deforestation, overgrazing, use of agrochemicals which eventually leads to loss of arable land, clogged and polluted waterways and increase in the occurrence of floods.

A **landslide** is the mass movement of rock, soil, and debris down a slope due to gravity. It occurs when the driving force is greater than the resisting force. It is a natural process that occurs on steep slopes. The movement may range from very slow to rapid. It can affect areas both near and far from the source. Landslide materials may include soil, debris, rock and garbage. What triggers landslides are natural triggers, intense rainfall, weathering of rocks, ground vibrations created during earthquakes, volcanic activity and man-made triggers. What triggers this hazardous event are: steep slopes, weakening of slope materials, weathering of rocks and overloading on the slope.

A **storm surge** also known as "Daluyong ng Bagyo" is the abnormal rise in sea level that occurs during tropical cyclones. It is caused by strong winds and low atmospheric pressures produced by tropical cyclones. As the tropical cyclone approaches the coast, strong winds push the ocean water over the low-lying coastal areas, which can lead to flooding. It becomes more dangerous when it arrives on top of a high tide. When this happens, it may flood areas that otherwise might have been dry or safe. On top of the storm surge, big and strong waves generated by powerful winds also come with it.

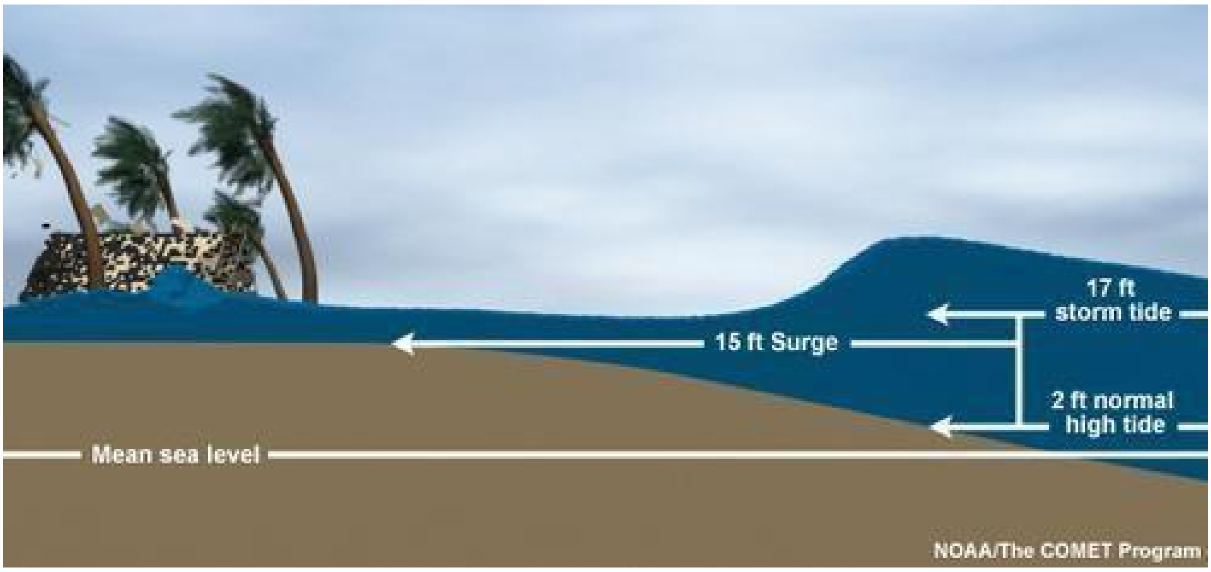



**Figure 5.** Storm surge vs. storm tide and normal high tide

**Sea level rise** refers to an increase in the volume of water in the world's ocean caused by global warming. Its causal factors relative to global warming such as added water from the melting land ice / glaciers and expansion of sea water as it warms were identified by NASA (National Aeronautics and Space Administration). According to Lewis as stated by Kim et al., (2010), there are two types of sea level rise: Eustatic sea level rise and Isostatic sea level rise. The Eustatic sea level rise responds to major climatic change and possibly affected by global warming while the Isostatic sea level rise is a localized representation of vertical displacements of land surface with respect to sea level.

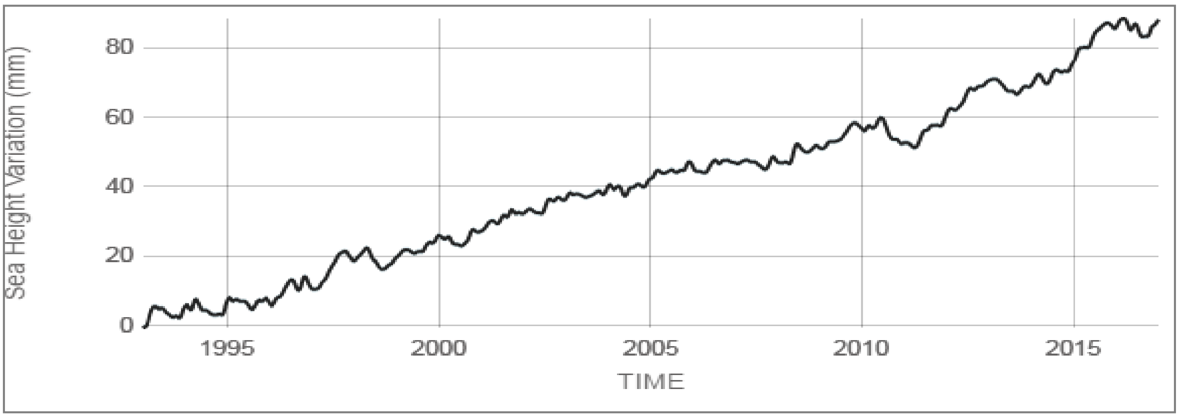



**Figure 6.** Global sea level observations by satellites showing the rate of change in mm/yr Source: (climate.nasa.gov)

**Saltwater intrusion** is defined as the movement of the saline water towards the freshwater aquifers that can lead to contamination of drinking water, as well as a decrease in freshwater storage in the aquifers. Along with coastal areas, saltwater intrusion naturally occurs and is found in the zone of dispersion or transition zone, where the freshwater and saltwater are diffused to keep it at a neutral level (USGS). Common mechanisms which cause saltwater intrusions are groundwater extraction, the deepening of canals and drainage networks, and other human activities that lower groundwater levels and reduce freshwater flow to coastal waters.

## Rainfall and Temperature

Crop suitability depends mainly on the temperature and precipitation of its location. Some crops favorably grow in hot areas with less amount of precipitation while some require low temperature but more precipitation or a sufficient amount of water. The increase or decrease of climatic suitability of selected crops to changes in temperature and precipitation is called the sensitivity of crops and such change will either have a positive or negative impact on crops grown at their respective locations.

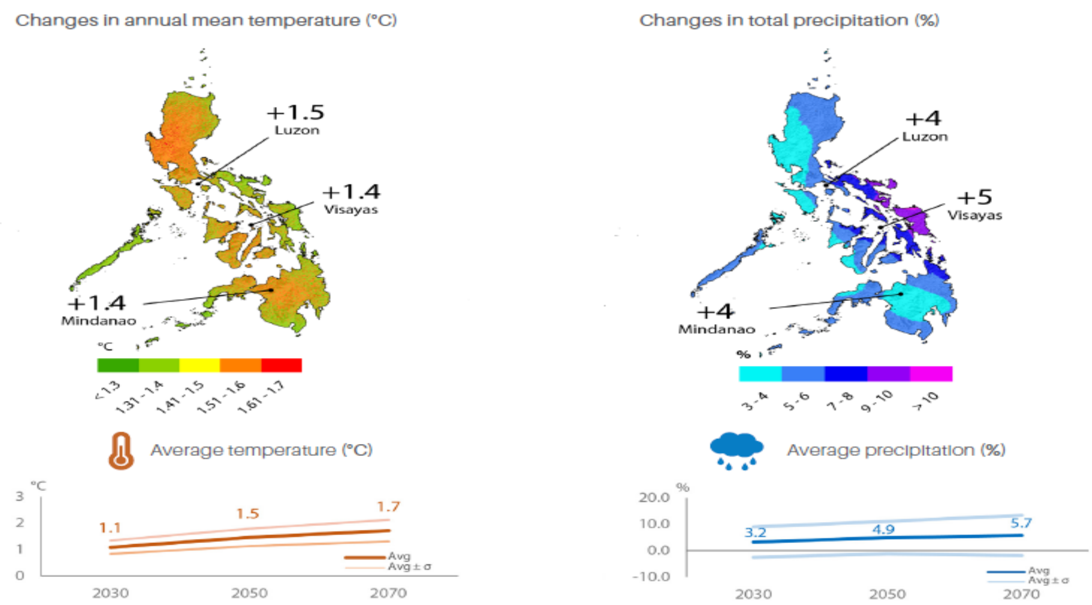



***Figure 7.*** *Projected changes in temperature and precipitation in the Philippines by 2050*

Hot temperature and heavy precipitation will likely continue to become more frequent in the future. The number of days with maximum temperature >35°C is expected to increase in all parts of the country in 2020 and 2050. Extreme rainfall is projected to increase in Luzon and Visayas in 2020 and 2050 (PAG-ASA).

## RESEARCH METHODOLOGY

### Study Sites and Duration

The study was conducted in all the municipalities/cities of the four provinces, namely: Aklan, Antique, Capiz and Guimaras, all in Western Visayas from 2020-2021. Concerned LGU officials and employees at the provincial and municipal levels and other respondents from the private sector were involved in the study.

### Evaluation Procedures

The evaluation procedures basically followed the Climate Risk Vulnerability Assessment (CRVA) Framework (Figure 2). In this framework, three major parameters or components of climate-risk vulnerability assessment were used, namely: two categories of exposures (Exposure I and II) and adaptive capacity. Exposure I (impact of climate change to crop suitability) involved changes in weather parameters like temperature and precipitation while Exposure II (climate-related pressures) represented biophysical indicators involving climate related pressures like tropical cyclone, drought, flooding, storm surge and others. Adaptive capacity, on the other hand, referred to the capacity of the area under evaluation to resist and adapt to pressures which involved economic, social, human, institutional and other related factors. How the framework was used is explained below.

Much of the needed data and information, and other research materials and documents were obtained from secondary sources. Hazard data were gathered from official releases of authorized government and non-government agencies as well as from other international institutions consolidated from AMIA I.

A hazard Index used in the study was generated through a GIS/QGIS processes given the formula and weights based on experts' opinion. Adaptive Capacity, on the other hand, was measured using seven major capitals of the LGUs as indicated in the CRVA framework. Values generated from these capitals were used to generate Adaptive Capacity Index. Since the generated potential impact was a negative impact, values for Adaptive Capacity Index were inverted and added to potential impact to generate the overall vulnerability assessment. Some evaluation tools and established procedures concerning risk and vulnerability evaluation relevant to climate change were also employed in generating the primary data. The use of these evaluation tools and procedures as well as other methodologies and processes employed in data gathering and processing are explained below.

**Exposure 1: Sensitivity** (Impact of Climate Change to Crop Suitability)

The crop sensitivity was assessed by changes in climatic suitability of crops by the year 2050 in comparison with the baseline suitability. MaxEnt or Maximum Entropy was used to map the climate suitability of crops. Analyzing changes in climate-crop suitability involves a two-step process: the first step is to assess the baseline (current climate condition) climate-crop suitability which is based on the condition that a species is predicted to occur at a particular location if it approximately matches the environmental condition where it is observed. And the second step is to predict the species suitability on a projected period, the year 2050 if it matches the environmental condition where it is observed from the baseline condition.

## Crop Selection and Collection of Occurrence Data

Top commodities produced in the province were identified as the basis for crop selection for the sensitivity component of CRVA. This was initiated by the AMIA Team of DA RFO 6 together with project partners from the Provincial Office for Agricultural Services through a series of consultations and data derived from PSA were also used. These crops included rice, corn, coconut, mango, banana, and sugarcane.

After the selection of crops to be subjected for sensitivity analysis, the AMIA Team invited Municipal Agriculturists and their representatives for the Crop Occurrence Workshop where they were provided with administrative maps of their municipalities having features such as road and river networks, digital elevation model scaled at 1 km grid and landmarks. They were asked to label each grid if the crop identified is present in the area. In addition, the rule "one crop per pixel" was followed, for instance, if rice is present in multiple locations within the pixel, it can only be marked once. However, multiple crops were allowed per pixel, so if both banana and coconut are present within a single pixel, then it must be marked using the assigned symbol for the two crops found in the designated area. A small or large area of the crop was marked if the crop is present in the pixel. The maps with markings were scanned, georeferenced, and was converted as point vector data to shapefile or CSV (comma-separated value).

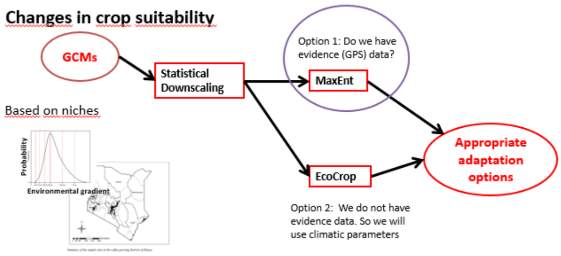
## Baseline Climate Conditions

A total of 20 bioclimatic variables (Annex 1) were selected to assess the climate suitability of crops representing annual trends, seasonality, and extreme or limiting environmental factors. For baseline conditions, the Wordclim dataset (available at Worldclim.org) (Hijmans, 2005) was used. The bioclimatic variables were derived from monthly temperature and rainfall values and were processed to generate more biologically significant climate variables (Hijmans, 2005). These described bioclimatic factors are relevant in understanding the species response to climate change (O'Donnell, M., and Ignizio, D., 2012).

## Future Conditions

Crop distribution was modeled for the present and future conditions to assess the degree of changes in suitability under climate change. Thirty-three (33) CMIP5 GCM models under Representative concentration pathway (RCP) 8.5 scenario (IPCC, 2013 - based on IPCC Assessment Report 5) as the basis to assess the impact of climate change on climate-crop suitability. RCP 8.5 is characterized as increasing greenhouse gas emissions over time. The data can be downloaded from the Climate Change and Food Security website http://www.ccafs-climate.org/data_spatial_downscaling/

## Model Framework and Implementation




Bio1 = **Annual mean temperature**
Bio2 = **Mean diurnal range**
Bio3 = **Isothermally**
Bio4 = **Temperature seasonality**
Bio5 = **Maximum temperature of warmest month**
Bio6 = **Minimum temperature of coldest month**
Bio7 = **Temperature annual range**
Bio8 = **Mean temperature of wettest quarter**
Bio9 = **Mean temperature of driest quarter**
Bio10 = **Mean temperature of warmest quarter**
Bio11 = **Mean temperature of coldest quarter**

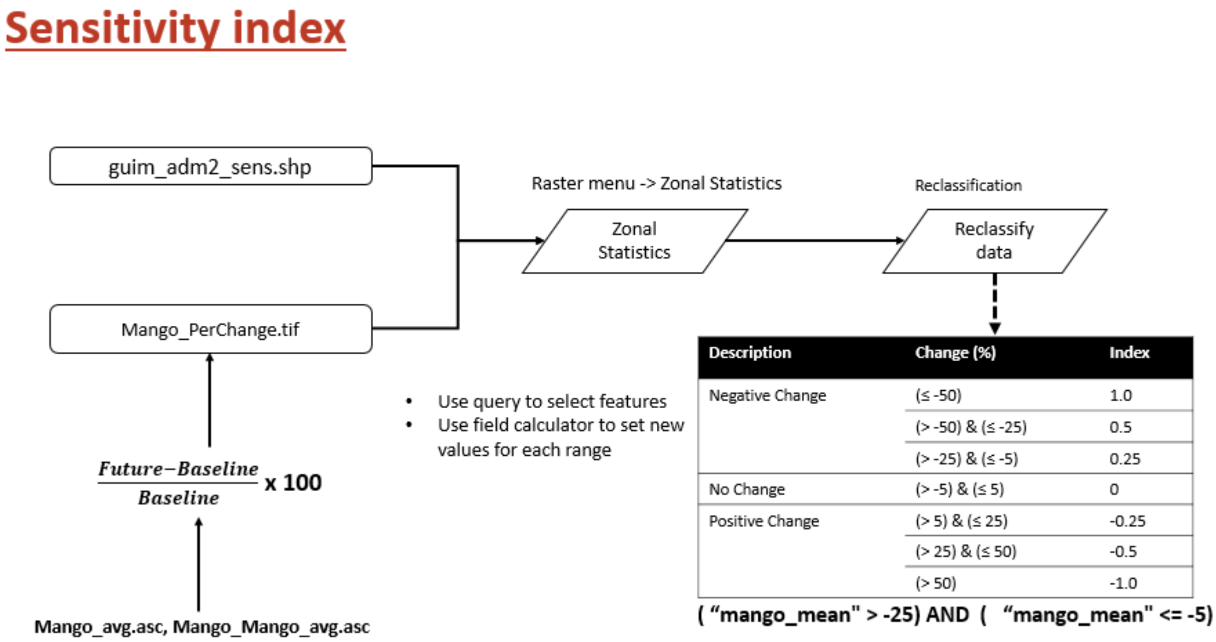
Bio12 = **Annual precipitation**
Bio13 = **Precipitation of wettest month**
Bio14 = **Precipitation of driest month**
Bio15 = **Precipitation seasonality**
Bio16 = **Precipitation of wettest quarter**
Bio17 = **Precipitation of driest quarter**
Bio18 = **Precipitation of warmest quarter**
Bio19 = **Precipitation of coldest quarter**
Bio 20 = **No. of consecutive dry days**

***Figure 8.*** *Available SDM and temperature and rainfall related bioclimatic variables used to download crop suitability from MaxEnt*

## Data Processing using MaxEnt

A crop occurrence workshop was conducted per province. Using a base map with 1 square kilometer grid, five (5) priority commodities were located by the Municipal Agriculturist or their representative on their respective base maps. After completion, base maps were scanned and georeferenced to generate the latitude and longitude of every point. Each point was validated and the GDB file was transferred to the excel file.

Excel file was then converted to CSV format and was uploaded to MaxEnt (Maximum Entropy) as input data and selecting environmental layers containing the temperature and rainfall related bioclimatic conditions to generate the ASC file containing the crop suitability to various bioclimatic conditions for the baseline (the year 2020 as present). Asc file was then loaded to GIS to generate Crop suitability values. Using the same process, future data were generated and the percent change in crop suitability was calculated using the formula on the process shown in Figure 9.




| Description | Change (%) | Index |
|---|---|---|
| Negative Change | (≤ -50) | 1.0 |
| | (> -50) & (≤ -25) | 0.5 |
| | (> -25) & (≤ -5) | 0.25 |
| No Change | (> -5) & (≤ 5) | 0 |
| Positive Change | (> 5) & (≤ 25) | -0.25 |
| | (> 25) & (≤ 50) | -0.5 |
| | (> 50) | -1.0 |

***Figure 9.*** *Steps in processing the sensitivity index of crops*

## Exposure 2: Exposure to Hazards

A combination of spatially enabled natural hazard datasets has been used to estimate the hydro-meteorological risks of each municipality. Most of the datasets referred to historical databases to evaluate the current potential risk. We limit the analysis of hazards to baseline conditions because many climate hazards can be large-scale singular events and projections of climate hazards (e.g. year 2050) would add further layers of uncertainty in the assessment.

However, while it was not possible to attribute singular extreme events to progressing climate change, it was agreed that the likelihood of most extreme events is increasing under progressing climate change (IPCC 2012). The succeeding section below discusses the procedure to develop the hazard index and a brief description of each hazard was considered in the study.

## Hazard Data Set

The development of a hazard index relies on spatial analysis of the weighted combination of different historical climate-related natural hazards in the Philippines using open-sourced and official data (Table 1). Eight (8) hazards were identified in Region 6 that affect crops and livelihoods, these are tropical cyclones, storm surge, flood, drought, soil erosion, landslide, saltwater intrusion, and the sea level rise. Since each hazard has different characteristics (i.e., degree of damage, intensity, and frequency) the potential damage also varies. We used the hazard weights developed by the International Center for Tropical Agriculture (CIAT) for the Visayas and applied them in Region 6. The weights were derived based on participatory workshops with regional partners and experts using the following criteria: 1) frequency of occurrence, 2) impact of local household income, 3) impact to key natural resources to sustain productivity (refers to how key resources such as water quality and quantity, soil fertility, and biodiversity are affected), 4) impact to food security of the country, and 5) impact to the national economy. The following hazards received the corresponding weights (Annex 2) for Visayas Island group where Region 6 belongs: Tropical Cyclone (18.21), Flood (16.40), Landslide (10.72), Soil Erosion (12.57), Drought (16.17), Salt Water Intrusion (7.21), Sea Level Rise (8.33) and Storm Surge (10.39). Each hazard data was aggregated by the municipality using zonal statistics. The spatially weighted sum of all hazards was used to develop the hazard index for each municipality. Values were normalized using Eq 3 to standardize the value from 0 to 1.

$$hazidx\_norm = \frac{X - X_{min}}{X_{max} - X_{min}} \qquad \text{Eq. 3}$$

*where: hazidx_norm is the normalized values of the hazard index.*

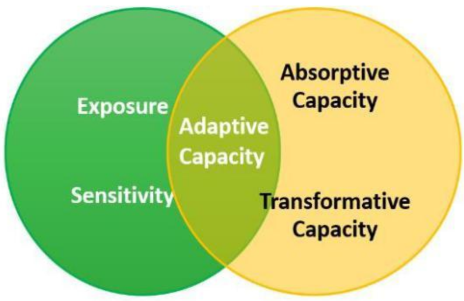
***Table 1.*** *Overview of hazard dataset used for exposure component*

| Parameter | Source | Unit of measurement, spatial and temporal resolution |
|---|---|---|
| **Typhoon** | UNEP / UNISDR, 2013 (https://preview.grid.unep.ch/) | 1 kilometer pixel resolution. Estimate of tropical cyclone frequency based on Saffir-Simpson scale category 5 (> 252 km/hr) from year 1970 to 2013. |
| **Flooding** | AMIA multi-hazard map / baseline data from Mines and Geosciences Bureau, Department of Environment and Natural Resources (MGB, DENR) | 1:10,000 scale. Susceptibility of flood risk for the Philippines from the past 10 years |
| **Drought** | AMIA multi-hazard map / baseline data from Mines and Geosciences Bureau, Department of Environment and Natural Resources (MGB, DENR) | Groundwater potential for the Philippines |
| **Erosion** | AMIA multi-hazard map / baseline data from Bureau of Soils and Water Management | 1:10,000 scale. Soil erosion classified from low to high susceptibility |
| **Landslide** | AMIA multi-hazard maps / baseline data from MGB, DENR | |
| **Storm Surge** | AMIA multi-hazard maps / baseline data from Disaster Risk and Exposure Assessment for Mitigation, Department of Science and Technology (DREAM, DOST) | |
| **Sea Level Rise** | AMIA multi-hazard map | Assumption based on 5m sea level rise |
| **Salt Water Intrusion** | AMIA multi-hazard map / baseline data from the NWRB | Groundwater potential for the Philippines |

## Adaptability Capacity

Adaptive capacity (AC) was one of the three key dimensions of CRVA (Figure 2). If exposure to a natural hazard will have a negative impact in agriculture while crop sensitivity due to change in precipitation and temperature will either gain, lose, or remain no change on crop suitability in the future, adaptive capacity will create a positive impact. In this text we define adaptive capacity according to the IPCC (2014): "Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences." Due to the country-wide scale, this vulnerability assessment took, thus, a broader approach to adaptive capacity than more in-depth resilience assessments.

## Vulnerability and Resilience




| [redacted] | |
|---|---|
| Components: Exposure, Sensitivity, Adaptive Capacity | Components: Absorptive Capacity, Adaptive Capacity, Transformative Capacity |
| "Passive": What stressors are regions/societies exposed to? | "Active" : Capacities to respond to stressors or changing conditions |

***Figure 10.*** *Concepts of vulnerability and resilience (Source: IPCC, 2014).*

The AC component of CRVA reflects the abundance of the asset of the municipality per province in terms of seven (7) major capitals and it also shows the ability of the municipality to mitigate the negative effects of climate change. In this study, CIAT set the seven standard capitals of CRVA to wit: economic, natural, social, human, physical, anticipatory, and institutional. Each capital gauged using indicators under each capital.

## Indicator Identification Process

The preliminary set of adaptive capacity data were developed by CIAT using official and local datasets. The dataset was analyzed using statistical analysis and integrating feedback from experts to select relevant variables. Country databases from the Cities and Municipalities Competitiveness Index (CMCI, 2015), Philippines Statistics Authority, and previous DA projects were used to collect country-wide socio-economic data. Other data sources were derived through a workshop conducted with Municipal Agriculturists / Representatives. An initial presentation of output was also conducted to verify the validity of initial data gathered and was attended by farmers and stakeholders coming from MLGUs, PLGU, and DA-Western Visayas. Furthermore, after series of editing and processing, online consultation with Municipal Agriculturists, Municipal Planning and Development Officers, Provincial Agriculturist and Provincial Planning and Development Officer including representatives from banner programs of DA and AMIA Team were also done to check and finalize the accuracy of such.

The values of the indicators (Annex 3) were normalized and were converted to a GIS spatial format by joining it to the shapefile of administrative maps per municipality. Each of the indicators and sub-indicators was aggregated for each capital. The sum of all the AC capitals was used to represent the AC index. The AC index was normalized before calculating the vulnerability. The process for deriving adaptive capacity is shown in figure 11.

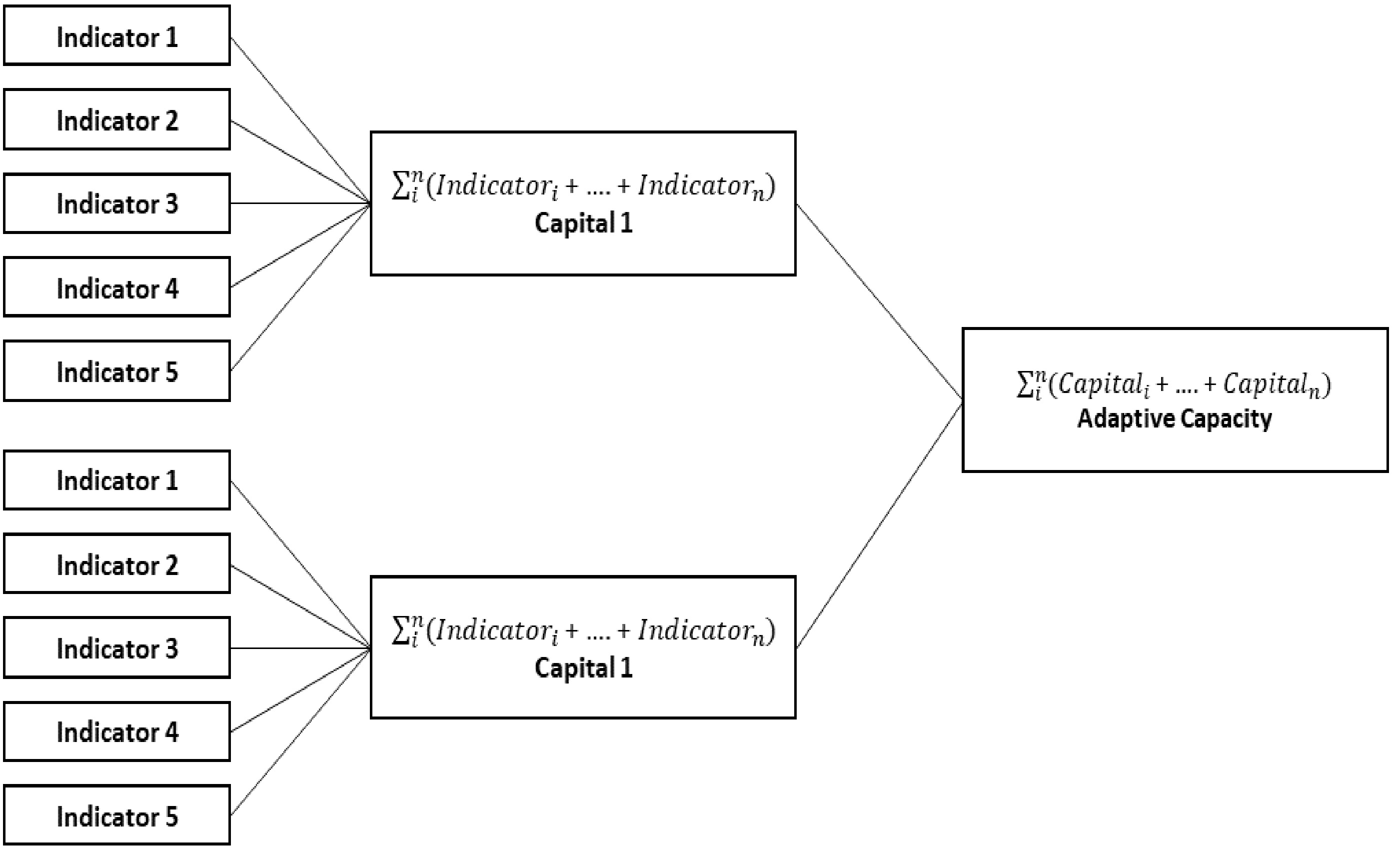



***Figure 11.*** *Process flow for deriving the overall adaptive capacity index for each municipality*

**RESULTS AND DISCUSSION**

**Preliminaries**

Relative to the risks and hazards associated with climate change, this study has generated significant information on the aspects of vulnerabilities and adaptive capacities of the five provinces studied. The results and discussions below deal with the three major components of climate-risk vulnerability assessment based on the CVRA framework, namely: two categories of exposures (Exposures I and II) and adaptive capacity. As described in the methodology, Exposure I involved assessment of the impact of climate change to crop suitability involving changes in weather parameters like temperature and precipitation while Exposure II assessed climate-related hazards and pressures such as tropical cyclone, drought, flooding, landslides, erosion, storm surge, saltwater intrusion, and others. On the other hand, adaptive capacity dealt with the capacity of the area under evaluation to cope and adapt to climatic pressures which involved assessment of economic, social, human, institutional capitals and other related factors. The more salient findings generated in this study are presented and discussed below by province in this sequence: Aklan, Antique, Capiz, and Guimaras.

# Province of Aklan

## Provincial Profile

The Province of Aklan is situated in the northwestern potion of Panay Island in Western Visayas. It is divided into 327 barangays grouped into 17 municipalities of which Kalibo is considered the capital town. Based on the 2020 census, the province has a population of 615,475 with a population density of 340 inhabitants per square kilometer. Basically, the economy of Aklan is largely agro-based where a greater majority of its population depends heavily on farming and fishing as primary form of livelihood. Primary agricultural crops raised include rice, corn, coconut, banana, mango and a large variety of vegetables and fruits, among others. Aklan is famous for Boracay, a world-known resort island one kilometer north from the tip of Panay. It is known for its white sandy beaches and is considered as one of the more prominent destinations in the country.

Kalibo is most famous also of its *Ati-atihan* festival which is celebrated annually – an economic asset to the tourism industry of the province.

Being located in the eastern part of Panay, the province is frequently visited by typhoons resulting in climate-related hazards such as floods, landslides, storm surge, and heavy erosion that bring havoc to the inhabitants of the area and the economy of the province. The long coastline which almost entirely stretches along the northern part of the province makes it highly vulnerable to typhoons and storm surge especially during the northeast monsoon season or *amihan.*

## Sensitivity Assessment of the Climate Change Impact to Crop Suitability (Exposure 1)

Presently, the selected priority commodity in the Province of Aklan is apparently suitable as a result of crop occurrence workshop conducted per province wherein occurrence of such crops in every municipality is a proof of suitability. Maps below will show the result of crop suitability of five priority crops in the province considering the temperature and rainfall related bioclimatic conditions where the crop is located. As a guide in the interpretation of visualization maps, color indicators were used. Color of areas ranging from green to blue tend to gain crop suitability which would correspond to climatic condition favorably increase more suitable areas (%) in the future (2050). This change is also called as positive change. Color ranging from orange to red indicate loss of crop suitability that would correspond to the decrease of suitable areas. This change is also called negative change. Color yellow indicates no significant change in crop suitability. Table 1 below contains values which were used in the determination of suitability of the five crops studied.

*Table 1. Percent change of crop suitability for the five prority crops in Aklan province from 2020 to 2050.*

| Municipality | Percent Change | | | | |
|---|---|---|---|---|---|
| | Rice | Corn | Coconut | Mango | Banana |
| **Altavas** | -1.68 | 2.63 | -1.58 | 10.33 | .85 |
| **Balete** | 2.73 | 2.11 | 2.57 | 3.30 | 3.6 |
| **Banga** | 2.36 | 0.37 | 3.98 | 0.19 | 2.13 |
| **Batan** | -2.40 | 2.05 | -4.62 | 7.75 | -0.91 |
| **Buruanga** | -3.61 | -3.68 | 1.23 | -4.13 | 2.66 |
| **Ibajay** | 4.37 | 6.87 | 5.73 | -5.86 | 0.36 |
| **Kalibo** | 1.58 | 0.44 | 1.83 | 5.96 | 0.30 |
| **Lezo** | 1.85 | -2.04 | 3.26 | 3.17 | -0.48 |
| **Libacao** | -0.98 | 0.98 | 0.31 | 13.51 | 0.36 |
| **Madalag** | -2.33 | -0.19 | -0.09 | -1.92 | 0.2 |

| | | | | | |
|---|---|---|---|---|---|
| **Makato** | 0.46 | -1.06 | 2.43 | 1.25 | -2.49 |
| **Malay** | 0.30 | -3.51 | -2.93 | -1.5 | -2.10 |
| **Malinao** | -1.50 | -4.21 | -1.51 | -5.86 | -2.02 |
| **Nabas** | 5.00 | 4.79 | 1.30 | -8.44 | 0.69 |
| **New Washington** | 1.59 | 3.02 | 1.87 | 1.85 | 0.32 |
| **Numancia** | 0.94 | -2.83 | 2.44 | 4.77 | -0.21 |
| **Tangalan** | -0.29 | -0.87 | 1.63 | 1.63 | -2.74 |

*Note: The above table of values shows the municipalities that will have no change if it ranges from greater than (-) 5% to less than or equal to (+) 5)%, positive change if values ranges greater than (+) 5% and negative change if it ranges lower than (-) 5%. Areas fell under no change will not be affected by climate change in the future significantly, while areas fell under positive change, future climatic condition will favor their growth and areas fell under negative change will loss climatic suitability where climatic condition will have a negative effect to their agronomic growth performance.*

Presented and discussed below are visualization maps showing possible changes in crop suitability of the five priority crops in the Province of Aklan projected from 2020-2050. Their corresponding percent change is shown in Table 1. The five crops are presented in sequence as follows: rice, corn, banana, coconut, and mango.

***Rice***. Aklan is primarily a rice growing province where a greater majority of its population are involved in the production of this crop. The results of the assessment show that the entire province would remain "no change" in the foreseeable future – that growing rice in this province would remain unchanged. That considering the projected climatic conditions, the areas presently planted with rice across the province will remain suited to the crop (Figure 21).

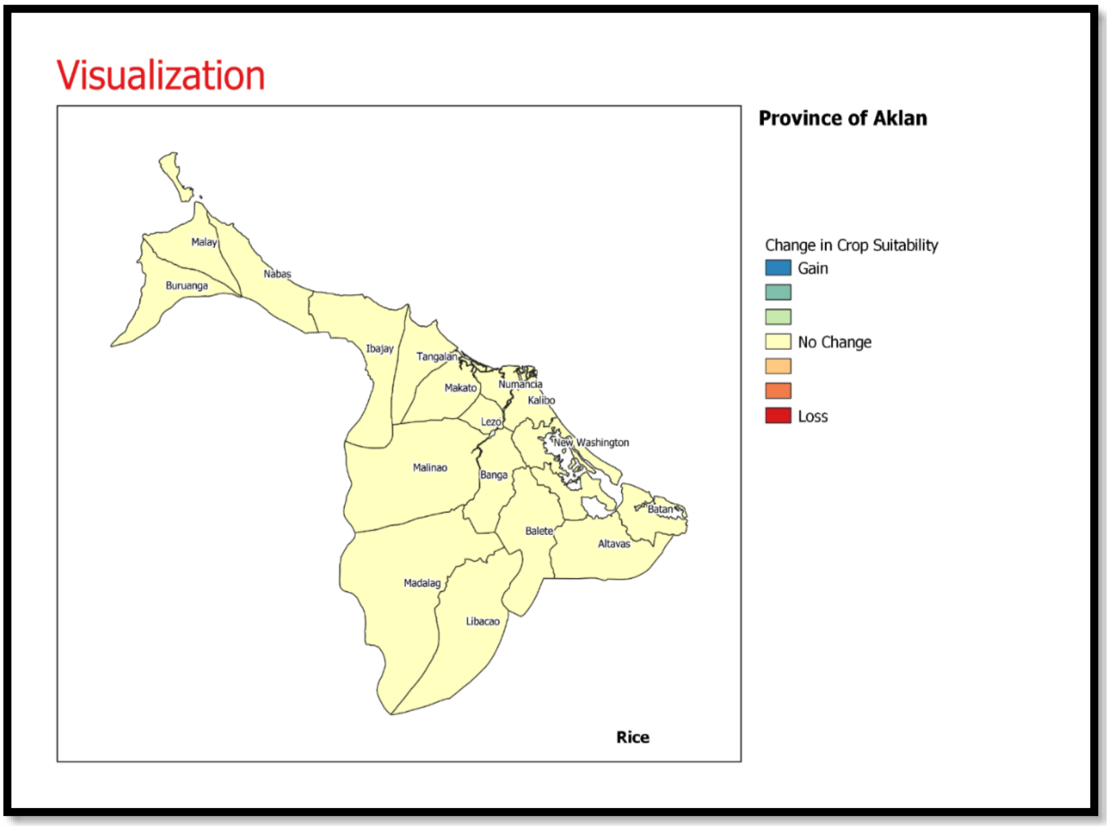



***Figure 21****. Visualization map showing the changes in crop suitability for rice in the Province of Aklan.*

***Corn.*** Second to rice, corn is the next important economic crop for *Aklanons.* The assessment results revealed that this crop will also remain suitable in the future, except in the municipality of Ibajay which gained even greater suitability (Figure 22). Corn in this town will grow well with favorable climatic conditions in the immediate future. The results also showed that the rest of the municipalities gained no negative change or loss of suitability, a good indicator that corn production in Aklan will be more feasible.

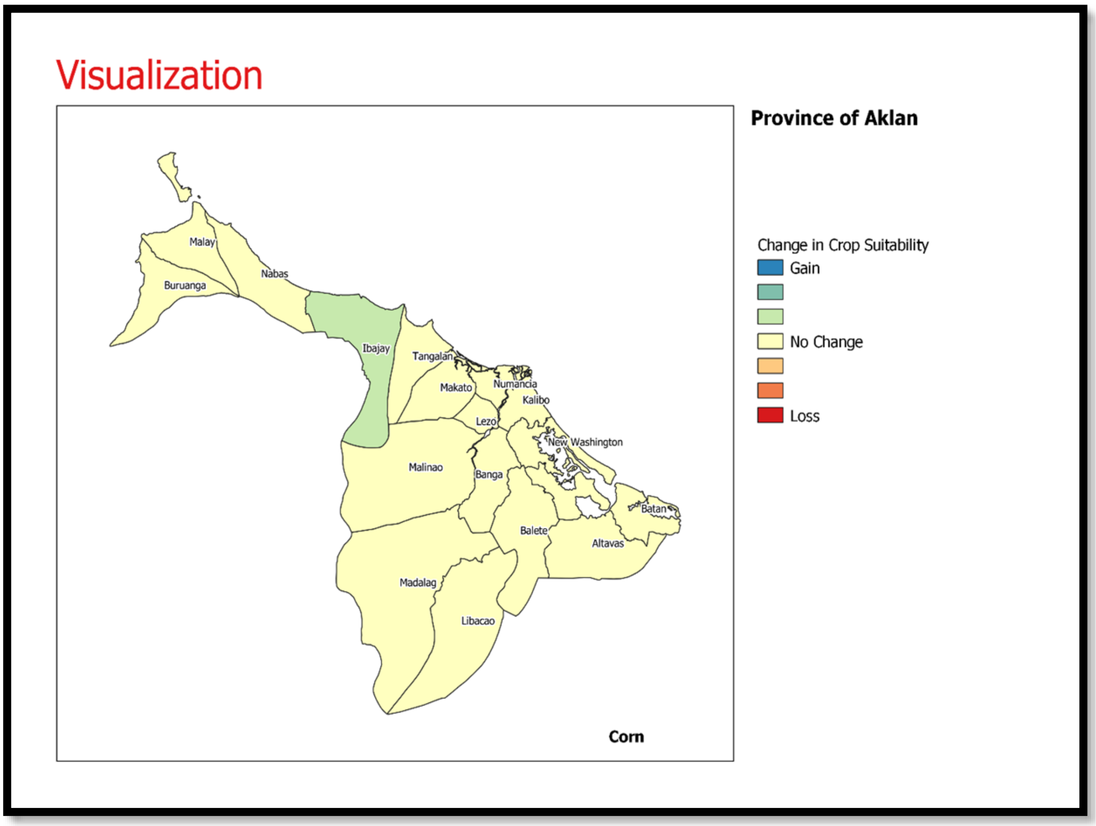



***Figure 22.*** *Visualization map showing the changes in crop suitability for corn in the Province of Aklan.*

***Banana***. Banana is likewise an important economic crop in the province of Aklan. The visualization map in Figure 23 indicates "no change" in crop suitability for corn – the crop will remain suitable in the future. This information is valuable to corn growers as it increases economic prospects for the crop in the province.

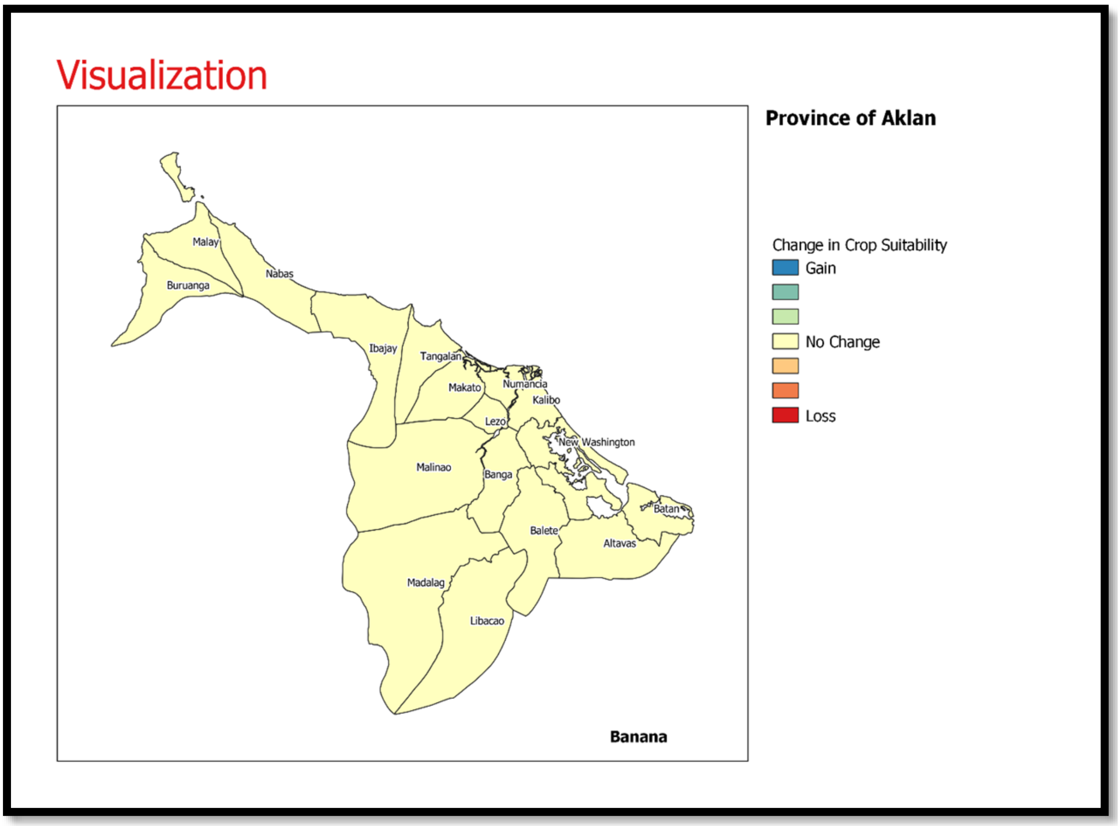



***Figure 23.*** *Visualization map showing the changes in crop suitability for banana in the Province of Aklan.*

***Coconut.*** The province of Aklan is a coconut land where one of the most important economic crops is coconut for copra production. Based on assessment results, this crop will also remain as a suitable crop in the province in the future; Ibajay even gained more suitability (Figure 24). Coconut will grow well in this town in the future due to favorable climatic conditions. The observation also suggests that there will be no negative change or loss of suitability in the future for the rest of the municipalities – a good indicator that coconut production in Aklan will be more feasible.

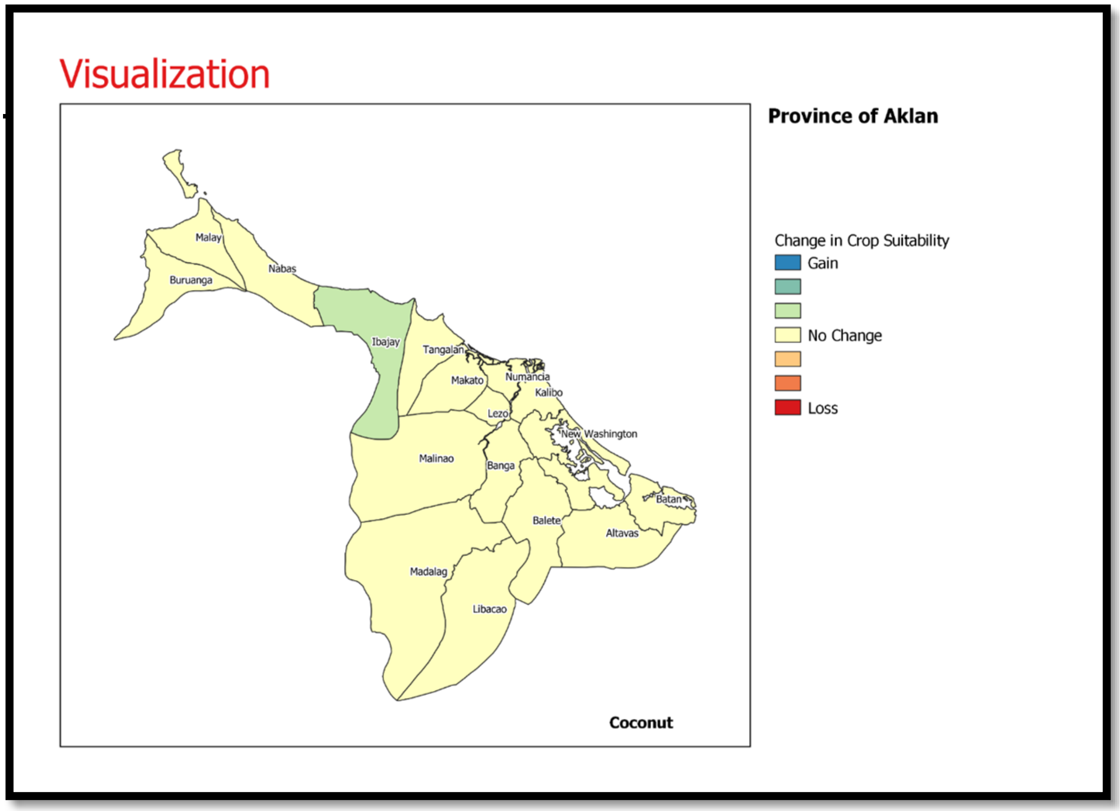



***Figure 24.*** *Visualization map showing the changes in crop suitability for coconut in the Province of Aklan.*

***Mango***. Thriving well in the province of Aklan is mango. It is a major fruit crop raised in the province. Evaluation results indicate that ten of the municipalities will remain *no change* in crop suitability. These included the towns of Malay, Madalag, Buruanga, Tangalan, Makato, Numancia, Lizo, Banga, New Washington, and Balete. However, four municipalities will be gaming suitability to this crop (*positive change*) to include the towns of Kalibo, Altavas, Batan and Libacao. Climatic conditions would be more favorable to mango production in these municipalities. On the other hand, three would be losing their suitability to this crop (*negative change*) to include the towns of Malinao, Nabas and Ibajay.

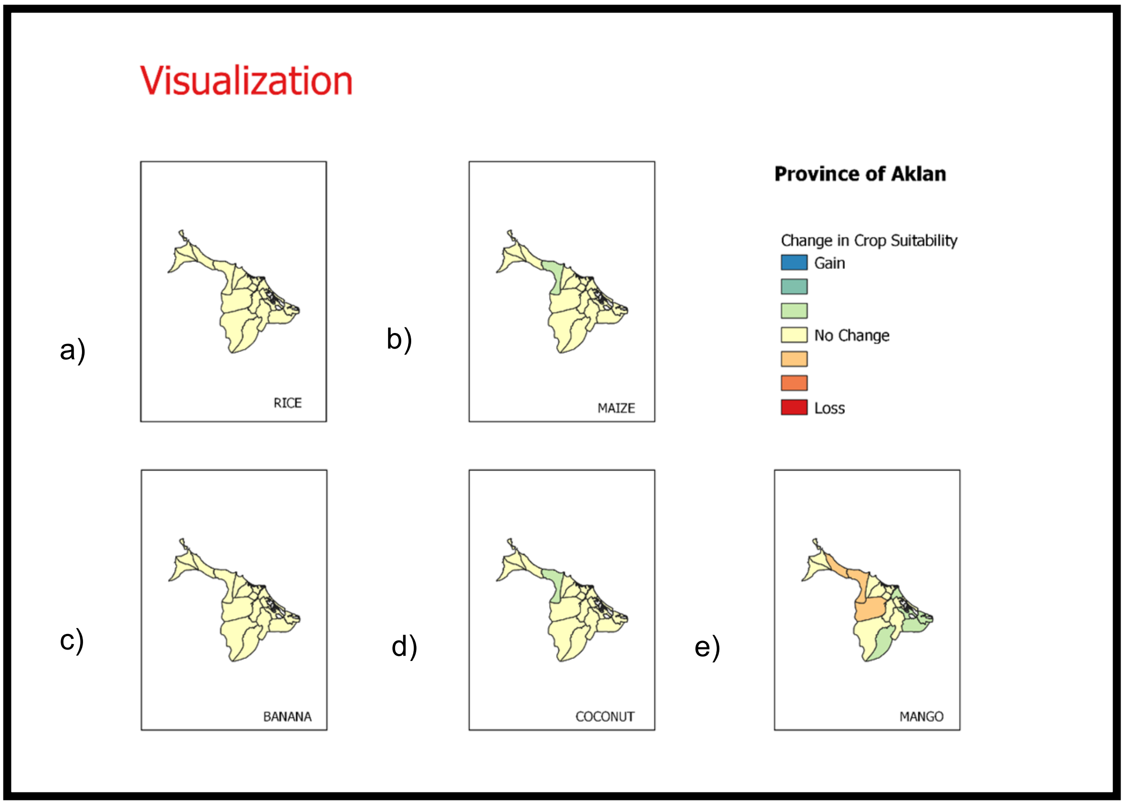



***Figure 25.*** *Visualization map showing the changes in crop suitability for mango in the Province of Aklan.*

Figure 20a-e presents a comparative change in suitability of the five priority crops in the Province of Aklan due to climate change from 2020 to 2050. Discussion of these is presented above separately.

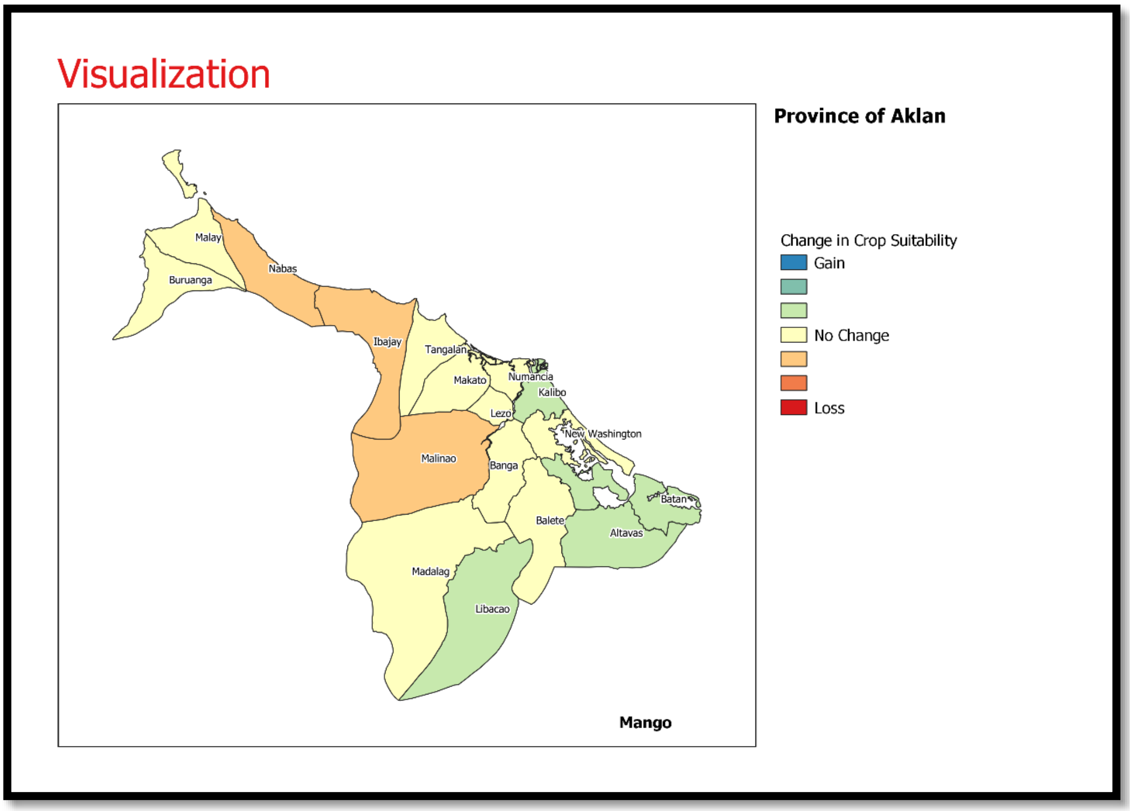



***Figure 20a-e***. *Visualization map showing the changes in crop suitabilility for the five priority crop (rice, corn, banana, coconut and mango) in the Province of Aklan.*

***Sensitivity index***. Figure 26 presents the sensitivity index for suitability of the five crop priorities evaluated in the Province of Aklan. The visualization map shows the following sensitivity index: *very high* for the municipalities of Malinao and Nabas; moderate for Buruanga, Malay, Tangalan, Makato, Numancia, Lizo, Banga, and Balete; and, very low for Ibajay, Kalibo, New Washington, Altavas, Batan, and Libacao. Eight of the municipalities, therefore, had moderate sensitivity index, six had *very low*, and two had *very high* index. For its interpretation, the higher the sensitivity index, the lower is the suitability of the crop in the area or municipality being evaluated, or the higher the index, the higher also is the projected impact from the hazards of climate change. Inversely, the lower is the index, the higher is the projected suitability of the five crops in the areas studied.

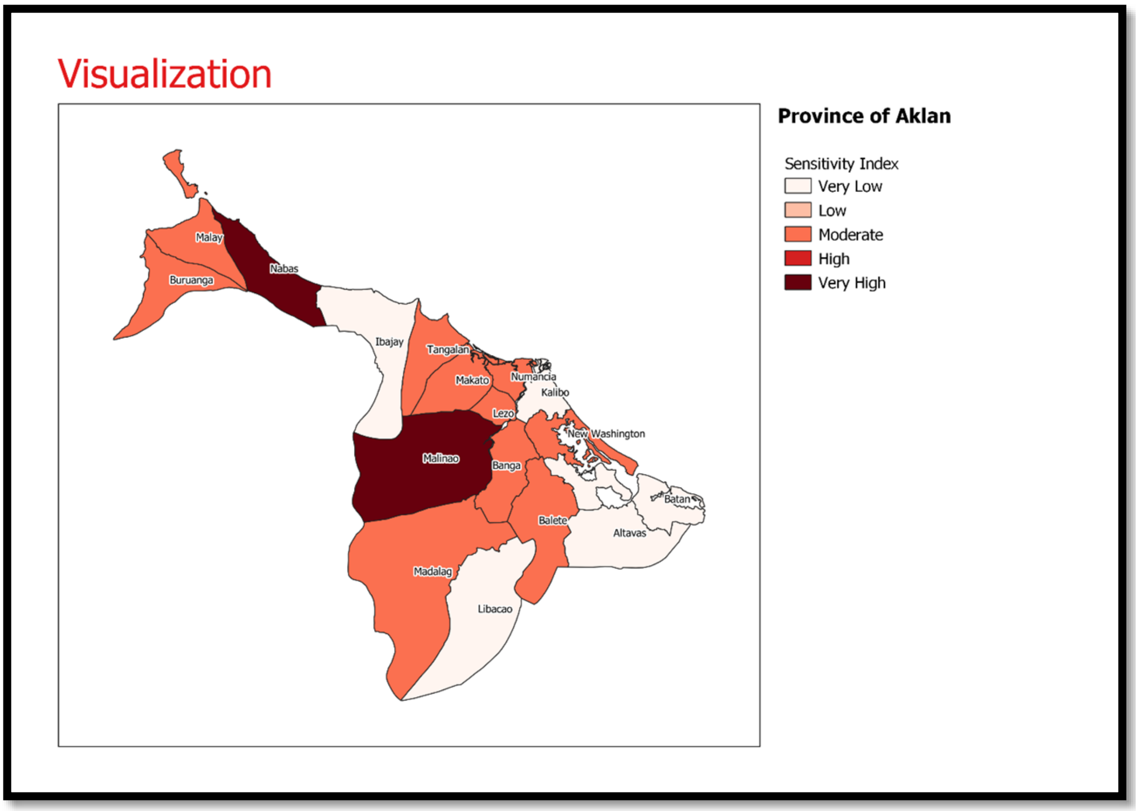



***Figure 26.*** *Visualization map showing the sensitivity index of the province of Aklan to climate change using the suitability values of the five priority crops in the province.*

## Hazard Assessment of Climate-Related Pressures (Exposure II)

Hazard assessment due to climate change was determined using as indicators five common natural climatic events. This included typhoon or tropical cyclone, drought, flooding, landslides, erosion, storm surge, saltwater intrusion, and sea level rise. The assessments made in this respect are presented and discussed below.

***Tropical cyclone***. Historical events showed that more frequent tropical cyclone occurrences are observed in Northern Panay than in the southern portion of the island. The tropical cyclone is a common occurrence in the province. Typhoons were noted to be *very high* in Northern Aklan, particularly in the municipalities of Buruanga, Malay, and Nabas (Figure 28). It is however, *very low* in Madalag, Libacao, Balete, and Altavas; and l*ow* in the towns of Malinao, Banga, New Washington, and Batan, but *moderate* in the towns of Tangalan, Makato, Numancia, Kalibo and Lezo.

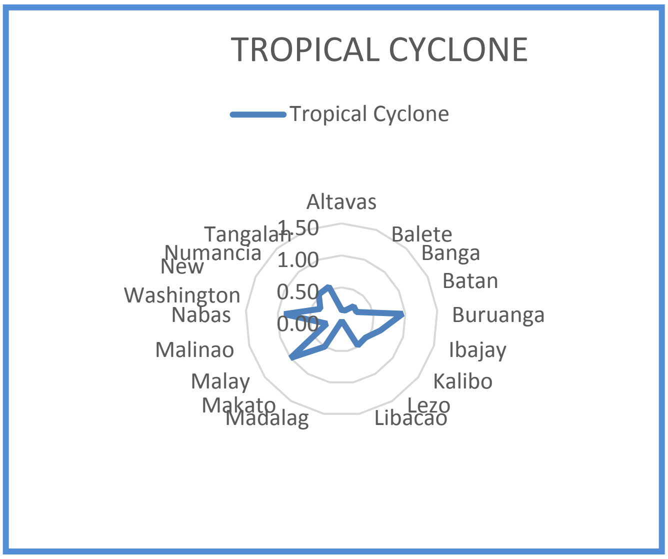



*Figure 28. Visualization map showing the level of vulnerability to tropical cyclones of municipalities in the province of Aklan.*

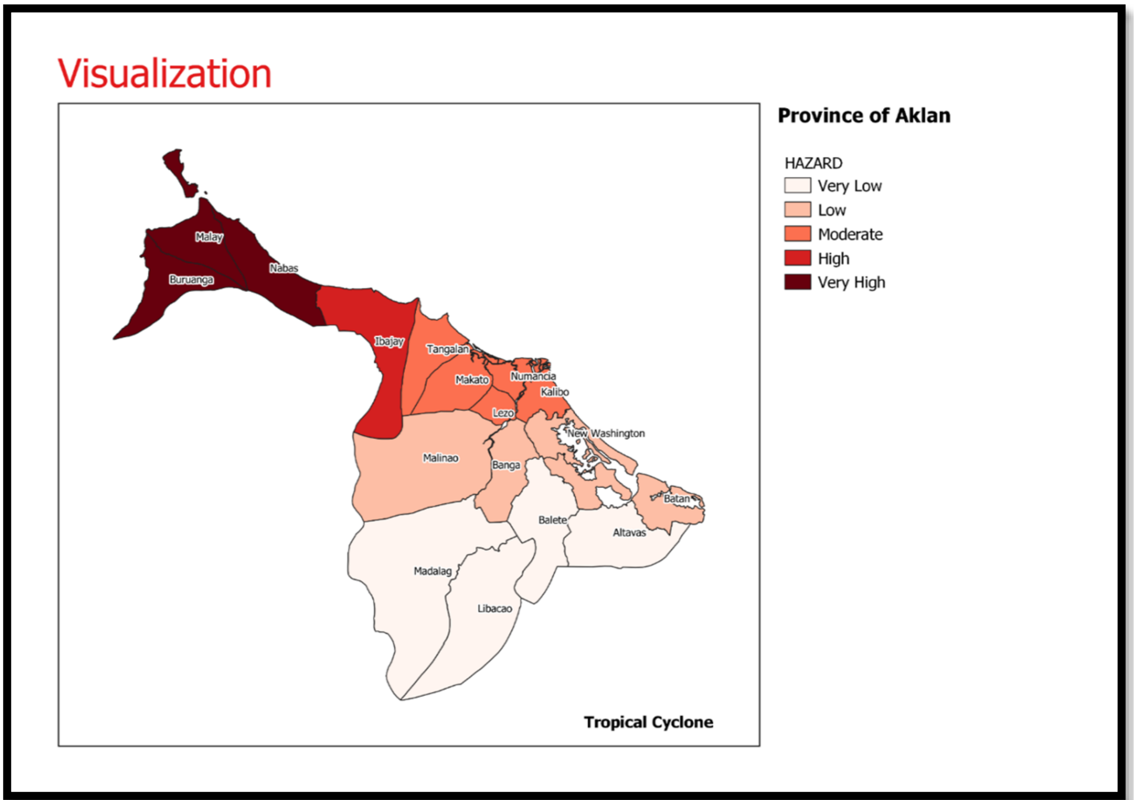



***Figure 28a.** Radar chart showing the tropical cyclone occurrence in the Province of Aklan.*

***Drought.*** As sown in Figure 28b, *d*rought in the province was visibly higher in the upland municipalities than in the lowlands. Groundwater potential had been the most considerable factor in this case based on the data source from MGB and DENR (Table 1). Drought is expected also to be prevalent in some of the municipalities of the province.

The assessment results reflected in Figure 28b, Typhhon is projected to be *very high* in Malinao and Libacao, and *high* in Ibajay, Madalag, Balete, and Altavas; while it is *moderate* in the town of Batan, typhoon is predicted to be *very low* in the towns of Lazo, Numancia, Kalibao, and New Washington, but it is expected to be *low* in the five municipalities, namely: Malay, Buruanga, Nabas, Tangan, Makato and Banga.

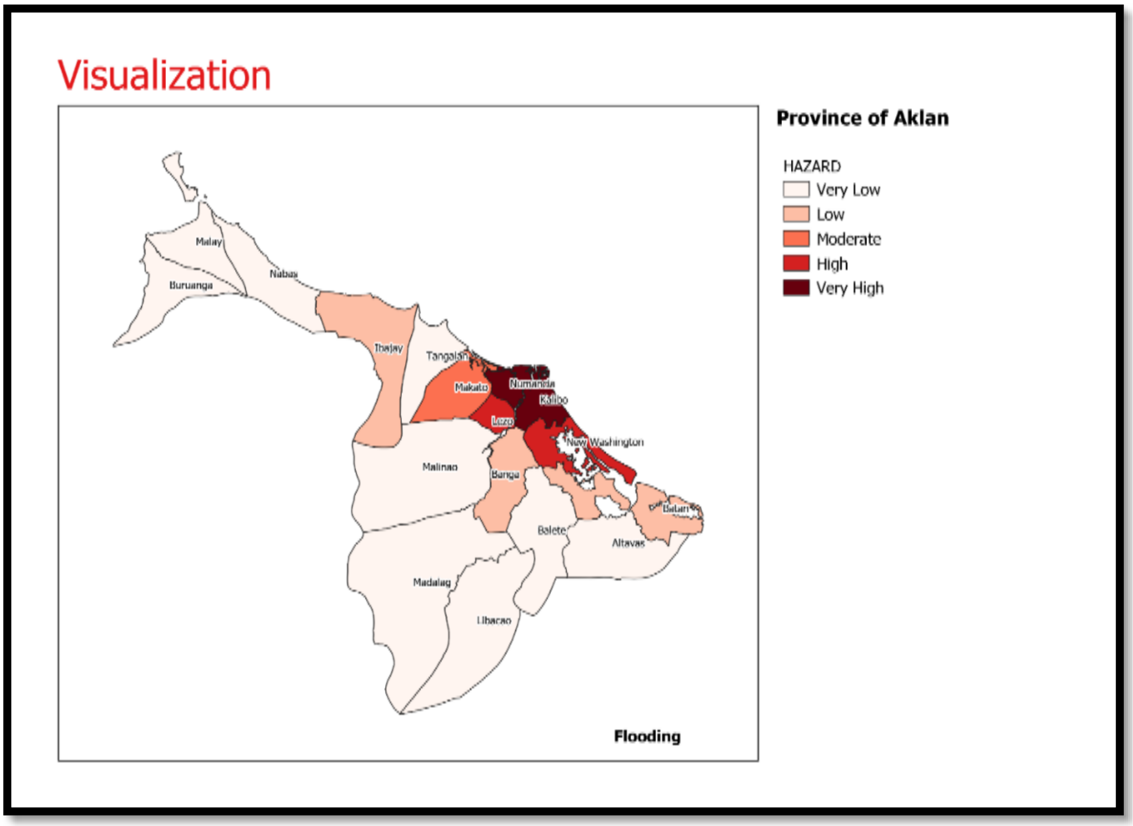



***Figure 28b.*** *Visualization map showing the level of vulnerability to drought of municipalities in the Province of Aklan.*

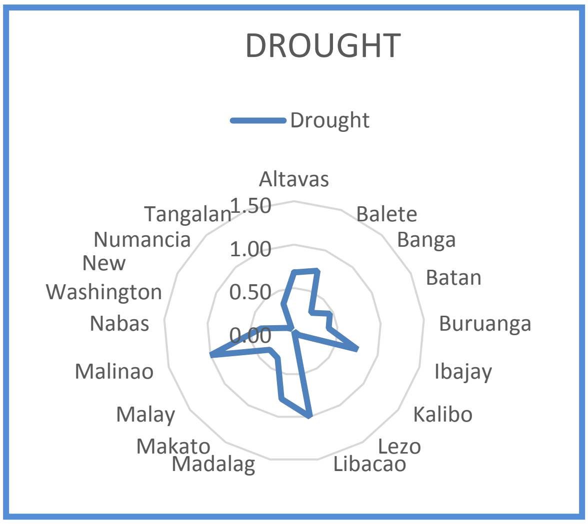



***Figure 29.*** *Radar chart showing the drought occurrence in the Province of Aklan.*

***Flooding.*** Areas that are low-lying are generally flood-prone. Historically, low-lying municipalities and catchment areas of major rivers in Aklan are to a large extent more prone to flooding. In the province, lowland areas especially in Kalibo and Numancia were predicted to have *very high* vulnerability to tropical cyclones (Figure 30). Typhoons are predicted to be *low* in Lezo and New Washington, and *moderate* in Makato. It is predicted, however, to be *very low* in the nine municipalities, to include Malay, Nabas, Buruanga, Tangalan, Malinao, Madalag, Libacao, Balete, and Altavas; and *low* in the towns of Ibajay, Banga and Batan.

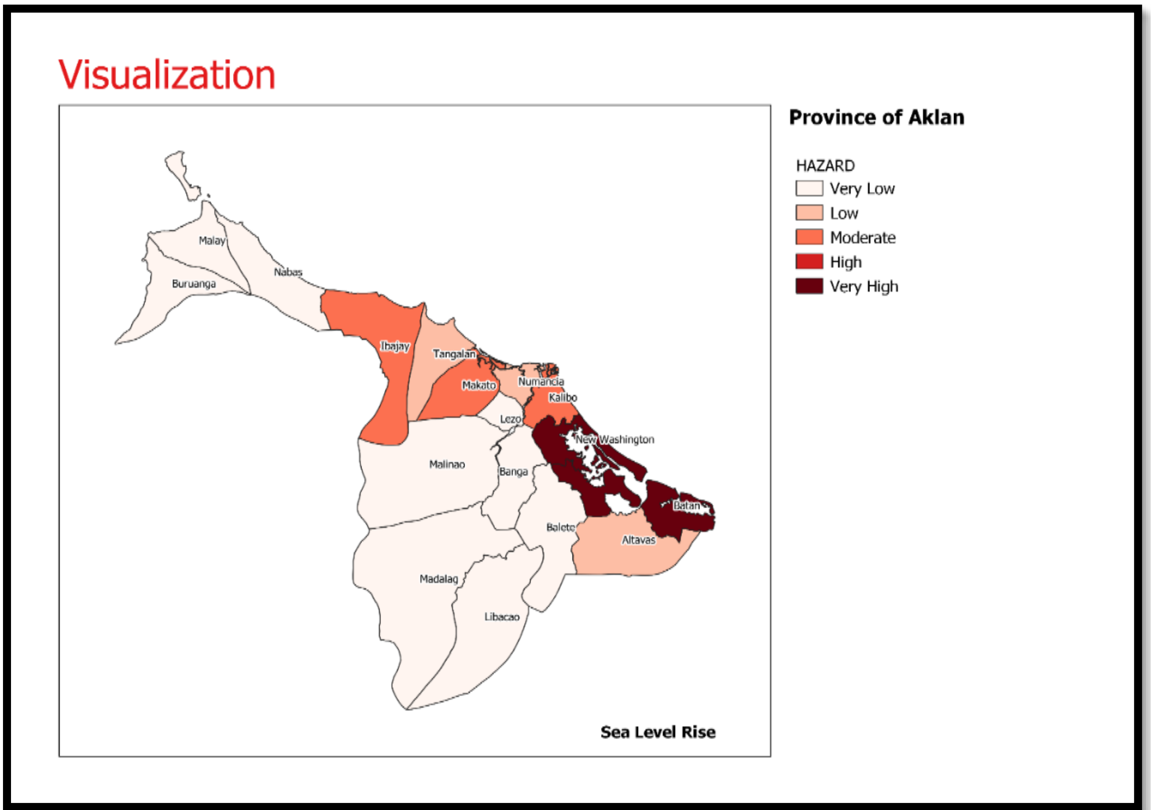



***Figure 30.*** *Visualization map showing the level of vulnerability of municipalities To flooding in the Province of Aklan.*

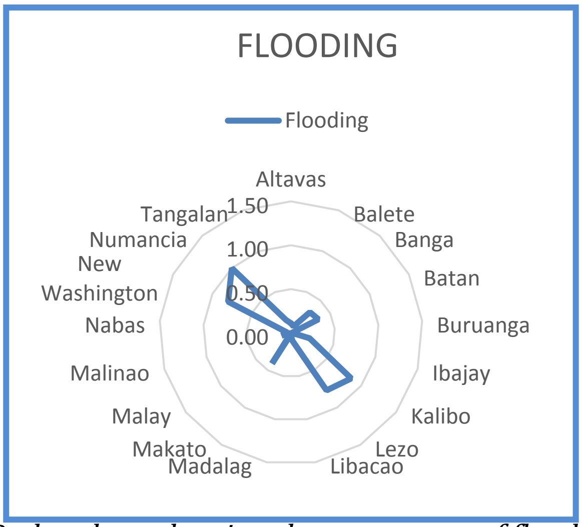



***Figure 31****. Radar chart showing the occurrence of floods in the in the Province of Aklan.*

***Landslides.*** Mountainous areas are highly susceptible to landslides. In this case, the findings show that Madalag was predicted to have very *high* vulnerability to landslides in the future (Figure 32) while seven other municipalities were rated to have *high* risk to this climatic hazard which included Balete, Libacao, Malinao, Tangalan, Nabas, Malay and Buruanga. On the other hand, while Altavas and Ibajay were assessed to have *moderate r*isk, the towns of Kalibo, Lezo, Numancia, Banga and New Washington were predicted to have *very low*, and Makato and Batan to have *low* risk.

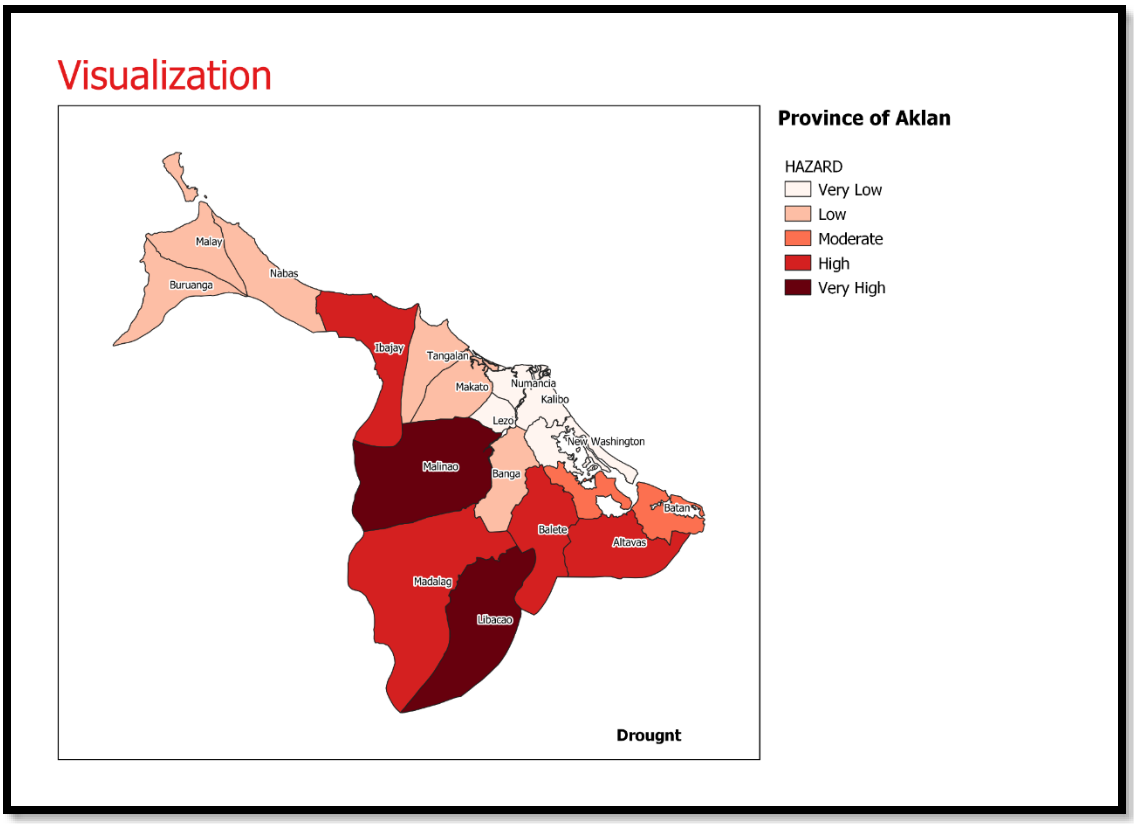



***Figure 32.*** *Visualization map showing the level of vulnerability of municipalities to landslides in the Province of Aklan.*

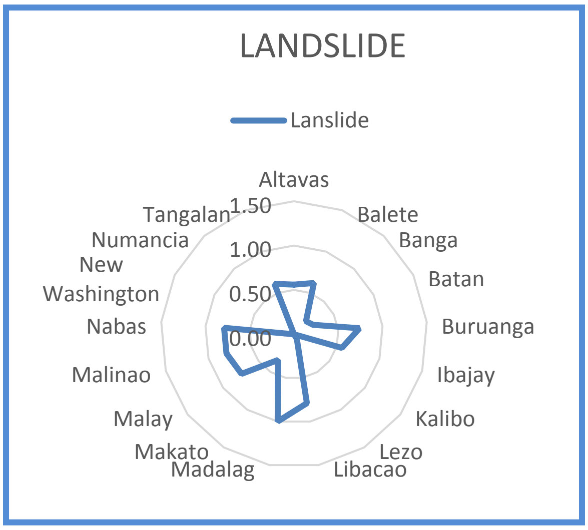



***Figure 33.*** *Radar chart showing landslide occurrence in the in the Province of Aklan.*

***Sea level rise.*** Generally, coastal areas of the province are vulnerable to sea level rise which a consequence of rising temperature brought about by climate change. The municipalities of Batan and New Washington got *very high* risk rating while Ibajay, Makato and Kalibo were predicted to have *high* risk to this hazard in the future. Tangalan and Altavas, however, were predicted to have *low* vulnerability, and the rest of the municipalities to have *very low* risk.

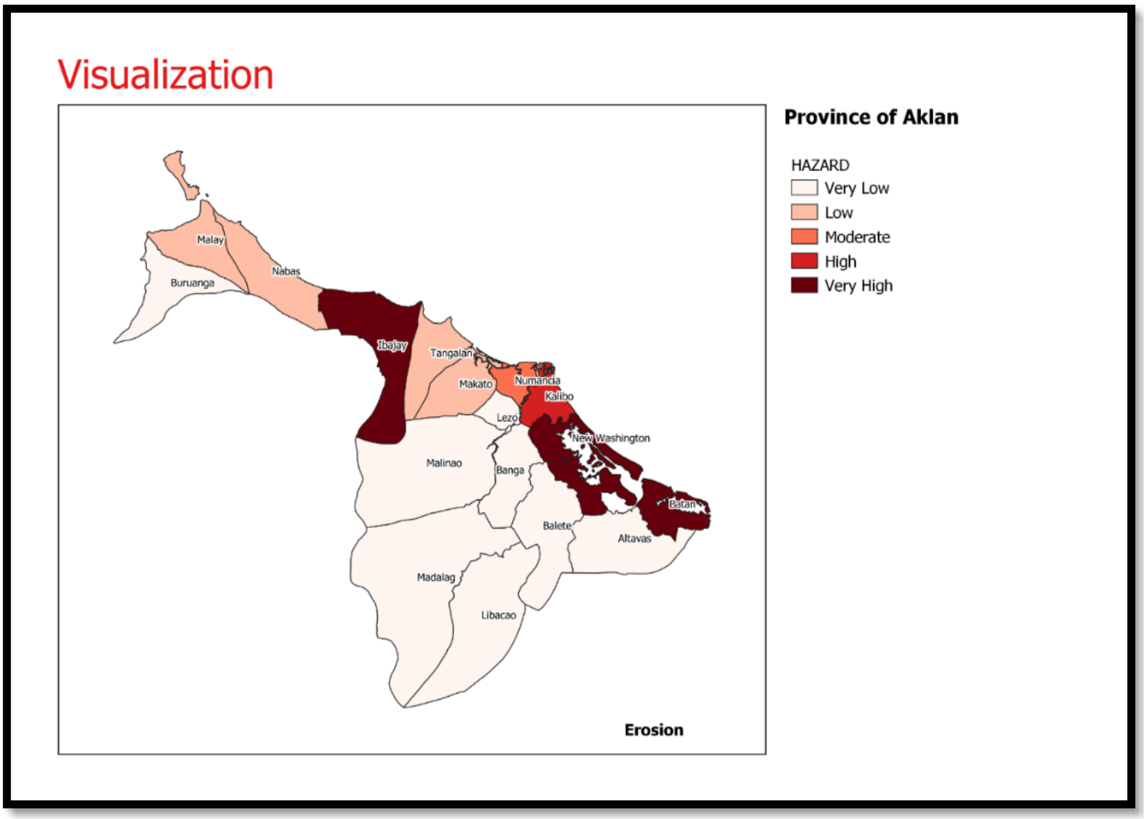



***Figure 34.*** *Visualization map showing the level of vulnerability to sea level rise of the municipalities in the Province of Aklan.*

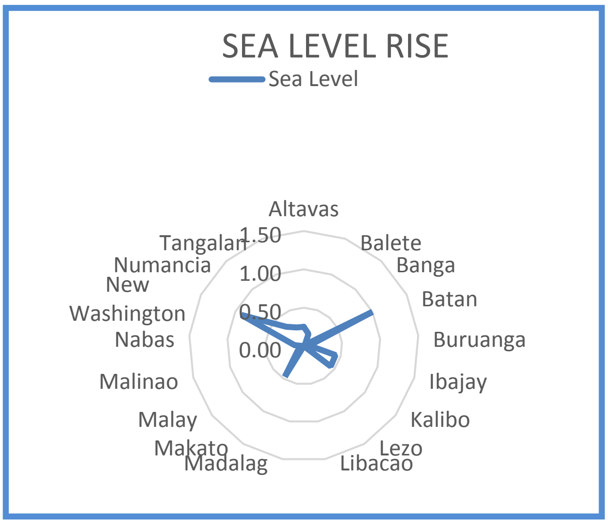



***Figure 35****. Radar chart showing the sea level rise occurrence in the in the Province of Aklan.*

***Soil erosion***. Soil erosion is another serious climate-related hazard, particularly in coastal as well as in hilly or mountainous areas. Many of these areas are present in the province of Aklan. The municipalities of Ibajay, New Washington and Batan being surrounded by seashores were predicted to have *very high* risk to erosion; while Kalibo was predicted to have *high* risk to this hazard. Except Numancia which was foreseen to have *moderate* risk, the eight other municipalities were predicted to have *very low* vulnerability to erosion as shown in Figure 36.

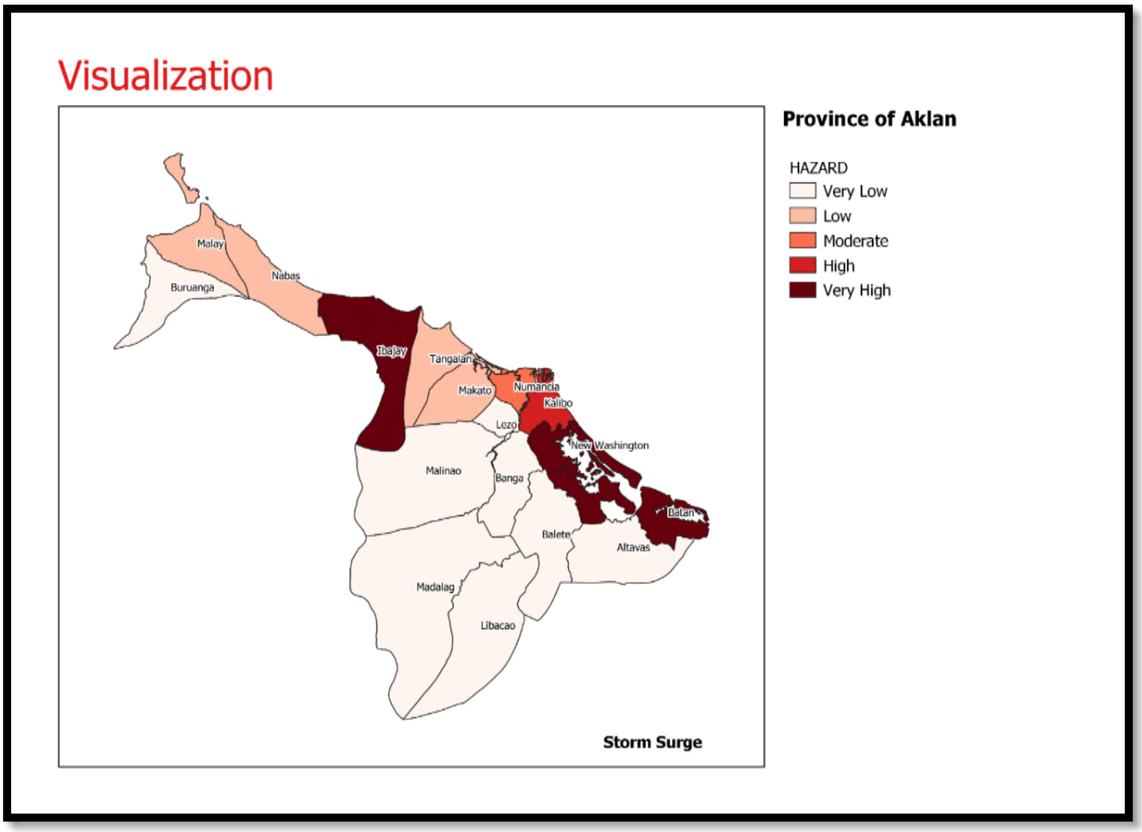



***Figure 36.*** *Visualization map showing the level of vulnerability to erosion of the municipalities in the Province of Aklan.*

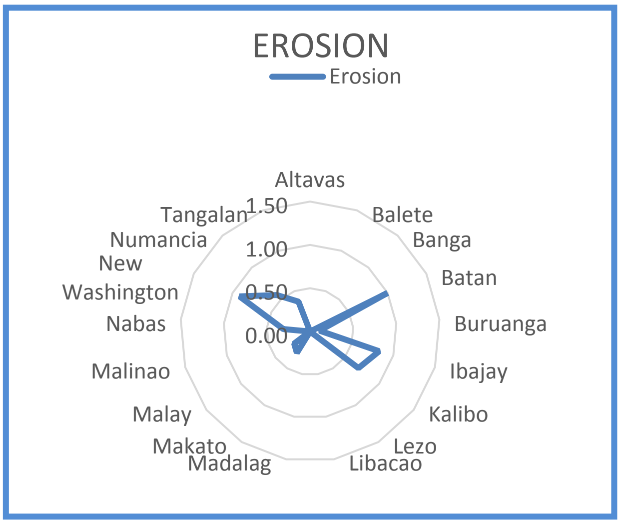



***Figure 37.*** *Radar chart showing the occurrence of erosion occurrence in the Province of Aklan.*

***Storm surge.*** Similar to erosion, coastal areas are highly vulnerable to storm surge. The results of the assessment in Figure 38 showed that the municipalities of Ibajay, Batan and New Washington obtained *very high* hazard values; in contrast, upland areas such as in Buruanga, Malinao, Lezo, Banga, Madalag, Balete, Libacao and Altavas were predicted to have *very low* risk while Makato, Tangalan, Malay and Nabas were predicted to have *low* risk to storm surge.

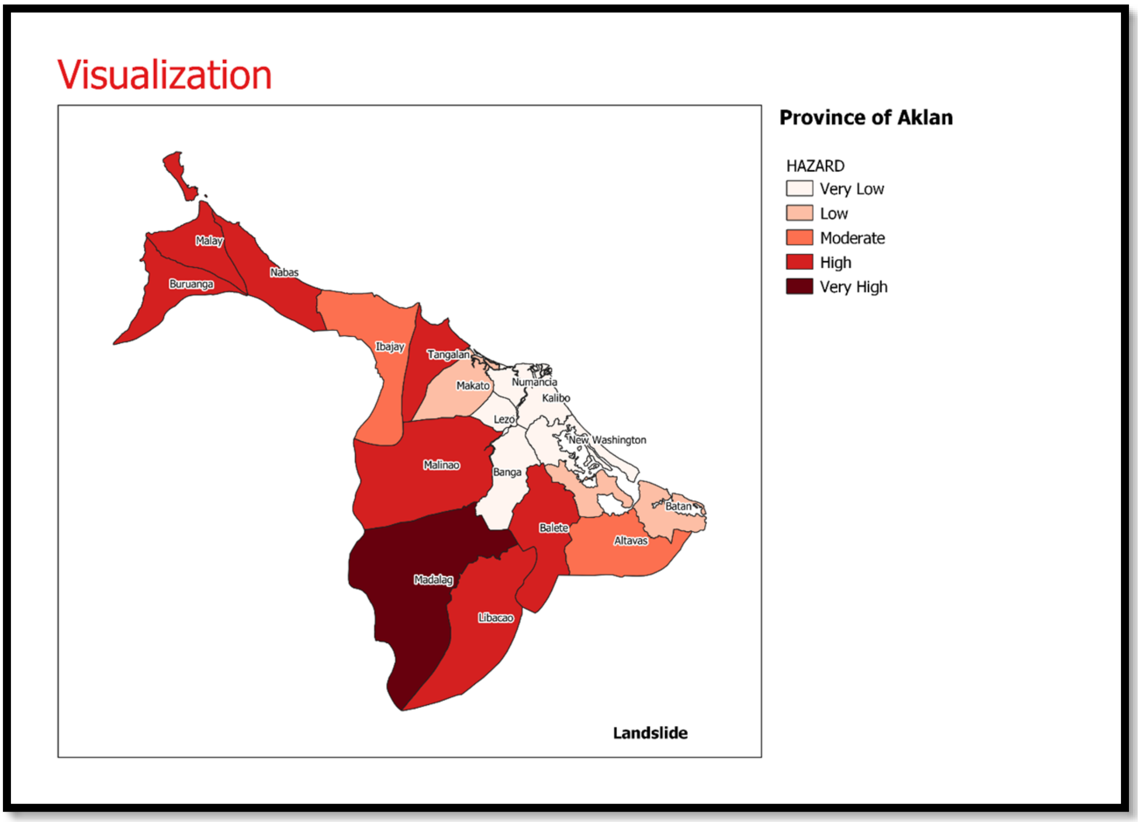



***Figure 38.*** *Visualization map showing the level of hazard to storm surge of municipalities in the Province of Aklan.*

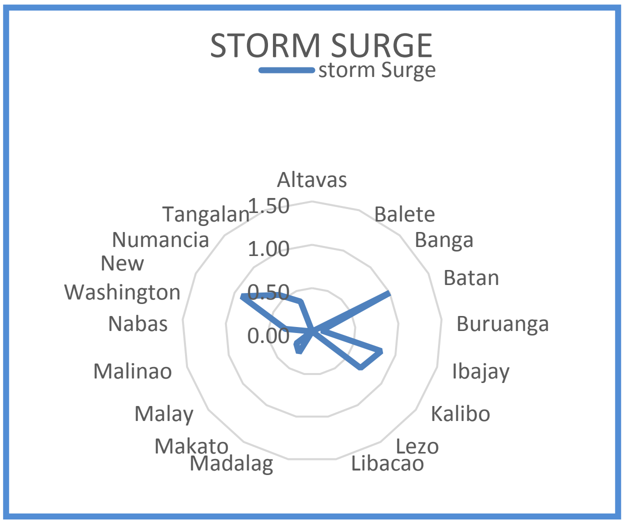



***Figure 39.*** *Radar chart showing the occurrence of storm surge occurrence in the Province of Aklan.*

***Saltwater intrusion.*** Understand, the likelihood of occurrence of saltwater intrusion are in the areas which are exposed to sea water as in shores and coastlines. The findings of the study showed that the hazard of the province of Aklan to salt water intrusion was essentially negligible. Figure 40 revealed that practically all the municipalities in the province of Aklan were assessed to have *very low* risk to the hazard of saltwater intrusion. That although the province has long coastlines, the hazard of this risk in the future is almost nil. While in other regions of the country salt water intrusion is a problem, the Province of Aklan based on these results is apparently exempt from this climate change-related hazard.

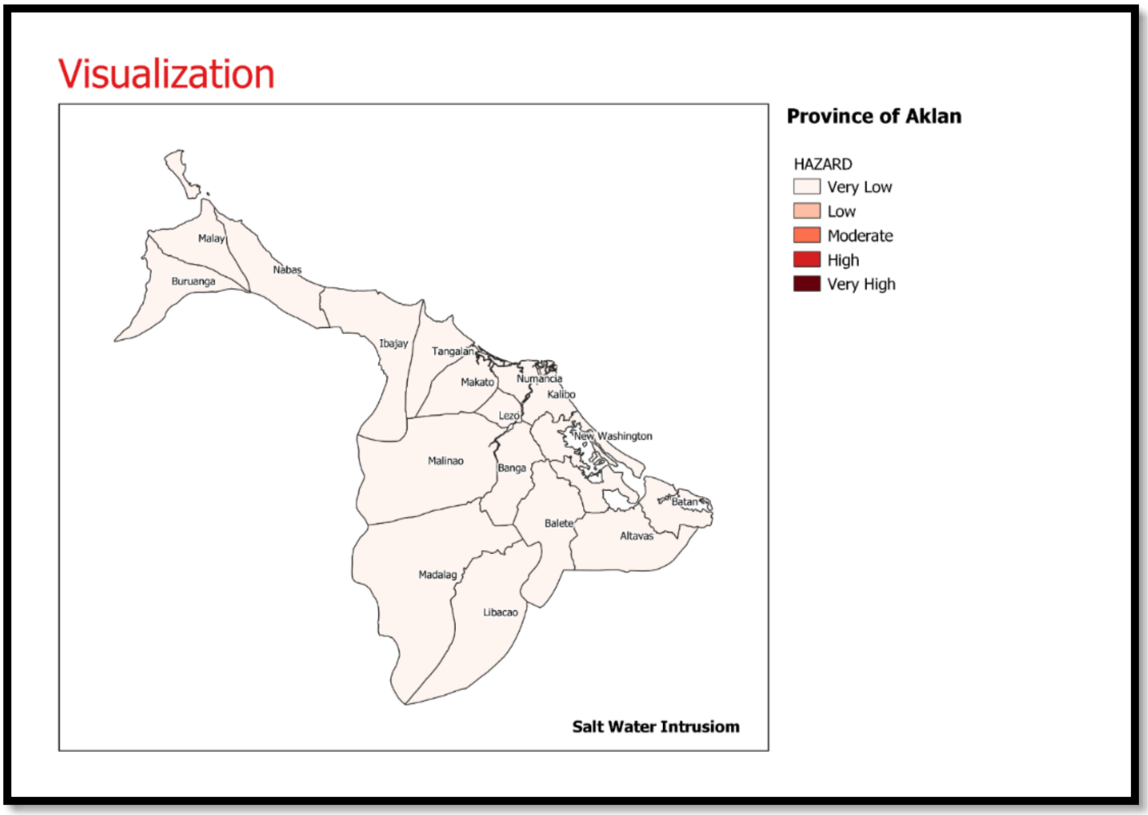



***Figure 40.*** *Visualization map showing the level of vulnerability of municipalities of Aklan to the risk of saltwater intrusion.*

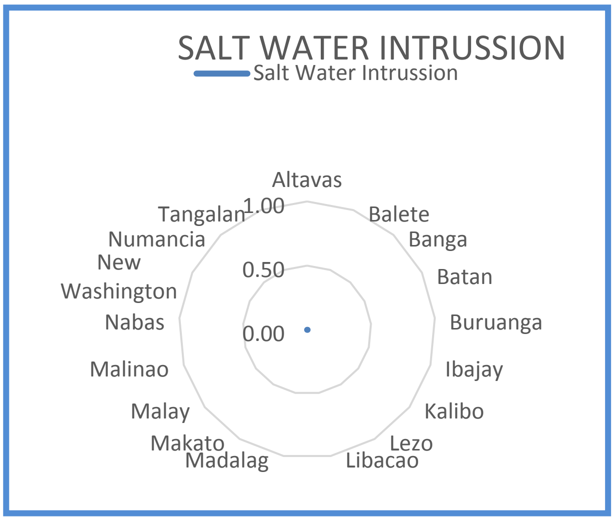



***Figure 41***. *Radar chart showing the occurrence of salt water intrusion in the Province of Aklan.*

## Comprehensive Hazard Maps for the Municipalities of Aklan

Figure 27 presents the comprehensive hazard maps of the municipalities of the province of Aklan. involving the common natural hazards such as typhoon, drought, landslides, flooding, erosion, sea level rise, saltwater intrusion and storm surge. These maps have already been discussed separately in the preceding sections.

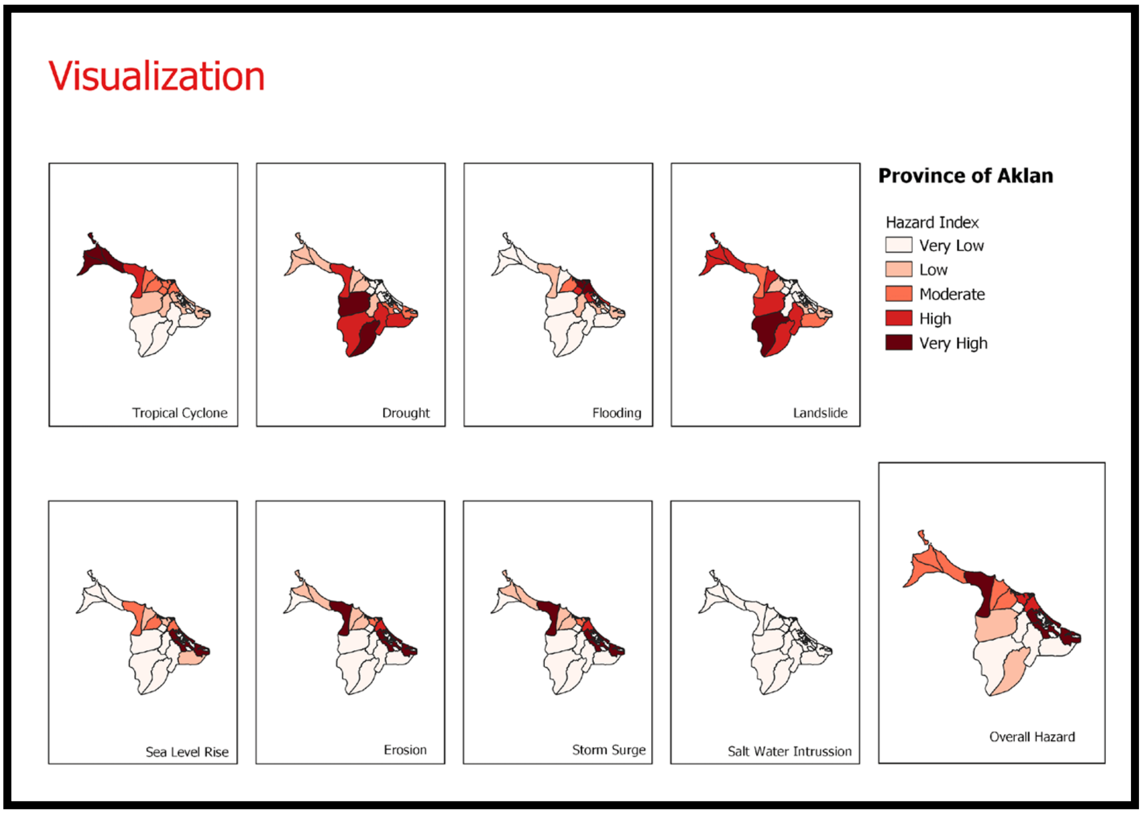



***Figure 27.*** *Visualization map showing the hazard index in the Province of Aklan.*

## Hazard Index of Municipalities in the Province of Aklan on the Common Natural Hazards

The map on the overall vulnerability to climate-related hazards of the Province of Aklan is presented in Figure 42. These summarized results are arrived at by considering the eight common natural hazards and the combination of their corresponding hazard weights. The results show that Batan, New Washington, and Ibajay were predicted to have a *very high* vulnerability risk to natural hazards among the municipalities in the future.

Moreover, Kalibo and Numancia were predicted to have *high* index while Malay, Buruanga, Nabas, Tangalan, and Makato had *moderate* hazard index. On the other hand, Malinao and Libacao were predicted to have *low* hazard index, while the remaining five municipalities had *very low* index.

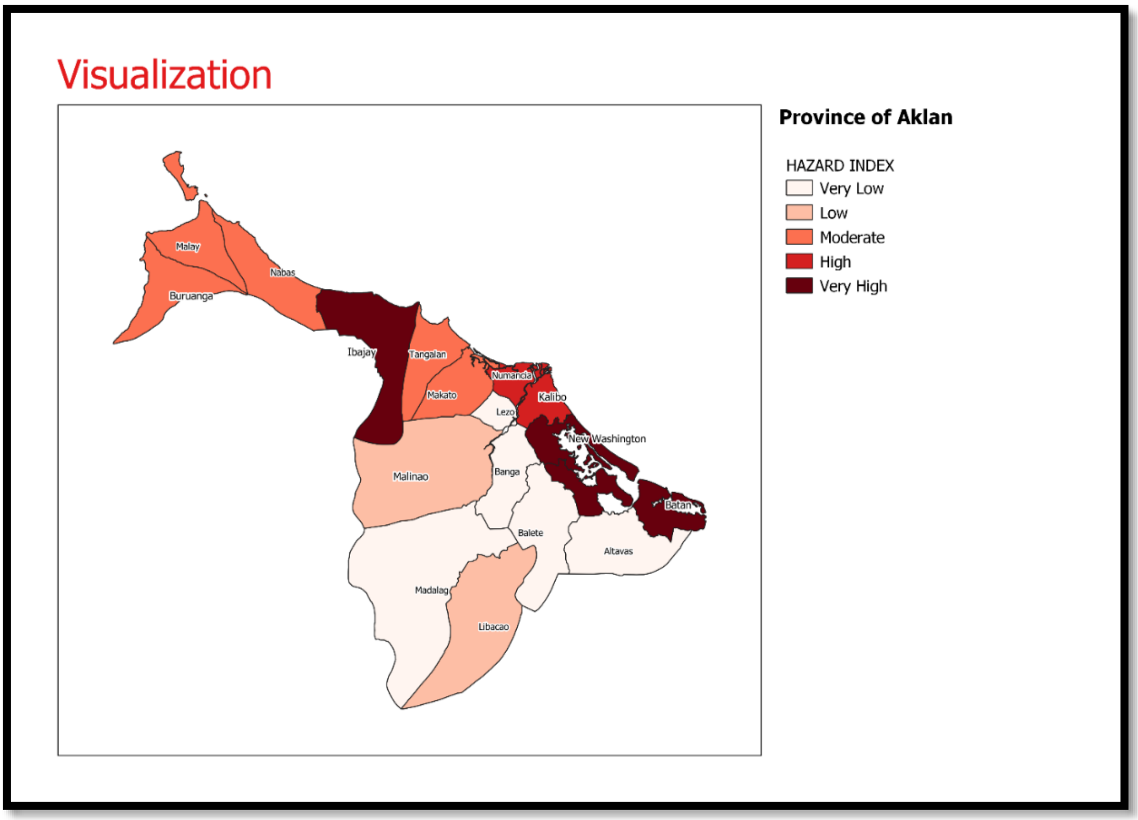



***Figure 42.*** *Visualization map showing the hazard index of the municipalities in the province of Aklan.*

## Adaptive Capacity of the Province of Aklan
(*How Communities Resist and Adapt to Climate Change-Related Pressures)*

One of the strengths of this vulnerability assessment is not only limited to the identification of the areas with a low adaptive capacity as a priority, but has also the capability to explore, analyze, and target specific capitals and indicators that can increase the resilience to climate change of communities under evaluation. The discussions below present the spatial analysis of the seven capitals of adaptive capacity, namely: a) economic, b) natural, c) social, d) human, e) physical, f) anticipatory, g) Institutional, and h) overall adaptive capacity for the Province of Aklan. These adaptive capitals are separately discussed below.

***Economic capital***. The results of the assessment done showed that Kalibo was found to had *very high* economic capital among the municipalities in Aklan (Figure 43); *high* economic capital was found in Malay, Banga and Ibajay while Malinao, Altavas, New Washington and Lezo had *moderate.* On the other hand, Buruanga, Nabas, Tangalan, Makato, Madalag, Balete, Batan and Libacao appeared to have *very low* economic capital. In this assessment, the following indicators were used: number of financial institutions and cooperatives, number of farmers with insurance, minimum wage in agriculture, area planted to the five crops under study, poverty incidence, and municipal class classification, among others. Considering these indicators, Kalibo which is the capital town of the province, would expectedly gain the highest economic capital. Aside from having the most population among the municipalities, much of the businesses or business establishments like banks and cooperatives are mostly located in this area. It has lower poverty incidence and comparatively higher municipal class. Being this, Kalibo and its inhabitants are more prepared to withstand the hazards and destructions caused by adverse weather conditions. The reverse is true for the municipalities which adaptive capacities were found to be very low. These areas direly need assistance in any form to build up their capacities in terms of the above indicators to become more resilient to face and manage the unpredictable occurrences of weather-related disturbances like typhoons and flash floods, among others.

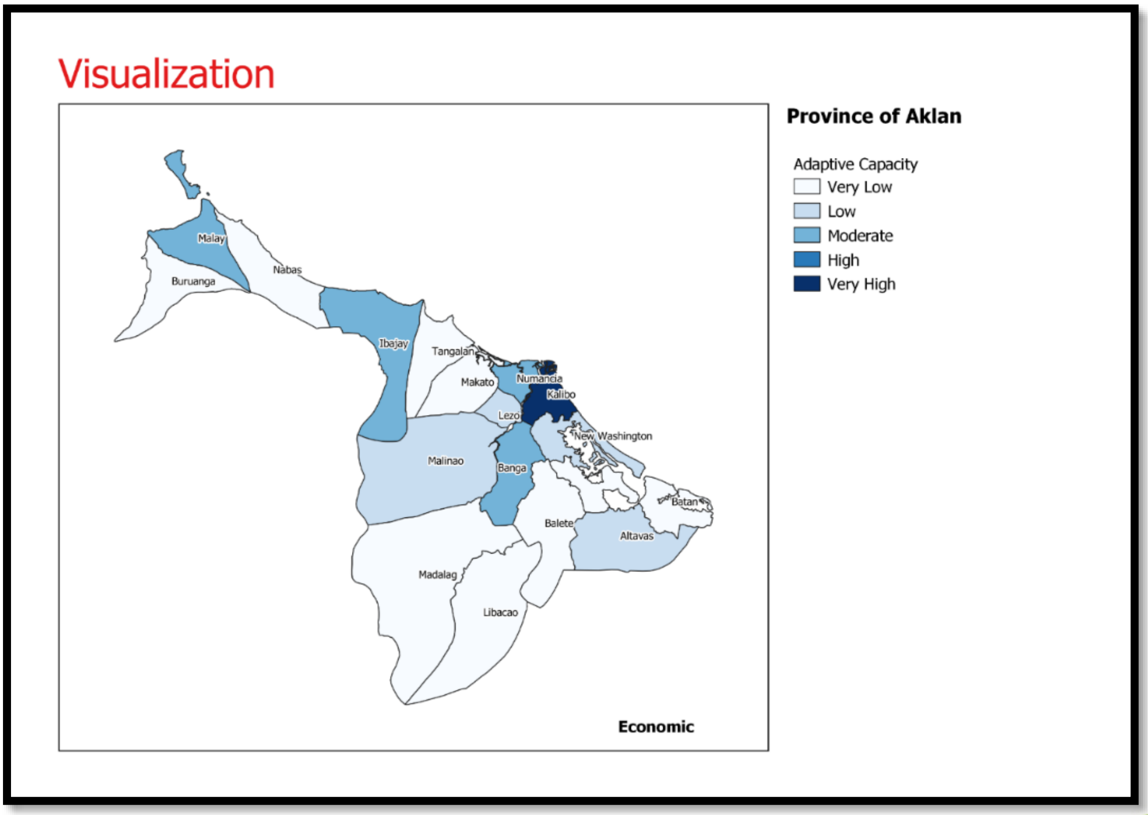



***Figure 43.*** *Visualization map showing the level of economic capital of different municipalities in the Province of Province of Aklan.*

***Natural capital***. On the assessment of natural capital, Malay, Makato, Malinao, Kalibo, Lezo and Altavas obtained ***very low*** ratings while Madalag obtained ***very high*** rating among the municipalities in Aklan (Figure 44). On the other hand, Balete, New Washington, Ibajay, Tangalan, and Buruanga had got ***high*** natural capital while Nabas, Banga, Numancia, Batan, Libacao had ***low*** rating in this capital. This evaluation was based on the following indicators, namely: presence of marine protected area, number of shallow-tube wells (STWs), service area covered by STWs, groundwater availability, and reliable source of water for irrigation. These criteria pertain primarily on water availability assessment in the area for both domestic and agricultural and industrial use. This is an adaptive capacity which depicts a picture as to the readiness of the municipalities to respond or mitigate water deficiency crises during dry months, or when there is drought, or during the occurrence of *El Nino* phenomenon. In this evaluation, Madalag came out to have highest rating (adaptive capacity) in natural capital based on the above criteria. For communities with low or very low ratings in natural capital, development of water resources in their respective area needs to be addressed with urgency by all concerned.

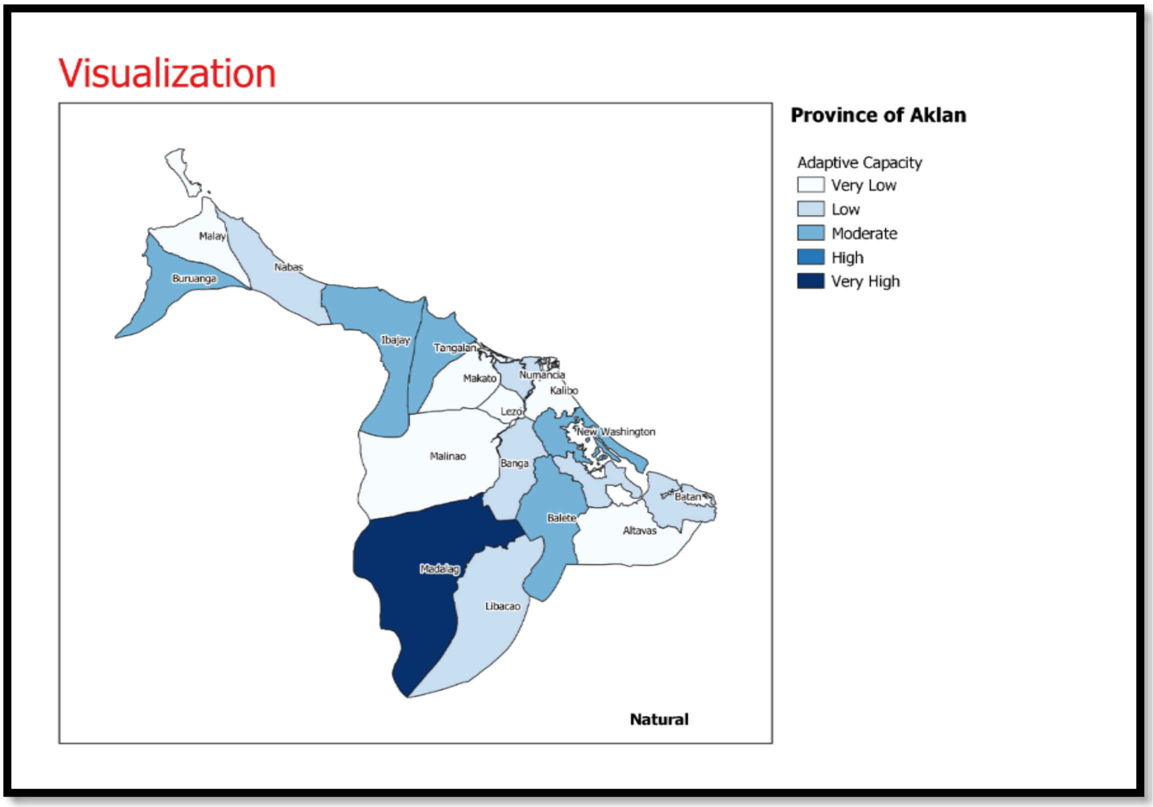



***Figure 44.*** *Visualization map showing the level of natural capital of different municipalities in the Province of Province of Aklan.*

***Social capital.*** On the social capital evaluation, the results showed that Ibajay, Banga and Madalag were found to have ***very high*** social capital among the municipalities in the province; ***very low*** ratings were obtained by the municipalities of Buruanga, Malay, Tangalan, Makato, Balete and Altavas. The status of this capital of other municipalities evaluated are found in Figure 45. Social capital was assessed using the following indicators: number of registered farmers' groups/inions, percentage of farmers who are members of coops/groups/unions, total number of farmers, and percentage of male and female farmers. Social capital primarily pertains to the number of active farmers in the municipality being assessed and their membership to various existing farmers' organizations. Membership to organizations is essential as a support component of adaptive capacity believing in the adage that in "unity there is strength." Inhabitants can better respond to climate related crises when they are organized and bound to common goals and objectives. Collective action is often more effective in bringing about positive results.

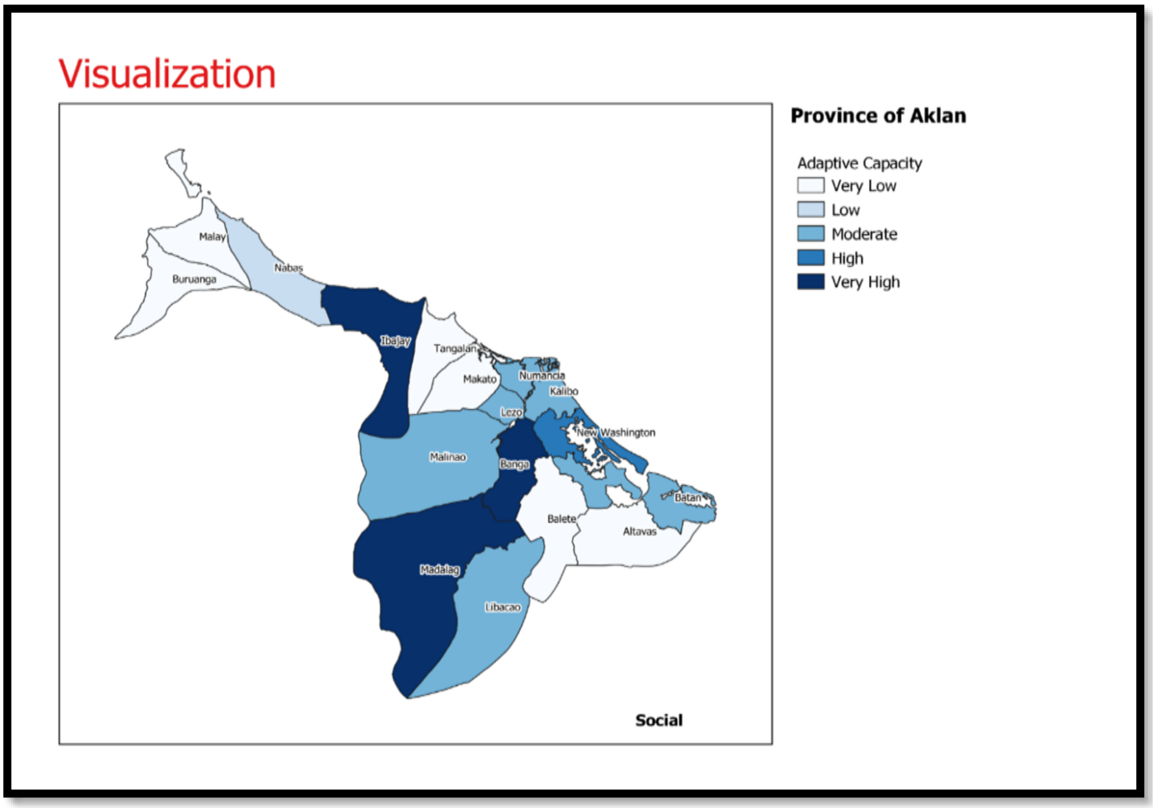



***Figure 45.*** *Visualization map showing the level of social capital of different municipalities in the Province of Province of Aklan.*

***Human capital***. Human capital was assessed as a measure of adaptive capacity of municipalities studied. The assessment used the following indicators: presence of secondary and tertiary schools, school attendance among the inhabitants, number of academic degree holders, health services manpower, number of public doctors, and number of citizens with Philhealth. As shown in Figure 46, the assessment results on this capital showed that Kalibo had ***very high*** human capital among the municipalities while ***very low*** human capital was found in the towns of Buruanga, Tangalan, Makato, Malinao, Madalag, Balete, Lezo, Batan and Altavas. The human capital of other municipalities is reflected in Figure 46. Being the center of commerce and economy in Aklan province, Kalibo has all the advantages to have the raining of human capital. School and colleges are located in this municipality to cater to the needs of the populace for education. Big hospitals and well-equipped medical clinics are found in this municipality staffed with needed health professionals to serve the inhabitants. These are the facilities which low-rated municipalities in human capital are seriously handicapped.

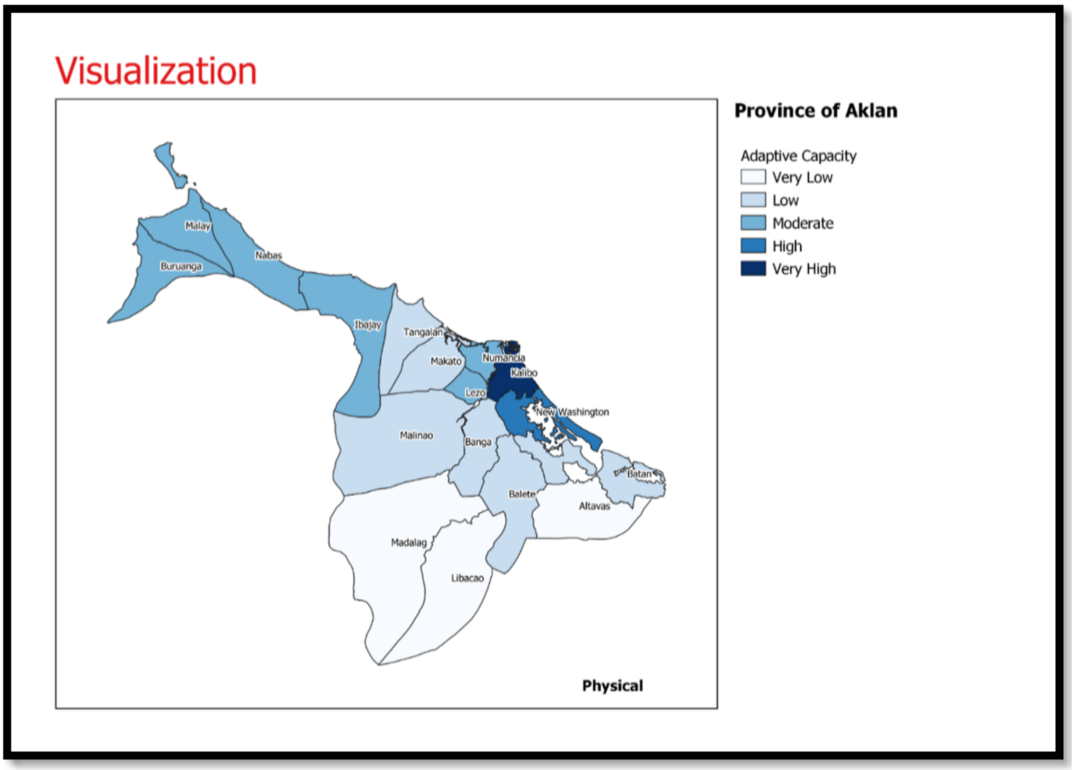



***Figure 46.*** *Visualization map showing the level of human capital of the municipalities in the Province of Province of Aklan*

***Physical capital.*** As shown in Figure 47, Kalibo got ***very high*** rating in physical capital among the municipalities in Aklan. ***Very low*** in physical capital were found in the towns of Madalag, Libacao and Altavas. The assessed physical capital of other municipalities is reflected in Figure 47. Physical capital evaluation included land ownership of farmers, their farm size, the number of livestock being raised, and distance of furthest barangay from the market. The results simply mean that more farmers living in Kalibo, the town capital of the province, own their farmlands, have bigger farm size, and raise more livestock, among others. Considering all these, the municipality of Kalibo and its inhabitants were rated to have the highest adaptive capacity – their capacity to respond and mitigate the impact of climate change, or have the capacity to respond and recover more quickly from weather-related calamities.

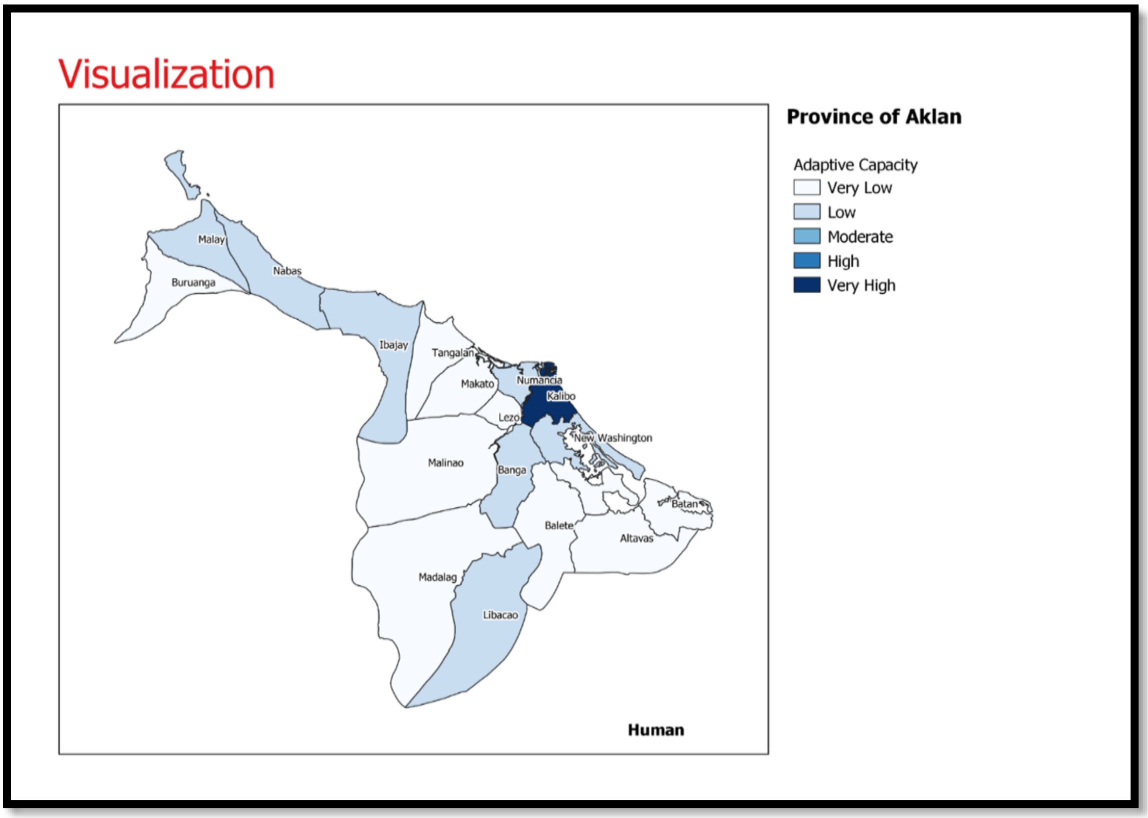



***Figure 47.*** *Visualization map showing the level of physical capital of the municipalities in the Province of Province of Aklan*

***Anticipatory capital.*** On the assessment of the anticipatory capital of the province, the results indicate that Altavas got ***very high*** in this capital among the municipalities in Aklan (Figure 48). ***Very low*** in anticipatory capital was recorded in the towns of Malay, Tangalan, Makato, Lezo, Banga, Madalag and Libacao. The anticipatory capital of other municipalities in the province are shown in Figure 48. Anticipatory capital was determined using the following indicators: number of trainings related to climate change, access to communication technology, and presence of DRRMP and CLUP in the area.

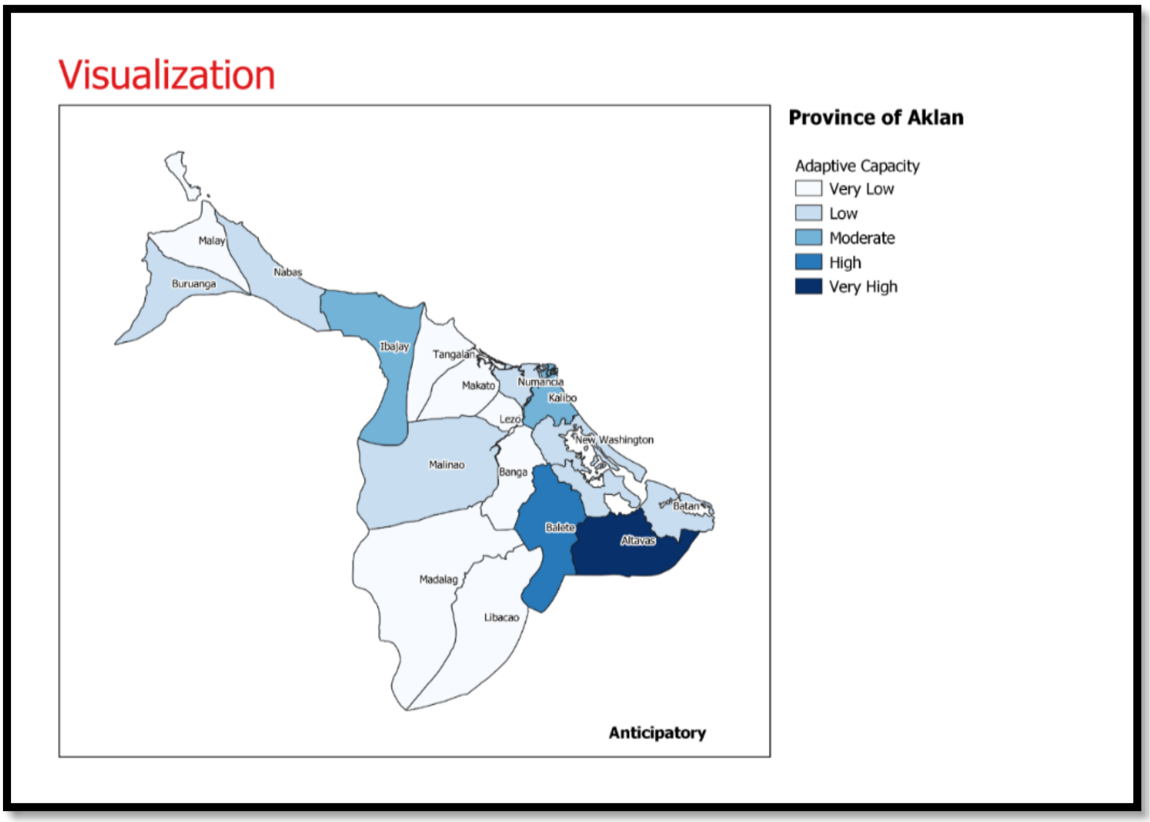



***Figure 48.*** *Visualization map showing the level of anticipatory capital of the municipalities in the Province of Province of Aklan*

***Institutional capital.*** The assessed Institutional capital of the different municipalities under study are reflected in Figure 49. Among others, the evaluation revealed that Kalibo, Madalag, Ibajay, Malay and Buruanga had very high institutional capital; very low institutional capital, however, was found in Tangalan and Batan. The two criteria used in this assessment were farmers' visit or consultation with the Agricultural Extension Officer, and number of AEO working under the office of the Municipal Agriculturist.

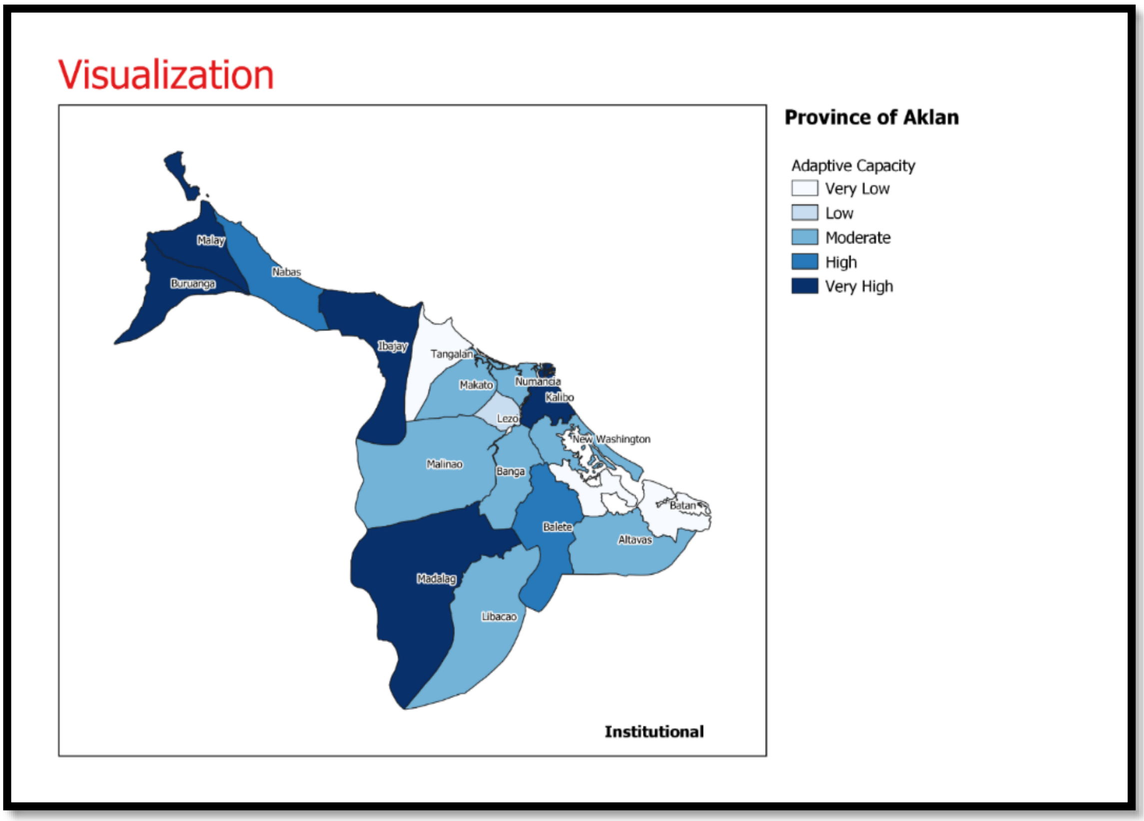



***Figure 49****. Visualization map showing the level of institutional capital of the municipalities in the Province of Province of Aklan*

***Adaptive capacity index.*** The adaptive capacity index of the province of Aklan is the inverted values of the overall adaptive capacity of the province. In the computation of this index, the values obtained from the seven adaptive capitals were used. As revealed in Figure 50, the municipalities of Batan, Libacao, Tangalan, Makato, Lezo, and Malinao obtained a ***very high*** adaptive capacity index compared to the other municipalities; Altavas, Banga, Madalag, Nabas, Malay, Buruanga, got ***high*** index. While Balete, New Washington and Numancia were rated moderate in this index, Ibajay got ***low***, and surprisingly, Kalibo, the capital town of the province, got ***very low*** adaptive capacity. Simply put, this means that the higher the value of this index, the greater also is the capability of the municipality to respond and adapt to adverse climatic conditions; and, the lower the value, the lower is the level of readiness of the municipality to face and adapt the consequences of these adverse climatic events.

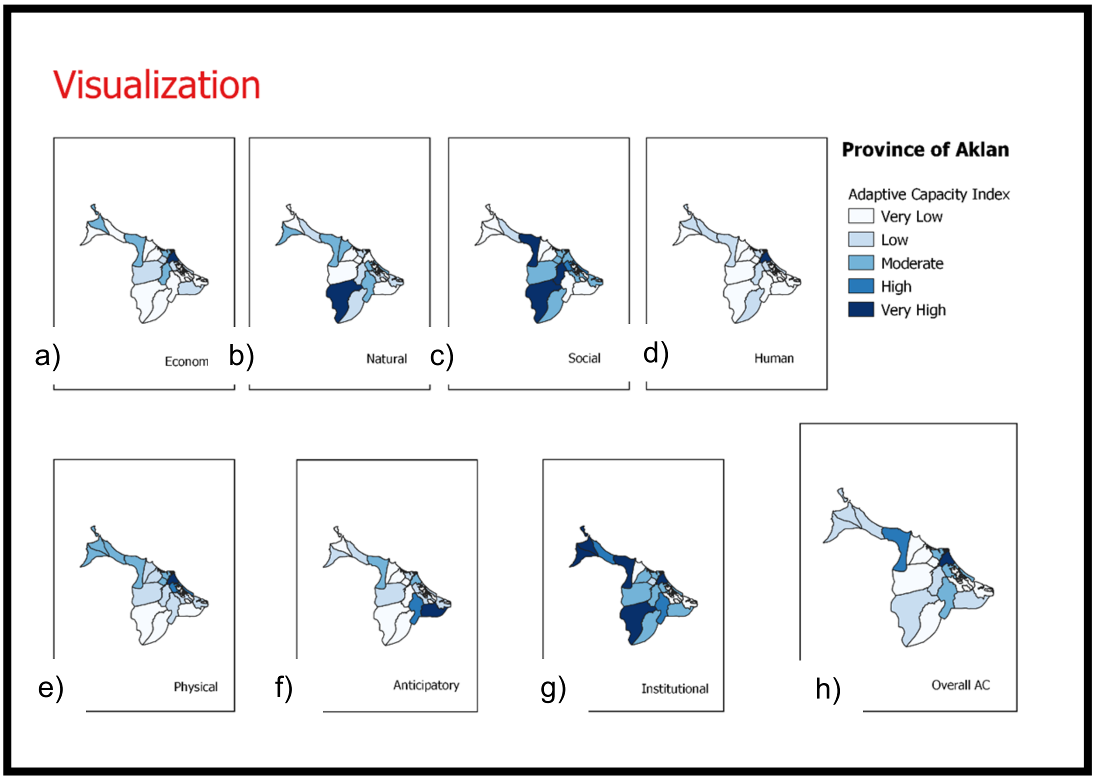



***Figure 50.*** *Visualization map showing the adaptive capacity index of the different municipalities of the Province of Aklan based on their level of the seven capitals of the adaptive capacity.*

*Figure 51 presents the over-all adaptive capacity for the Province of Aklan based on the seven capitals used in the evaluation process. This has already been explained above.*

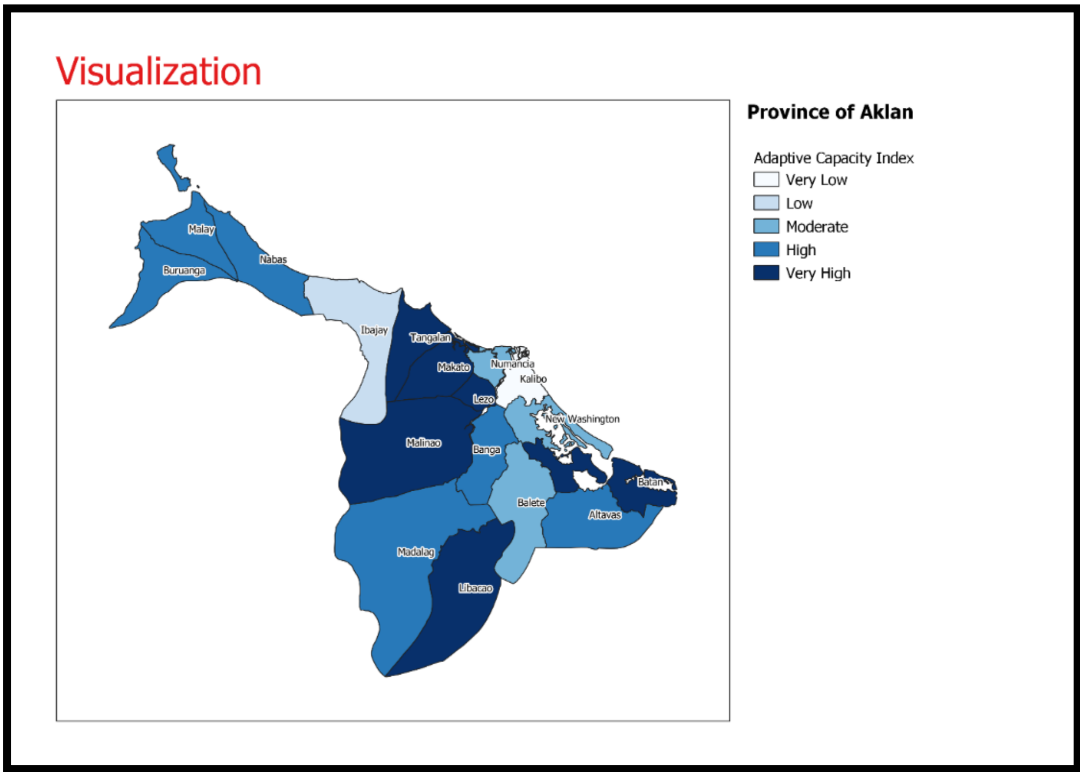



***Figure 51.*** *Visualization map showing the Adaptive capacity of the municipalities of the Province of Aklan based on the seven capitals considered in the assessment.*

## Over-all Climate Risk Vulnerability Assessment in the Province of Aklan

The over-all vulnerability assessment of the Province of Aklan was obtained from the summarized values of sensitivity, hazard and adaptive capacity index of the province. The results of the CRVA-based vulnerability evaluation revealed that the municipalities of Batan, Malinao, Makato, Tangalan were the most vulnerable (**very high**) to climate change (Figure 53). Only Kalibo had the **very low** vulnerability among the municipalities. The municipalities of Malay, Nabas, Buruanga, Lezo, Numancia, and Libacao had **high** vulnerability assessment; while Madalag, Banga, Balete, Altavas and New Washington got **moderate** rating. Ibajay was **rated** low and Kalibo **very low** assessment. The probable reasons for Kalibo to be the least vulnerable municipality in the province has already been elucidated earlier. The municipalities found to be most vulnerable are apparently economically handicapped which adaptive capacities were found to be similarly very low. Obviously, they are least prepared to respond to face the challenges of climate change. These are the municipalities which necessitate appropriate development programs relevant to countering the growing menace of climate change.

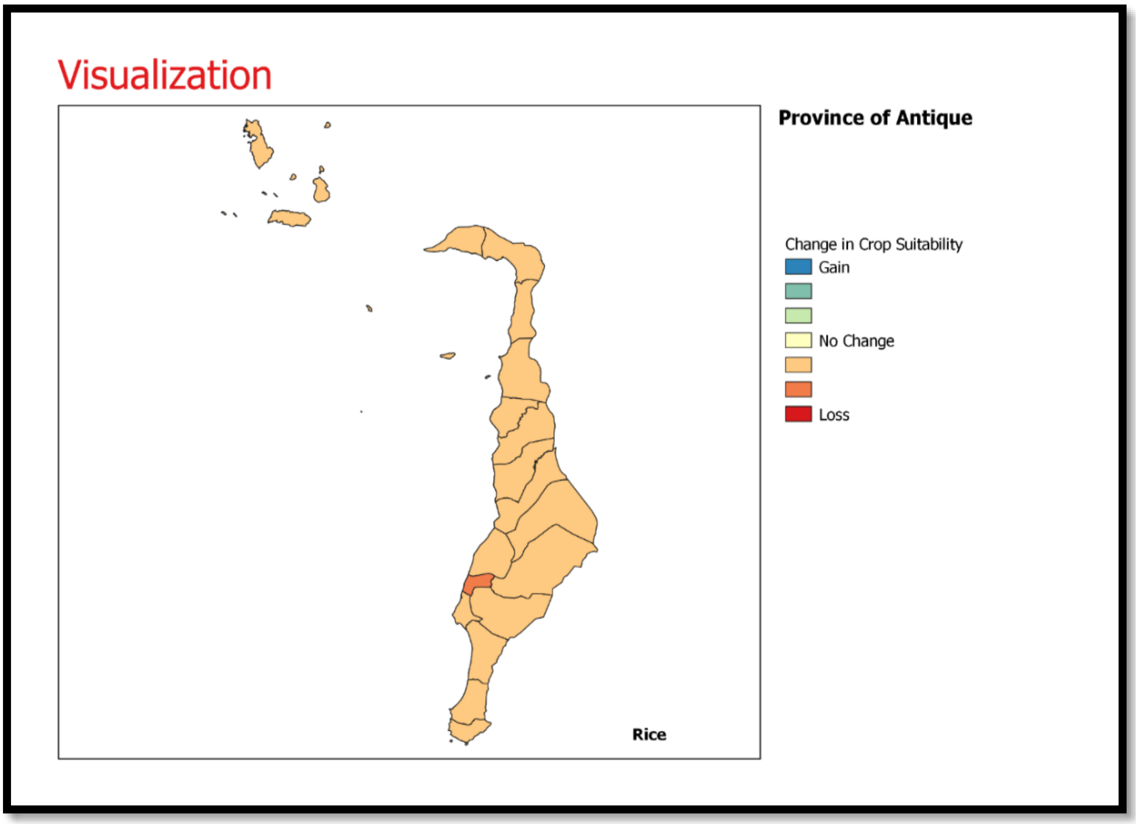



***Figure 53.*** *Visualization map showing the over-all climate risk vulnerability assessment results of the municipalities of the Province of Aklan.*

# Province of Antique

## Provincial Profile

The Province of Antique is one of the five provinces comprising Region VI – Western Visayas, and one of those that composed the Island of Panay. It is located in the southwestern part of the island made up of 18 municipalities with San Jose Buenavista as its capital town. In the 2020 census, the province has a total population of 472, 822; Sibalom, San Jose Buenavista and Hamtic came out as the three most populous municipalities in the province. Bordering the province are the provinces of Aklan in the north, Iloilo and Capiz in the east while facing Sulu Sea to the west. It has a long coastline in the southern and western seaboards which makes it highly vulnerable to typhoons and high waves during both the southwest (*Habagat)* and northeast monsoon *(Amihan)* seasons. Antique described as a seahorse-shaped province which occupies nearly the entire western coast of Panay Island is also known as the "land where the mountains meet the sea;" this is because of the high mountain ranges that dominate much of its area. The province has a Type I climate characterized as distinct dry and wet seasons usually experienced from December to May and June to November, respectively. Farming and fishing are the primary industries in the province. The major crops include rice, muscovado sugar, legumes, vegetables, fruits, bananas, fish and seaweeds, among others.

## Assessments for the Province of Antique

Similar to procedures used in the province of Aklan, the results of assessments done for the province of Antique involved the three major components of climate-risk vulnerability components based on the CVRA framework, namely: two categories of exposures (Exposures I and II) and adaptive capacity. Exposure I involved assessment of the impact of climate change to crop suitability in in the area in the future while Exposure II assessed common natural hazards, e. g., typhoons, drought, sea level rise and others. Adaptive capacity on the other hand, involved assessment of adaptive capitals like economic, social, human, institutional and other related factors. The findings obtained are discussed below.

## Sensitivity Assessment on Climate Impact on Crop Suitability (Exposure 1)

In this crop sensitivity/suitability assessment, the five top crops of the province used were rice, corn, banana, sugarcane, and mango. Similar to Aklan, the map below can serve as a guide in identifying crops suited for a specific location based on future climatic conditions. As would be expected, some of these may gain suitability in the future, others may loss it, while still others may remain the same depending on location. Table 1 below contain values which were used in the determining crop sensitivty or suitabiloity. Visualization maps are also presented to show changes in crop suitability of the five priority crop commodities projected until year 2050 in the Province of Antique.

*Table 1. Percent change of crop suitability in the Province of Antique in a projected period from 2020 to 2050.*

| **Municipality** | **Percent Change** | | | | |
|---|---|---|---|---|---|
| | Rice | Corn | Sugarcane | Banana | Mango |
| **Anini-y** | -23.70 | -8.50 | -17.50 | -0.78 | 7.42 |
| **Barbaza** | -19.50 | 1.24 | 9.62 | 0.26 | -0.82 |
| **Belison** | -25.00 | -4.40 | 4.69 | -0.24 | -1.04 |
| **Bugasong** | -21.10 | -0.28 | 6.47 | -0.6 | -1.09 |
| **Caluya** | -16.80 | -4.07 | 8.86 | -7.97 | -10.50 |
| **Culasi** | -17.80 | -0.57 | -1.94 | 1.76 | -1.61 |
| **Hamtic** | -21.00 | -2.77 | -9.66 | -0.2 | 0.99 |
| **Laua-an** | -20.60 | 1.29 | 4.80 | -0.48 | -0.44 |
| **Libertad** | -21.90 | 1.64 | 31.81 | 2.77 | 0.1 |
| **Pandan** | -14.10 | 11.30 | 12.78 | 2.22 | 7.45 |
| **Patnongon** | -21.50 | 1.47 | 5.35 | 0.5 | 1.42 |
| **San Jose** | -22.80 | -3.14 | -4.40 | -0.69 | -2.10 |
| **San Remegio** | -20.90 | 0.37 | 29.71 | 0.28 | 0.17 |
| **Sebaste** | -18.10 | -2.99 | 8.81 | 2.23 | -1.10 |
| **Sibalom** | -20.10 | 1.16 | 4.46 | 0.73 | 1.99 |
| **Tibiao** | -21.80 | 2.22 | 11.23 | 0.98 | 0.24 |
| **Tobias Fornier** | -24.80 | -6.94 | -17.20 | -0.98 | 5.66 |
| **Valderrama** | -20.10 | -1.71 | 16.05 | -0.52 | -2.05 |

***Note**: Above is the table of values showing the municipalities that will have no change if the values range from greater than negative (-) 5% to less than or equal to positive (+) 5)%; positive change can be attained if the values range greater than +5%; and, negative change if the values range lower than - 5%. Areas fell under no change will not be affected signiificantly by climate change in the future; those areas falling under positive change, the future climatic conditions will favor their growth; while those areas falling under negative change will lose crop suitability where climatic conditions would bring a negative effect on their agronomic growth performance.*

***Rice.*** This crop is a major crop in the province of Antique where a large number of the farmers are involved in rice farming. As shown in Figure 55, rice growing will remain ***no change*** in the province of Antique. The crop remains generally suitable in the area in the foreseeable future. The crop suitability values are contained in Table 1.

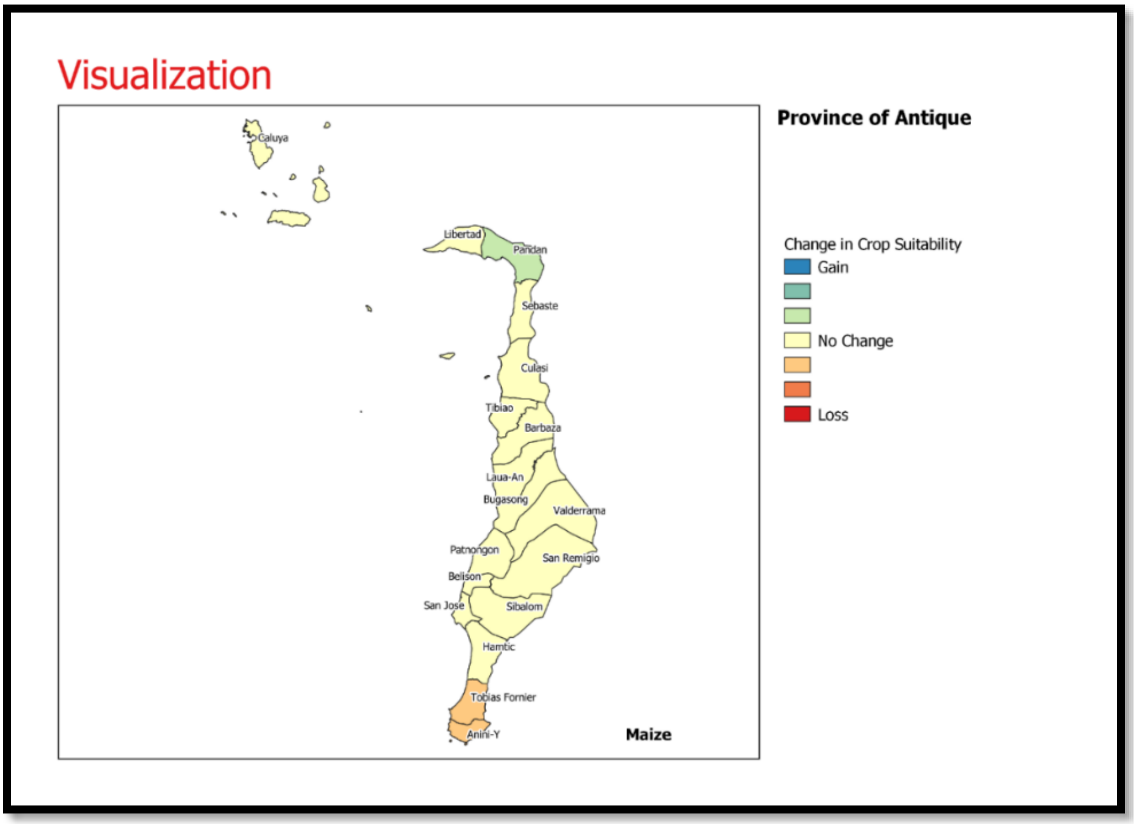



***Figure 55.*** *Visualization map showing the changes in suitability of rice farming in the province of Antique in the future.*

***Maize***. Corn is another major crop in the province that at times of rice shortage, it serves also as a staple crop. As shown by the visualization map in Figure 56, practically all the municipalities in this province will have ***no change*** in terms of suitability of corn to climate forecast in the area. This is with the exception of Pandan which tend to ***gain greater suitability***, and two other municipalities (Anini-Y and Tomas Fornier) which tended to ***loss their suitability*** to corn growing in the near future. Suitability values are contained in Table 1.

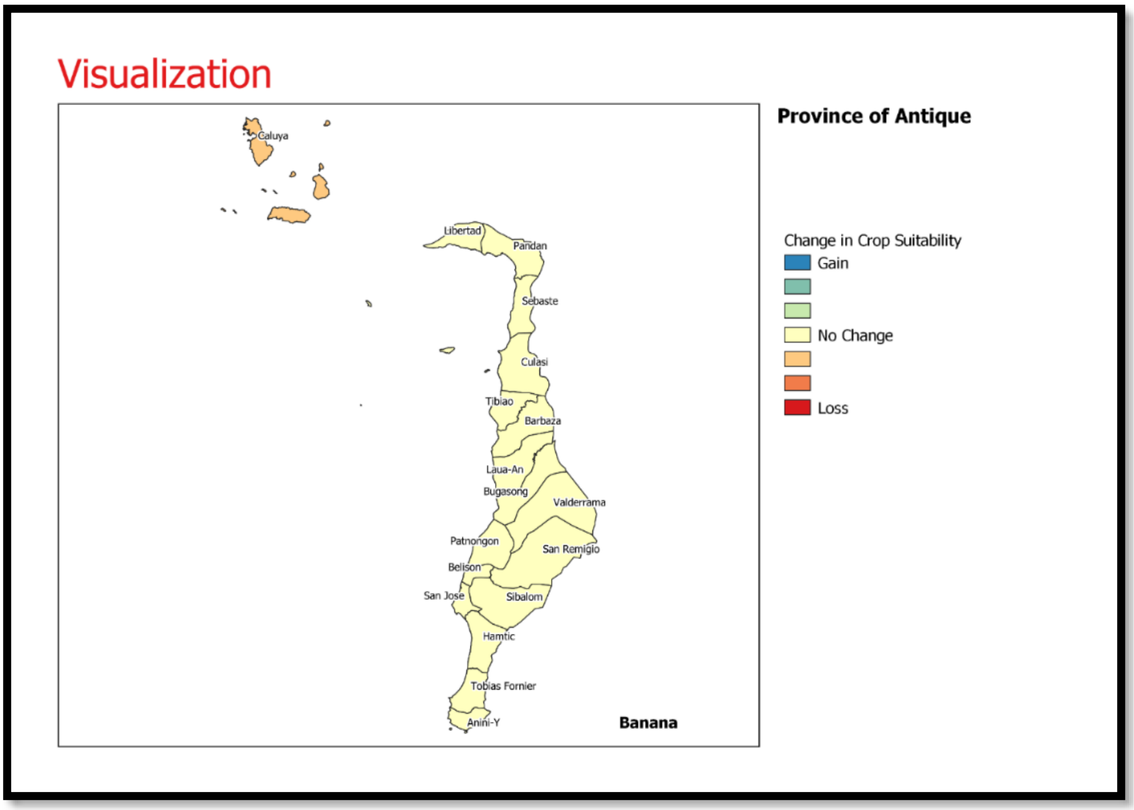



***Figure 56.*** *Visualization map showing the changes in suitability of corn growing in the province of Antique.*

***Banana***. Large areas of the province of Antique are planted productively to banana, thus considered as an important crop in the province. The assessment results revealed that with the exception of Caluya, the rest of the municipalities in the province appeared to retain their suitability for banana production (Figure 57). ***No change*** was noted on the suitability values for banana in these areas. On the other hand, Caluya got a suitability value of -7.97% indicating that growing banana in this municipality would slowly disappear in the future.

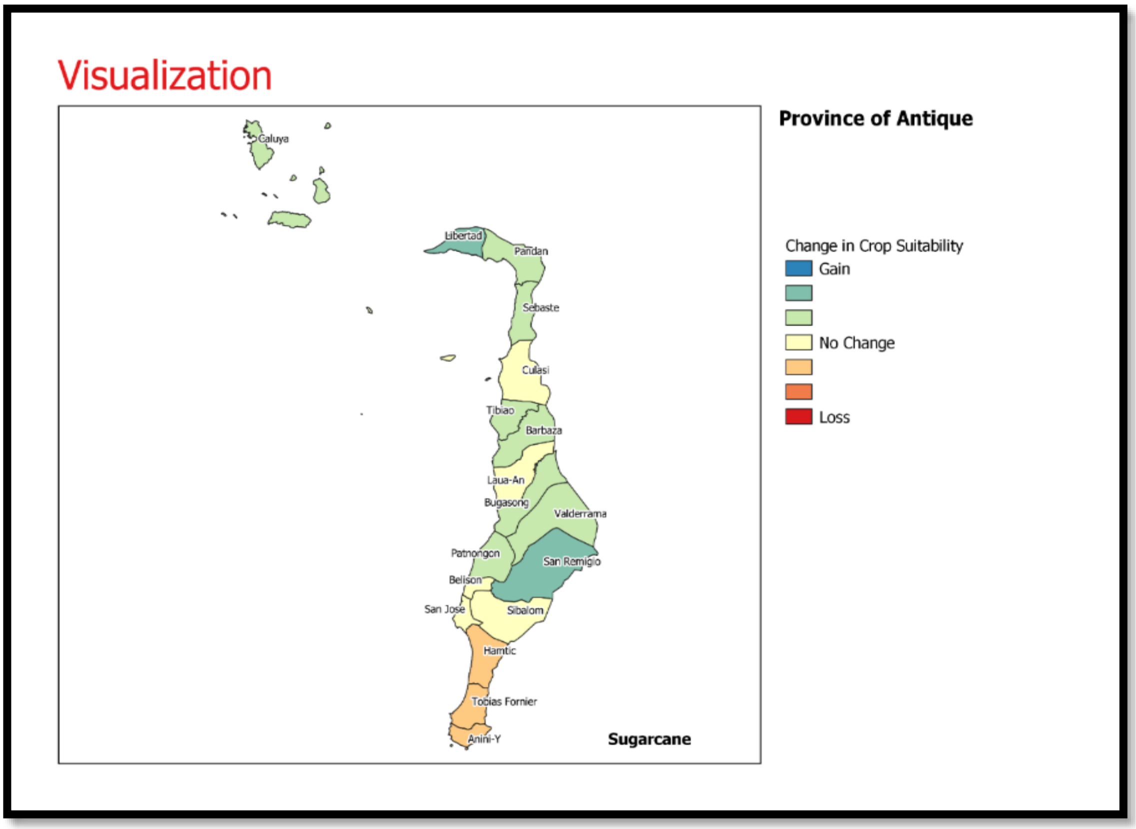



***Figure 57.*** *Visualization map showing the changes in suitability of Sugarcane production in the province of Antique*

***Sugarcane.*** Antique is known for muscovado sugar, hence growing sugarcane in this province is important. As shown in Figure 58, the municipalities mostly in the northern part of Antique, sugarcane gained ***positive suitability values***. This is particularly shown in Barbaza (+9.62%), Bugasong (+6.47%), Caluya (+8.86%), Libertad (+31.81%), Pandan (+12.78%), Patnongon (+5.35%), San Remigio (+29.71%), Sebaste (+8.81%), Tibiao (+11.23%) and Valderrama (+16.05). ***Negative suitability values*** for the crop, however, were gained by three municipalities. These are Anini-y (-17.50%), Hamtic (-9.66%) and Tobias Fornier (-17.20%). These areas will slowly loss suitability to sugarcane production in the foreseeable future due to changing weather conditions. Furthermore, the municipalities of Belison, Culasi, Laua-an, San Jose and Sibalom got ***no change*** in their suitability values, hence will remain suitable in the future.

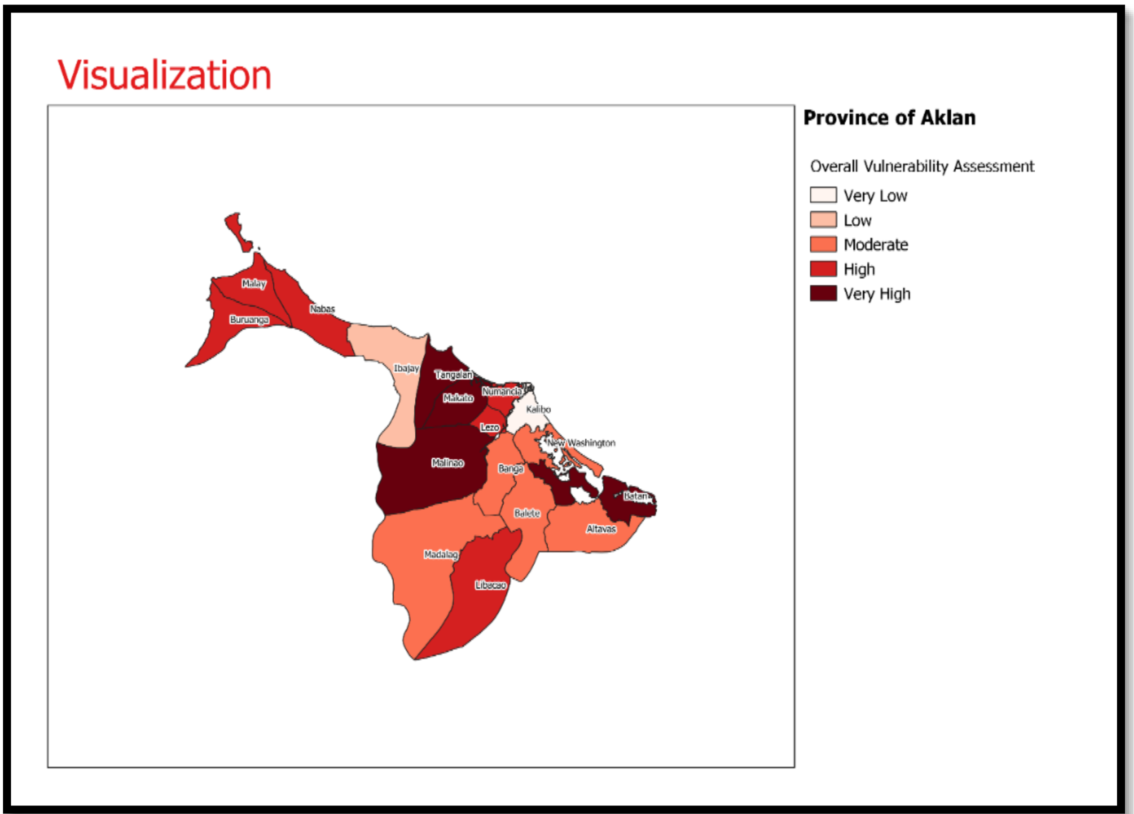



***Figure 58.*** *Visualization map showing the changes in suitability of Sugarcane production in the province of Antique.*

***Mango***. One important fruit crop in the province of Antique is mango. The4 suitability assessment indicated that there are three municipalities in the province that **gained positive suitab**ility values for mango production. This included Anini-y (+ 7.42%), Pandan (+7.45%), and Tobias Fornier (+5.66%). These areas are foreseen to be suitable for the crop even in the presence of predicted climate change impact. Based on available data, only Caluya recorded a ***negative suitability value*** (-10.50%) which indicate that it will lose its suitability for growing mango due to climate change (Figure 59).

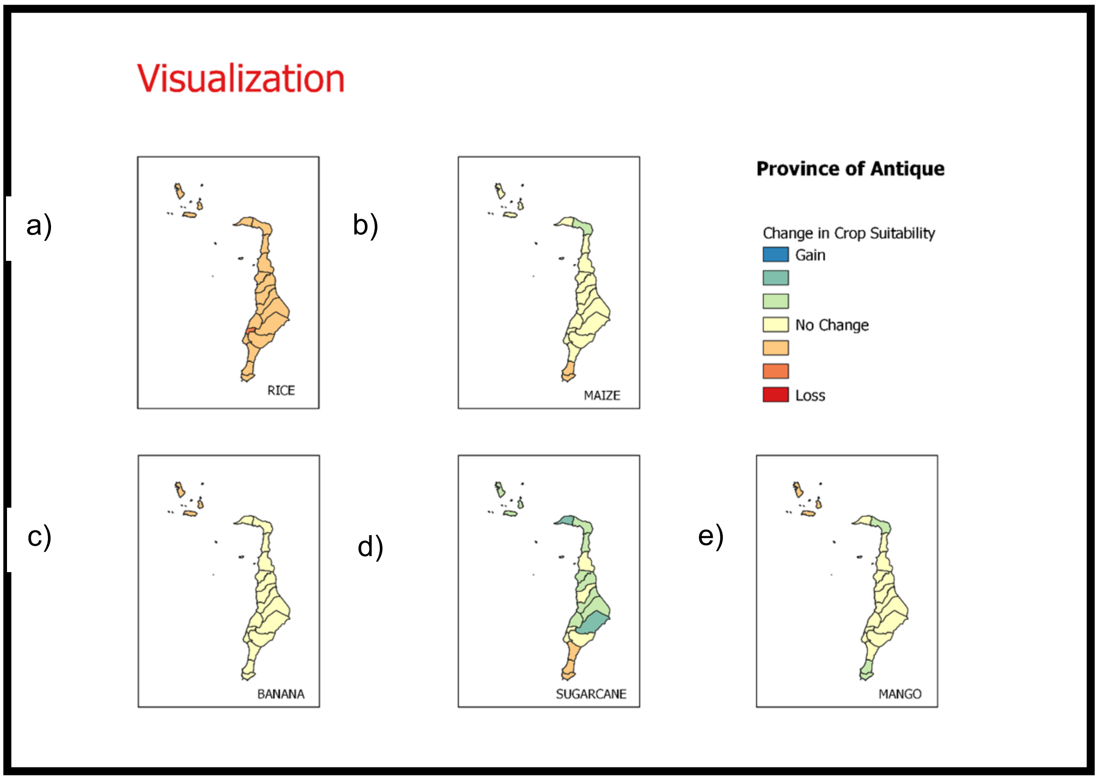



***Figure 59.*** *Visualization map showing the changes in suitability of mango production in the province of Antique.*

Figure 54a-e shows the comparative changes in crop suitability of five priority crops (rice, corn, banana, sugarcane, and mango) in the province of Antique. The details of this crop suitability maps were already discussed in the preceding sections.

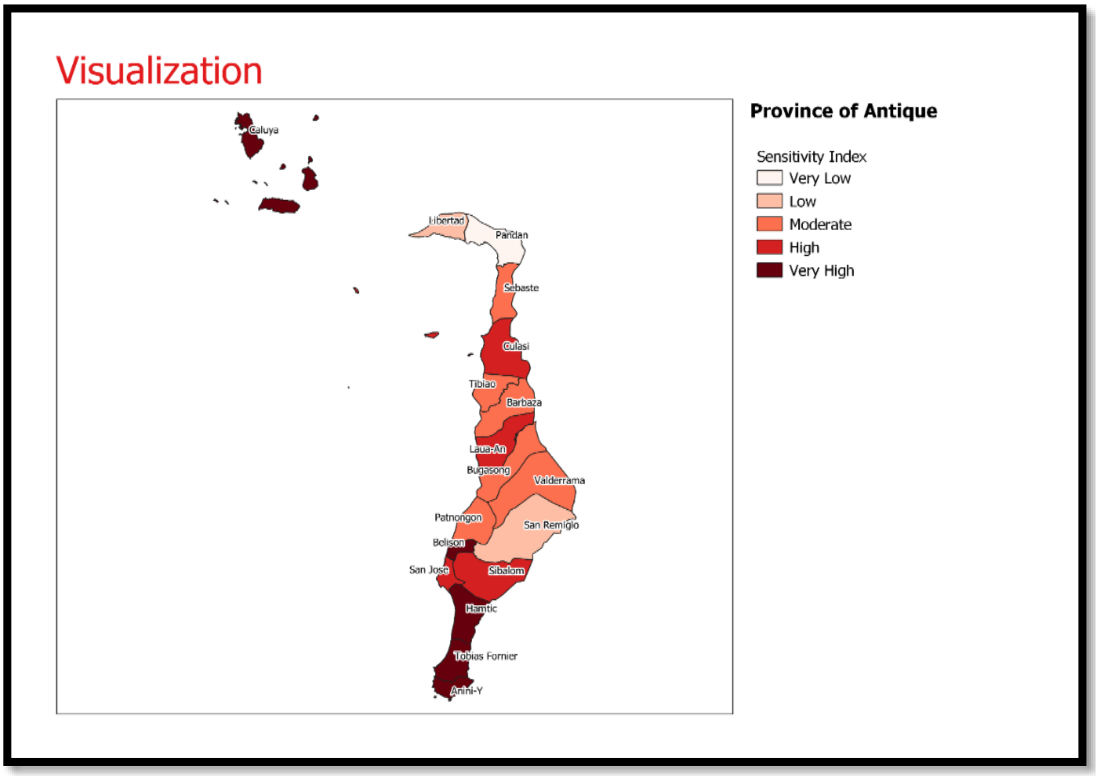



***Figure 54a-e.*** *Visualization map showing the changes in crop suitability for the five priority crops such as rice, corn, banana, sugarcane and mango in the province of Antique.*

***Sensitivity index***. The sensitivity index for crop suitability of the Province of Antique to the five crop priorities is shown in Figure 60. The following sensitivity index are shown by the visualization map: ***very high*** for the municipalities Anini-y, Belison, Caluya, Hamtic, and Tobias Fornier; ***high*** for Culasi, Lawaan, Sibalom and San Jose; ***moderate*** for Sibaste, Tibiao, Barbaza, Bugasong, Valderama and Patnongon; ***low*** for Libertad, and San Remegio; and ***very low*** for Pandan. The usual interpretation of these results is, that the higher the sensitivity index, the lower is the suitability of the crop in the area or municipality being evaluated, or the higher the index, the higher also is the projected potential impact from the hazards of climate change. To summarize the above results, it came out that, majority of the municipalities had ***moderate*** sensitivity index while seven of them had index ranging from ***high to very high***, and three ranging from ***low to very low***.

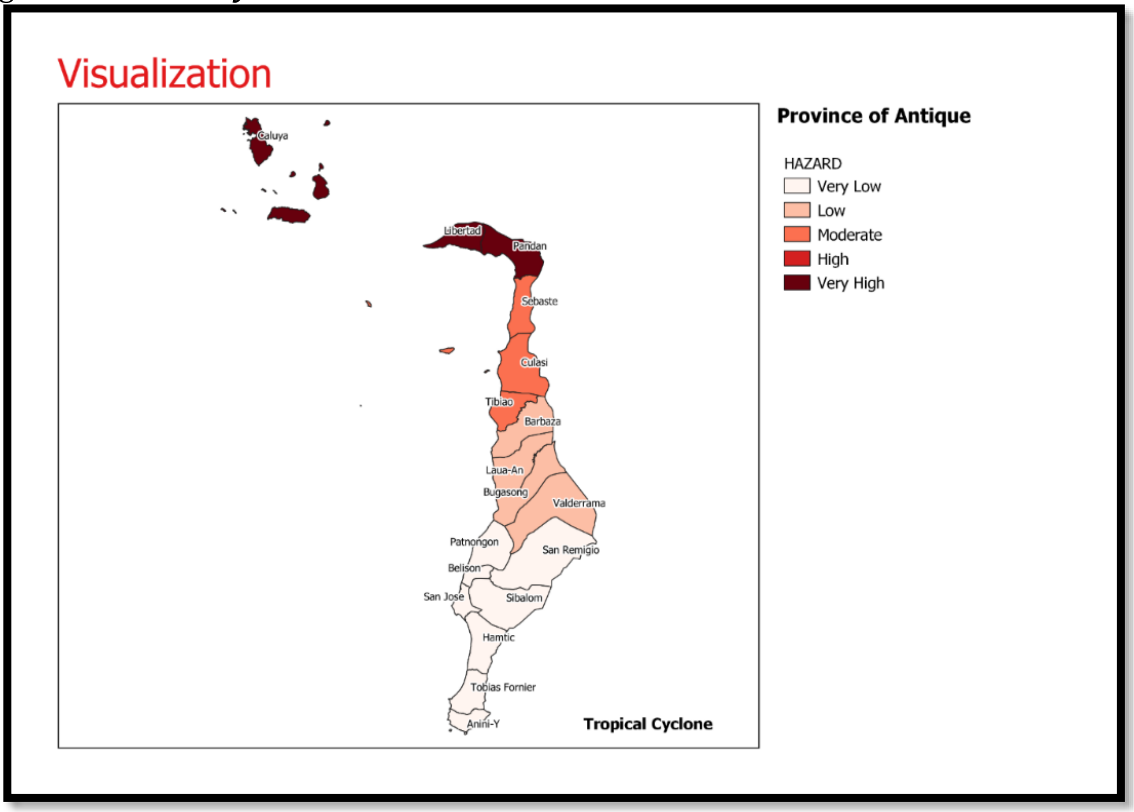



***Figure 60.*** *Visualization map showing the sensitivity index of the province of Antique to climate change using the suitability values of the five priority crops in the province.*

## Hazard Assessment of Climate-Related Pressures in Antique (Exposure II)

The results in the assessment of the eight natural hazards associated with climate change are presented and discussed below.

These common natural hazards include tropical cyclone, drought, flooding, erosion, sea level rice, storm surge and salt water intrusion.

***Tropical cyclone***. Figure 62 presents the hazard vulnerability of the municipalities in the Province of Antique to tropical cyclone. Since Antique is geographically located along the coastline, flooding and other coastal related risks are very high. The northern portion is frequently visited by typhoons; historically, the occurrence of tropical cyclone in the north is observed to be higher than in the south. The presence of mountainous areas in the province likewise adds up to greater risk of the area to landslides and soil erosion. The top three municipalities with ***very high*** risk to tropical cyclones are Libertad, Caluya and Pandan. These municipalities are located in the northern portion of the province. Culasi, Tibao and Sebaste, on the other hand were rated to have ***high*** hazard to this climatic event while the municipalities of Barboza, Lawaa-an, Bugasong and Valderama were ***moderate***. All the remaining municipalities were rated ***very low.***

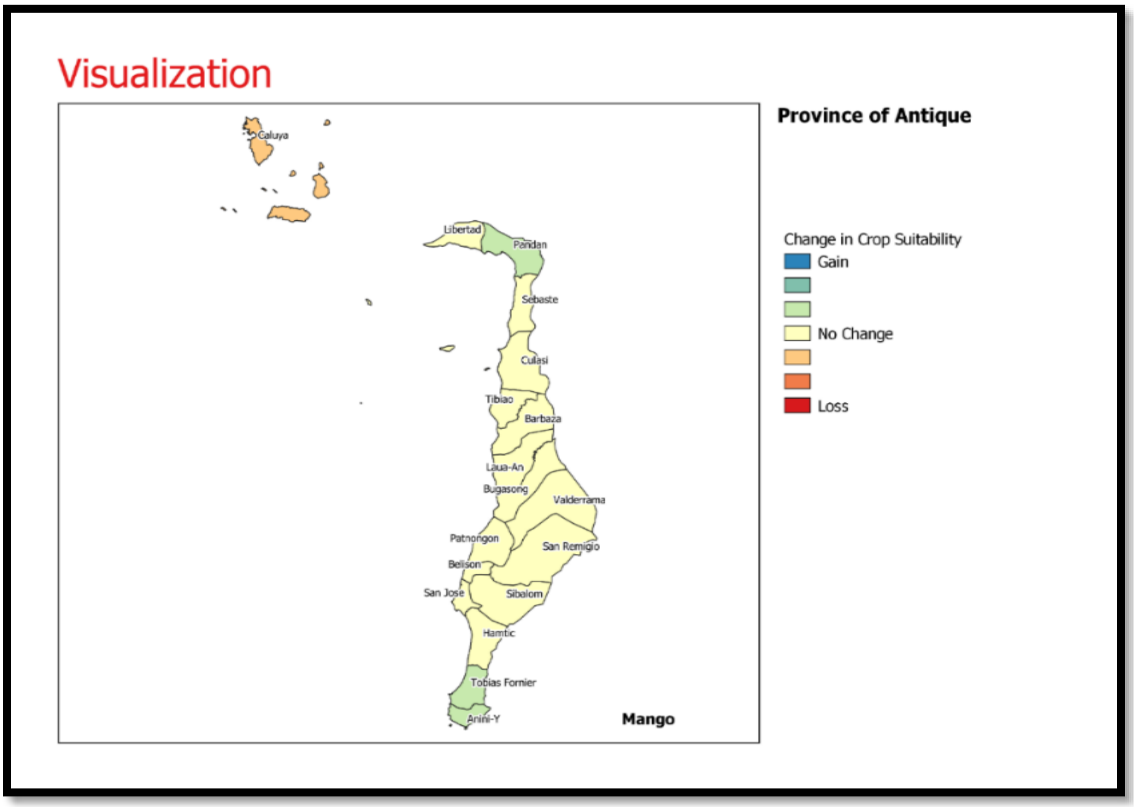



***Figure 62.*** *Visualization map showing the level of hazard to tropical cyclones of the Province of Antique.*

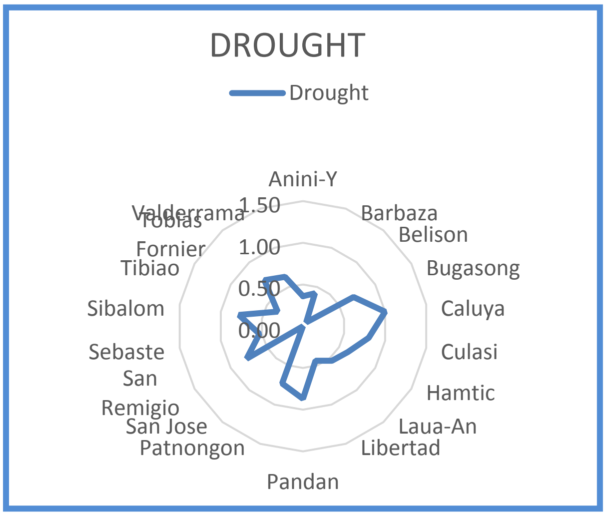



***Figure 63.*** *Radar chart indicating the areas having potential hazard to tropical cyclones in the Province of Antique.*

***Drought***. The hazard due to prolonged dry weather or drought is predicted to be ***very high*** in the future in the Pandan and Caluya area; a ***moderate*** hazard was predicted for the towns of Libertad, Sebaste, Barboza and Valderrama, and ***low*** in Tibiao. The nine remaining municipalities were predicted to have ***high*** hazard in the future (Figure 64). The hazard to drought in this case is predicted to occur in practically all parts of Antique.

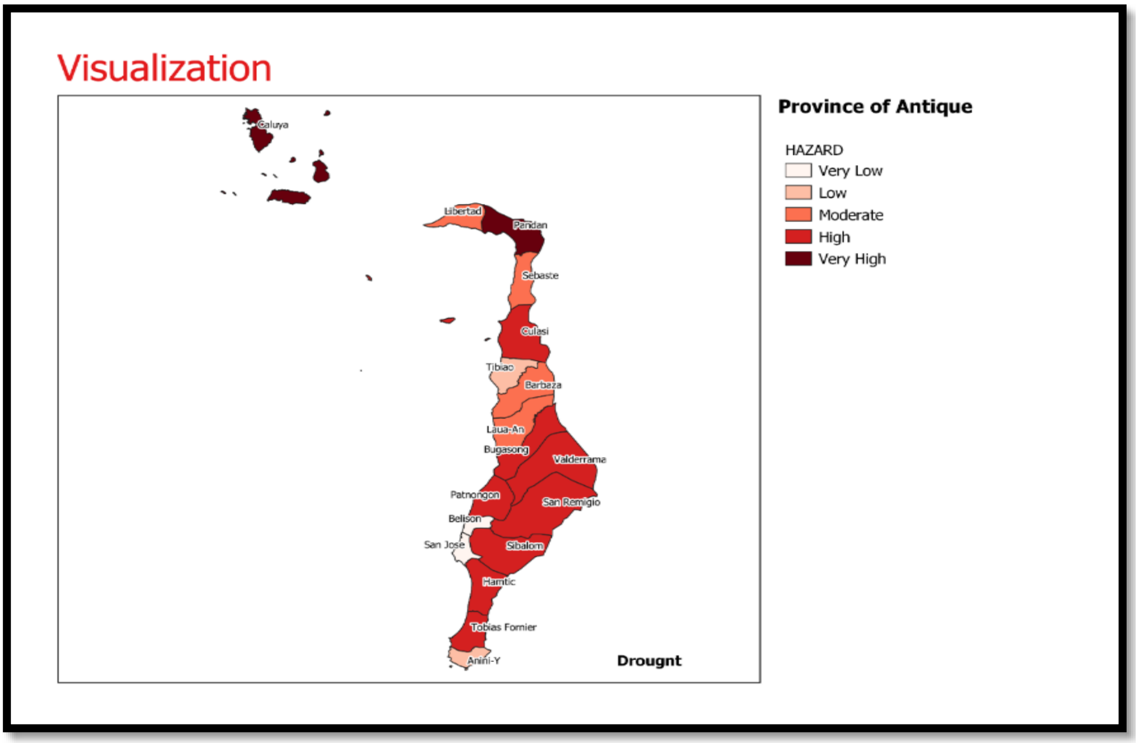



***Figure 64****. Visualization map showing the level of hazards to drought in the Province of Antique.*

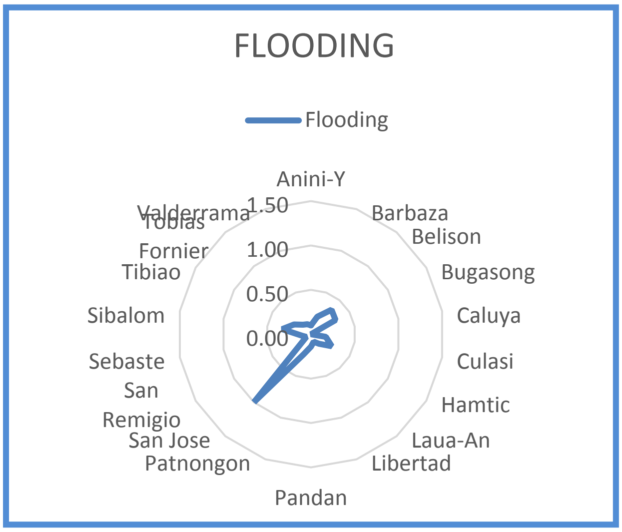



***Figure 65.*** *Radar chart indicating the areas having potential hazard to drought in the Province of Antique.*

***Flooding.*** As shown in Figure 66, the municipality of San Jose appeared to have a very high risk to flooding while the rest of the towns in the province had hazards ranging from low to very low. This is further confirmed by radar chart readings obtained from normalized values derived from zonal statistics using GIS based on the consolidated hazard data of AMIA 1 (Figure 67). With the exception of the low-lying municipality of San Jose, then, flooding is not much of a problem in Antique.

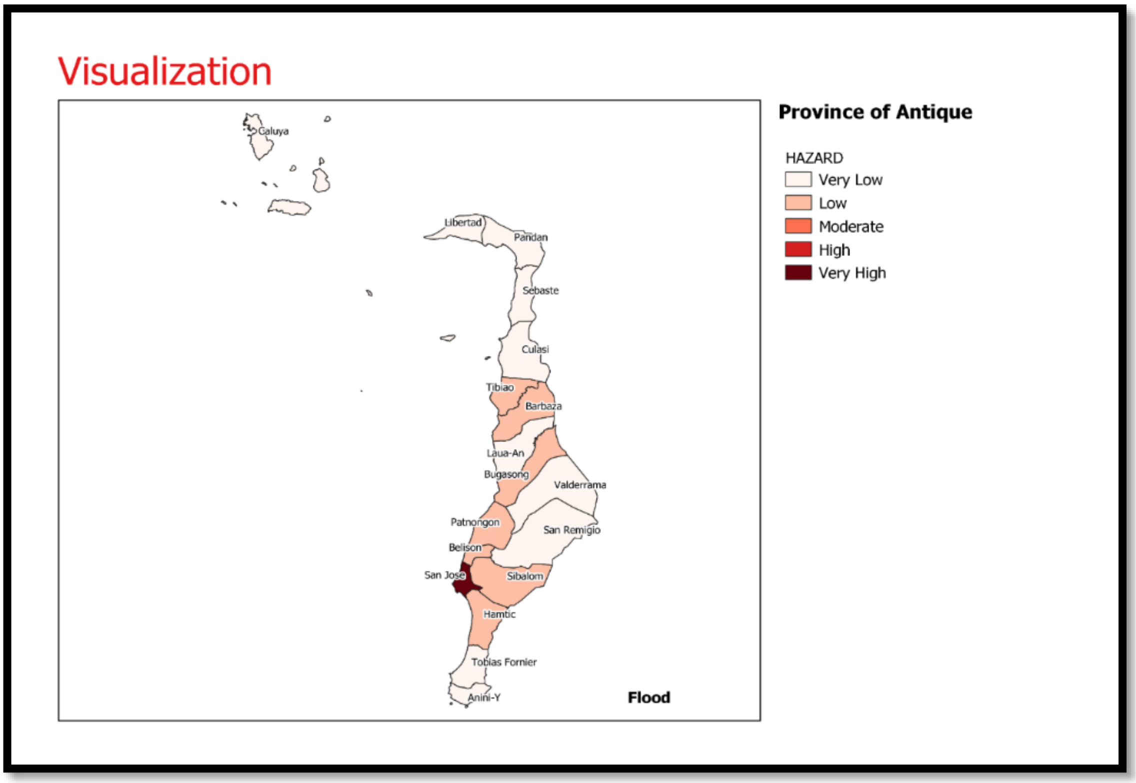



**Figure 66.** *Visualization map showing the level of hazards to flooding in the Province of Antique.*

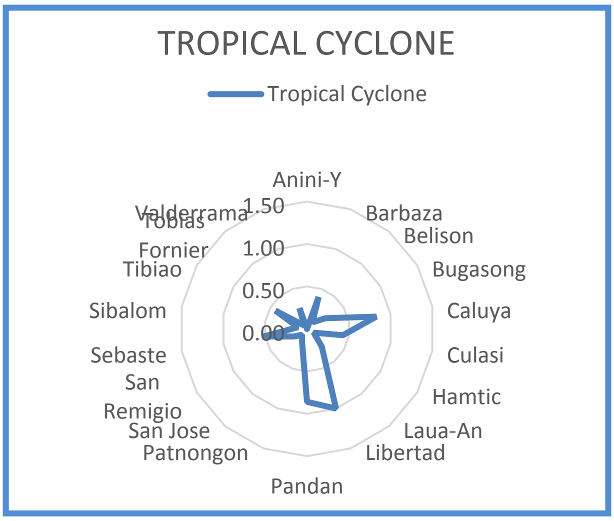



***Figure 67.*** *Radar chart indicating the areas having potential hazard to flooding in the Province of Antique.*

***Landslides***. Landslides generally occur in upland areas during seasonal heavy rains; torrential rains can soften the ground in the area resulting to landslides or mudslides. In Antique, only San Jose and Caluya appeared to be least prone to landslides (***very low*** hazard; as shown in Figure 68, nine municipalities were predicted to have ***very high*** hazard to landslides. These municipalities are: Libertad, Sebaste, Culasi, Tibiao, Barboza, Lawa-an. Bugasong, Valderama, and San Remegio. Moreover, six municipalities were assessed to have high hazard to landslides in the future. These are Pandan, Patnongon, Belison, Sibalom, Hamtic and Tobias Fornier. As shown in the visualization map, practically the whole of the province of Antique is vulnerable to landslides.

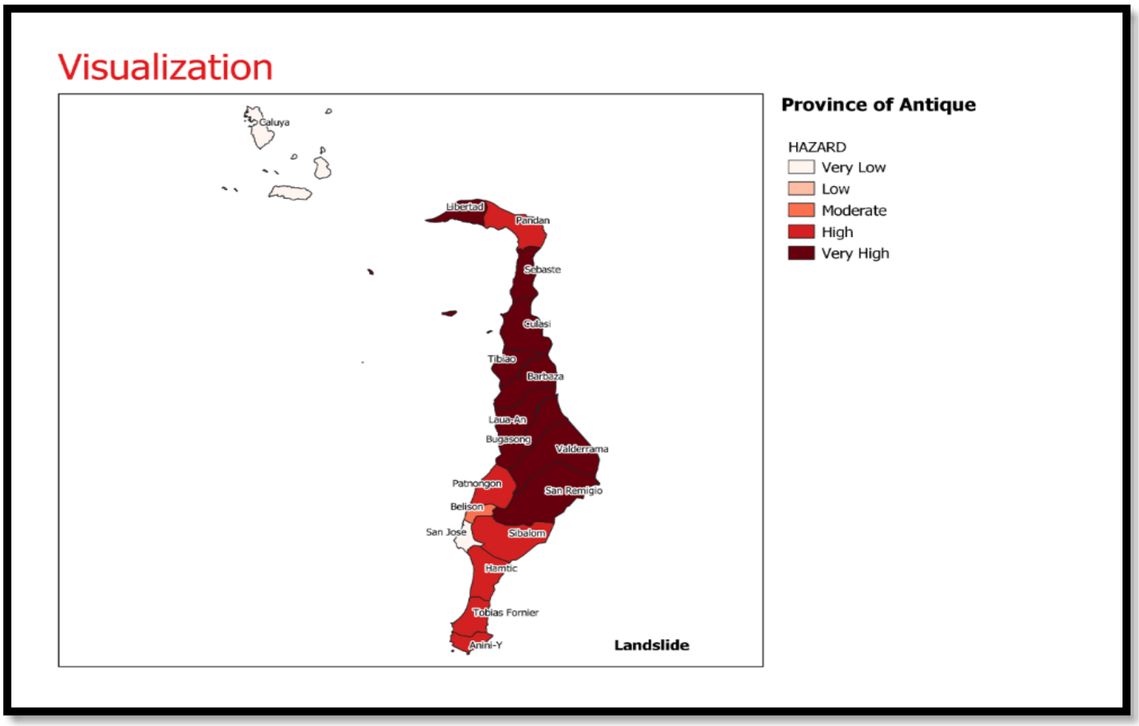



***Figure 68.*** *Visualization map showing the level of hazard to landslides in the Province of Antique.*

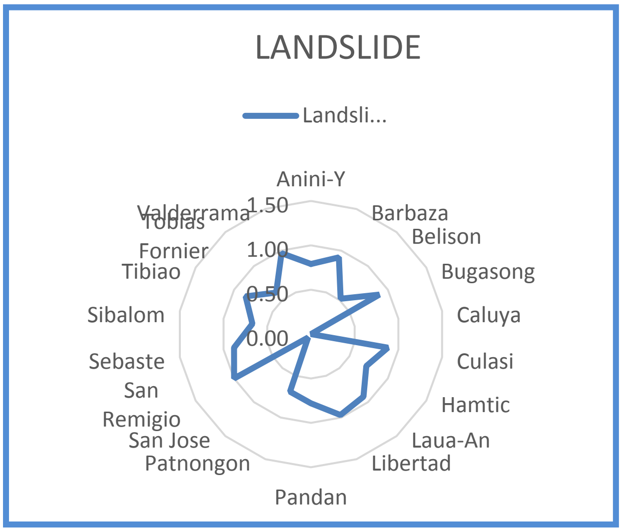



***Figure 69.*** *Radar chart indicating the areas having potential hazard to flooding in the Province of Antique.*

***Sea level rise***. The assessment data gathered on hazard to sea level rise of the province of Antique. The visualization map in Figure 70 reveal that Hamtic is the only municipality predicted to have a very high hazard to sea level rise. The towns of Caluya and Culasi. Patnongon, on the other hand, were rated to have a ***moderate*** risk while Pandan, Sebaste, Barbaza, Bugasong, Belison and San Jose had ***low*** risk to rising sea level. The rest of the municipalities were predicted to have a ***very low*** hazard to this climate-related phenomenon. The gradually increasing temperature worldwide is one single major cause of rising sea level. This can result to the gradual sinking of lands, particularly in low-lying areas. The Philippines being an archipelagic country composed of so many islands is extremely vulnerable to the danger of rising sea level.

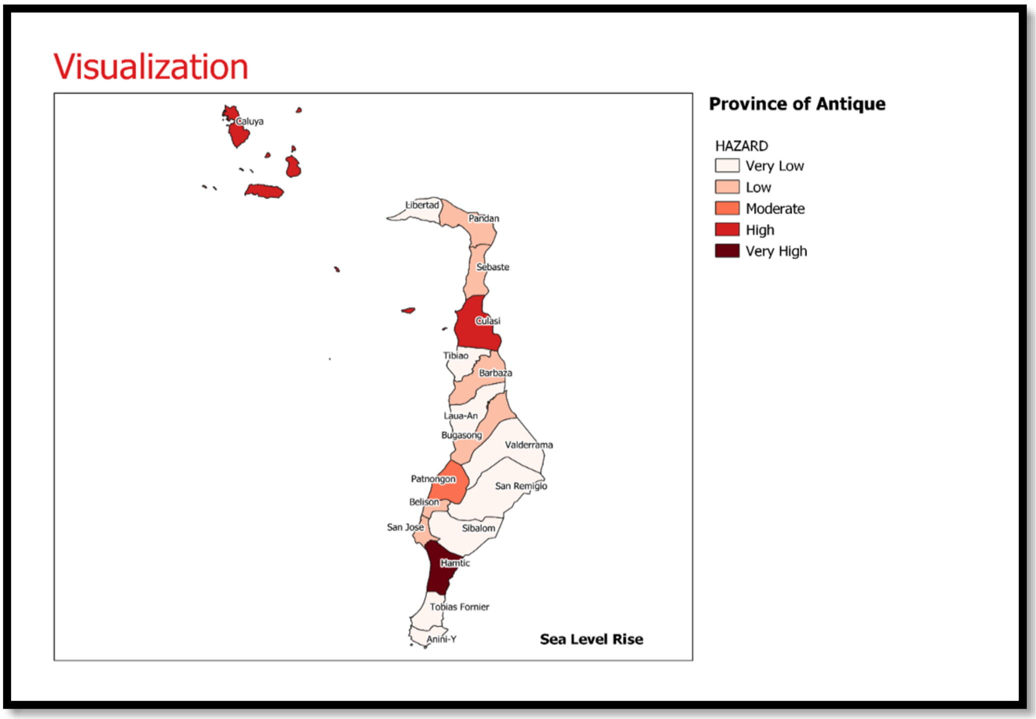



***Figure 70****. Visualization map showing the level of hazard to sea level rise in the province of Antique.*

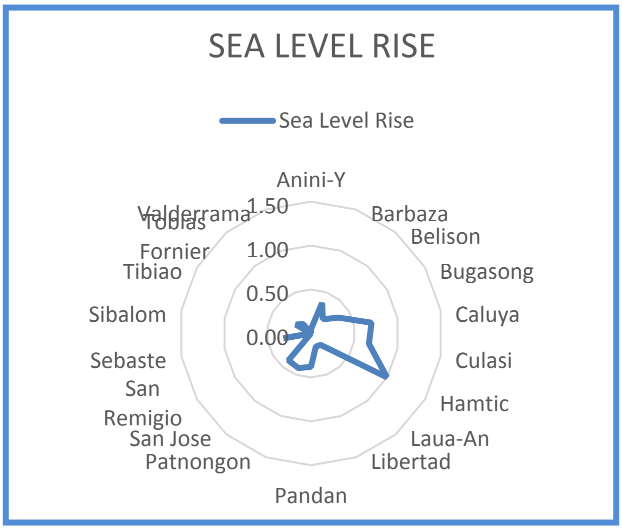



***Figure 71.*** *Radar chart indicating the areas having potential hazard to sea level rise in the Province of Antique.*

***Soil erosion***. Erosion is usually a consequence of heavy rainfall, sloping land terrain, loose soil, and absence of vegetative cover. These factors are probably present in Antique. As shown in hazard map in Figure 72 the whole province is almost entirely vulnerable to erosion. With the exception of San Jose and Caluya which obtained ***very low*** hazard rating, all other municipalities had hazard ratings ranging from ***high*** to ***very high***.

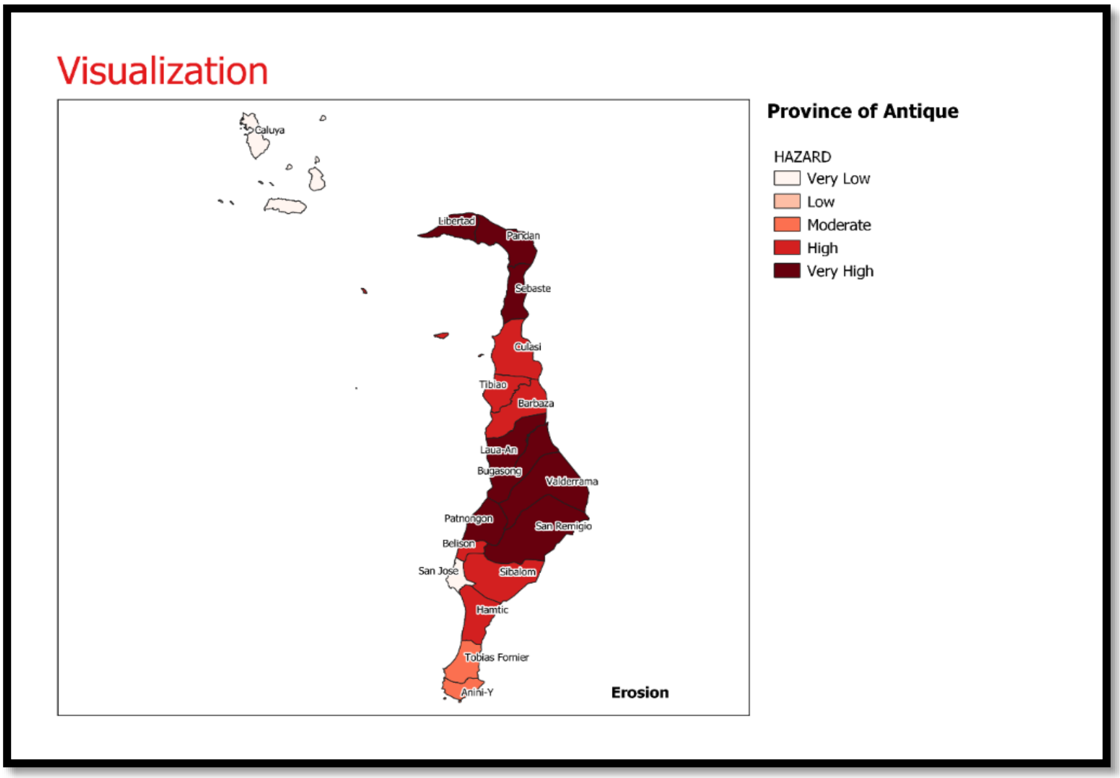



***Figure 72.*** *Visualization map showing the level of hazard to erosion of the province of Antique.*

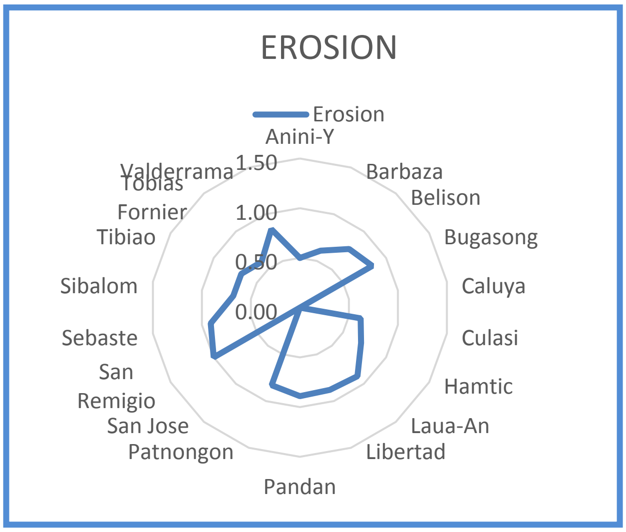



***Figure 73.*** *Radar chart indicating the areas having potential hazard to erosion in the Province of Antique.*

***Storm surge.*** The level of hazard of this climatic event is very ***high*** in Hamtic, ***moderat***e in Pandan, Bugasong, Patnongon, and San Jose, but ***low*** in Belison, Sebaste, Patnongon, Tibiao, and Barbaza; the rest of the municipalities had ***very low*** risk to storm surge (Figure 74).

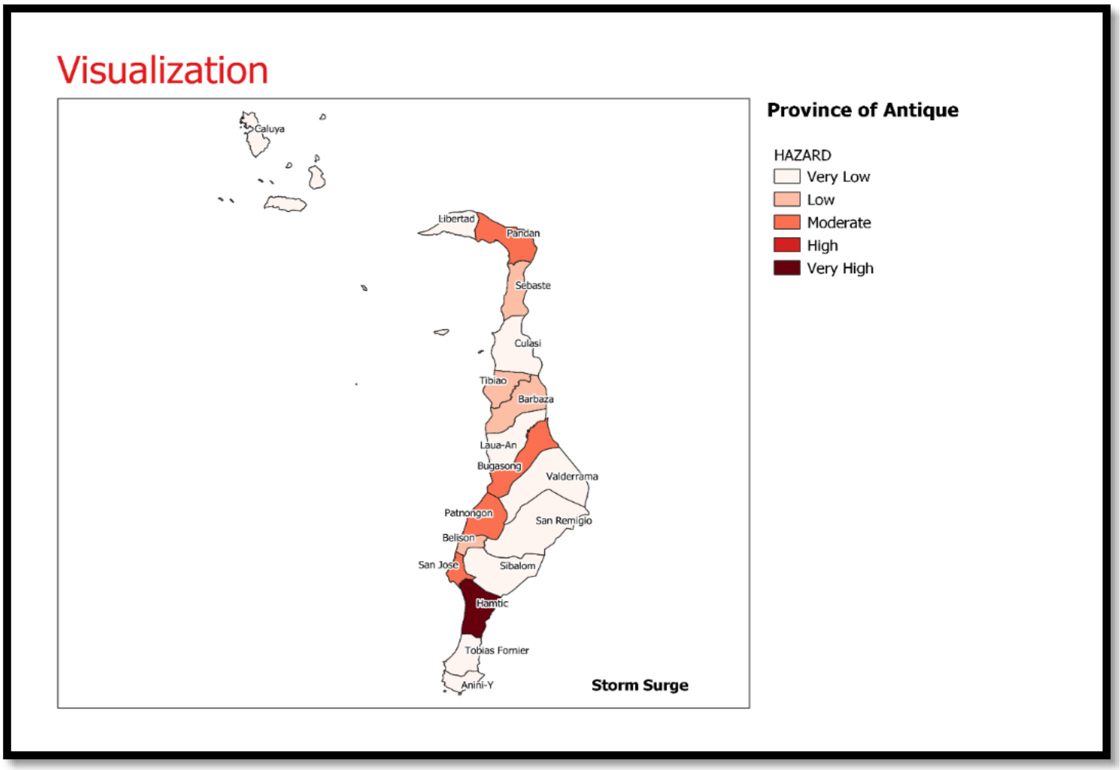



***Figure 74.*** *Visualization map showing the municipalities of Antique and their level of vulnerability or risk to storm surge.*

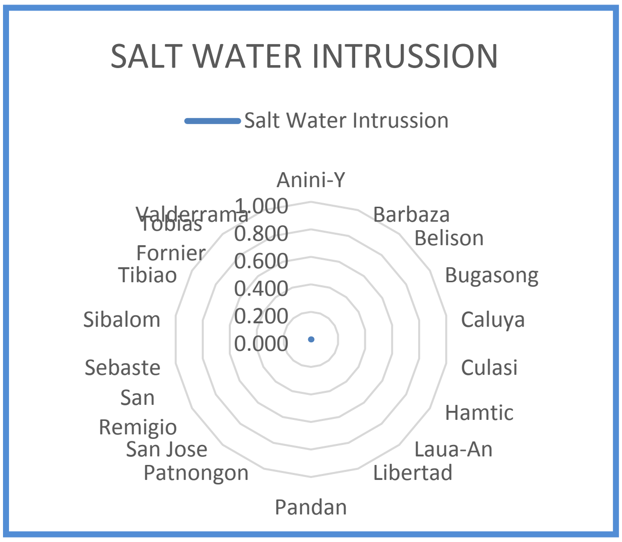



***Figure 75.*** *Radar chart indicating the areas having potential hazard to storm surge in the Province of Antique.*

***Salt water intrusion***. The visualization map in Figure 76 showed that saltwater intrusion was predicted to be ***very low*** throughout the province of Antique. The hazard due to this climatic event is practically negligible in the in the future in the entire province.

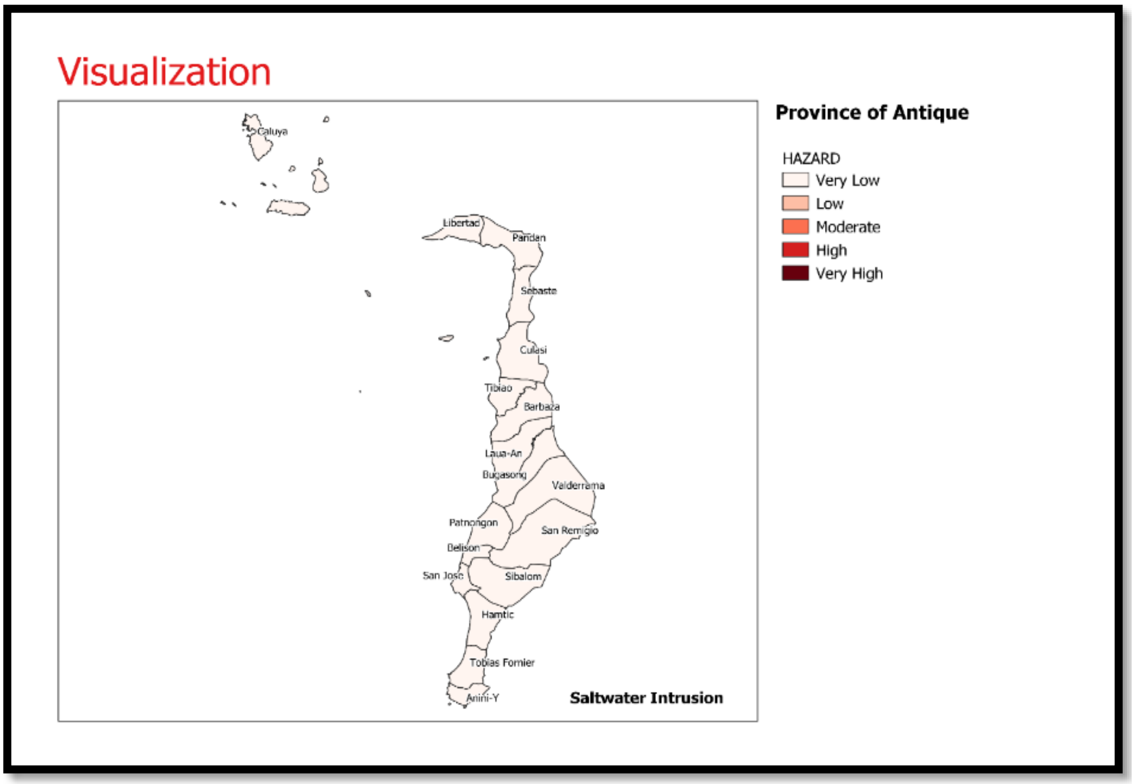



***Figure 76.*** *Visualization map showing the level of hazard to saltwater intrusion in the province of Antique.*

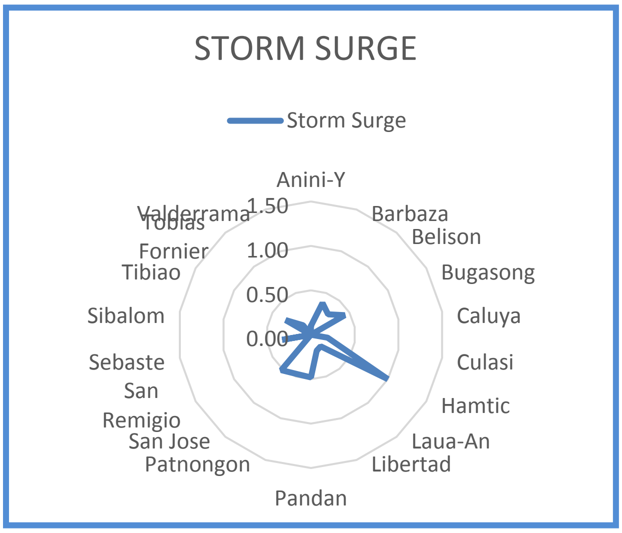



**Figure 77.** *Radar chart indicating the areas having potential hazard to salt water intrusion in the Province of Antique.*

***Hazard index.*** Figure 61 presents the degree of hazards to natural weather-related events the province of Antique. Typhoons, flood, and drought were consistently rated high across the province and were considered the major driving factors that contributed to the high hazard exposures which led to a high hazard index. Although typhoons had the highest weight (Annex 2) among all hazards, their impact was most prominent in northern Luzon, southeastern Luzon, and eastern Visayas regions in the Philippines. Since the hazard index is a composite of multiple hazards, the higher hazard index (red and dark red colors on the map) reflects several geographical overlaps of hazards (overlap of the typhoon, flood, and drought), and wider geographical extent of hazards.

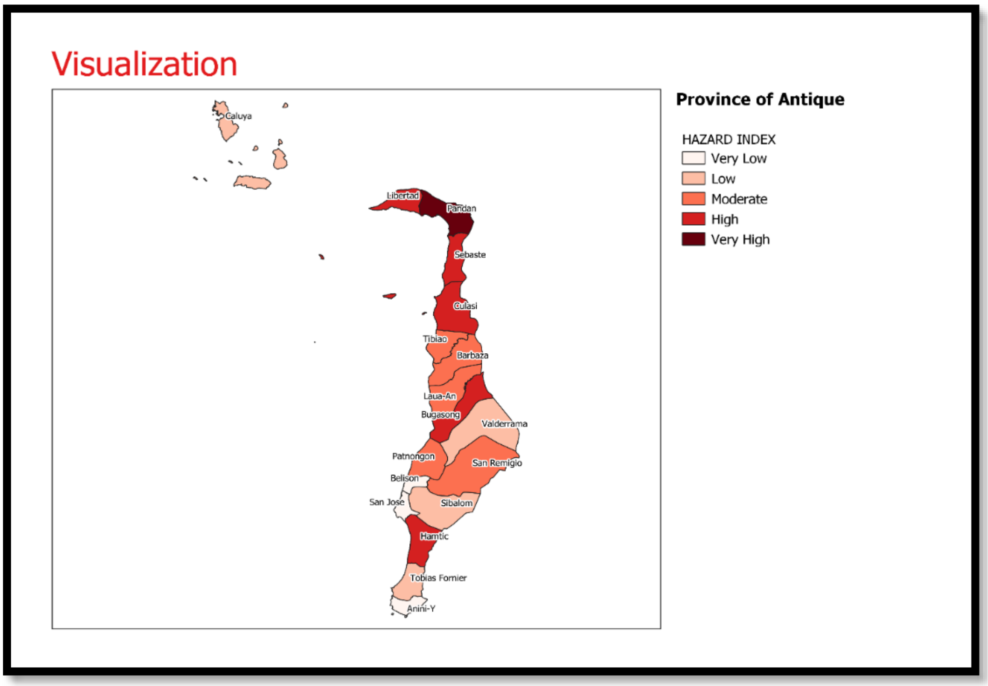



***Figure 61**. Visualization map showing the hazard index of the province of Antique summarized from the province's exposures to various common climate-related hazards.*

***Hazard index.*** Figure 78 presents the degree of exposure to climate-related hazards across the Antique province. Typhoons, flood, and drought were consistently rated high across the province and were considered the major driving factors that contributed to the high hazard exposures which led to a high hazard index. Although typhoons had the highest weight (Annex 2) among all hazards, their impact was most prominent in northern Luzon, southeastern Luzon, and eastern Visayas regions in the Philippines. Since the hazard index is a composite of multiple hazards, the higher hazard index (red and dark red colors on the map) reflects several geographical overlaps of hazards (overlap of the typhoon, flood, and drought), and wider geographical extent of hazards.

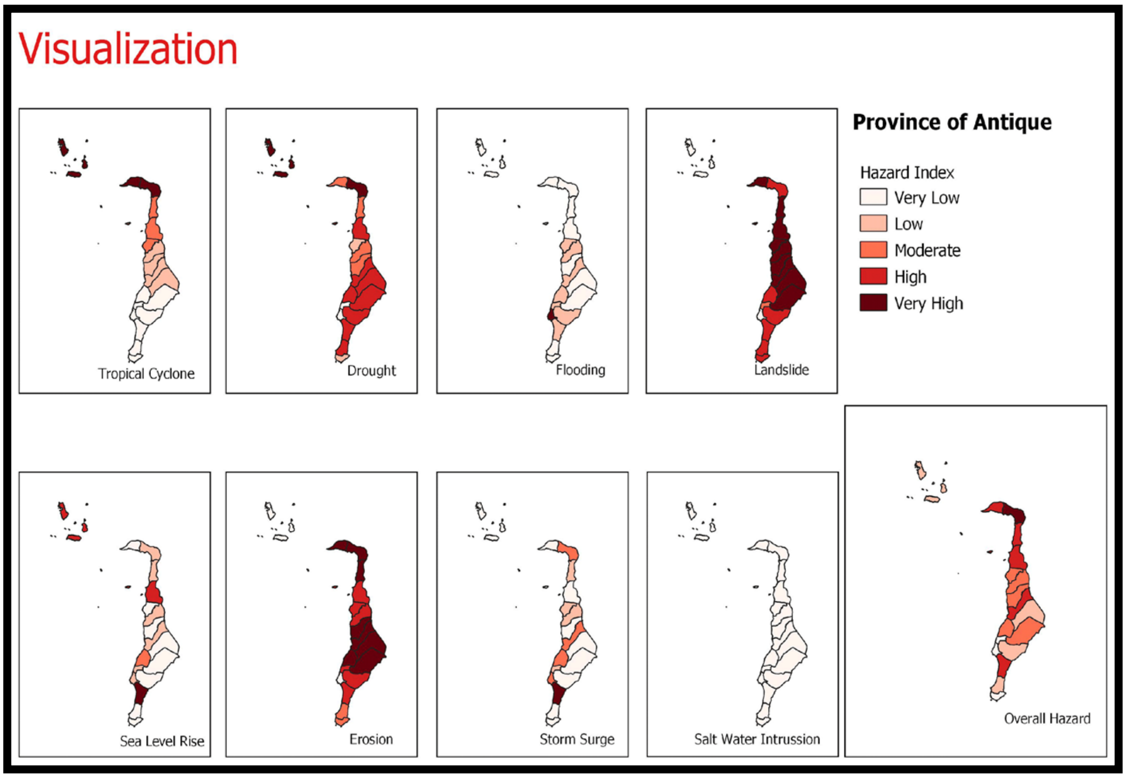



***Figure 78.*** *Map showing the hazard index of the Province of Antique summarized from the province's exposures to various climate-related events.*

## Adaptive Capacity Assessment of Antique Province
### (How Communities Resist and Adapt to Climate Change-Related Pressures)

Adaptive capacity assessment tried to explore, analyze, and interpret specific capitals and indicators that can increase the resilience of communities to climate change. Figure 79 Based on the CRVA protocol, this assessment involved spatial analysis of the seven capitals of adaptive capacity, namely: economic, natural, social, human, physical, anticipatory, and institutional.

Normally, the progressive municipalities in the study sites get have higher adaptive capacities. This is particularly true since progressive municipalities tend to have higher economic activity and availability of financial services, good access to health and education, and have more provision in terms of support services for agriculture. The results obtained from the assessment of these capitals are presented and discussed below.

## *Assessment of the Seven Capitals of Adaptive Capacity*

***Economic capital***. Sebaste and Patnongon were found to have ***very high*** economic capital among the municipalities in Antique while Libertad, Valderrama, San Remigio and Anini-y got ***very low*** (Figure 80). On the other hand, Caluya, Culasi, and Hamtic had ***moderate*** while Pandan, and Bugasong were ***low*** in this capital. The rest of the municipalities got ***very low*** economic capital. This assessment used the following indicators: number of financial institutions and cooperatives, number of farmers with insurance, minimum wage in agriculture, area planted to the five crops under study, poverty incidence, and municipal class classification, among others. Considering these indicators, Sebaste and Patnongon may have more of the above establishments, wider area devoted for the five priority crops and lower poverty incidence. The reverse is true for the municipalities which have very low economic capital. The inhabitants of these areas must initiate to build up their capacities in terms of the above indicators to become resilient to face the impact of weather-related disturbances like typhoons and flash floods, among others.

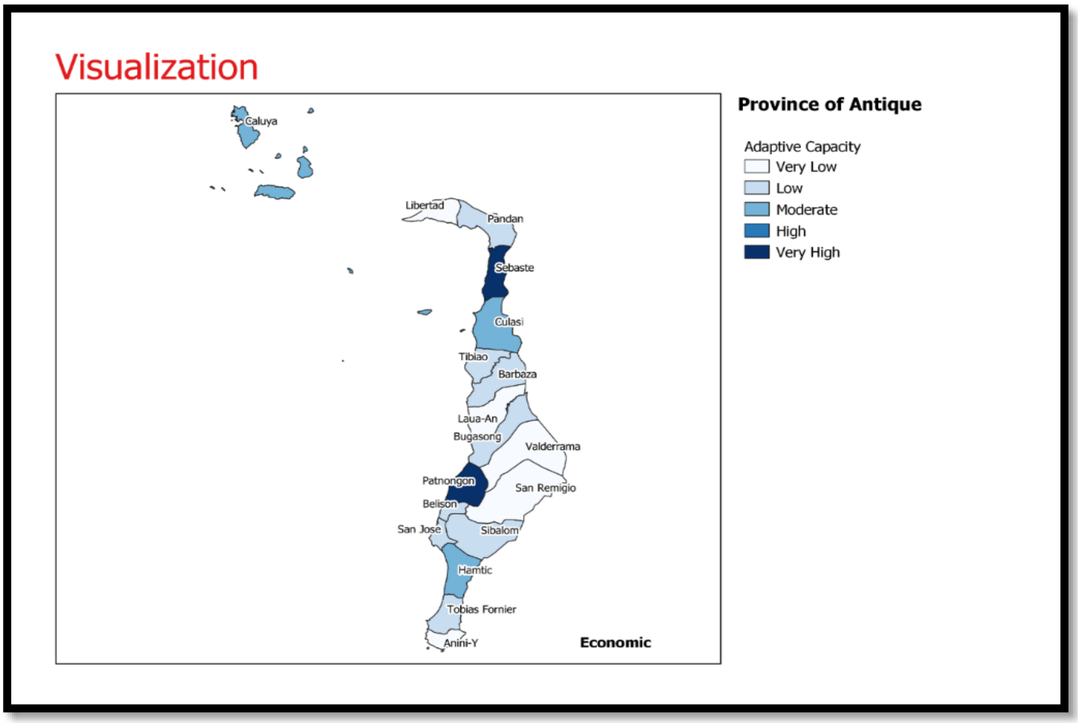



***Figure 80***. *Visualization map showing the adaptive capacities against climate change of the different municipalities of the Province of Antique based on their economic capital.*

***Natural capital***. In terms of natural capital, Sebaste, Culasi, Bugasong and Valderrama obtained ***very high*** ratings while Pandan, Tibiao, Laua-an, Hamtic and Anini-y were found to have ***very low*** natural capital. The municipalities of Caluya, Barboza, Patnongon, San Jose, Tobias Fornier and Libertad, however, were rated ***moderate*** (Figure 81). Municipalities which were not mentioned got a ***low*** natural capital. This assessment was based on the following indicators, namely: presence of marine protected area, number of shallow-tube wells (STWs), service area covered by STWs, groundwater availability, and reliable source of water for irrigation. These criteria pertain primarily on water availability assessment in the area for both domestic and agricultural and industrial use. This is an adaptive capacity which depicts a picture as to the readiness of the municipalities to respond or mitigate water deficiency crises during dry months, or when there is drought, or during the occurrence of *El Nino* phenomenon. In this evaluation, Sebaste, Culasi and Valderrama came out to have highest rating (adaptive capacity) in natural capital based on the above criteria. For communities with low or very low ratings in natural capital, development of water resources in their respective area needs to be addressed with urgency by all concerned.

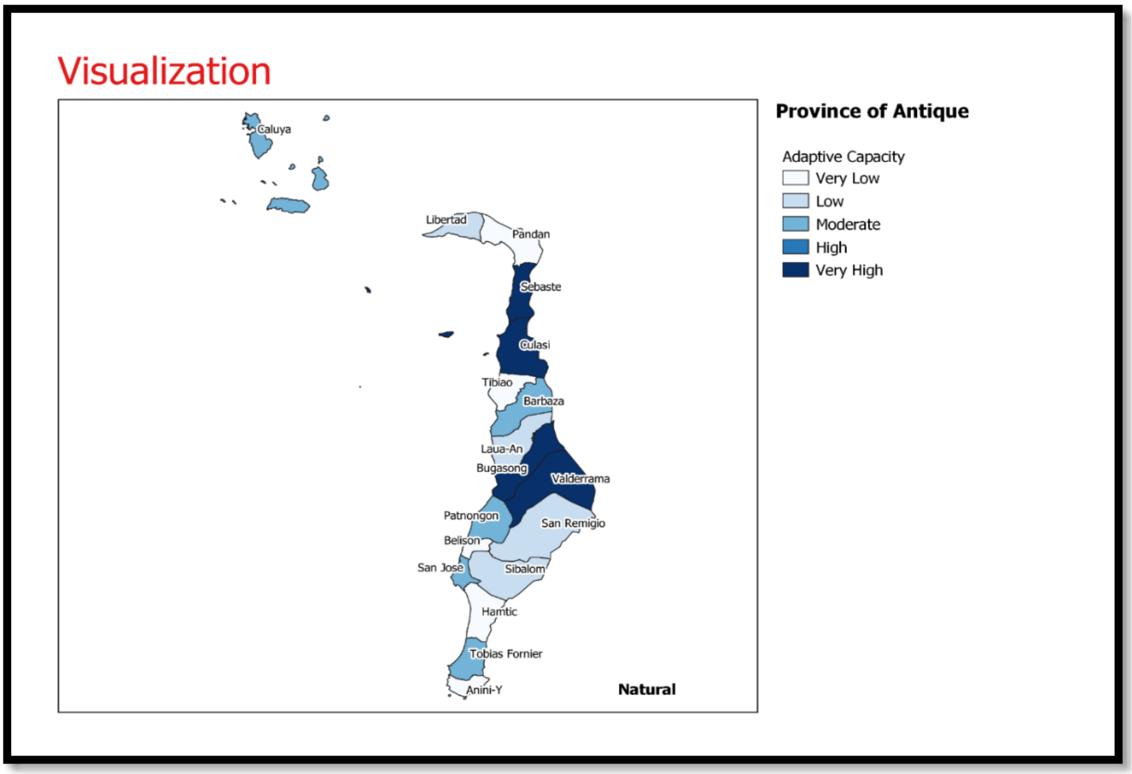



***Figure 81.*** *Visualization map showing the adaptive capacities against climate change of the different municipalities of the province of Antique based on their natural capital.*

***Social capital.*** On the social capital assessment, Caluya, Sebaste, Tibiao and Patnongon had ***very high*** social capital among the municipalities in Antique; ***very low*** ratings were obtained by the municipalities of Laua-an, Belison, Hamtic and Tobias Fornier. Valderama had ***high*** while Barbaza and Bugasong had ***moderate*** capital. Other municipalities not mentioned got ***low*** social capital Figure 82). Social capital was assessed using the following indicators: number of registered farmers' groups/inions, percentage of farmers who are members of coops/groups/unions, total number of farmers, and percentage of male and female farmers. Social capital primarily pertains to the number of active farmers in the municipality being assessed and their membership to various existing farmers' organizations. Membership to organizations is essential as a support component of adaptive capacity believing in the adage that in "unity there is strength." Inhabitants can better respond to climate related crises when they are organized and bound to common goals and objectives. Collective action is often more effective in bringing about positive results.

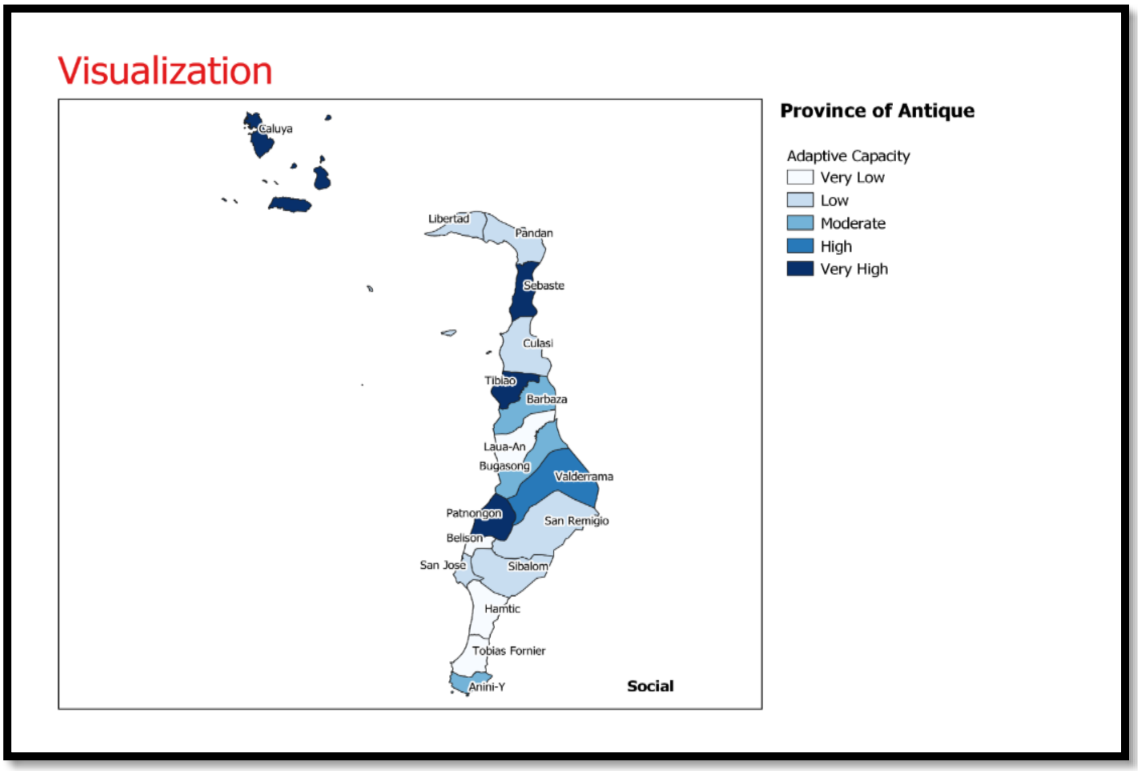



***Figure 82****. Visualization m Map showing the adaptive capacities of the different municipalities of the Province of Antique based on their social capital.*

***Human capital****.* Human capital was a measure used to assess the adaptive capacity of municipalities to mitigate and survive the hazards climate change. The assessment used the following indicators: presence of secondary and tertiary schools, school attendance among the inhabitants, number of academic degree holders, health services manpower, number of public doctors, and number of citizens with Philhealth. In this assessment, Patnongon got ***very high*** human capital while Caluya, Sebaste and Tobias Fornier had ***moderate***. On the other hand, the municipalities of Libertad, Culasi, Tibiao, Laua-an and Bugasong were rated ***low*** in this capital. The rest of the towns were rated ***very low***. Despite not being the capital town of Antique province, Patnongon has all the advantages to have the requisites of human capital considered in this study (Figure 83).

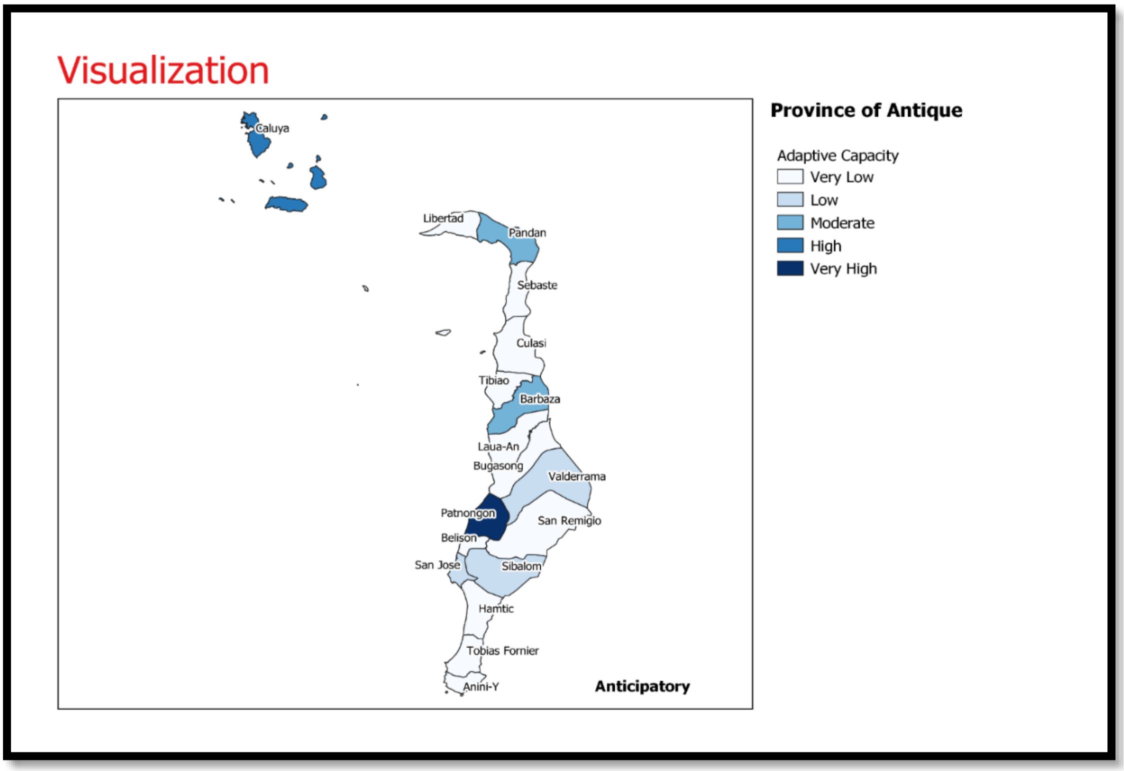



***Figure 83.*** *Visualization map showing the adaptive capacities against climate change of the different municipalities of the Province of Antique based on their human capital.*

***Physical capital.*** Sebaste got very high in physical capital among the municipalities in Antique while Belison, Patnongon and Valderama got a ***high*** rating. ***Moderate*** in this capital were the municipalities of Caluya, Pandan, San Remegio, Sibalom and Tobias Fornier. On the other hand, ***very low*** in physical capital were the towns of Libertad, Laua-an and San Jose (Figure 84). Physical capital evaluation included land ownership of farmers, their farm size, the number of livestock being raised, and distance of furthest barangay from the market. The results simply mean that more farmers living in Sebaste own their land, larger farm size, a greater number of livestock raised and are accessible to market.

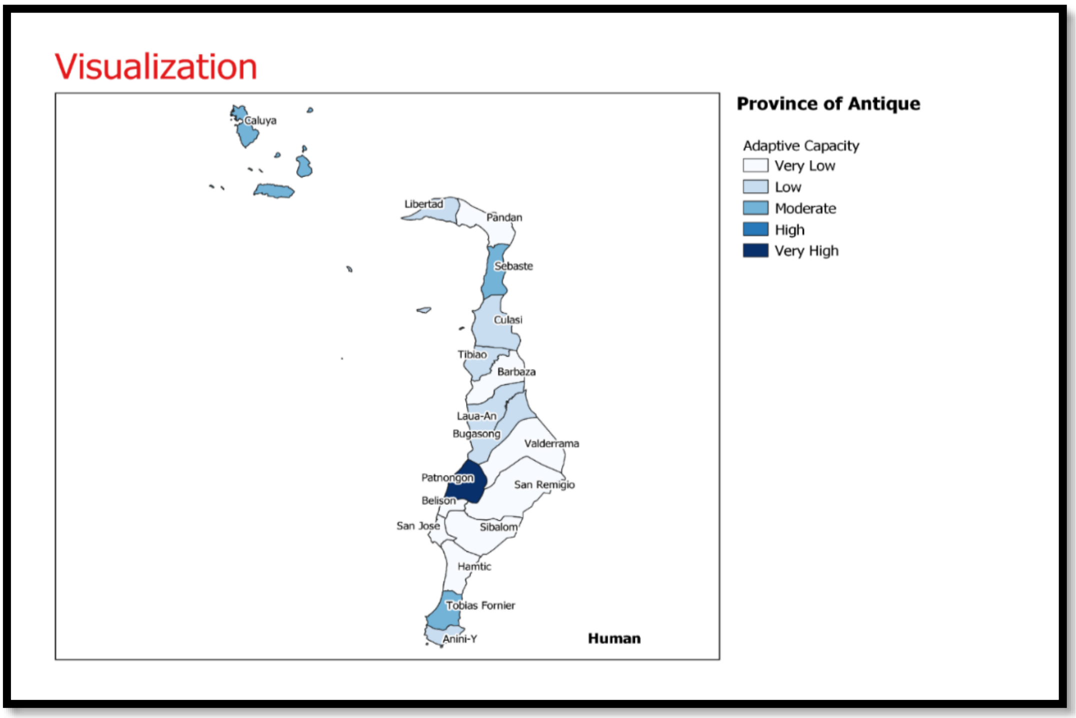



***Figure 84**. Visualization map showing the adaptive capacities against climate change of the different municipalities of the Province of Antique based on their physical capital.*

***Anticipatory capital.*** Patnongon got ***very high*** anticipatory capital among the municipalities in Antique. With v***ery low*** anticipatory capital were Libertad, Sebaste, Culasi, Tibiao, laua-an, Bugasong, San Remigio, Hamtic, Tobias Fornier and Anini-y (Figure 85). Pandan and Barbaza were rated ***moderate*** while those towns not mentioned were found to have ***low*** anticipatory capital. Anticipatory capital was determined using the following indicators: number of trainings related to climate change, access to communication technology, and presence of DRRMP and CLUP in the area.

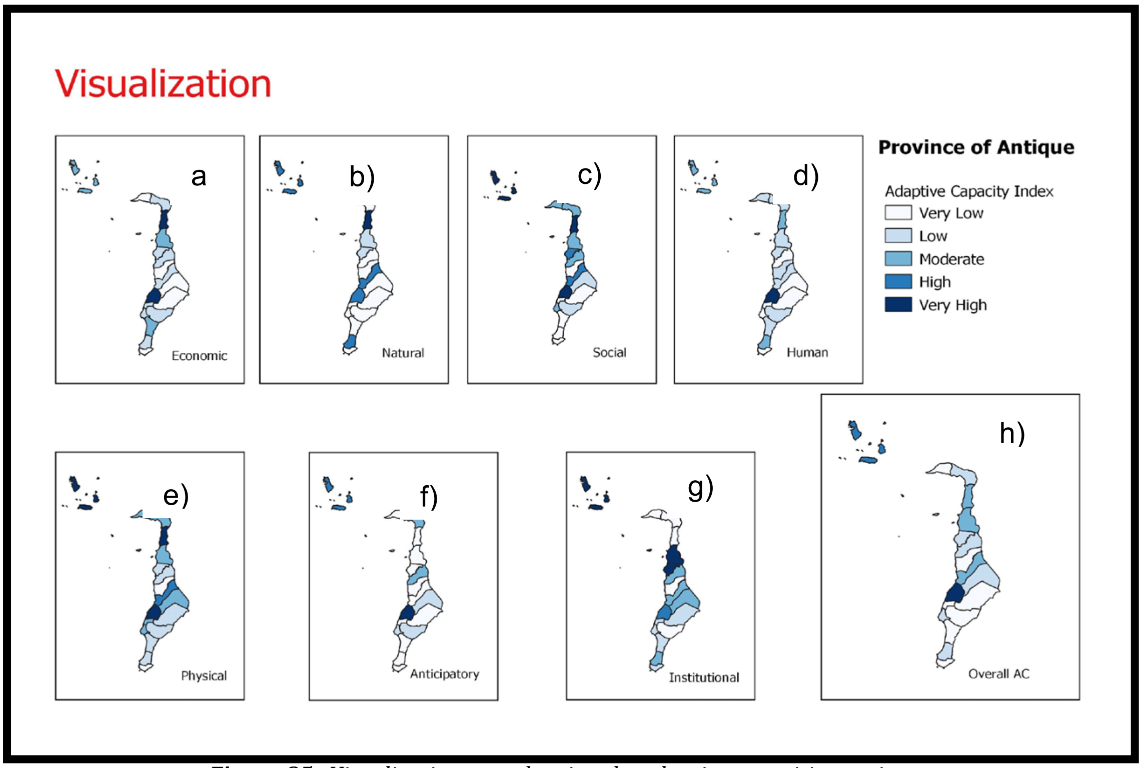



***Figure 85.*** *Visualization map showing the adaptive capacities against climate change of the different municipalities of the Province of Antique based on their anticipatory capital.*

***Institutional capital.*** Eight municipalities were found to have ***very high*** institutional capital. These were Caluya, Tobias Fornier, Tibiao, Culasi, Barbaza, Patnungon, Bugasong and Valderama. All other towns not mentioned were rated ***very low*** in this capital (Figure 86). Institutional capital was assessed using two indicators, namely: farmers' visit or consultation with the Agricultural Extension Officer, and number of AEO working under the office of the Municipal Agriculturist.

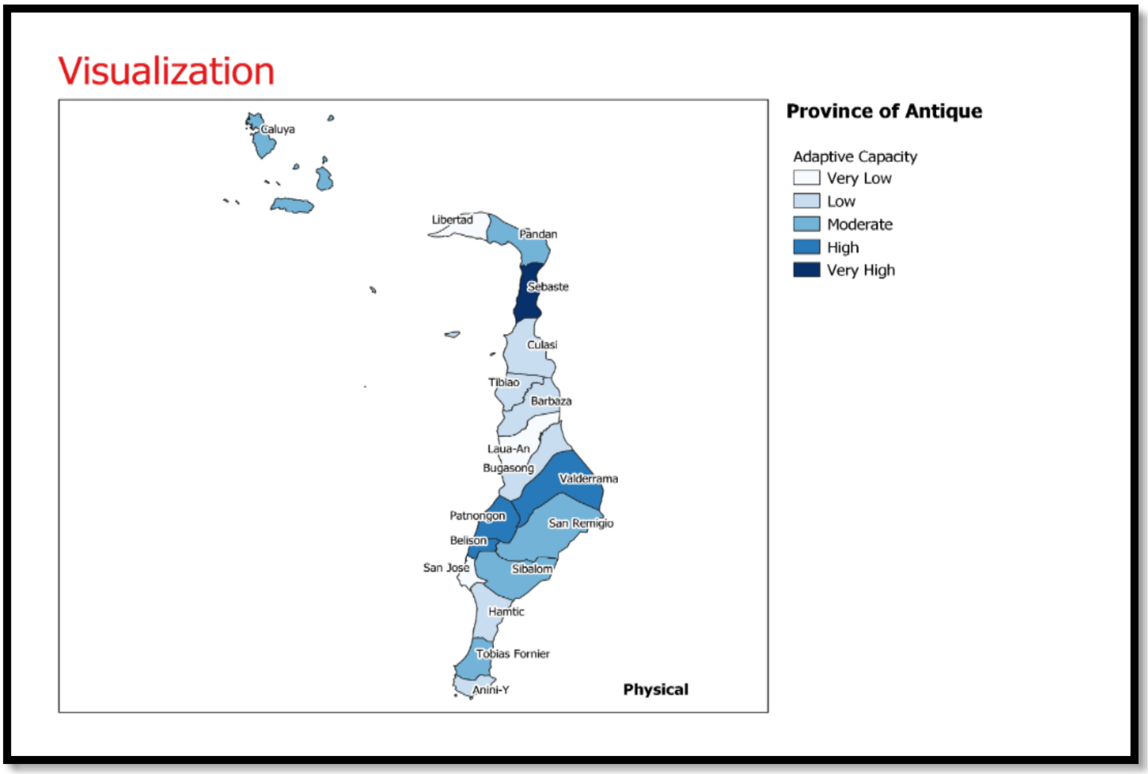



***Figure 86.*** *Visualization map showing the adaptive capacities against climate change of the different municipalities of the Province of Antique based on their institutional capital.*

## Adaptive Capacity

Figure 79 presents the adaptive capacity for the Province of Antique. It illustrates that the municipality of Caluya and Patnongon has the highest adaptive capacity among all the municipalities, which means that it has the highest potential to mitigate the negative impacts of climate change quickly. Moreover, the municipalities of Libertad, Laua-an, Belison and Anini-y were found to have the very low adaptive capacities. Due to a positive impact of the adaptive capacity on vulnerability assessment, the table values were inverted to serve as an adaptive capacity index and added to the overall vulnerability.

Therefore, municipalities with higher adaptive capacity will have lesser risks. Below are the blown-up adaptive capacity maps of the province according to seven (7) major capitals.

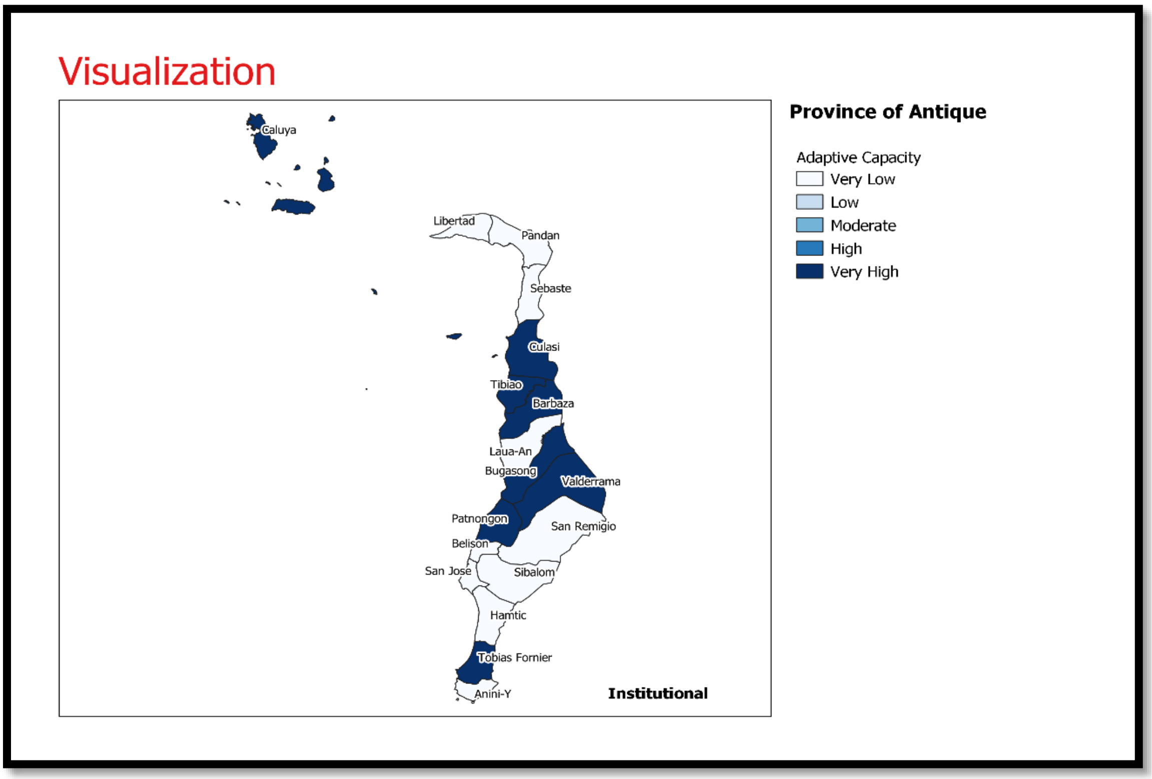



***Figure* 79**. *Maps showing the adaptive capacities of the different municipalities of the Province of Antique.*

***Adaptive capacity index.*** The municipalities of Libertad, Laua-an, Belison, and Anini-Y were found to have a ***very high*** adaptive capacity index. ***High*** index was also noted in the municipalities of Pandan, San Remegio, Hamtic and Tobias Fornier while the remaining unmentioned municipalities got ***moderate*** index. Caluya was rated to have ***very low*** adaptive capacity index. The adaptive capacity index of the province is the inverted values of the overall adaptive capacity. The index is inverted in order that the values if added to the potential impact, those municipalities with higher adaptive capacity will have a lower vulnerability and those that have a lower adaptive capacity shall have a higher vulnerability.

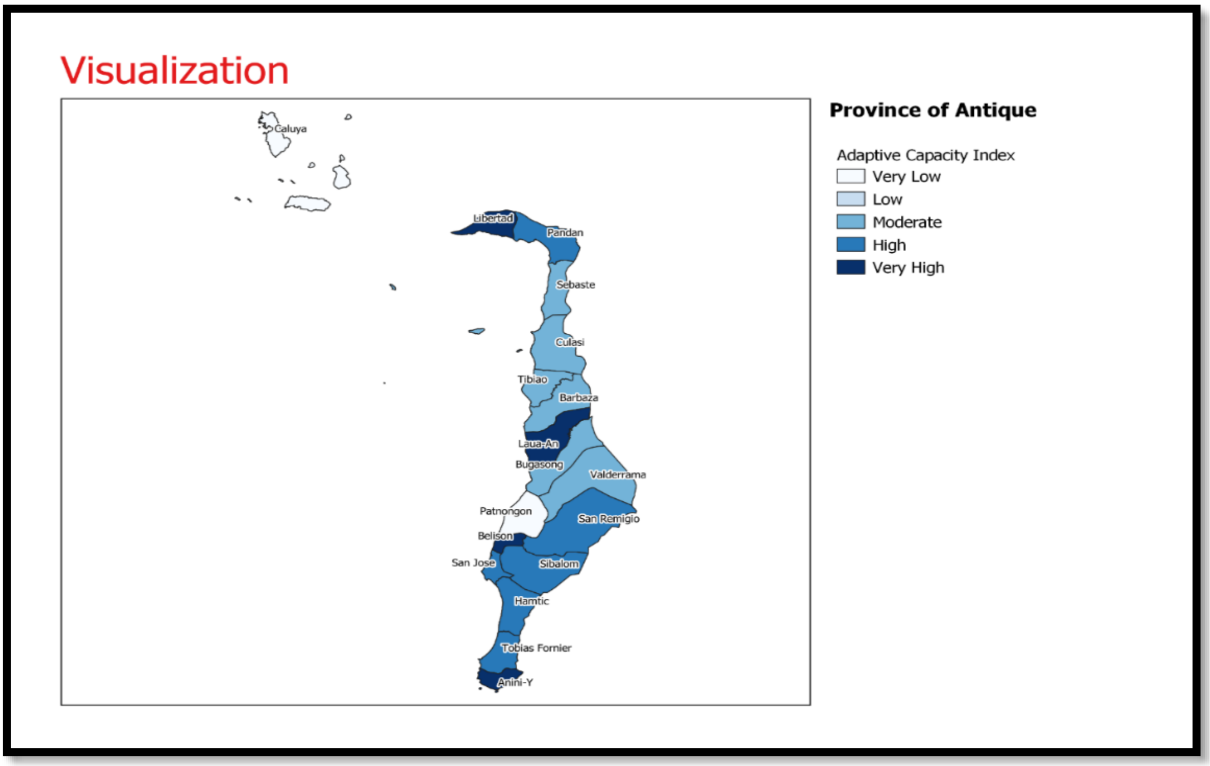



***Figure 87.*** *Visualization map showing the adaptive capacity index of the different municipalities of the Province of Antique based on the seven adaptive capacity capitals.*

## Over-all Vulnerability Assessment of Municipalities of Antique Province

In the assessment of the over-all vulnerability of the municipalities in the province, the weights assigned to each of the components were adopted from the study of CIAT which were classified into five levels - very low, low, moderate, high, and very high. The over-all results of this CRVA-based vulnerability assessment revealed that the municipalities of Libertad, Laua-an, Hamtic and Anini-y were the most vulnerable to climate change (***very high***). Only Patnongon had the ***very low*** vulnerability among the municipalities. The probable reasons for Patnongon to be the least vulnerable municipality in the province has already been elucidated earlier. The municipalities found to be most vulnerable are apparently economically handicapped which adaptive capacities were found to be similarly very low. Apparently, they are least prepared to respond to face the challenges of climate change. These are the municipalities which necessitate appropriate development programs relevant to countering the growing menace of climate change.

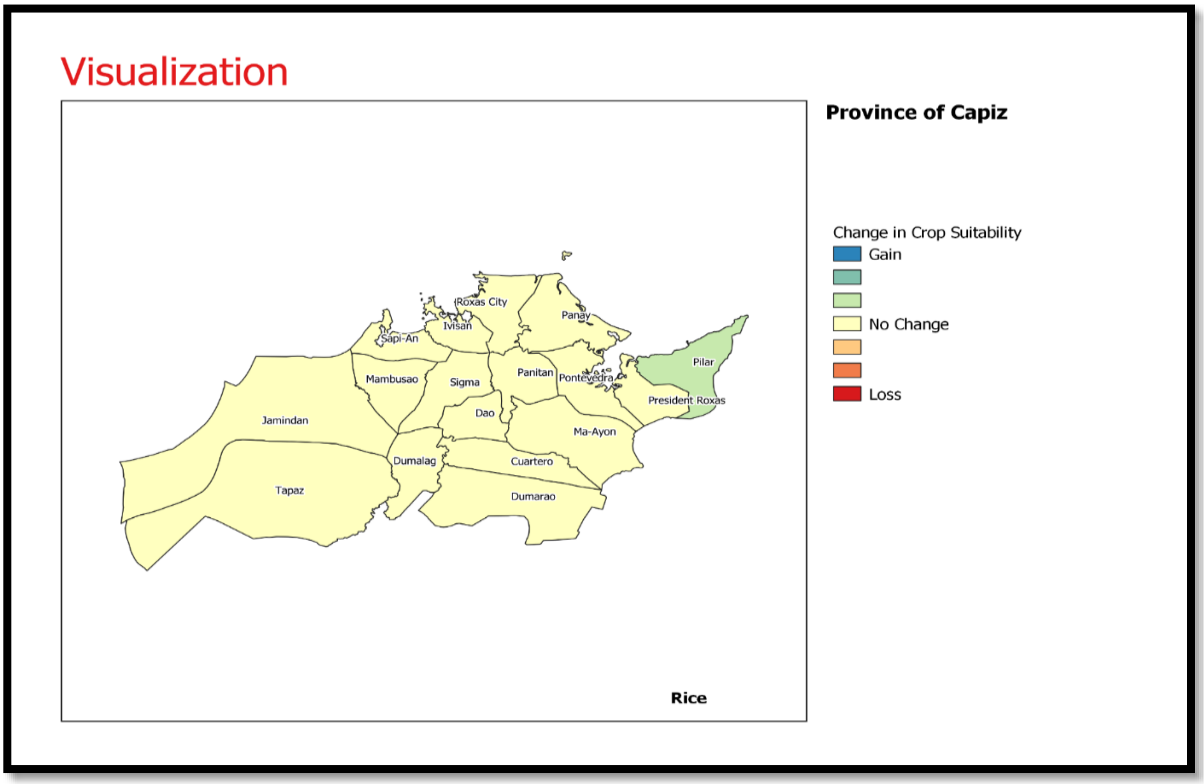



***Figure 88**. Visualization map showing the over-all climate risk vulnerability assessment results of the municipalities of the Province of Antique. (Note: The over-all vulnerability assessment was obtained from the summarized values of sensitivity, hazard and adaptive capacity index of the province).*

## Province of Capiz

### Preliminaries

The Province of Capiz popularly known as the Seafood Capital of the Philippines, is located in the central section of Western Visayas; one of the four provinces comprising the Island of Panay located in the northern portion of the island. Its border provinces are Aklan to the north, Antique to the west and Iloilo to the south; the province faces the Sibuyan Sea to the north. It is composed of 473 barangays, 16 municipalities and one city; Roxas City is the capital of the province. It has a total land area of 2,594.64 square kilometers and a population of 804,952 with a density of 310 inhabitants per square kilometer based on the 2020 census.

The province enjoys two types of climates, namely: tropical rainforest and tropical monsoon. These climates make the province experience extreme weather events like frequent typhoons, torrential rains, floods, landslides, landslides and erosion, among others. Farming and fishing are the primary form of livelihood of the inhabitants in this province. The major crops raised by the farmers include rice, corn, banana, fruits, coconuts, vegetables, and roots crops, among others. With the presence of a long coastline in the northern seaboard, a lot of the province's population are involved in fishing and other marine-related occupations.

## Sensitivity and Crop Suitability Assessment for the Province of Capiz (Exposure 1)

The sensitivity or crop suitability assessment employed similar procedures as in other provinces covered by the study. The visualization map shows the crop suitability of Five priority crops such as rice, corn, banana, sugarcane, and coconut were used in this sensitivity evaluation which was carried out considering such factors as temperature, rainfall and other related bioclimatic conditions where the crops are located. Similar to other provinces, the visualization maps generated from the study are presented and discussed below. Contained in Table 1 are values which were determined using procedures already described earlier. As conceived, these maps can serve as guide in identifying economic crops suited in the area based on climatic conditions predicted to prevail in the area in the near future.

***Table 1: Percent change of crop suitability for the five priority crops in the Province of Capiz from 2020 to 2050.***

| Municipality | Percent Change | | | | |
|---|---|---|---|---|---|
| | Rice | Corn | Sugarcane | Banana | Coconut |
| Cuartero | 2.39 | -1.85 | 1.87 | -1.89 | 1.17 |
| Dao | 1.81 | -0.04 | 5.01 | 2.04 | 2.74 |
| Dumalag | 2.64 | -29.95 | 5.32 | 3.23 | 3.47 |
| Dumarao | 0.81 | 14.20 | -8.58 | -5.68 | 2.12 |
| Ivisan | -2.10 | 3.43 | 4.00 | -2.10 | -3.83 |
| Jamindan | -1.60 | -68.25 | 2.98 | -2.23 | -0.78 |
| Maayon | -2.30 | -23.86 | -0.32 | -0.38 | -3.06 |
| Mambusao | 2.59 | -43.76 | 1.90 | 3.87 | 4.37 |
| Panay | -3.10 | 29.93 | -14.10 | -1.07 | -3.00 |
| Panit-an | -2.20 | 43.51 | 3.04 | -1.19 | -2.70 |
| Pilar | 7.69 | -61.77 | 5.26 | 11.74 | 6.73 |
| Pontevedra | -3.90 | -66.42 | -10.20 | -2.06 | -4.66 |
| President Roxas | 3.69 | -65.63 | -0.83 | 6.39 | -0.80 |
| Roxas City | -1.80 | 59.70 | -7.84 | -4.24 | -5.15 |
| Sapian | 1.16 | -38.30 | -2.66 | 2.19 | 4.26 |
| Sigma | 0.59 | -21.46 | 7.26 | 1.07 | 1.66 |
| Tapaz | 0.42 | -45.52 | 1.69 | 0.54 | 0.80 |

*This table of values in Table 1 was used in determining the crop suitability in the municipalities of the province. As used in the other provinces, three categories were adopted in determining crop suitability, namely: no change, positive and negative change. No change, if the values range from greater than negative (-) 5% to less than or equal to positive (+) 5%; positive change if values range greater than positive (+) 5%; and, negative change, if the values range from lower than negative (-) 5%. Areas falling under no change will not besignificantly be affected by climate change in the future; in areas falling under positive change, future climatic conditions will favor crop growth; and, in areas falling under negative change will loss crop suitability in the future - climatic conditions will have negatives effect on the crop's agronomic growth performance.*

## Projected Suitability to Climate of the Five Crop Priorities in the Province of Capiz

One tangible output achieved in this study are the developed visualization maps which essentially show changes in crop suitability to climate of the five priority crop commodities projected to occur from 2020 to 2050. Their corresponding percent changes is presented in Table 1. The more important results are presented below.

***Rice***. As shown in Figure 90, rice growing would remain no change for the foreseeable future even with changing climate. It will remain suitable as a prominent crop in the province as it is at present. The crop even gained greater suitability in the municipality of Pilar by getting a crop suitability value of +7.69%.

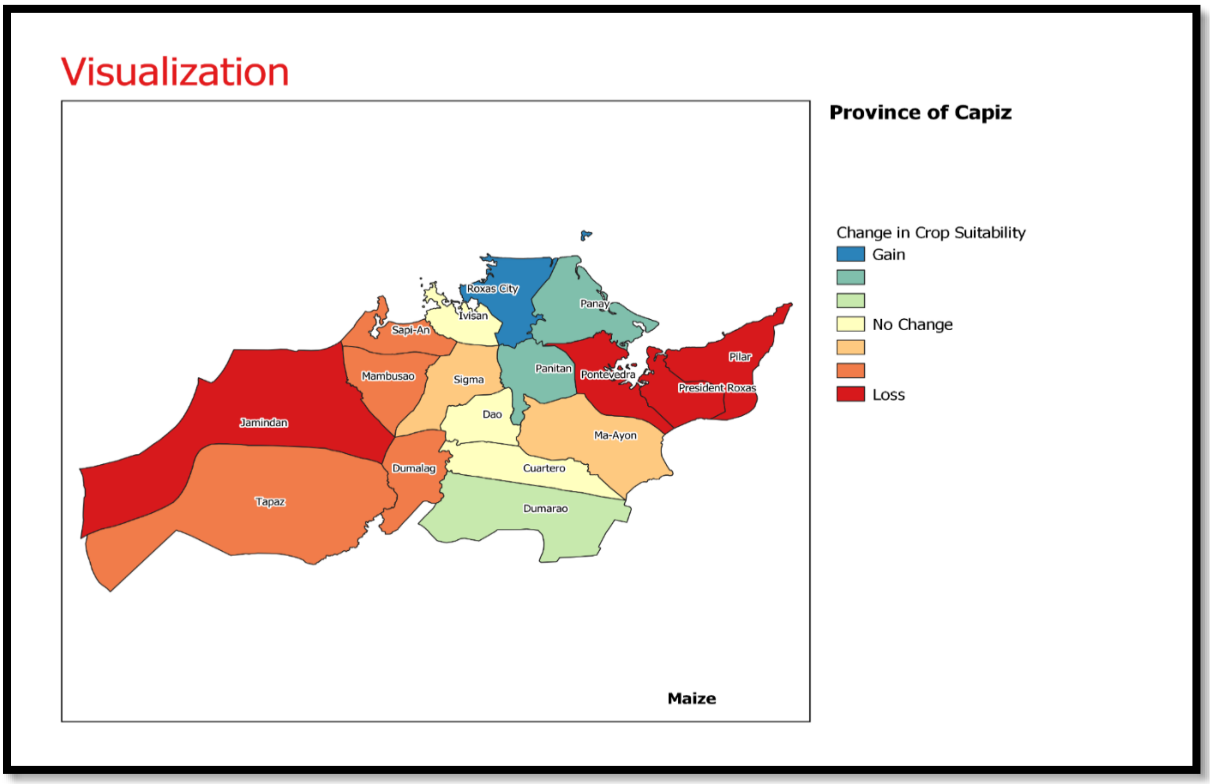



**Figure 90.** *Visualization map showing the changes in rice suitability to climate in the Province of Capiz.*

***Corn***. Corn ***gained suitability*** in the area. The crop would remain suited in the municipalities of Dumarao (+4.20%), Panay (+29.93%), Panit-an (+43.51%), and Roxas City (+59.70%; Figure 91). The following municipalities, however, are projected to ***lose*** their suitability to corn in the future: Dumalag (-29.95%), Jamindan (-68.25%), Maayon (-23.86%), Mambusao (-43.76%), Pilar (-61.77%), Pontevedra (-66.42%), Pres. Roxas (-65.63%), Sapi-an (-38.30%), Sigma (-21.46%). and Tapaz (- 45.52%). The municipalities of Cuartero, Dao and Ivisan will remain ***no change*** in the production of corn in the near future. These projections are quite alarming considering that corn is also one of the major economic crops of the Province of Capiz.

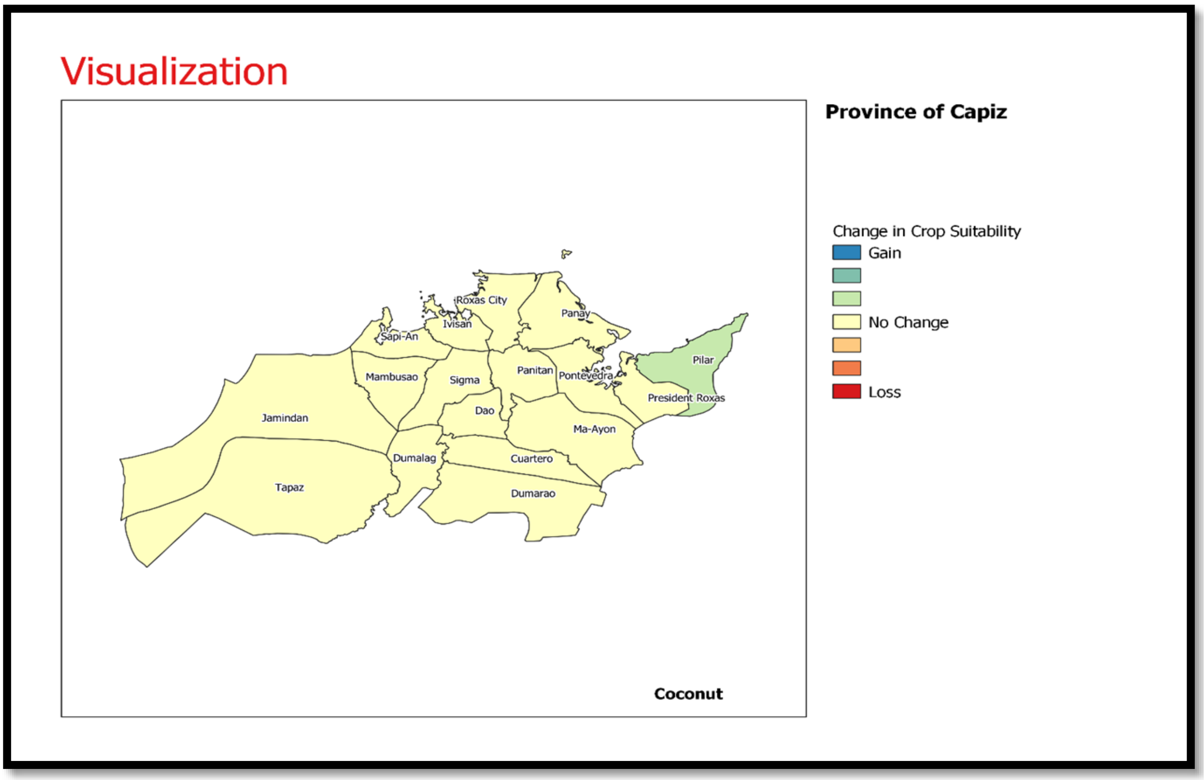



***Figure 91****. Visualization map showing the changes in crop suitability to climate of corn in the Province of Capiz.*

***Banana.*** For banana, growing the crop is suitable in the municipalities of Pilar at (+11.74%) and Pres. Roxas (+6.39%) while Dumarao will lose crop suitability in the future with a value of -5.68% (Figure 92). The rest of the municipalities in the province will remain suitable for banana growing as it is now.

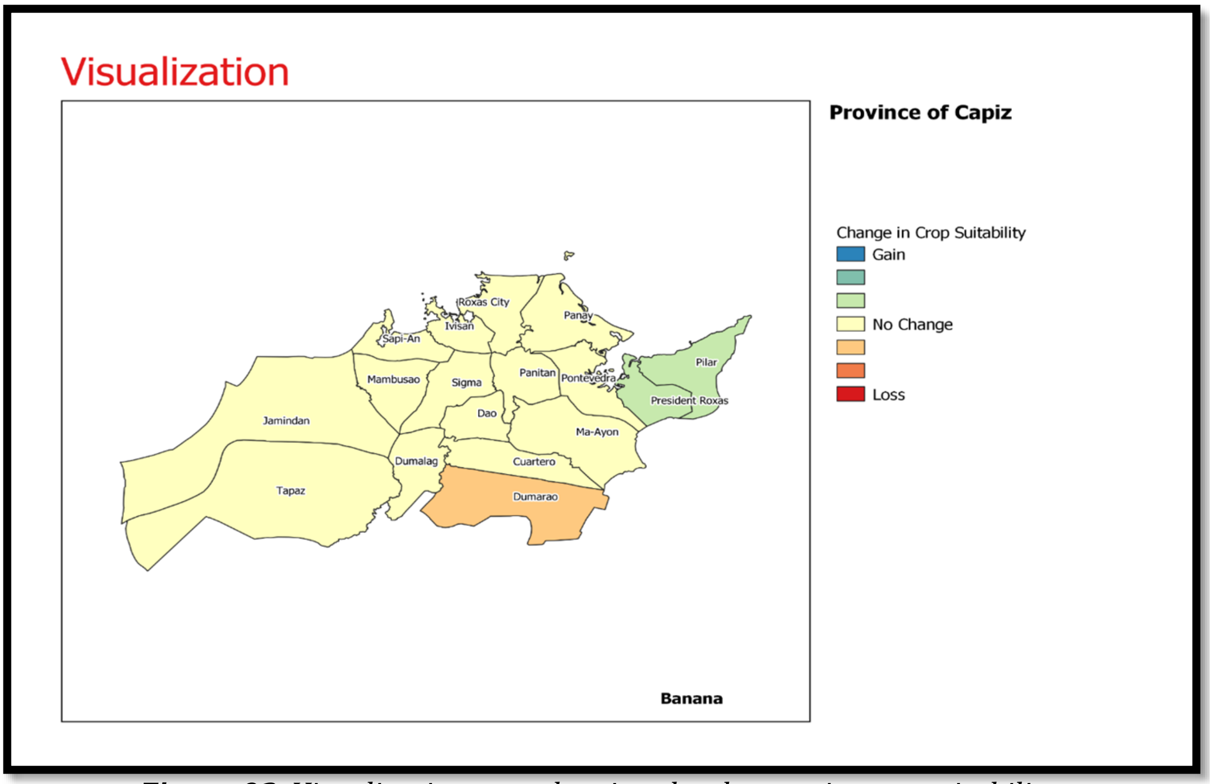



***Figure 92**. Visualization map showing the changes in crop suitability of banana in the Province of Capiz.*

***Sugarcane***. This crop is economically important in the province of Capiz. The crop is predicted to ***gain suitability*** in the municipalities of Dao (+5.01%), Dumalag (+5.32%), Pilar (+5.26%) and Sigma (+7.26%; Figure 92). On the other hand, the following municipalities are projected to ***lose*** their suitability to sugarcane growing in the future: Dumarao (-8.58%), Panay (-14.10%), Pontevedra (-10.20%) and Roxas City (-7.84%) will loss. The rest of the municipalities in the province will remain ***no change***, hence are projected to continue growing sugarcane as an economic crop in the coming years as it is now.

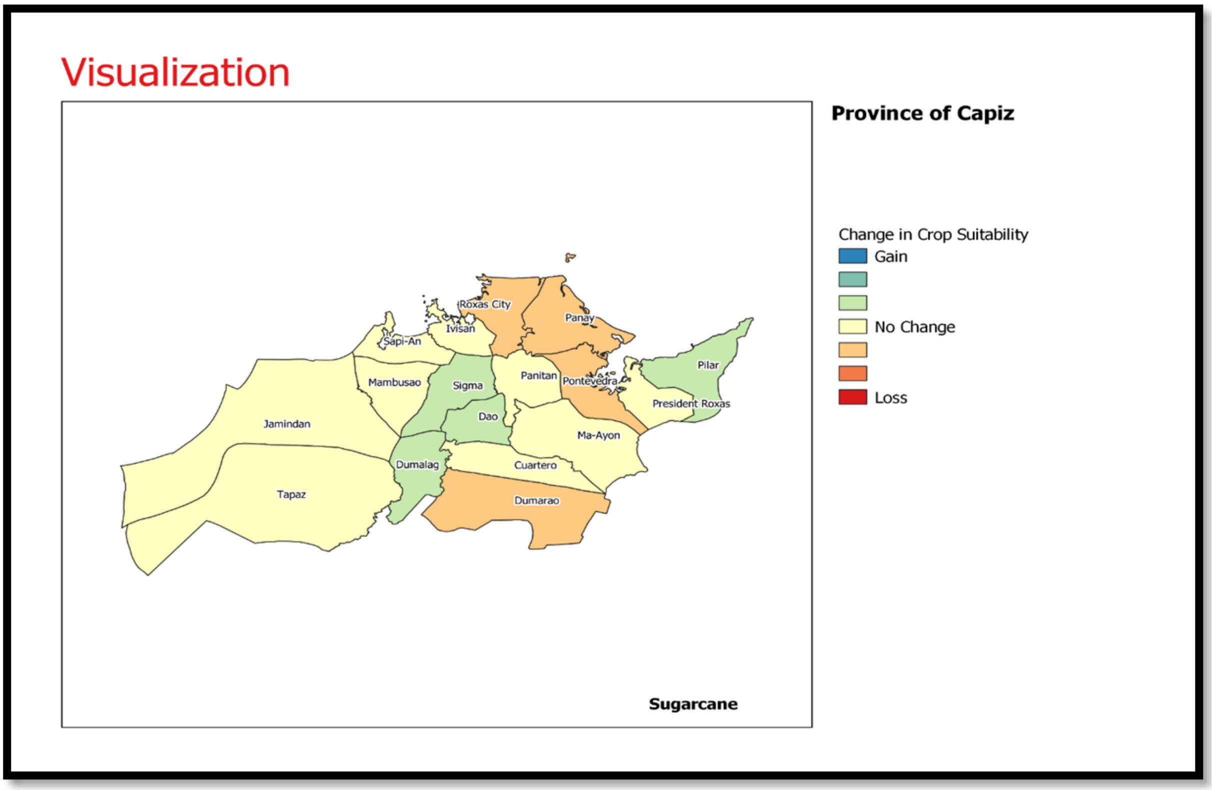



***Figure 92****. Visualization map showing the changes in crop suitability of sugarcane in the Province of Capiz*.

***Coconut***. As shown in Figure 93, a greater majority of the municipalities in the province of Capiz appeared to remain suitable for coconut production in the future. The municipality of Pilar (+6.73%) even indicated to gain greater suitability to the crop as shown in the visualization map.

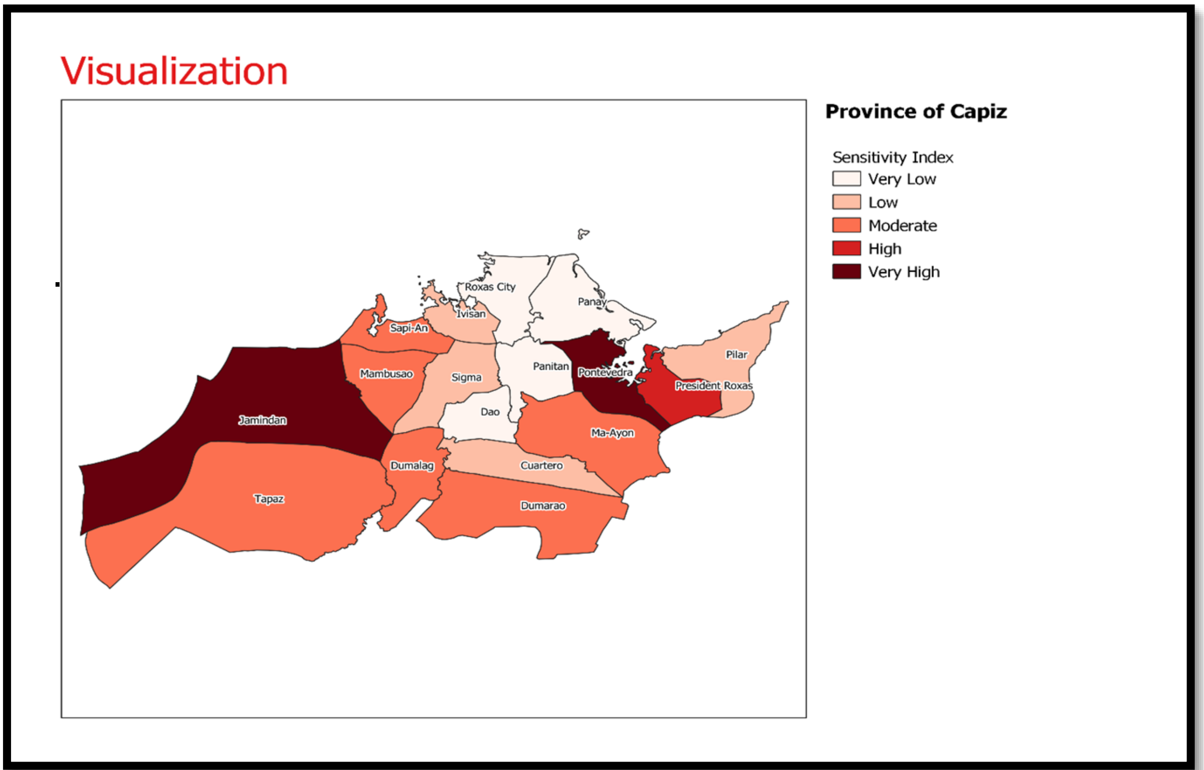



***Figure 93.*** *Visualization map showing the changes in crop suitability of coconut to climate in the Province of Capiz.*

***Sensitivity index.*** The above visualization maps for the five priority crops generated the sensitivity index for the Province of Capiz (Figure 94). As observed in the visualization map below, the sensitivity index of the different municipalities indicates that Jamindan and Pontevedra were found to have a ***very high*** index; Pres. Roxas had ***high***; Tapaz, Dumarao, Mambusao, Sapian, Dumalag, Maayon had ***moderate***; on the other hand, ***low*** index was noted for Sigma, Ivisan and Cuartero while Dao, Panitan, and Roxas City had ***very low*** sensitivity index. As a rule, the higher the sensitivity index of the area, the higher would be the impact of climate change or the lower is its suitability to growing the studied priority crops in the future.

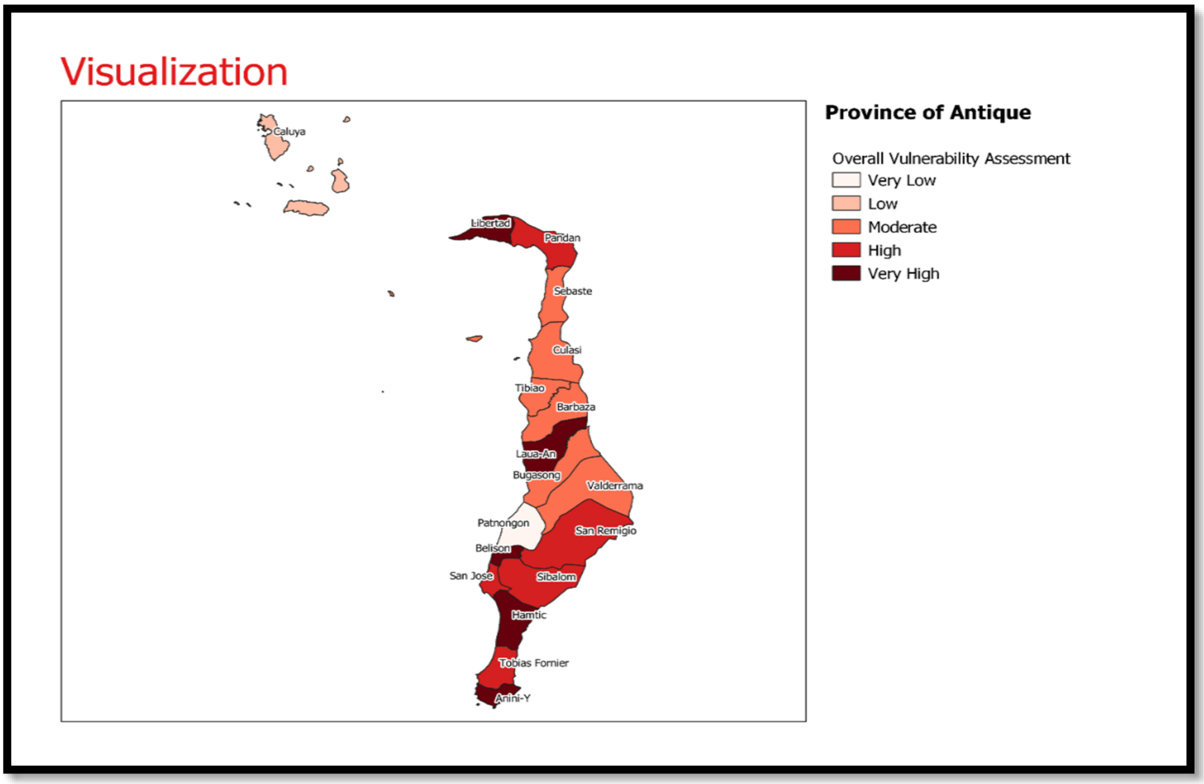



**Figure 94**. *Visualization map showing the sensitivity index of the province of Capiz to climate change using the suitability values of the five priority crops in the province.*

## Hazard Assessment of Climate-Related Pressures (Exposure II)

The vulnerability to natural hazards of the municipalities in Capiz is a historical record. The province is geographically located in the northeastern part of Panay Island. Along the coastline, sea level rise, storm surge and other coastal related risks are present. The northern portion is frequently visited by typhoons – historically, tropical cyclone in the north is higher than in the south. This brings about torrential rains making flooding one serious climate-related hazards in the province. Mountainous areas in the southern portion promote higher risk of erosion and landslides which are notably indicated in the map. Similar to other provinces evaluated, eight natural climatic hazards were assessed in the Province of Capiz.
This included tropical cyclone, drought, flooding, landslides, erosion, sea level rise, storm surge, and salt water intrusion. Hereunder are the results of this assessment.

***Tropical cyclone***. The visualization map in Figure 96, showed that the northeastern part of Capiz greatly exposed to hazards of tropical cyclones or typhoons; this is opposite to southwestern part of the province. Specifically, the hazard ratings of the municipalities were as follows: ***very high*** for Panay Pilar and Roxas City; ***high*** for Ivisan, Pontevedra and Pres. Roxas; ***moderate*** for Panitan and Maayon; and the rest got ratings ranging from low to very low.

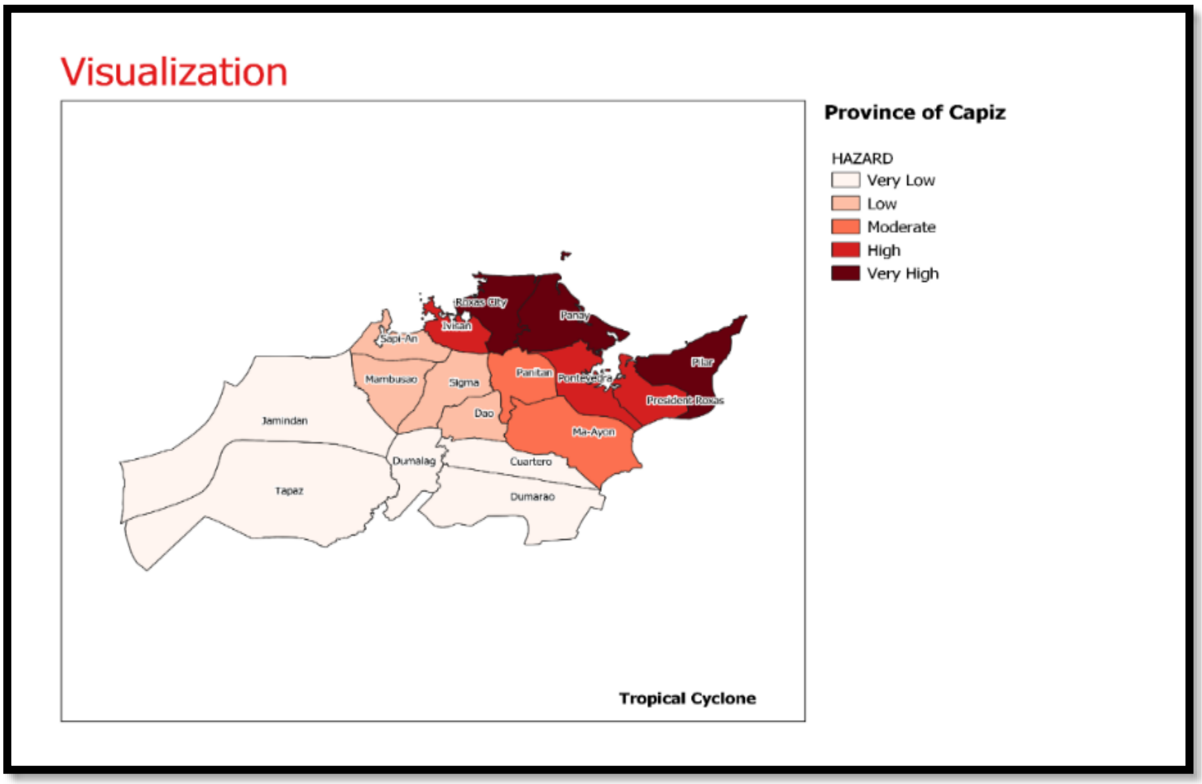



***Figure 96.*** *Visualization map showing the level of hazard to tropical cyclones in the province of Capiz.*

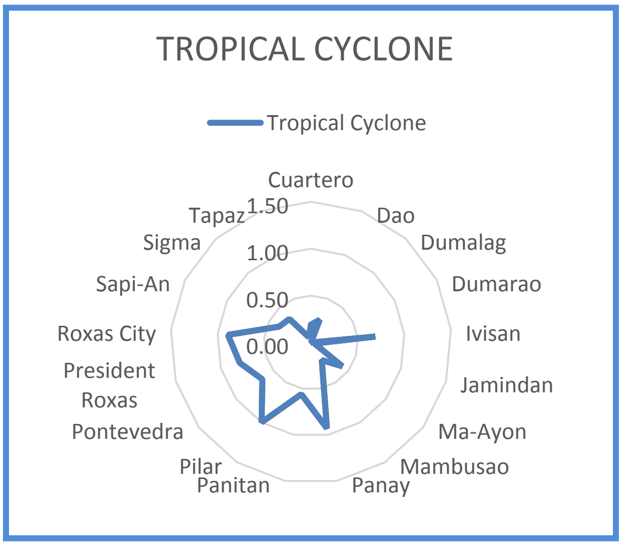



***Figure 97.*** *Radar chart showing the tropical cyclone occurrence in the Province of Capiz.*

***Drought***. As shown in Figure 98, three municipalities had high to ***very high*** hazard ratings to drought, particularly in the southern part of the province. Dumalag had ***high*** hazard rating while the municipalities of Tapaz and Jamindan had ***very high***. On the other hand, Pilar, Panay, Dumalag and Mambusao had ***low*** and the rest of the towns in the province had ***very low*** hazard ratings.

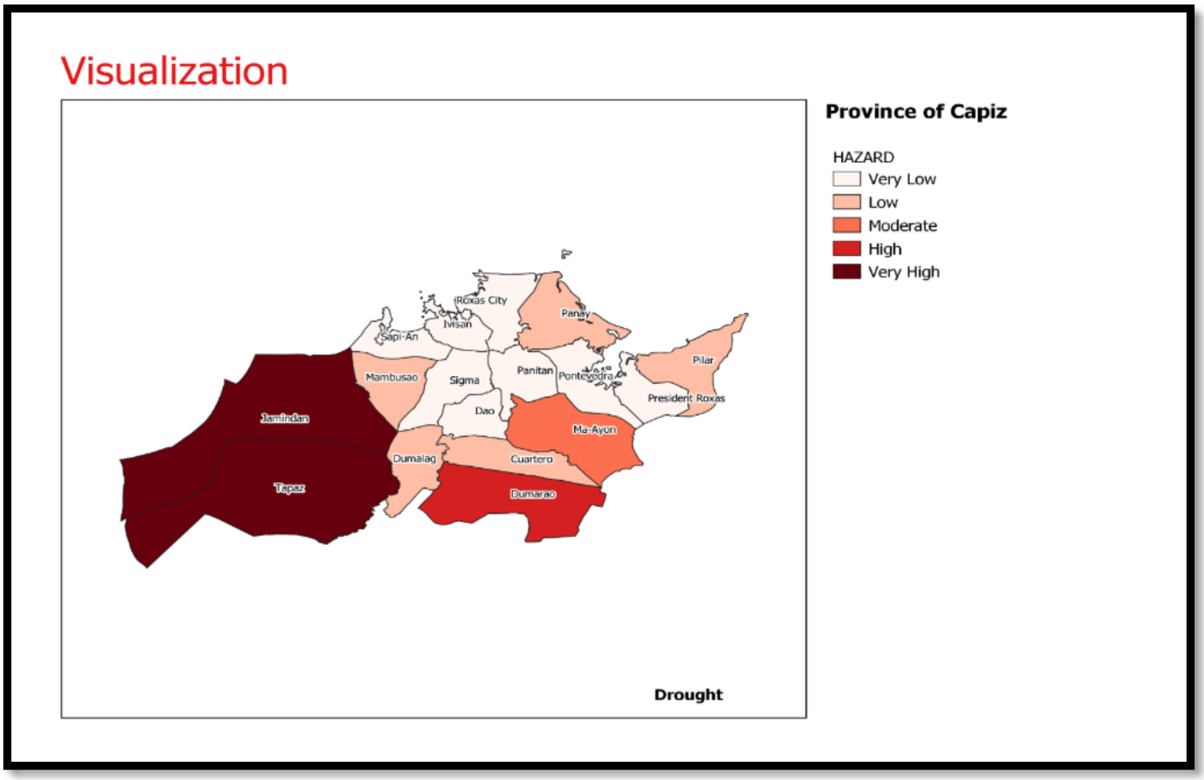



***Figure 98***. *Visualization map showing the level of vulnerability to hazards of drought in the province of Capiz.*

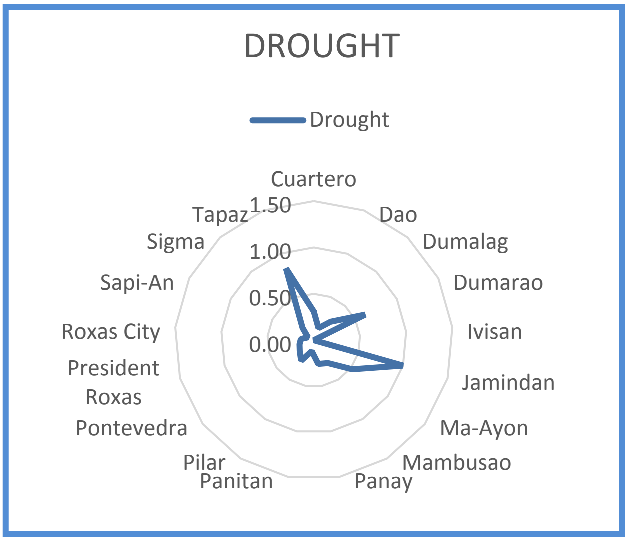



***Figure 99.*** *Radar chart showing the drought occurrence in the Province of Capiz.*

***Flooding.*** The northern part of the province of Capiz appeared to be most prone to flooding. Panay is the most vulnerable municipality getting the ***very high*** rating to the hazard of flooding; Roxas City and Dao got *high* rating while Pontevedra, Sapian and Panitan had ***moderate*** (Figure 100). On the other hand, Mambusao, Sigma, Ivisan, Dumalag, Cuartero, President Roxas and Pilar obtained a ***low*** hazard rating, although traditionally, the first five municipalities found at the central portion of the province are often experiencing heavy floods. The rest of the province had low rating for flooding.

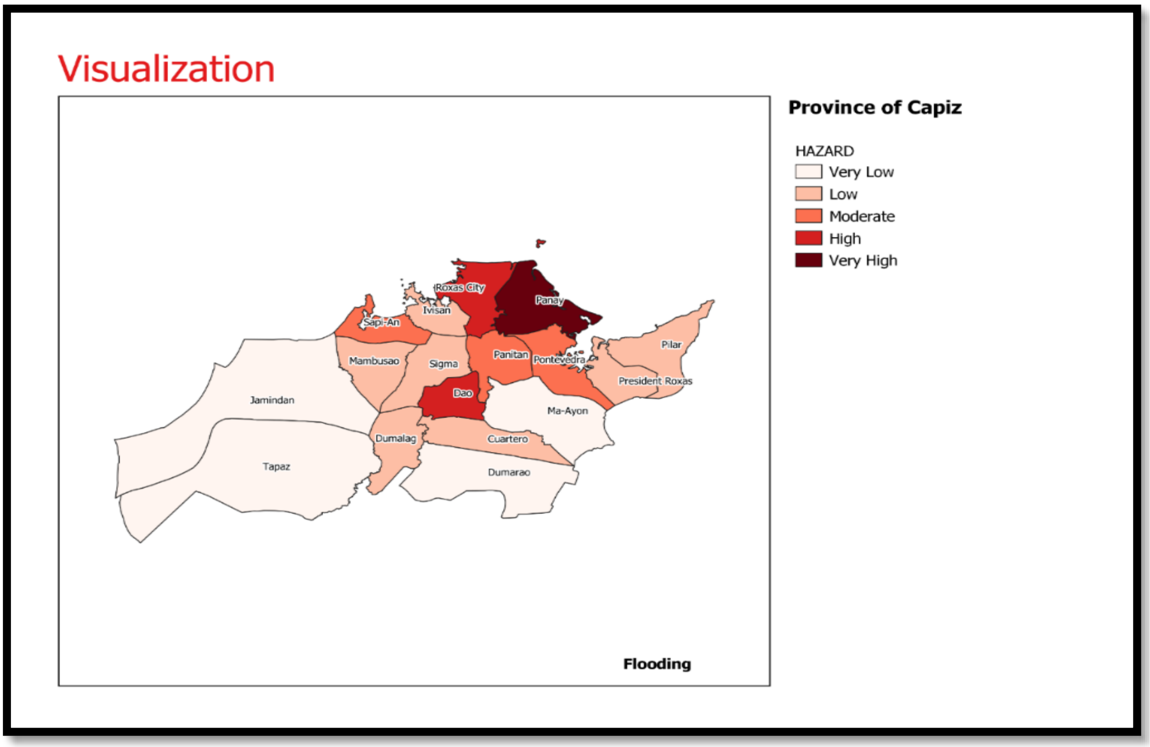



*Figure 100. Visualization map showing the level of hazard to flooding in the province of Capiz.*

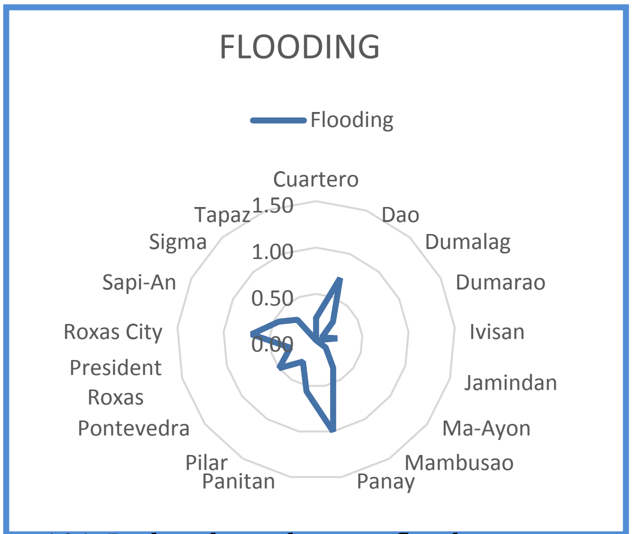



*Figure 101. Radar chart showing flooding occurrence in the Province of Capiz.*

***Landslides***. The hazards to landslides are projected to occur most intensely (***very high***) in the upland portions in the western and southern parts of the province, notably in the municipalities of Jamindan and Tapaz (Figure 102). Landslides are also expected to occur ***moderately*** in the municipalities of Ivisan, Pilar, Pres. Roxas. Maayon, Cuartero and Dumalag. On the other hand, Mambusao, Sigma, Sapian and Pontevedra are predicted to have ***low*** hazards to landslides. The rest of the municipalities got ***very low*** hazard rating.

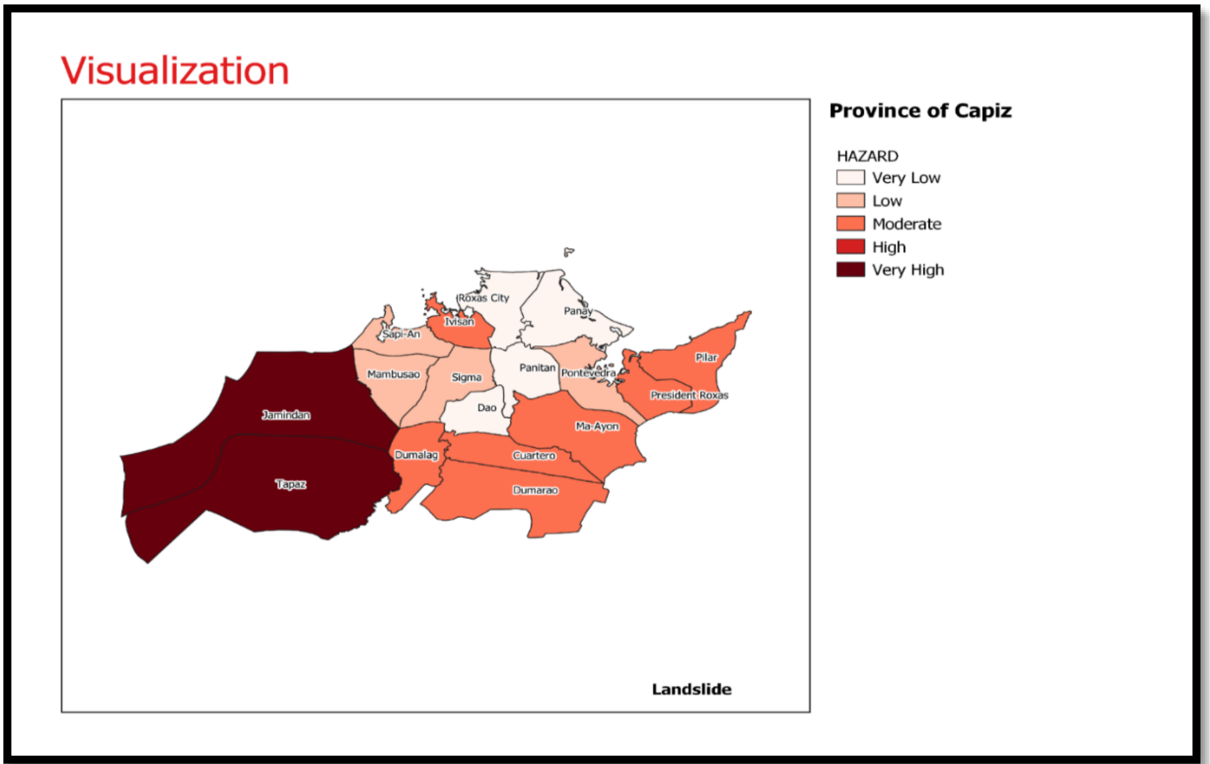



*Figure 102. Visualization map showing the level of hazards to landslides in the province of Capiz.*

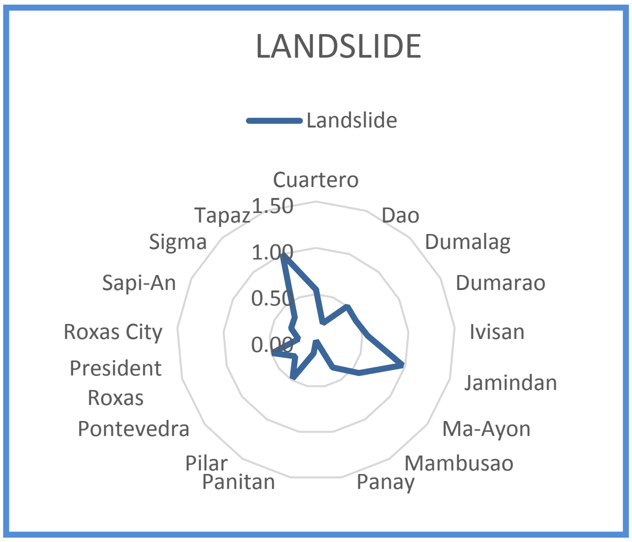



***Figure 103***. *Radar chart showing landslides projected occurrence in the Province of Capiz.*

***Sea level rise.*** Sea level rise is not predicted to occur in much of the areas of the province. Only municipalities facing the northern seaboard were found vulnerable to the hazard of sea level rise. The hazard would be ***very high*** in Panay, ***high*** in Roxas City and ***moderate*** in Sapian and Pontevdra (Figure 104). All other municipalities had ***very low*** hazard to sea level rise.

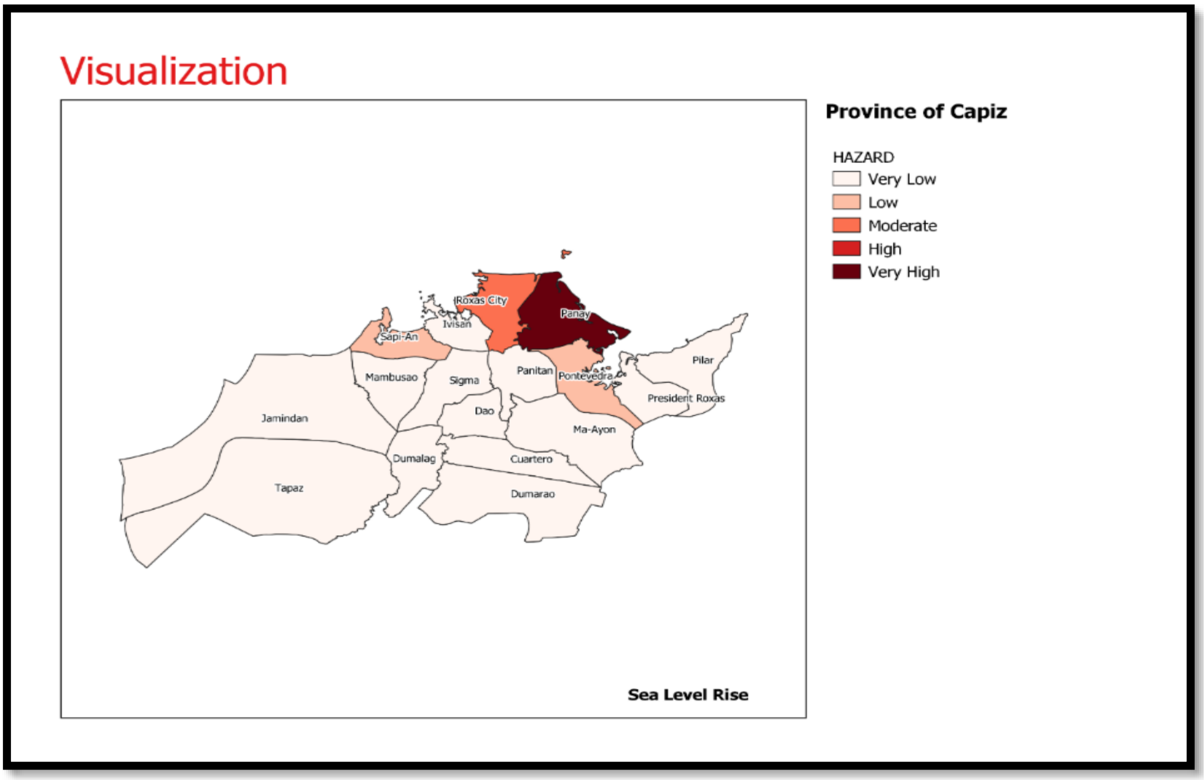



***Figure 104.*** *Visualization map showing the level of hazard to sea level rise in the province of Capiz.*

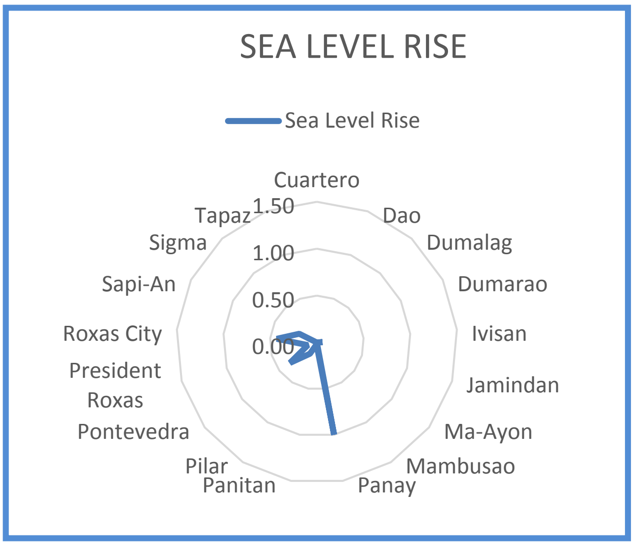



***Figure 105.*** *Radar chart showing the projected occurrence of sea level rise in the Province of Capiz.*

***Erosion***. Practically all the municipalities in the Province of Capiz are prone to the hazards of soil erosion. This is projected to be particularly intense in the western and southern municipalities of the province which are located in the uplands. As shown in Figure 106, ***very high*** hazard ratings were given to Sigma, Maayon, Pres. Roxas, Cuartero and Dumarao. On the other hand, the municipalities of Jamindan, Tapaz, Pilar, Panitan and Ivisan had ***high*** hazard ratings; Sapian, Roxas City, Mambusao, Dumalag and Pontevedra were rated ***moderate***. Panay got a ***very low*** hazard rating.

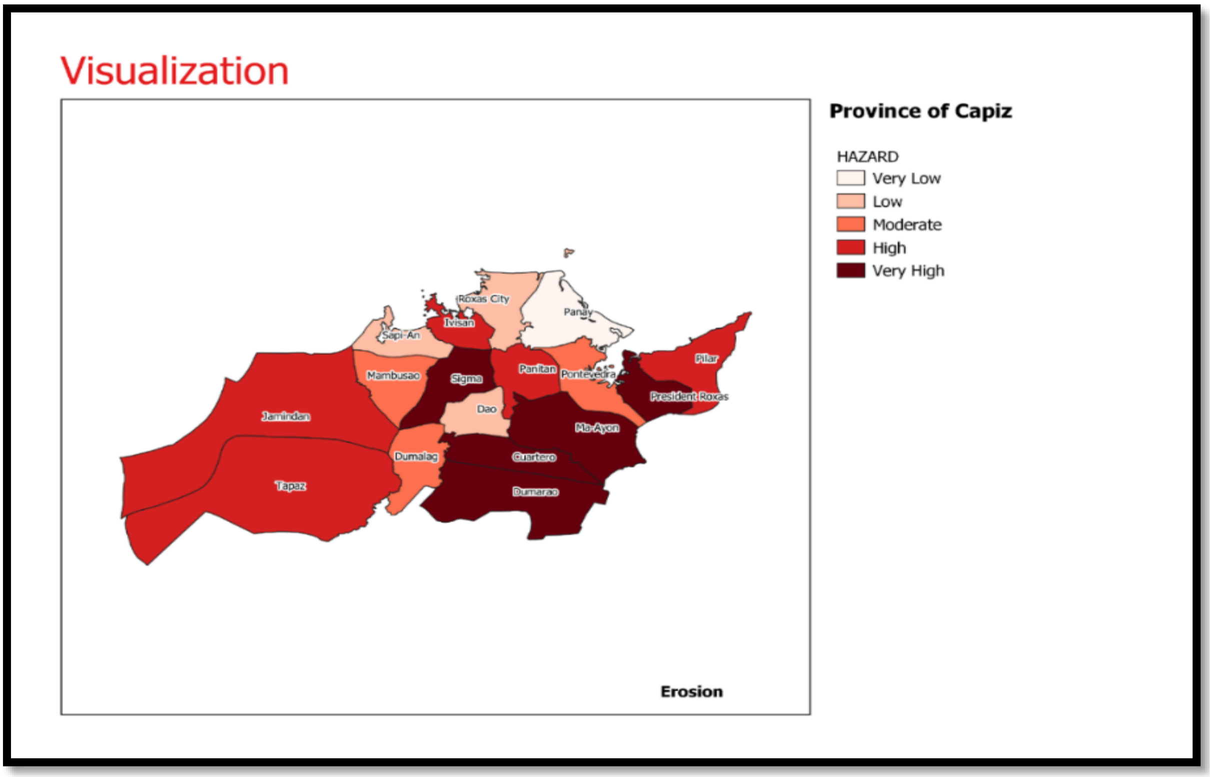



***Figure 104***. *Visualization map showing the level of hazard to erosion in the province of Capiz.*

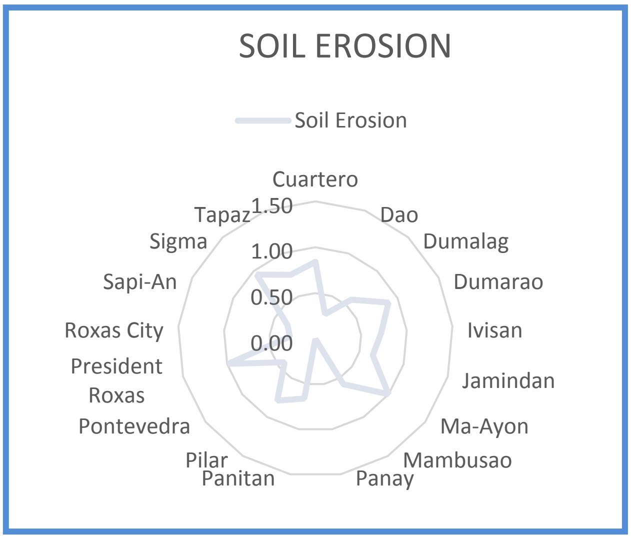



***Figure 105***. *Radar chart showing the projected occurrence of erosion in the Province of Capiz.*

***Storm surge***. This weather event was not predicted to occur in much part of the province. It is only predicted to occur in the three coastal towns. That although the hazard was predicted to be ***very high*** in Panay, and ***moderate*** in the municipalities of Sapi-an, Pilar and Pontevedra, all the remaining municipalities were rated ***very low*** in this climate-related hazard (Figure 106).

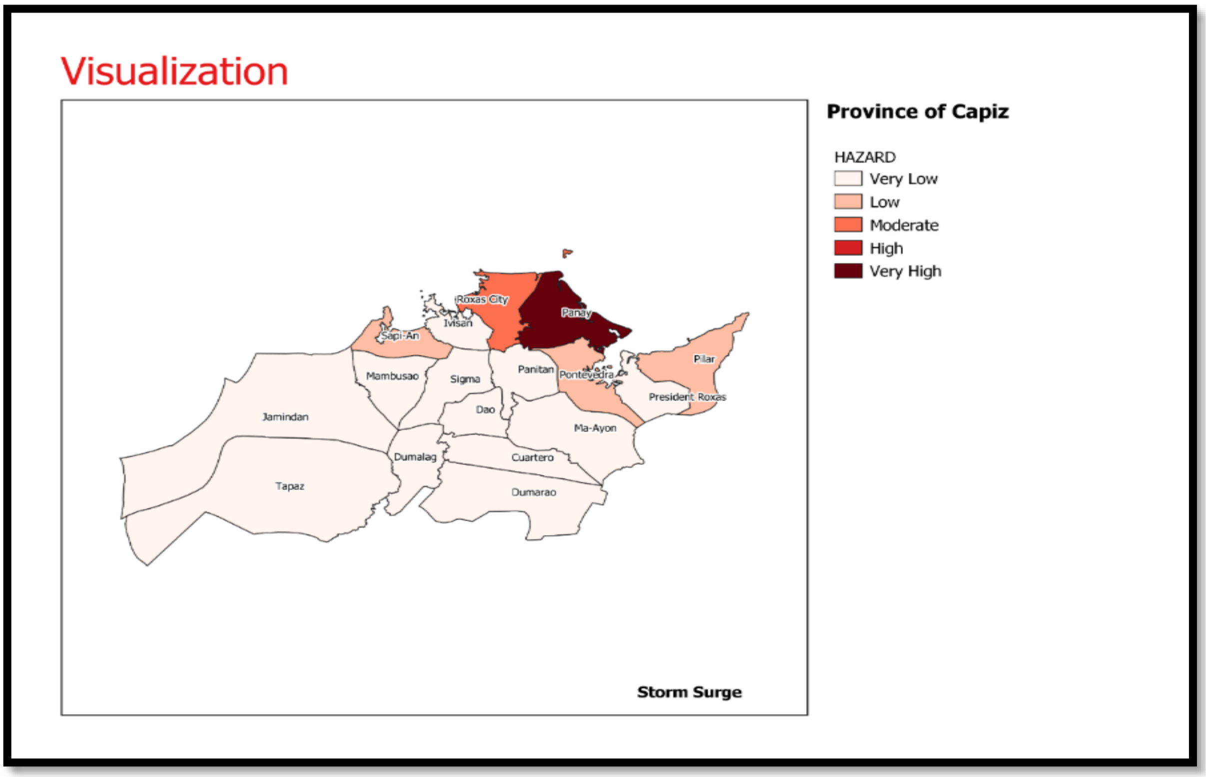



***Figure 106.*** *Visualization map showing the level of hazard to storm surge in the province of Capiz.*

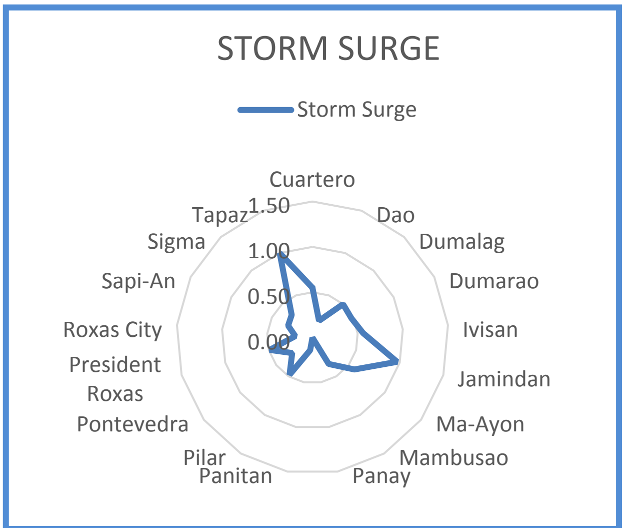



***Figure 107.*** *Radar chart showing the projected occurrence of storm surge in the Province of Capiz.*

***Saltwater intrusion***. Based on the results of the assessment made, the occurrence of saltwater intrusion was negligible across the province of Capiz (Figure 108). GIS-generated radar chart using zonal statistics and normalized values from the consolidated hazard data of AMIA 1 yielded also a zero value which means that the hazard to this climatic event is almost negligible in the province.

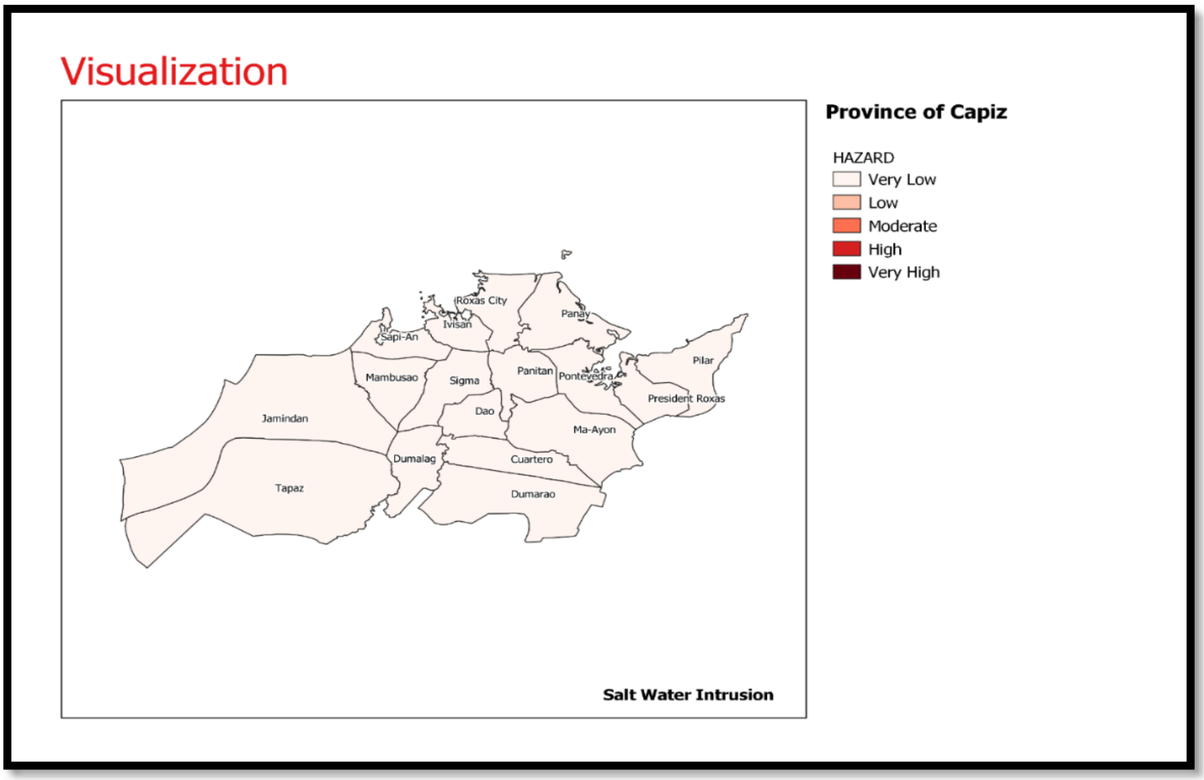



***Figure 108.*** *Visualization map showing the level of hazard to saltwater intrusion in the province of Capiz.*

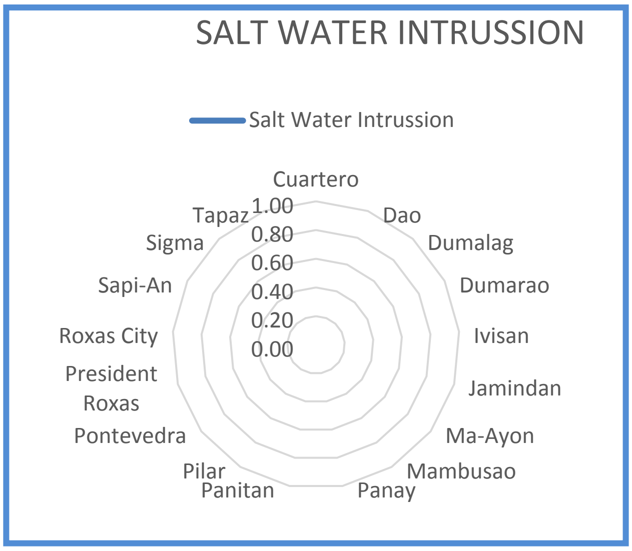



***Figure 109.*** *Radar chart showing the projected occurrence of saltwater intrusion in the Province of Capiz.*

The degree of hazards from the natural climatic events predicted to occur in the province of Capiz is presented in Figure 95. These climatic events were already explained in the previous sections.

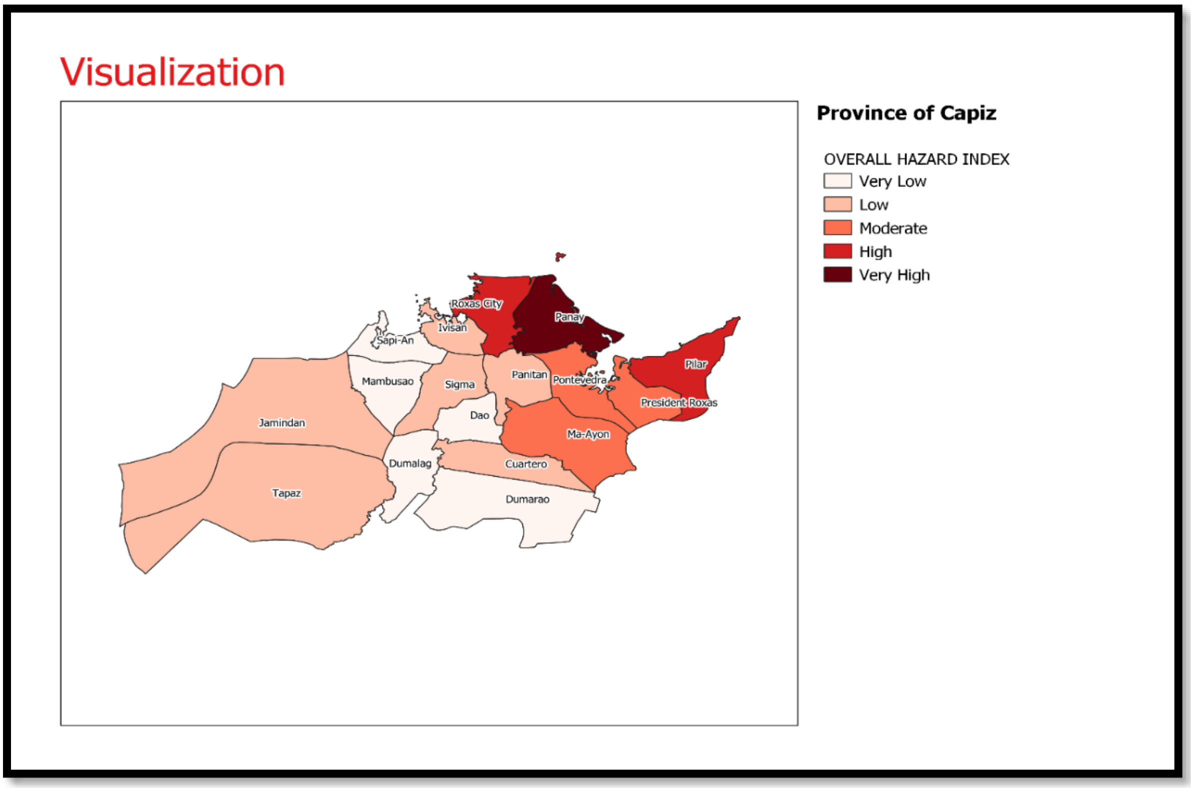



***Figure 95****. Visualization map showing the hazards from common climatic hazards Predicted to occur in the Province of Capiz.*

***Hazard index***. The index of consolidated assessment of the climate-related hazards in the Province of Capiz is shown in the visualization map in Figure 110. The map revealed that among the 17 municipalities in the province, Panay got ***very high*** hazard index, thus projecting it to be the most vulnerable municipality to natural climate-related hazards. Pilar and Roxas City were rated ***high,*** while Pontevedra, Maayon and President Roxas got ***moderate*** index. On the other hand, Jamindan, Tapaz, Invisan, Sigma, Panitan and Cuartero got a ***low*** index while Mambusao, Sapian, Dao, Dumalag and Dumarao got ***very low***.

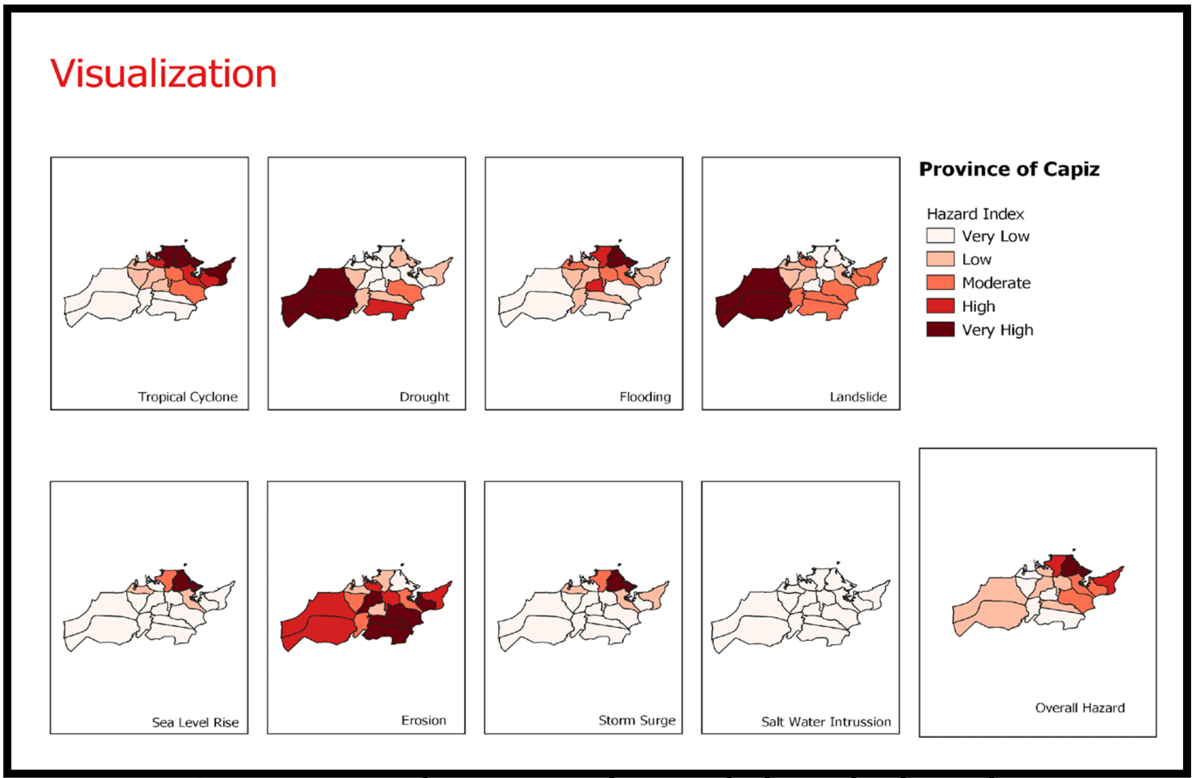



***Figure 110.*** *Visualization map showing the hazard index in the Province of Capiz.*

## Adaptive Capacity Assessment

Climate-vulnerability assessment is likewise concerned with finding out and describing adaptive capacities of the study areas. Basically, it involved crop suitability, hazard vulnerability and adaptive capacity. This section focuses on adaptive capacity which tried to evaluate the inherent capacities of the subject municipalities to withstand, mitigate and adapt to the extreme events of climate change. Adaptive capacity assessed the capability of the study sites by exploring and analyzing specific capitals and indicators that can enhance the resilience of communities to the impact of climate change.

The results of the assessment results on the adaptive capacity of the province in terms of the seven capitals and indicators used are presented and discussed hereunder. As may be recalled, the seven capitals of adaptive capacity included the following: a) economic, b) natural, c) social, d) human, e) physical, f) anticipatory, g) Institutional, and the h) overall adaptive capacity of the Province of Capiz.

***Economic capital***. Dumarao was found to have ***very high*** economic capital among the municipalities in Aklan; Tapaz, Dumalag, Mambusao, Roxas City had ***high*** while Jamindan, Sigma, Panay and Pillar had ***moderate*** capacity. On the other hand, Sapian, Maayon, Pres. Roxas had ***low*** and the rest of the municipalities had ***very low*** capacities on economic capital. In the assessment of economic capital, these indicators were used: number of financial institutions and cooperatives, number of farmers with insurance, minimum wage in agriculture, area planted to the five crops under study, poverty incidence, and municipal class classification, among others. Considering these indicators, Dumarao appeared to gain the highest economic capital. Aside from having a higher population, some financial institutions like banks and cooperatives are located in this area. It has lower poverty incidence and comparatively higher municipal class. Being this, Dumarao and its inhabitants are more prepared to withstand the hazards and destructions caused by adverse weather conditions. The reverse is true for the municipalities which adaptive capacities were found to be moderate to very low. These areas direly need assistance in any form to build up their capacities in terms of the above indicators to become more resilient to face and manage the unpredictable occurrences of weather-related disturbances like typhoons and flash floods, among others.

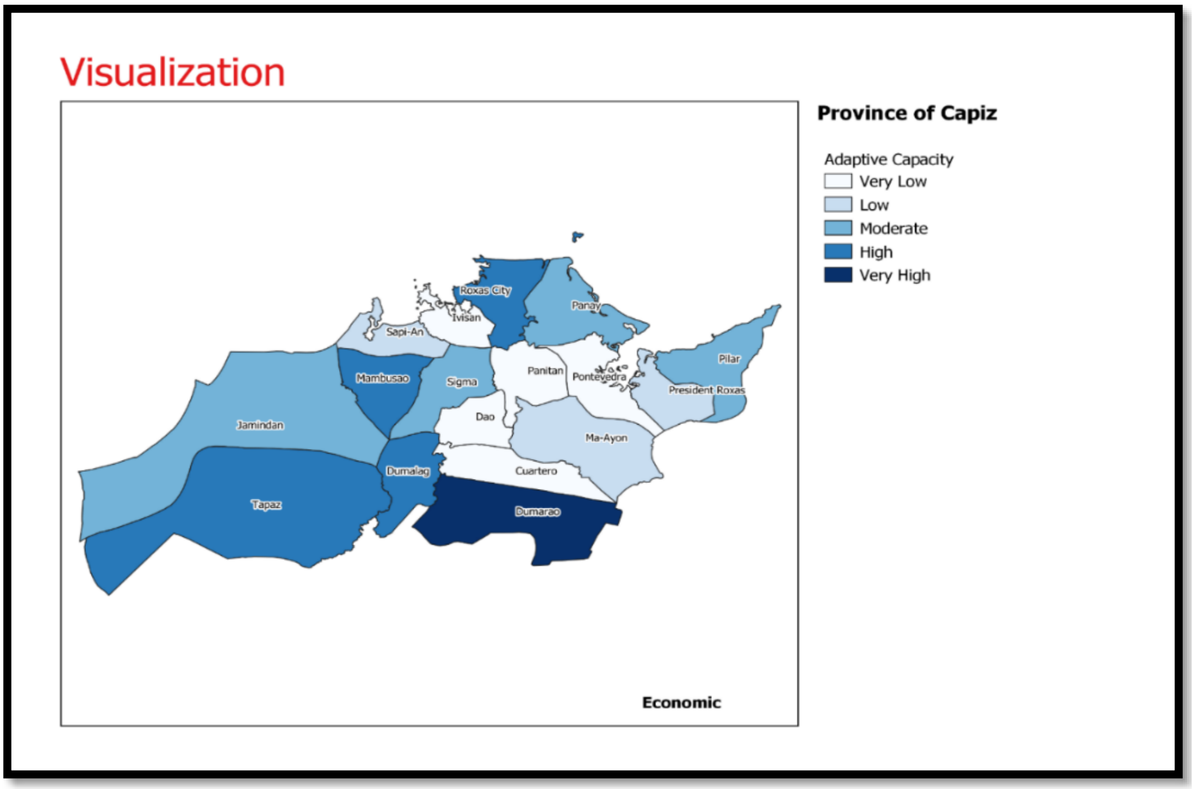



***Figure 112****. Visualization map showing the adaptive capacity of the Province of Capiz based on economic capital.*

***Natural capital.*** In terms of natural capital, Panay got ***very high*** rating while the rest of the remaining municipalities obtained the opposite – ***very low*** natural capital (Figure 113). This assessment was based on such indicators as presence of marine protected area, number of shallow-tube wells (STWs), service area covered by STWs, groundwater availability, and reliable source of water for irrigation. These criteria pertain primarily on water availability assessment in the area for domestic, agricultural and industrial use. This is an adaptive capacity which depicts a picture as to the readiness of the municipalities to respond or mitigate water deficiency crises during dry months, or when there is drought, or during the occurrence of *El Nino* phenomenon. In this evaluation, Panay came out to have highest rating (adaptive capacity) in natural capital based on the above criteria. For communities with low or very low ratings, the development of water resources in their respective area needs to be addressed with urgency by all concerned.

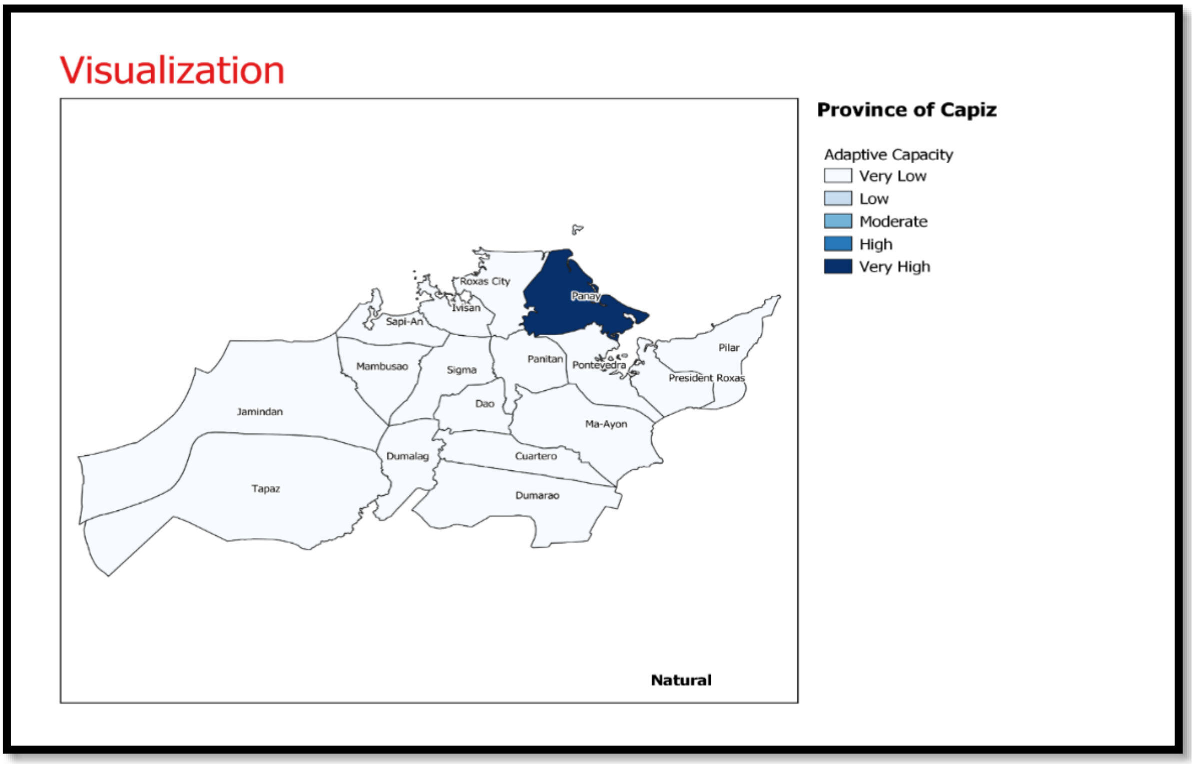



***Figure 113****. Visualization map showing the adaptive capacity of the Province of Capiz based on natural capital.*

***Social capital.*** On the social capital assessment, Roxas City and President Roxas were ***very low*** in this capita; Sapian and Pilar had ***low*** while Jamindan, Dumalag, Dao and Panay had ***moderate*** social capital (Figure 114). On the other hand, Mambusao, Panitan and Ivisan got ***high*** rating on this capital.

Topping them all are the municipalities of Tapaz, Sigma, Cuartero, Dumarao and Maayon which obtained ***very high*** social capital. Social capital was evaluated using four indicators such as number of registered farmers' groups/unions, percentage of farmers who are members of coops/groups/unions, total number of farmers, and percentage of male and female farmers. Social capital primarily pertains to the number of active farmers in the municipality being assessed and their membership to various existing farmers' organizations. Membership to organizations is essential as a support component of adaptive capacity believing in the adage that in "unity there is strength." Inhabitants can better respond to climate related crises when they are organized and bound to common goals and objectives. Collective action is often more effective in bringing about positive results.

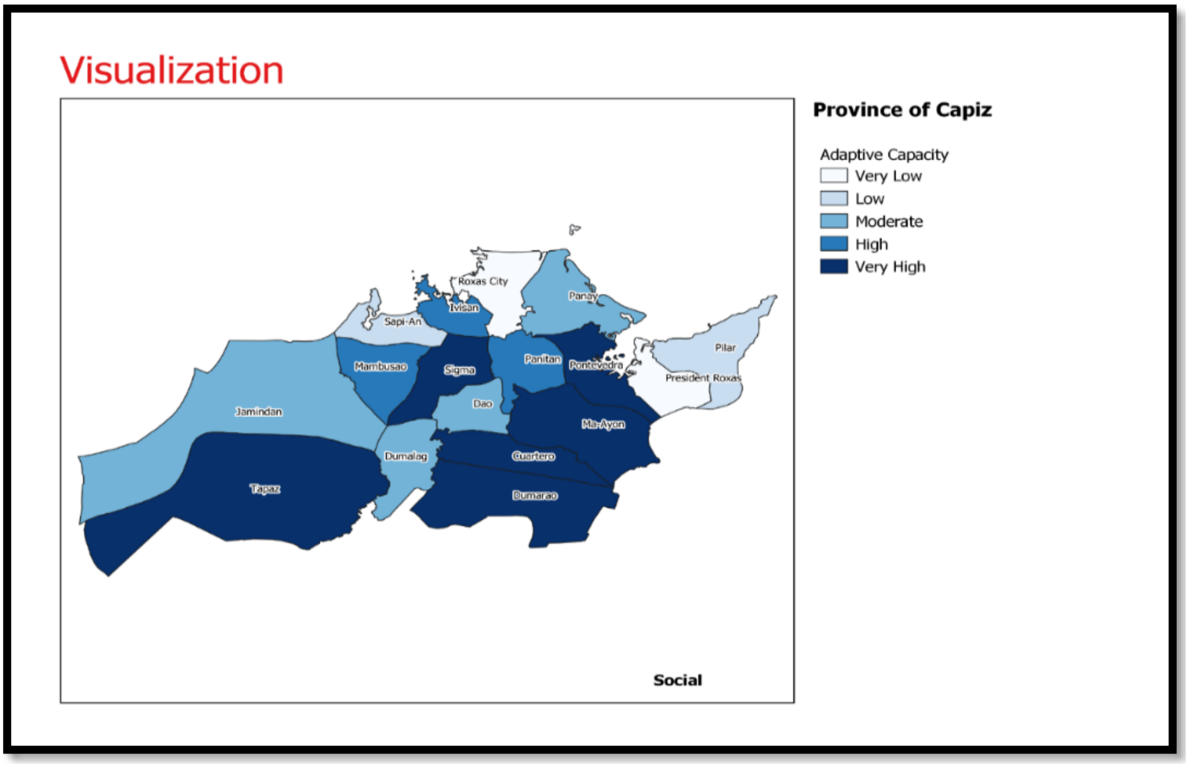



***Figure 114.*** *Visualization map showing the adaptive capacity of the Province of Capiz based on social capital.*

***Human capital***. Human capital was a measure used to assess the adaptive capacity of municipalities to mitigate and survive the hazards of climate change. The assessment used the following indicators: presence of secondary and tertiary schools, school attendance among the inhabitants, number of academic degree holders, health services manpower, number of public doctors, and number of citizens with Philhealth.

In this assessment, Roxas City obtained ***very high*** while Pontevedra was rated ***high in human capital***. On the other hand, the municipalities Ivisan, Mambusao, Dumalag, Cuartero and Pilar were ***low*** in this capital and ***very low*** for the municipalities of Panay, President Roxas, Panitan, Maayon, Sapi-an, Sigma, Dao, Dumarao, Jamindan, and Tapaz.

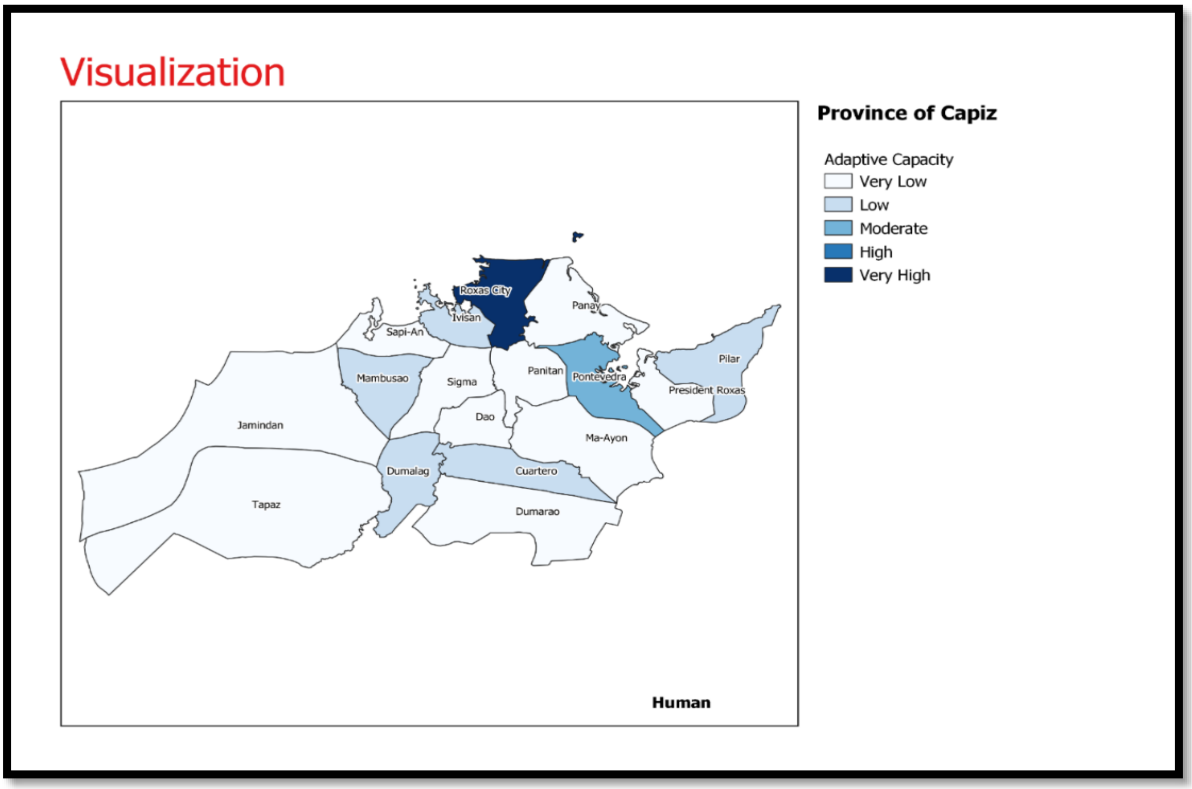



***Figure 115****. Visualization map showing the adaptive capacity of the Province of Capiz based on human capital.*

***Physical capital.*** Roxas City was rated to have ***very high*** in physical capital, and ***very low*** for the town of Tapaz (Figure 116). Rated to have ***moderate*** physical capital were the municipalities of Jamindan, Dumarao, Cuartero and Pilar. The remaining municipalities were all rated ***high*** in this capital. The four indicators used in assessing physical capital were: land ownership of farmers, their farm size, the number of livestock being raised, and distance of furthest barangay from the market. The results simply mean that more farmers living in Roxas City, the town capital of the province, own their farmlands, have bigger farm size, and raise more livestock, among others. Considering all these, the City of Roxas and its inhabitants were rated to have the highest physical capital – their capacity to respond and mitigate the impact of climate change, or have the capacity to respond and recover more quickly from weather-related calamities.

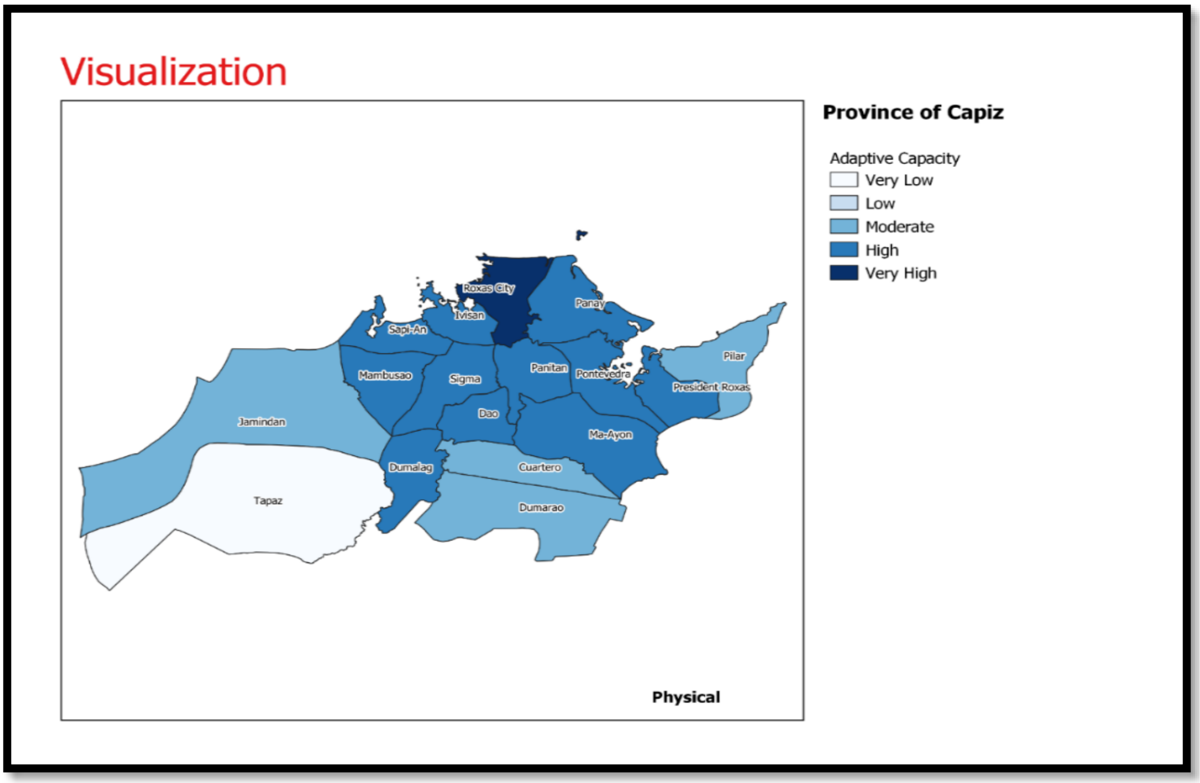



***Figure 116****. Visualization map showing the adaptive capacity of the Province of Capiz based on physical capital.*

***Anticipatory capital.*** The result of assessment made on this capital is reflected in Figure 117. The results showed that the municipality of Ivisan had a ***very high*** rating in anticipatory capital; in contrast, the municipalities of Jamindan, Sapi-an, Sigma, Dumalag, Dao, Panitan, Maayon, Pres. Roxas, Pilar, Cuartero and Dumarao had ***very low*** (Figure 117). Moreover, Roxas City and Panay got ***moderate*** while Mambusao and Pontevedra were rated ***high*** in this capital. Anticipatory capital was determined using the following indicators: number of trainings related to climate change, access to communication technology, and presence of DRRMP and CLUP in the area.

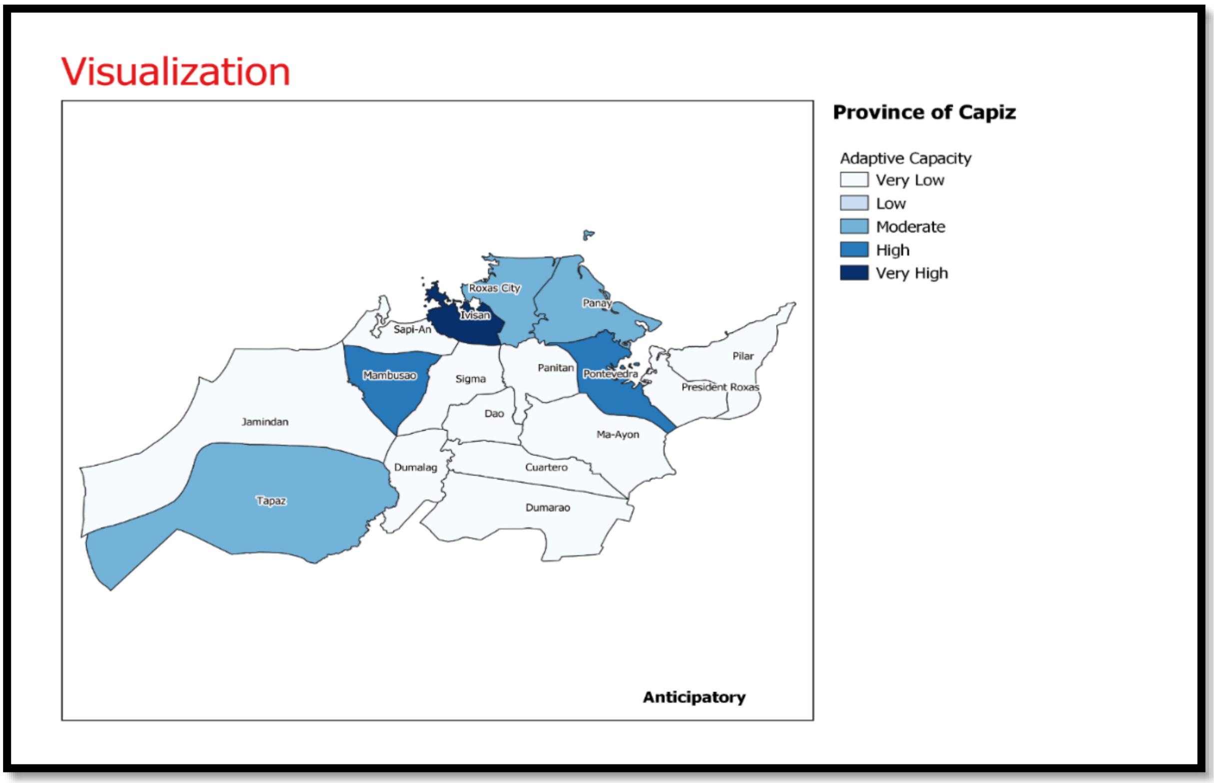



***Figure 117**. Visualization map showing the adaptive capacity of the Province of Capiz based on anticipatory capital.*

***Institutional capital.*** For institutional capital, the following ratings were obtained: ***very high*** for Sapian; ***high*** for Tapaz and Ivisan; ***low*** for Roxas City, Jamindan, Dumalag, Dumarao, Maayon, Panitan, and Sigma. Mambusao, Panay, Dao, Cuartero, Panay and Pontevedra were the weakest in anticipatory capital with a ***very low*** rating (Figure 118). The two criteria used in this assessment were farmers' visit or consultation with the Agricultural Extension Officer, and number of AEO working under the office of the Municipal Agriculturist.

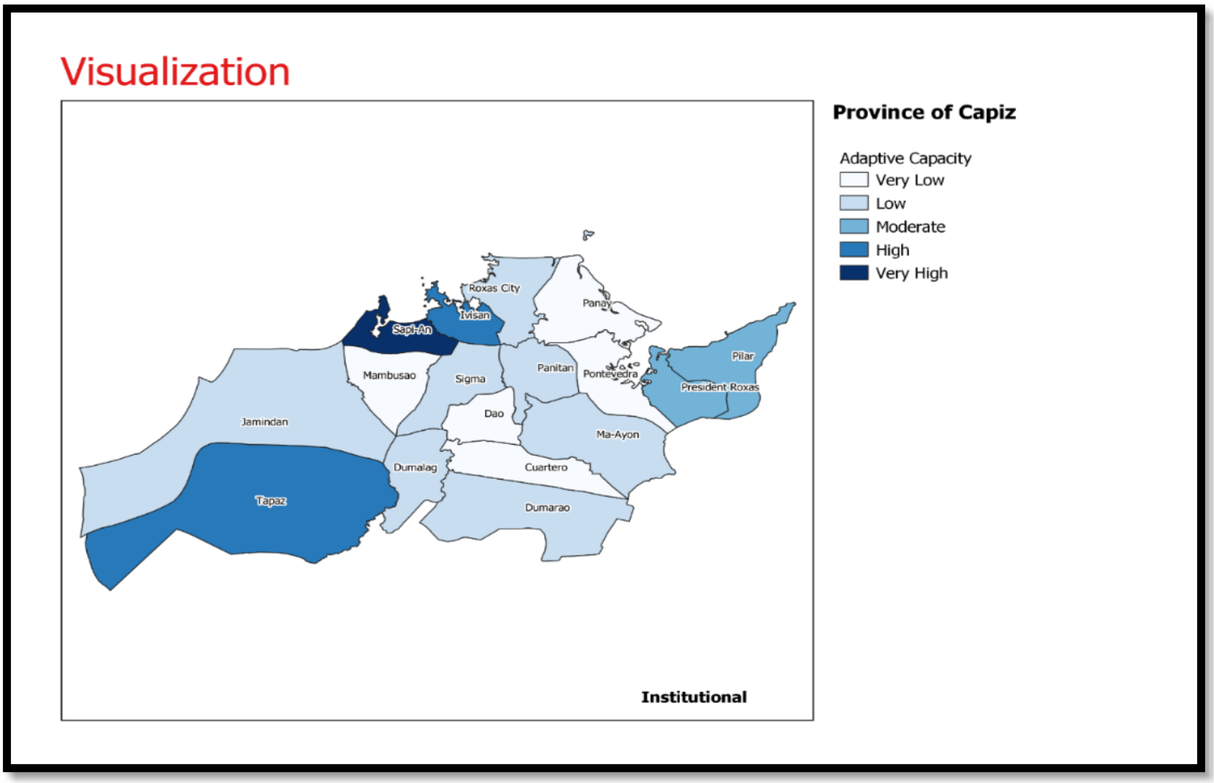



***Figure 118.*** *Visualization map showing the adaptive capacity of the Province of Capiz based on institutional capital.*

The visualization maps in Figure 119 presents a gist of the assessment results on the adaptive capacities of the 17 municipalities of the Province of Capiz. These maps have already been discussed separately in previous sections.

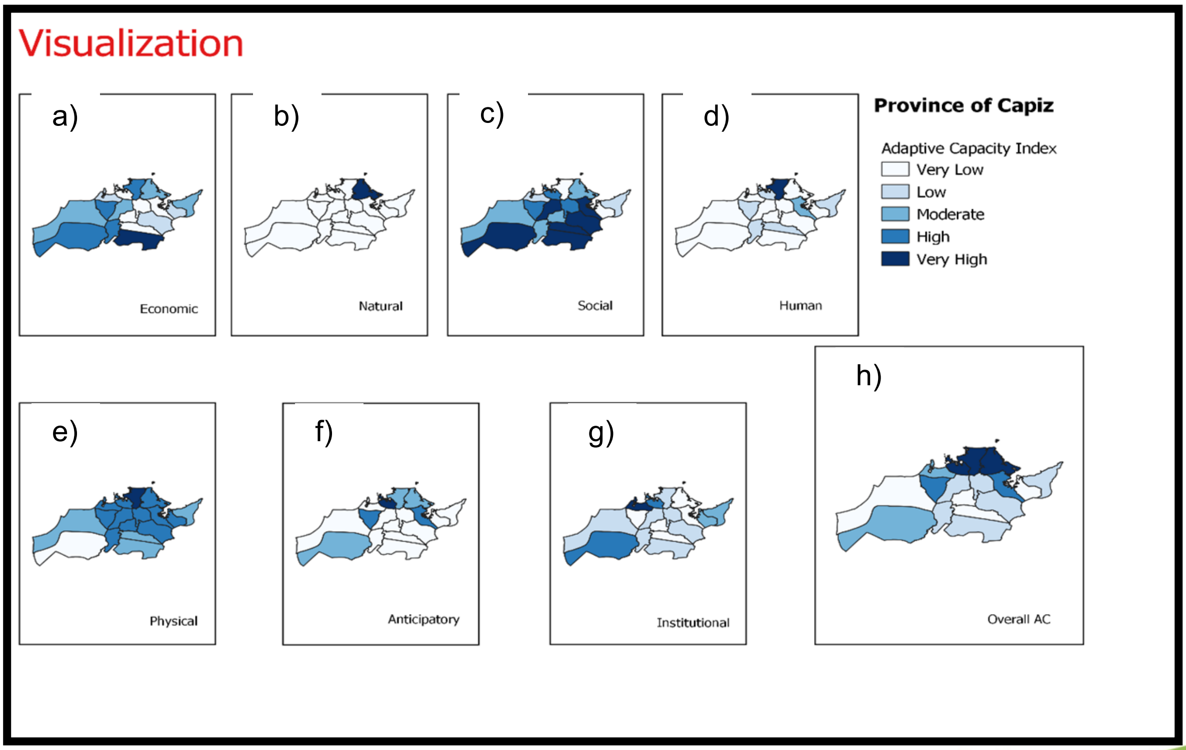



***Figure 119.*** *Adaptive capacities of the municipalities of Capiz based on the assessed seven capitals.*

***Adaptive capacity index.*** Adaptive capacity index presents a picture of the ability or capability of the municipalities studied to cope, respond, mitigate and adapt to the adverse conditions brought about by climate change. This serves as a guide to development planners and hazard mitigators in addressing climate-related challenges to improve climate readiness and resiliency among the municipalities concerned. The above results on the assessment of the seven capitals are summarized in Figure 120. As shown by this figure, the municipalities of Jamindan, Dao, Cuartero and Pres. Roxas had **very high** adaptive capacity index while Roxas City and Panay were the reverse by getting a very ***low index***. Moreover, Sigma, Dumalag, Dumarao, Maayon, Pilar, and Panitan got a ***high*** index; Tapaz, ***moderate***; and Mambusao and Pontevedra with ***low index***. Simply put, these indices gained by the municipalities studied mean that the higher is the adaptability capacity index of a particular area, the greater or higher also is the ability or capability of the area to respond and adapt effectively to the challenges of climate change; and, the lower the index, the capability of the area to respond to these challenges is also lesser

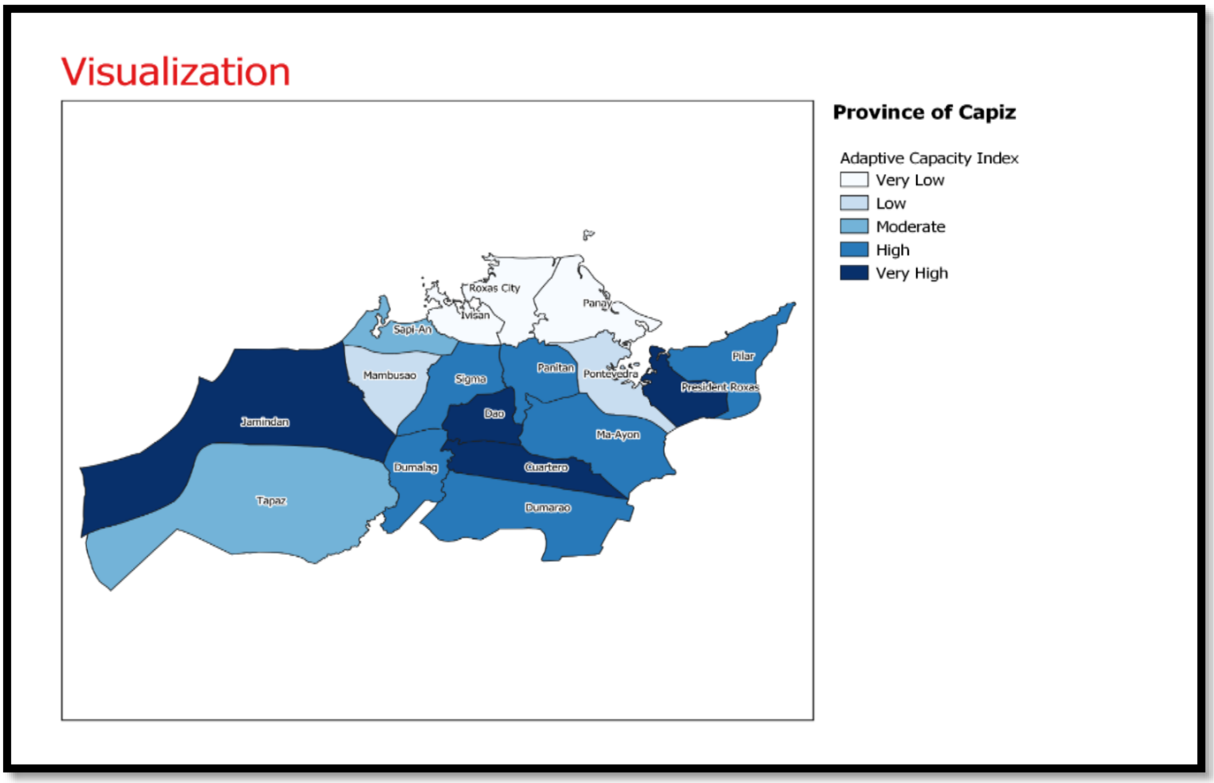



***Figure 120***. *Adaptive capacity index of the Province of Capiz*

## Over-all Vulnerability Assessment for the Municipalities of Capiz

In the assessment of climate vulnerability was done by using the values obtained from the three indices, namely sensitivity, hazard, and adaptive capacity index. In the vulnerability assessment for the province of Capiz, the results showed that the municipalities of Jamindan, Dao, and President Roxas were rated ***very high*** (Figure 53). Seven other municipalities were rated ***high*** to include the towns of Dumalag, Sigma, Panitan, Maayon, Cuartero, Dumalag and Pilar while Sapi-an, Pontevedra and Tapaz got ***moderate.*** On the other hand, Jamindan, Dao and President Roxas obtained ***very low*** rating. In this assessment, the results predict that the municipalities of Jamindan, Dao, and President Roxas came out as the most vulnerable municipalities to climate change while Jamindan, Dao and President Roxas are considered as the least vulnerable in the province if Capiz.

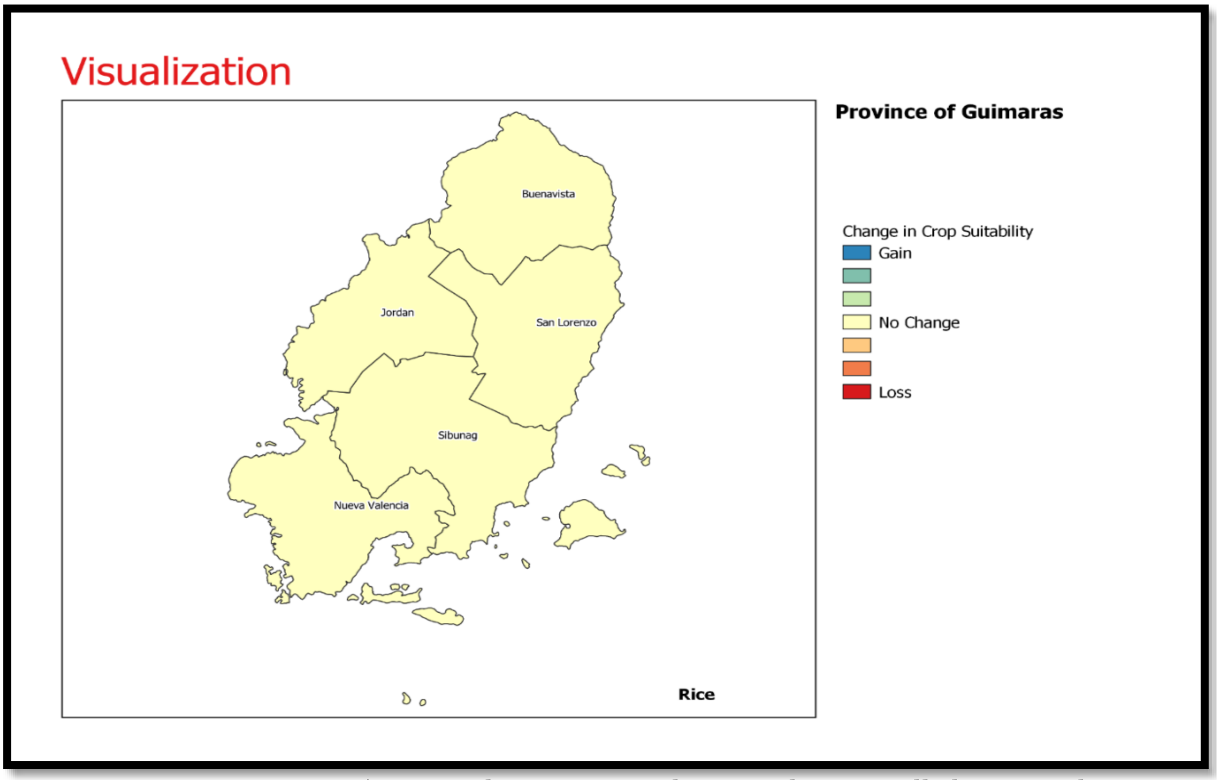



***Figure 53.*** *Visualization map showing the over-all climate risk vulnerability assessment results of the municipalities of the Province of Capiz*

## Province of Guimaras

## Preliminaries

The Province of Guimaras is composed of the main Island of Guimaras, and the minor islets of Inampulugan, Guiwanon, Panobolon, Natunga, Nadulao, and many more. The province is situated in the Panay Gulf between Panay and Negros islands in the southeastern section of Western Visayas. To the northeast of the province is Iloilo and Negros Occidental to the southeast. The province formerly known as *Himal-us* was once a sub-province of Iloilo and became an independent province on May 22, 1992. It has a total land area of 604.57 square kilometers. Jordan is the capital and most densely populated town of the province; it has one legislative district covering the five municipalities of the province. Based on 2020 census, the island province has a population of 187,842 people with a density of 310 inhabitants per square kilometer. Guimaras is basically an agricultural province producing such major products as mangoes, rice, coconuts, root crops, vegetables, fruits, livestock and poultry. Guimaras is famous of its sweetest mangoes, thus earning the nickname *Mango Capital of the Philippines* throughout the world. Being an island with marine-rich coastlines, *Guimarasnons* are largely involved in fish farming which is considered as a major industry. Other known industries in the province include tourism, fruit and coconut processing, handicraft-making, lime production, quarrying and mining. Being surrounded by bodies of water, the island province just like the other provinces of the region, is likewise prone or vulnerable to adverse climate-related events such as typhoons, sea-level rise, floods, erosion and drought, among others.

## Sensitivity Assessment of the Climate Change Impact to Crop Suitability (Exposure 1)

As a part of the sensitivity (crop suitability) assessment, five top crops presently grown in the province of Guimaras were involved. This included rice, corn, coconut, banana and mango. While these crops are at present suited to the agroclimatic conditions of the province, their suitability is projected to change in the foreseeable future in the same manner as in other provinces, the assessment considered or used parameters such as temperature, rainfall and other related bioclimatic conditions prevailing in the area.

As shown in the maps below a change in suitability may be projected where some may gain suitability, others may loss while others may remain the same depending on the change in the values of the parameters used. The values in Table 1 were used in determining the degree of changes in crop suitability in the future.

*Table 1. Percent change of crop suitability for the five prority crops in Guimaras province from 2020 to 2050.*

| Municipality | Percent Change | | | | |
|---|---|---|---|---|---|
| | Rice | Corn | Mango | Banana | Coconut |
| **Buenavista** | -3.14 | -3.31 | -5.24 | -1.24 | -4.18 |
| **Jordan** | -0.58 | 0.05 | -1.01 | -2.09 | 2.35 |
| **Nueva Valencia** | 3.91 | 7.93 | 6.24 | -0.40 | 4.15 |
| **San Lorenzo** | -1.38 | -3.71 | -3.71 | -1.81 | -0.04 |
| **Sibunag** | -0.39 | 1.31 | 1.33 | -1.56 | 0.01 |

***Not**e: The above table of values shows the municipalities that will have no change if it ranges from greater than (-) 5% to less than or equal to (+) 5)%, positive change if values ranges greater than (+) 5% and negative change if it ranges lower than (-) 5%. Areas fell under no change will not be affected by climate change in the future significantly, while areas fell under positive change, future climatic condition will favor their growth and areas fell under negative change will loss climatic suitability where climatic condition will have a negative effect to their agronomic growth performance.*

Hereunder are visualization maps showing changes in crop suitability of the five priority commodities projected for year 2050 in the Province of Guimaras. This sensitivity assessment can serve as guide to identify crop suited for a specific location based on future climatic conditions. In the determination of suitability values and consequently sensitivity index, values in Table 1 were used.

***Rice***. Rice as a traditional staple crop will remain suitable in the Province of Guimaras. Figure 100 essentially reflects ***no change*** in crop suitability for corn in the area. Simply put, there will be no significant changes in the suitability of the rice in the province in the future.

The crop will remain suited in the areas where it is now grown and would not likely be influenced by future climatic variations expected to occur in the province.

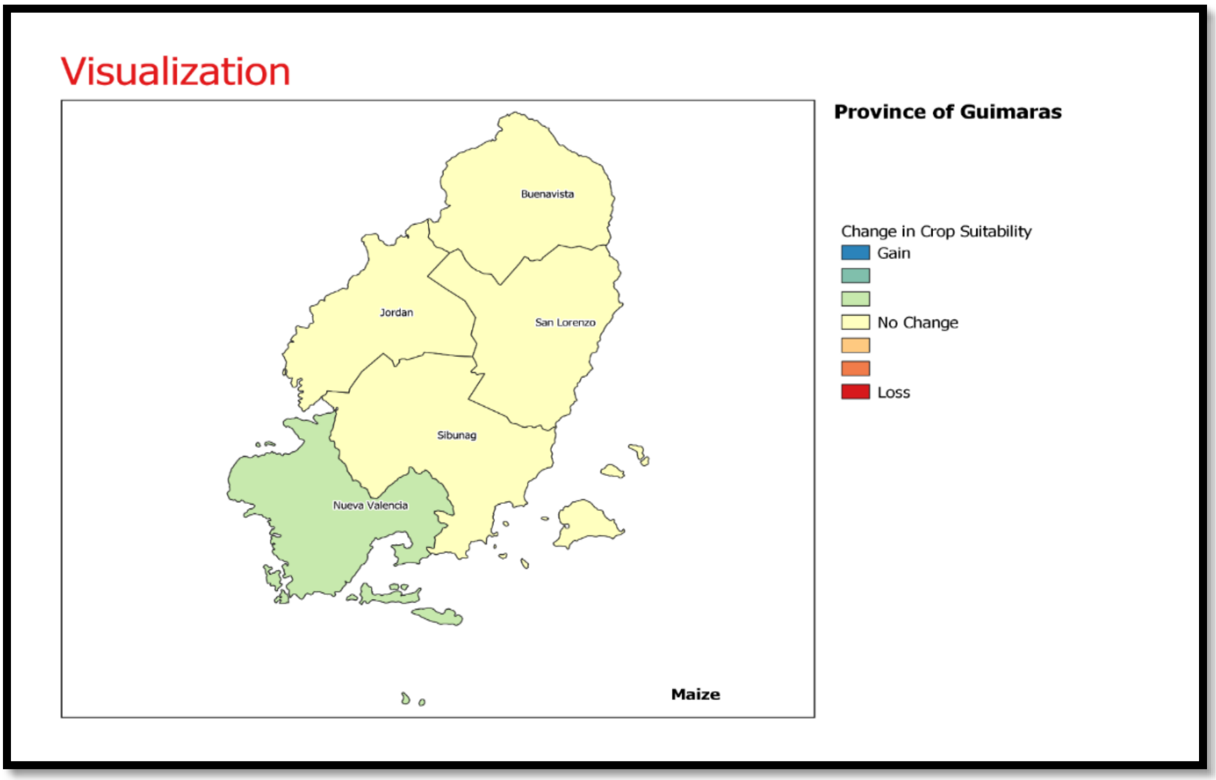



***Figure 100.*** *Visualization map showing the changes in crop suitability for rice in the future in the Province of Guimaras.*

***Corn.*** As shown in Figure 101, corn will largely remain suitable in the future in Guimaras. While Nueva Valencia is projected to gain greater suitability for the crop in the future, all other municipalities would remain ***no change***. This forecast is apparently favorable for Guimaras since corn which is also an important economic crop would remain suitable in the province despite predicted climatic variabilities.

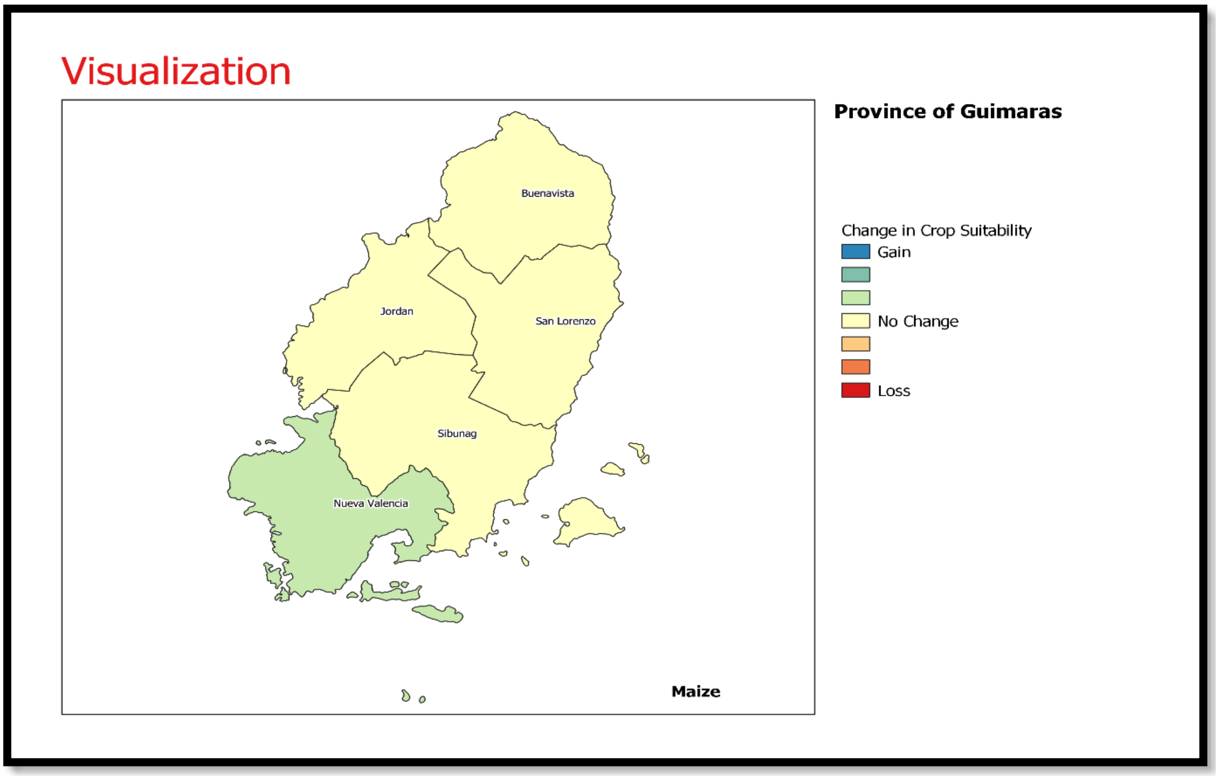



***Figure 101.*** *Visualization map showing the changes in crop suitability for corn in the Province of Guimaras.*

***Banana***. As an economic crop, banana is a traditional economic crop in the province of Guimaras. The results of the study as shown in Figure 102 is encouraging – the suitability of banana as an economic crop remains ***no change*** in the five municipalities of the province The evaluation results show that there are no significant changes in crop suitability for banana in the province in the future. This may imply that the future changes in climatic events in the area would not adversely influence the growing of this crop in Guimaras.

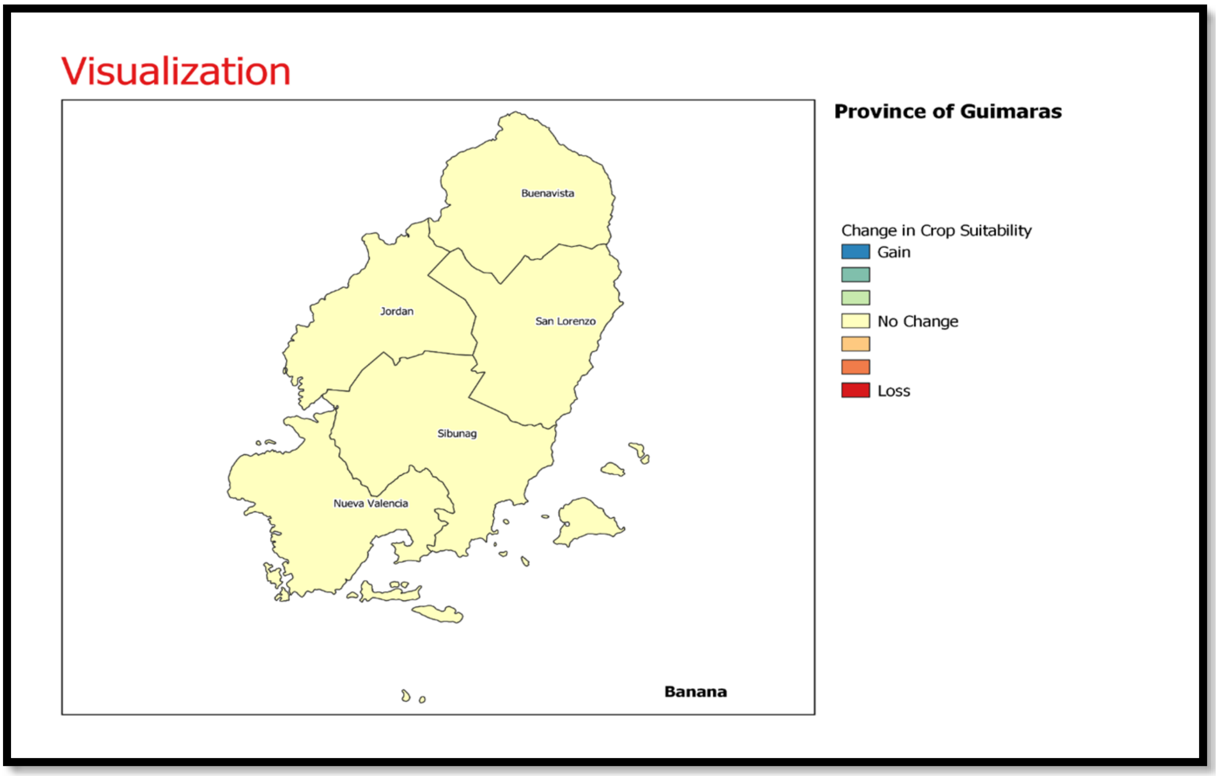



***Figure 102****. Visualization map showing the changes in crop suitability for banana in the Province of Guimaras.*

***Coconut.*** This crop thrives well in many areas in the province of Guimaras. The suitability assessment results for coconut in this province remains ***no change*** – meaning the crop will remain suitable in the province in the near future (Figure 103). This essentially suggests that the prevailing climatic conditions in the province would remain favorable for the production of coconut. It also suggests that there will be no negative change or loss of suitability in the future making coconut production more feasible in the province.

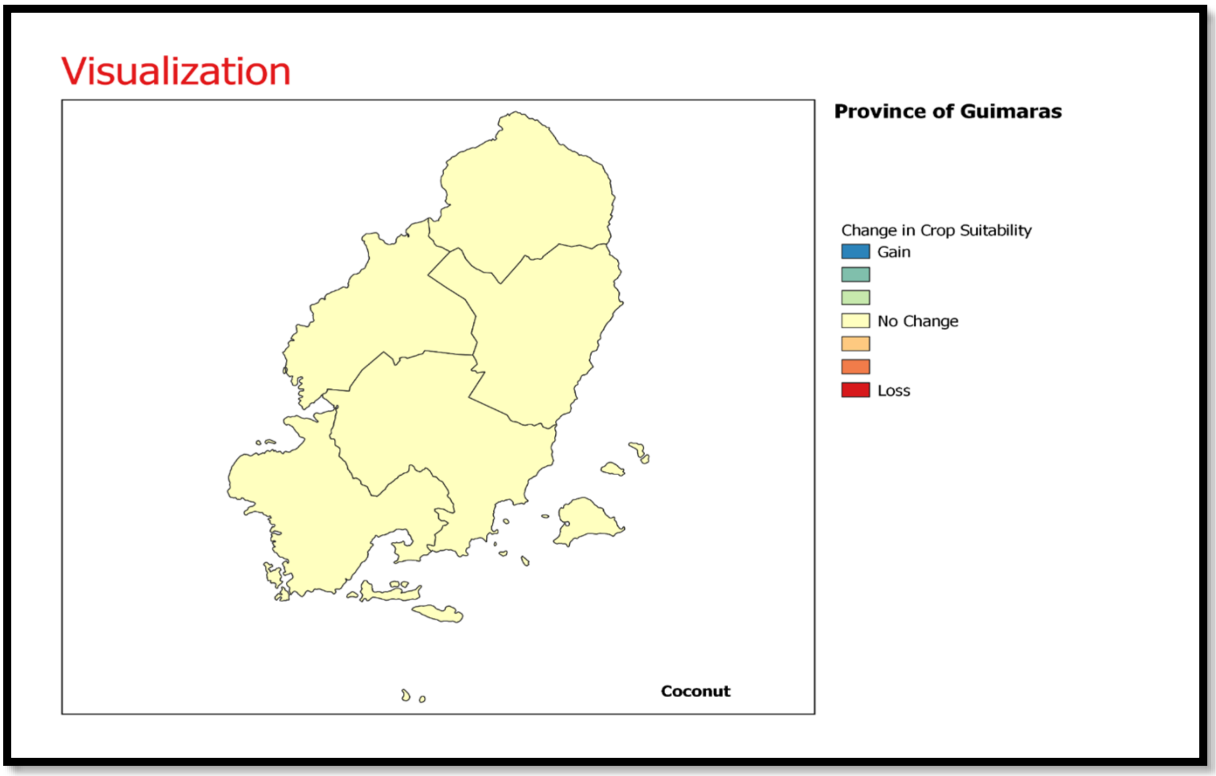



***Figure 103.*** *Visualization map showing the changes in crop suitability for coconut in the Province of Guimaras.*

***Mango***. Mango is a very important economic crop in Guimaras – being the banner fruit crop of the province. While Nueva Valencia tended to ***gain greater suitability*** for this crop in the future, three of the municipalities (Jordan, Sibunag and San Lorenzo) gained ***no changes*** or remained unchanged for the foreseeable future. This may mean that the future climatic conditions are not expected to change the present suitability status of mango in the three municipalities (Figure 104). The town of Buenavista, however, is expected to lose suitability to this crop; this is most likely due to the unfavorable influence of climate projected to occur in the area.

The visualization maps in Figure 105 is a comparative presentation of the predicted suitability of the crop commoiditieis studied in the province of Guimaras. As can be observed in the map, most of the areas (in yellow color) in the province gained ***no change*** in suitability for the five economic crops involved in the study.

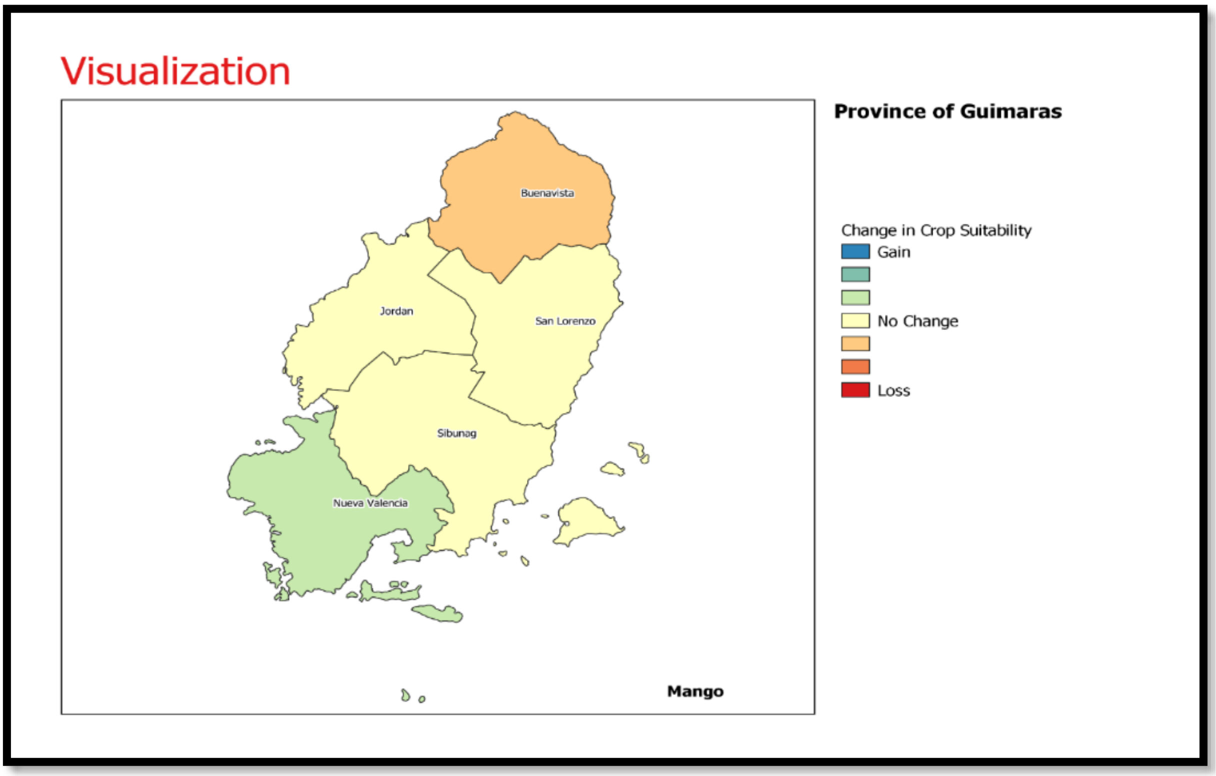



***Figure 104.*** *Visualization map showing the changes in crop suitability for mango in the Province of Guimaras.*

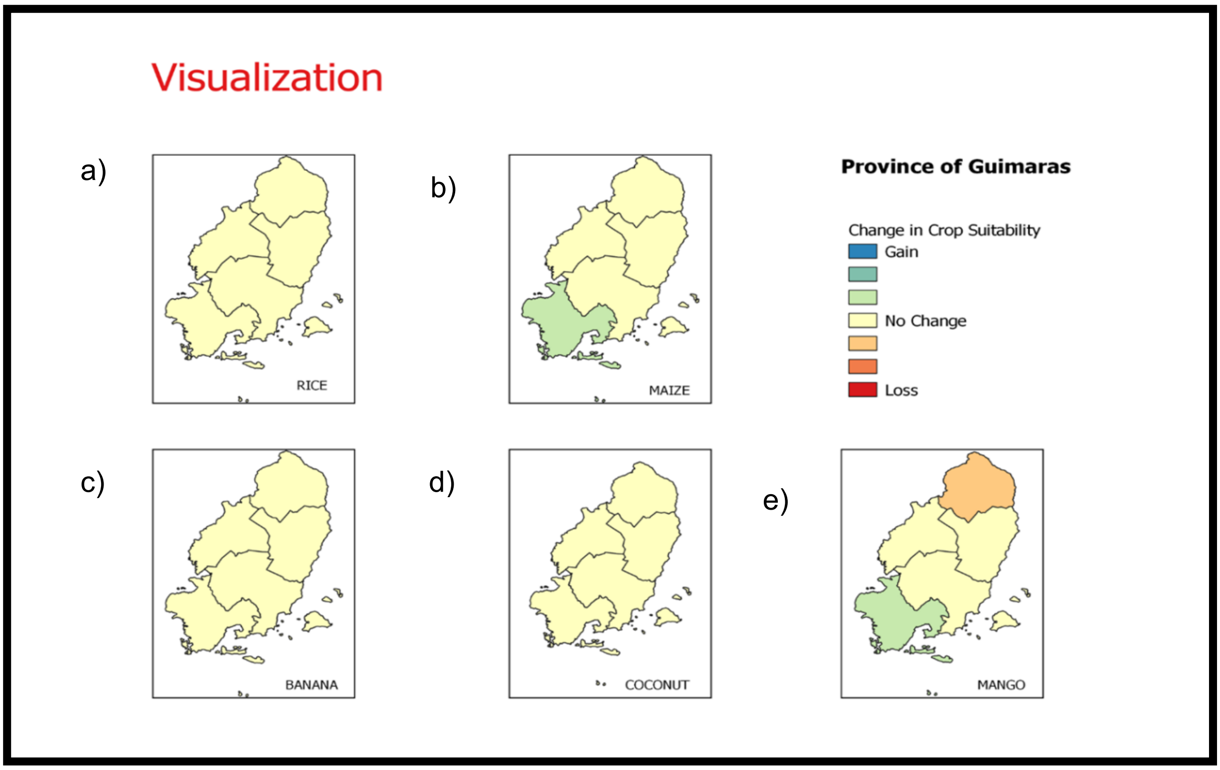



***Figure 105.*** *Visualization map showing the comparative suitabilility of the five priority crops: a) rice,  b) corn, c) banana, d) coconut and e) mango) in the Province of Guimaras.*

***Sensitivity index***. Relative to the future suitability of the five above-discussed crop commodities in the province of Guimaras, the sensitivity index derived from the suitability data is presented in Figure 106. The map shows that the town of Buenavista obtained a ***very high*** sensitivity index; Jordan, San Lorenzo and Sibunag had ***high*** index while Nueva Valencia got ***very low***. Higher sensitivity index means lower suitability of the crop in the area or municipality evaluated in the future, or the higher the index, the higher also is the projected impact from the hazards of climate change. Conversely, the lower is the index, the higher is the projected suitability of the five crops in the areas studied.

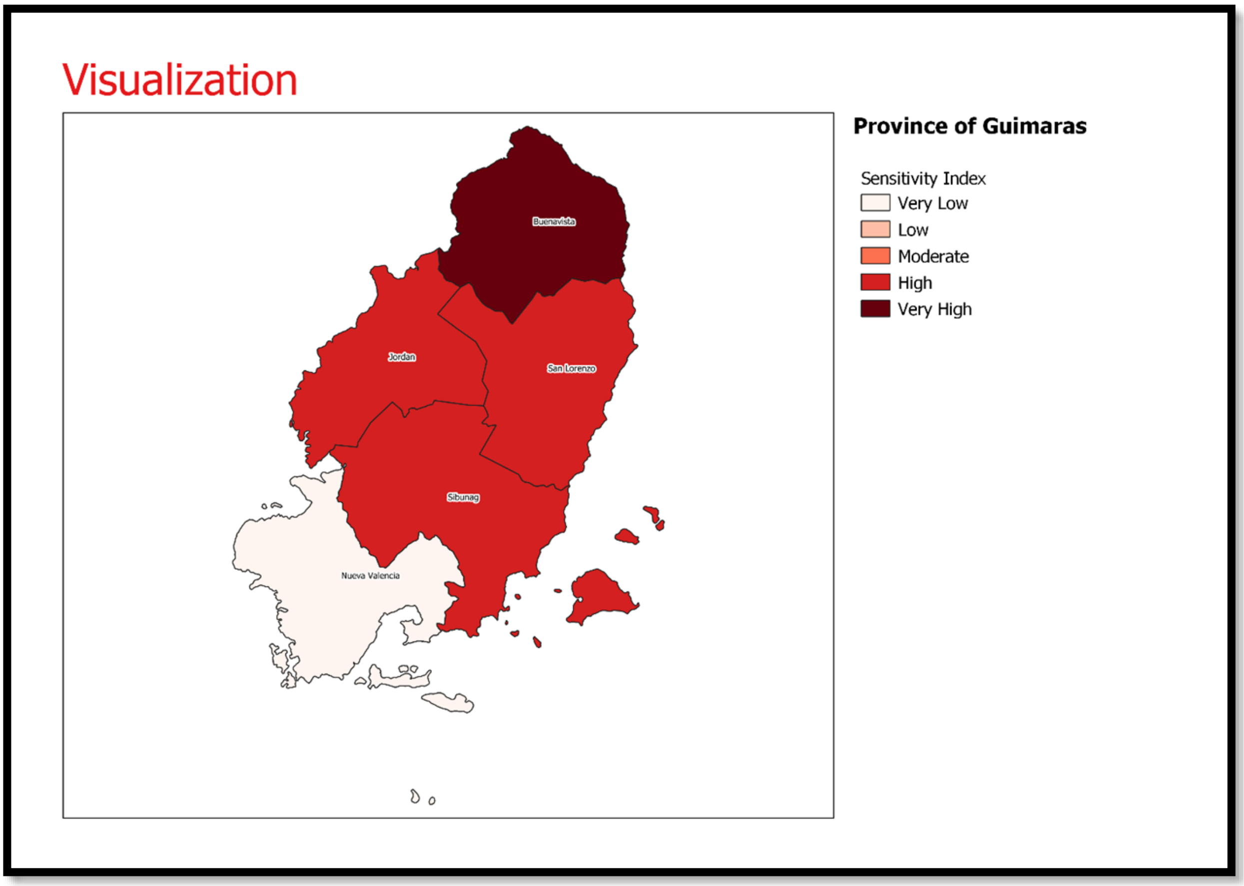



***Figure 106.*** *Visualization map showing the sensitivity index of the province of Guimaras to climate change using the suitability values of the five priority crops in the province.*

## Hazard Assessment of Climate-Related Pressures (Exposure II)

Below are the hazard assessment results, particularly on the vulnerability of the municipalities of the province of Guimaras to the eight major common natural climatic hazards, namely: tropical cyclones, drought, flooding, landslides, erosion, sea level rise, storm surge, and saltwater intrusion.

***Tropical cyclone*s**. Being an island in itself, Guimaras is generally exposed to the hazards of tropical cyclones or typhoons. Though partly shielded by Negros Island in the southeastern seaboard, the Island is exposed to the path of the southwestern monsoon (*Habagat*) which traditionally brings typhoons in the Visayas area. San Lorenzo which got ***very high*** hazard rating to tropical cyclone is located in this area (Figure 107). Adjacent to it are the municipalities of Sibunag, Jordan and San Lorenzo which also got a ***high*** risk rating. Nueva Valencia which is located opposite to the municipality of San Lorenzo, however, got a ***very low*** risk rating to typhoons.

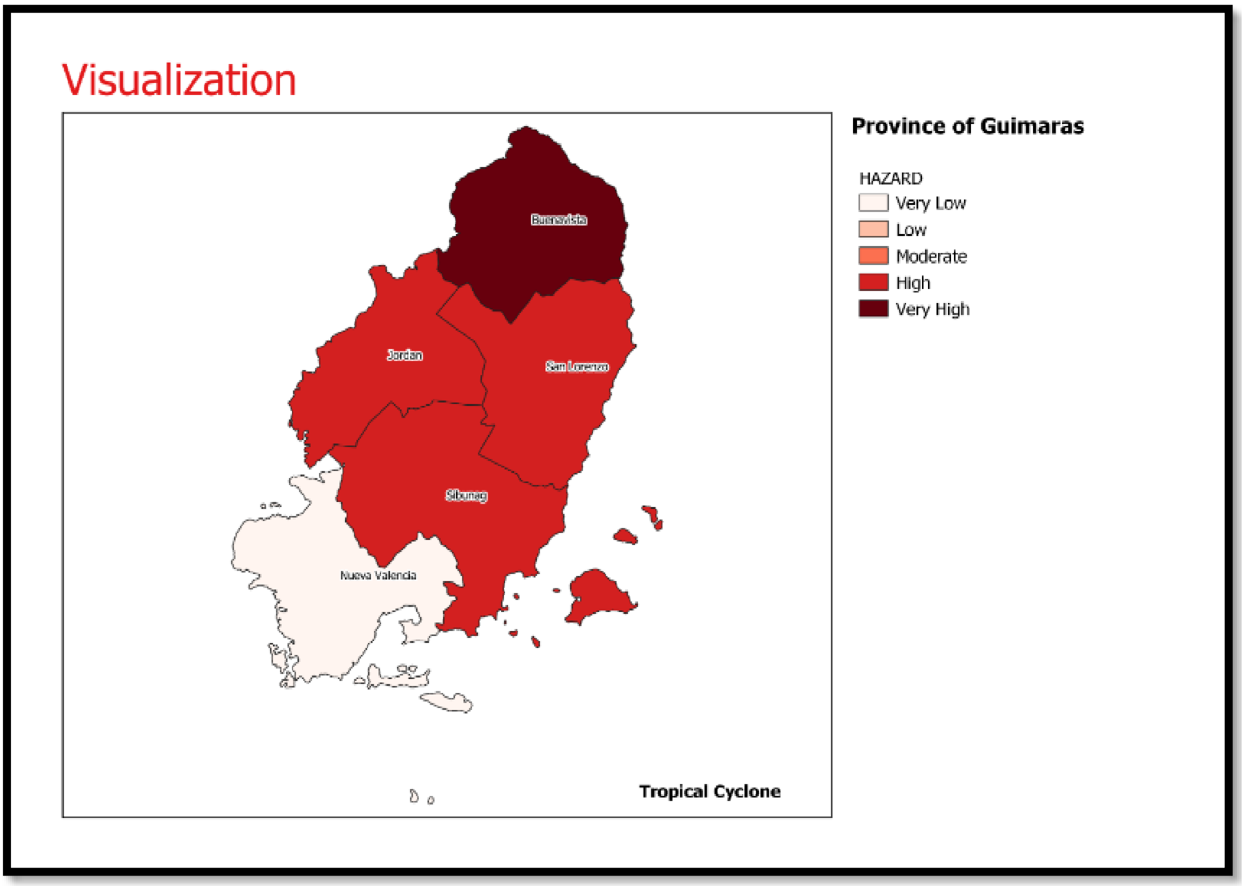



***Figure 107.*** *Visualization map showing the level of vulnerability of the province of Guimaras to tropical cyclones.*

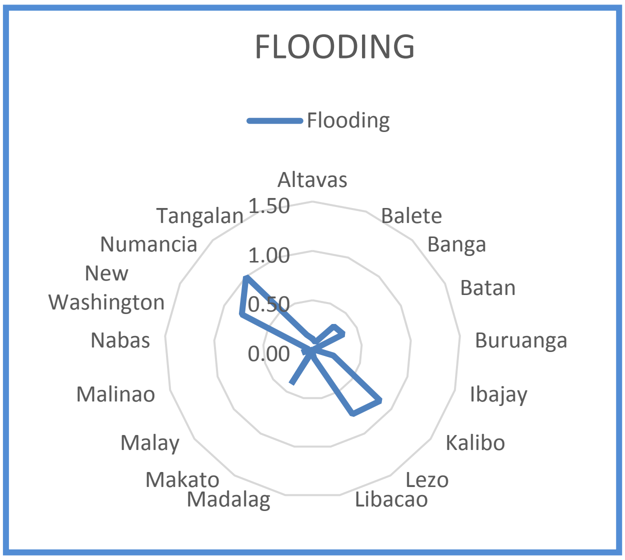



***Figure 28a.*** *Radar chart showing the tropical cyclone occurrence in the Province of Aklan.*

***Drought.*** As sown in Figure 108, drought occurrence in the province of Guimaras is very apparent, particularly in the three municipalities. The municipalities of Buenavista and Jordan had ***very high*** rating to drought while San Lorenzo had ***high***. On the other hand, Nueva Valencia got ***very low*** rating. Three of the five municipalities, therefore, are expected to suffer the risks of droughty conditions in their area in the near future.

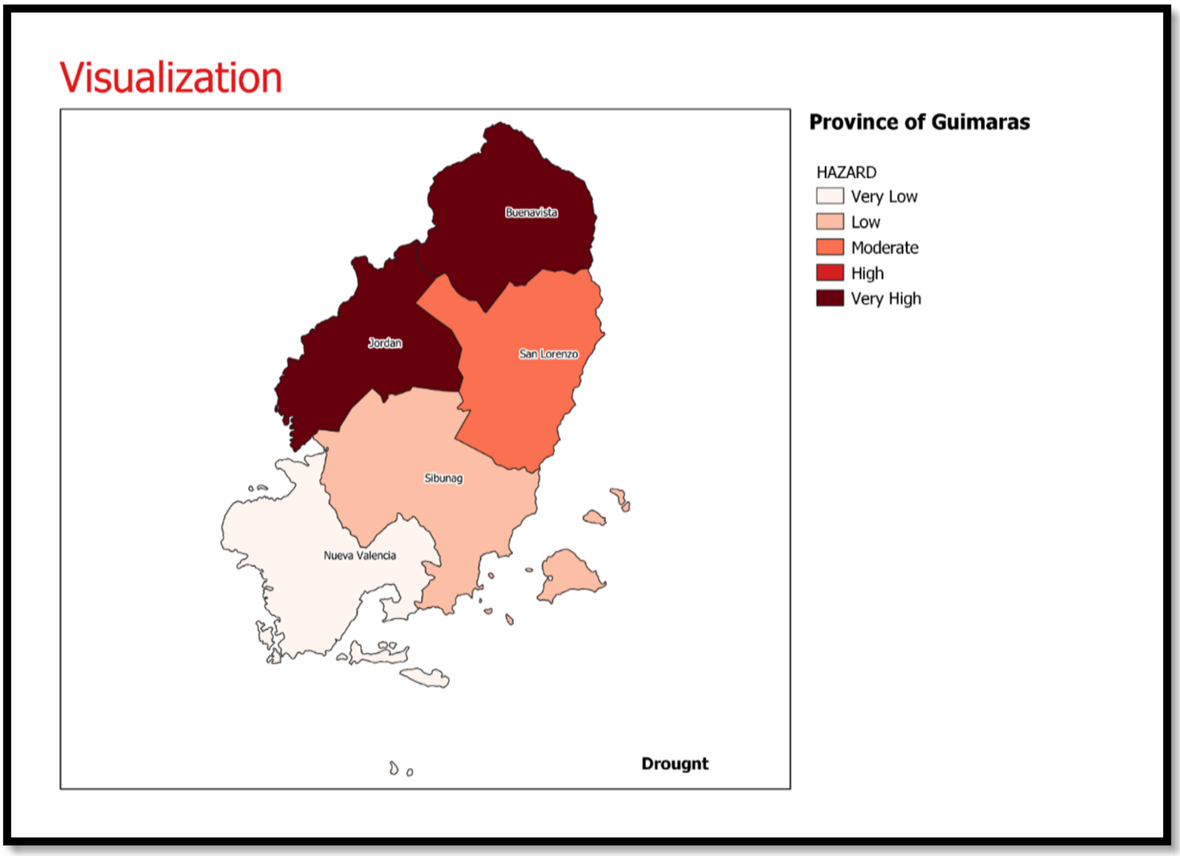



***Figure 108.*** *Visualization map showing the level of vulnerability of the province of Guimaras to drought.*

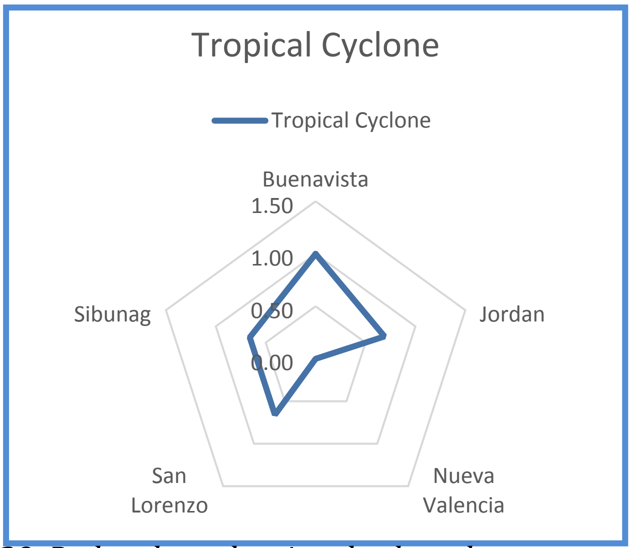



***Figure 29.*** *Radar chart showing the drought occurrence in the Province of Aklan.*

***Flooding.*** Low-lying areas of the province are generally flood-prone. In the province of Guimaras, the western tip of the island is flood-prone. Nueva Valencia which is located in this area had ***very high*** rating to the risk of flooding; Sibunag got ***high*** rating. On the other hand, the rating for Buenavista was ***moderate*** while Jordan and San Lorenzo got ***very low*** rating (Figure 109).

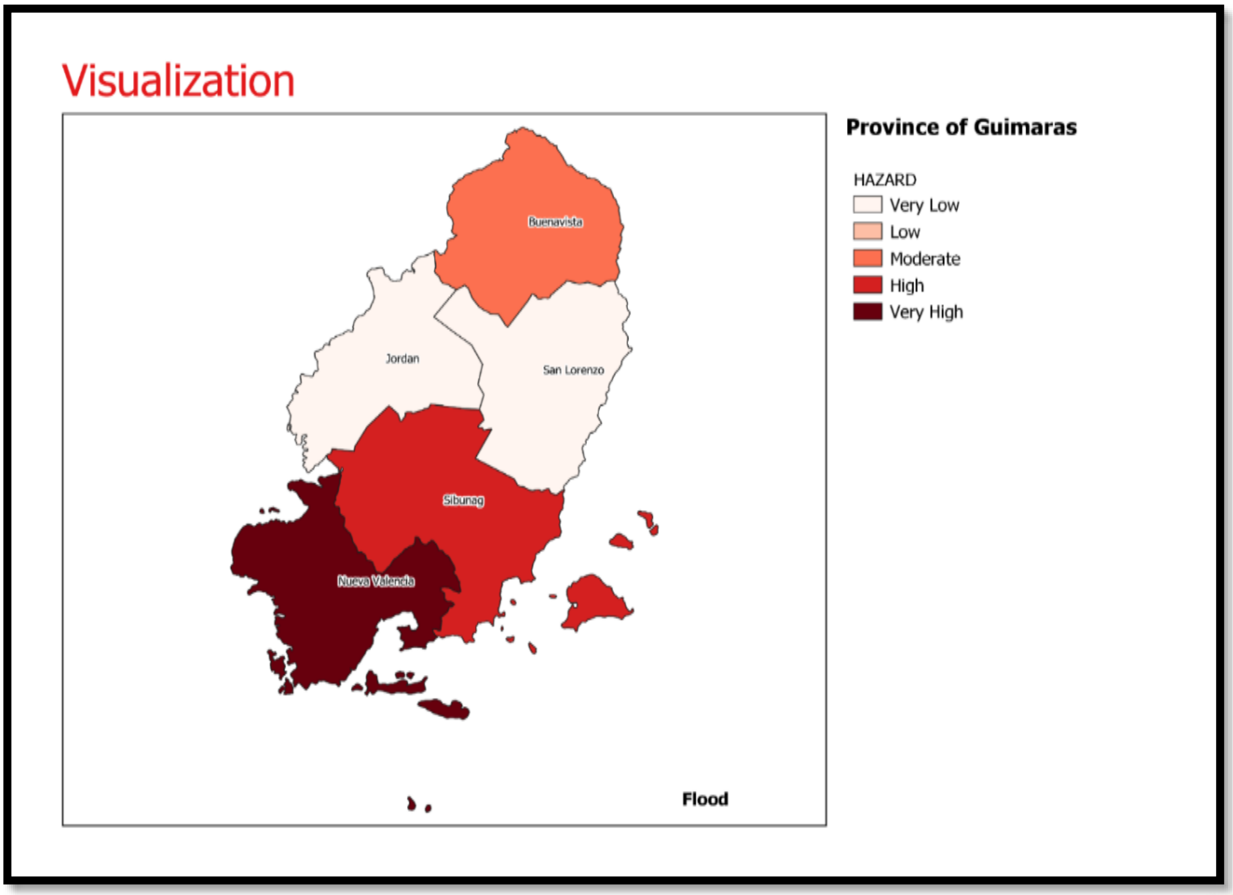



***Figure 109.*** *Visualization map showing the level of vulnerability of the Province of Guimaras to the hazard of flooding.*

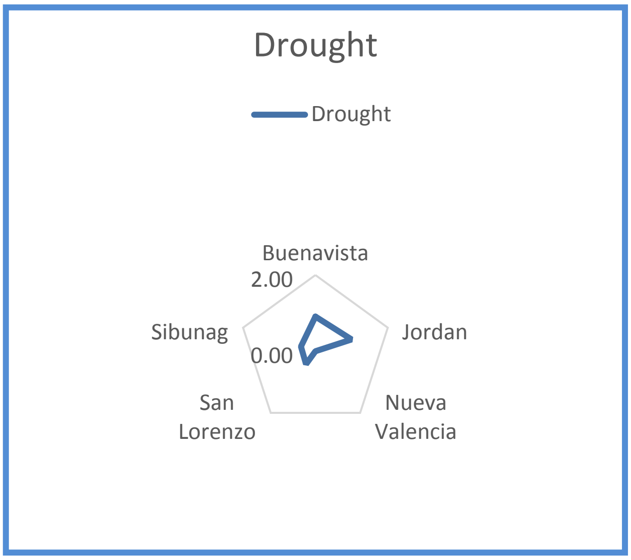



***Figure 31.*** *Radar chart showing the occurrence of floods in the in the Province of Aklan.*

***Landslides.*** Mountainous areas without sufficient vegetative cover are highly susceptible to landslides. Buenavista which is located in the eastern portion of the island appeared to be vulnerable to this risk (Figure 110). It got a ***very high*** rating to landslides. Jordan was rated ***high*** while Sibunag was ***moderate***. On the other hand, San Lorenzo and Nueva Valencia were rated ***low*** and very low risk, respectively.

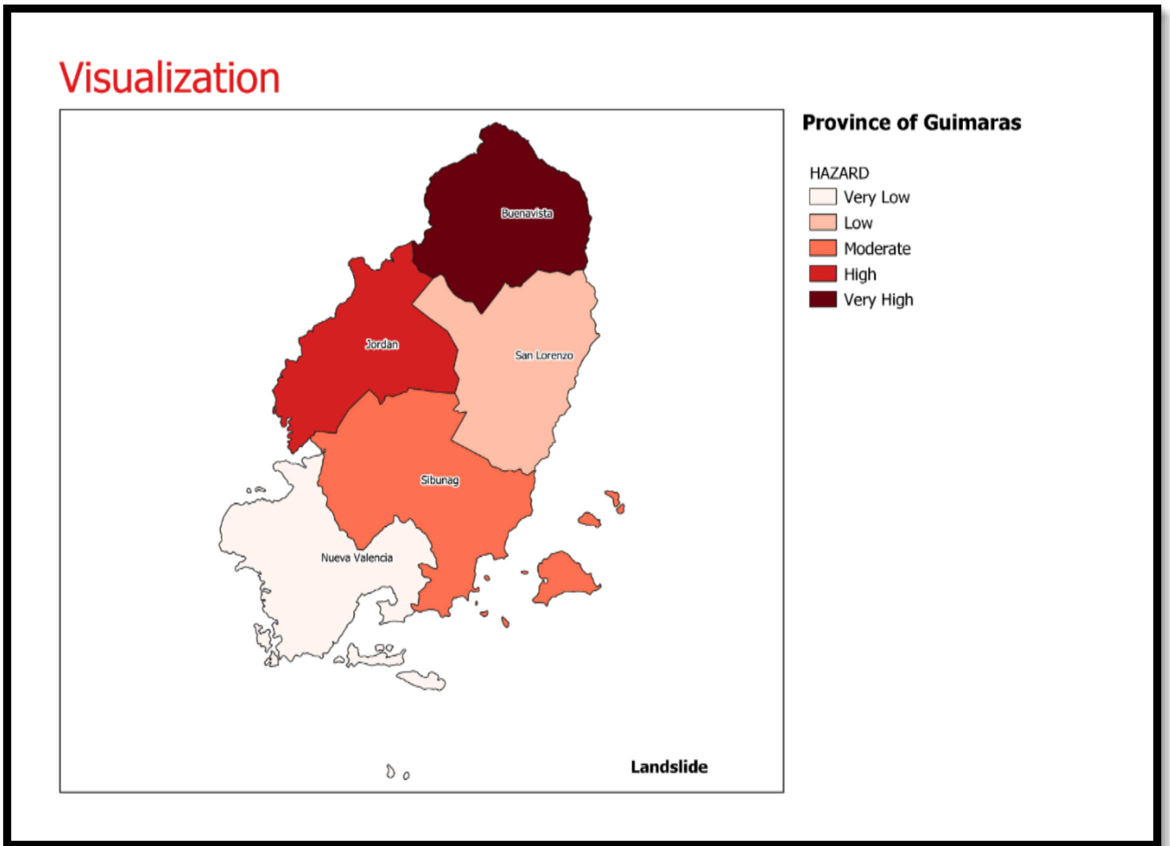



***Figure 110.*** *Visualization map showing the level of vulnerability of the Province of Guimaras to landslides.*

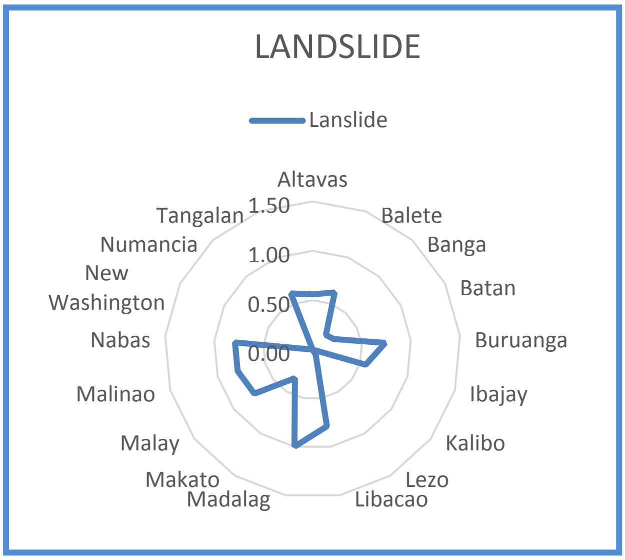



***Figure 33.*** *Radar chart showing landslide occurrence in the in the Province of Aklan.*

***Sea level rise.*** The Province of Guimaras is an Island surrounded by bodies of water, hence some of its areas are also vulnerable to sea level rise. Specifically, two of its municipalities (Nueva Valencia and Sibunag) had ***very high*** rating to this climate event (Figure 111). San Lorenzo got ***high*** hazard rating, Buenavista had ***low*** while Jordan got ***very low*** rating.

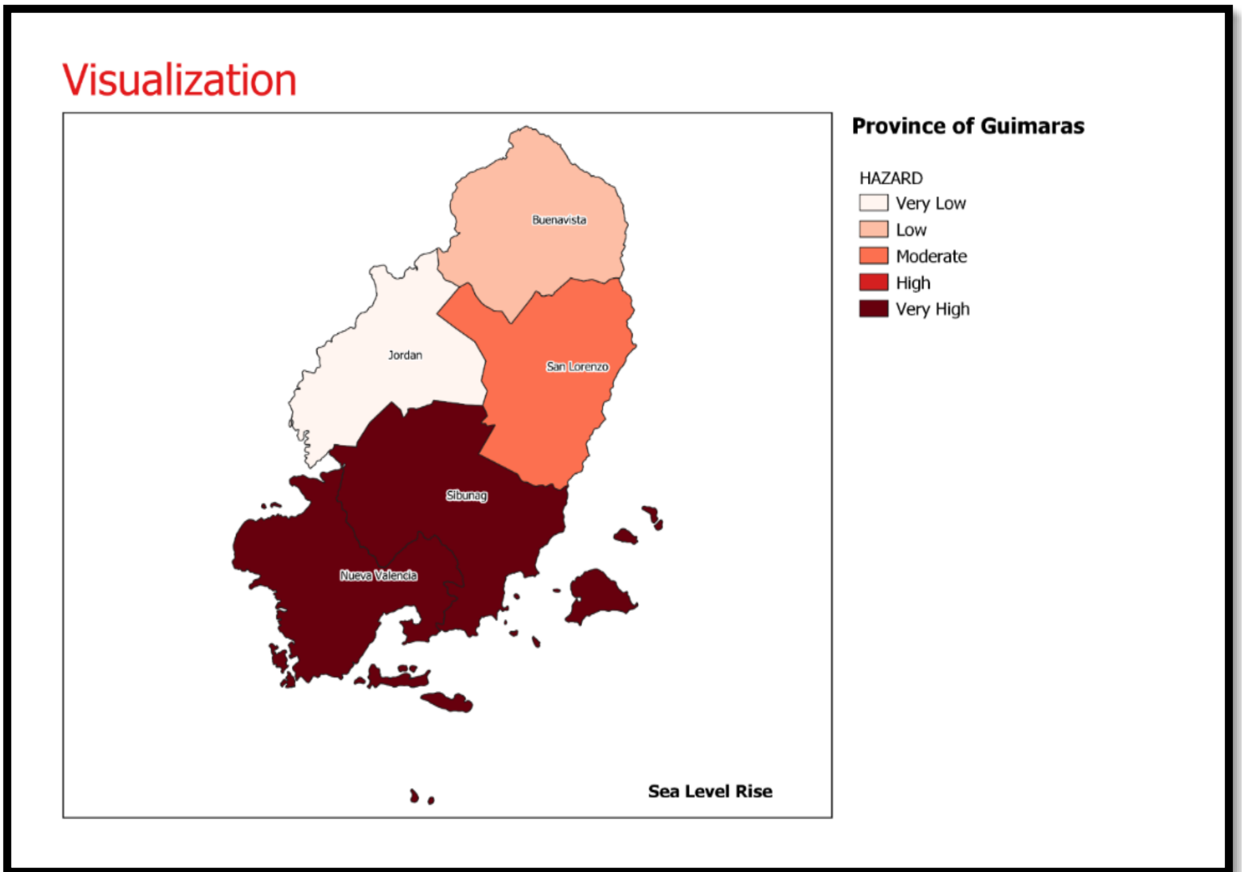



***Figure 111.*** *Visualization map showing the level of vulnerability of the province of Guimaras to sea level rise.*

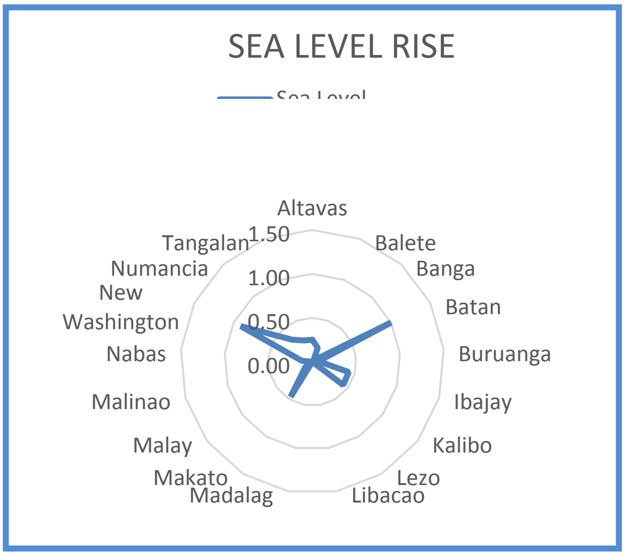



***Figure 35**. Radar chart showing the sea level rise occurrence in the in the Province of Aklan.*

***Soil erosion***. Soil erosion is another hazard to which coastal as well as hilly and mountainous areas are inevitably vulnerable. As shown in Figure 112, the municipalities of Jordan and Buenavista were rated to have a ***very high*** risk to erosion while San Lorenzo was rated ***high***. On the other hand, Sibunag and Nueva Valencia had ***low*** and ***very low*** rating, respectively.

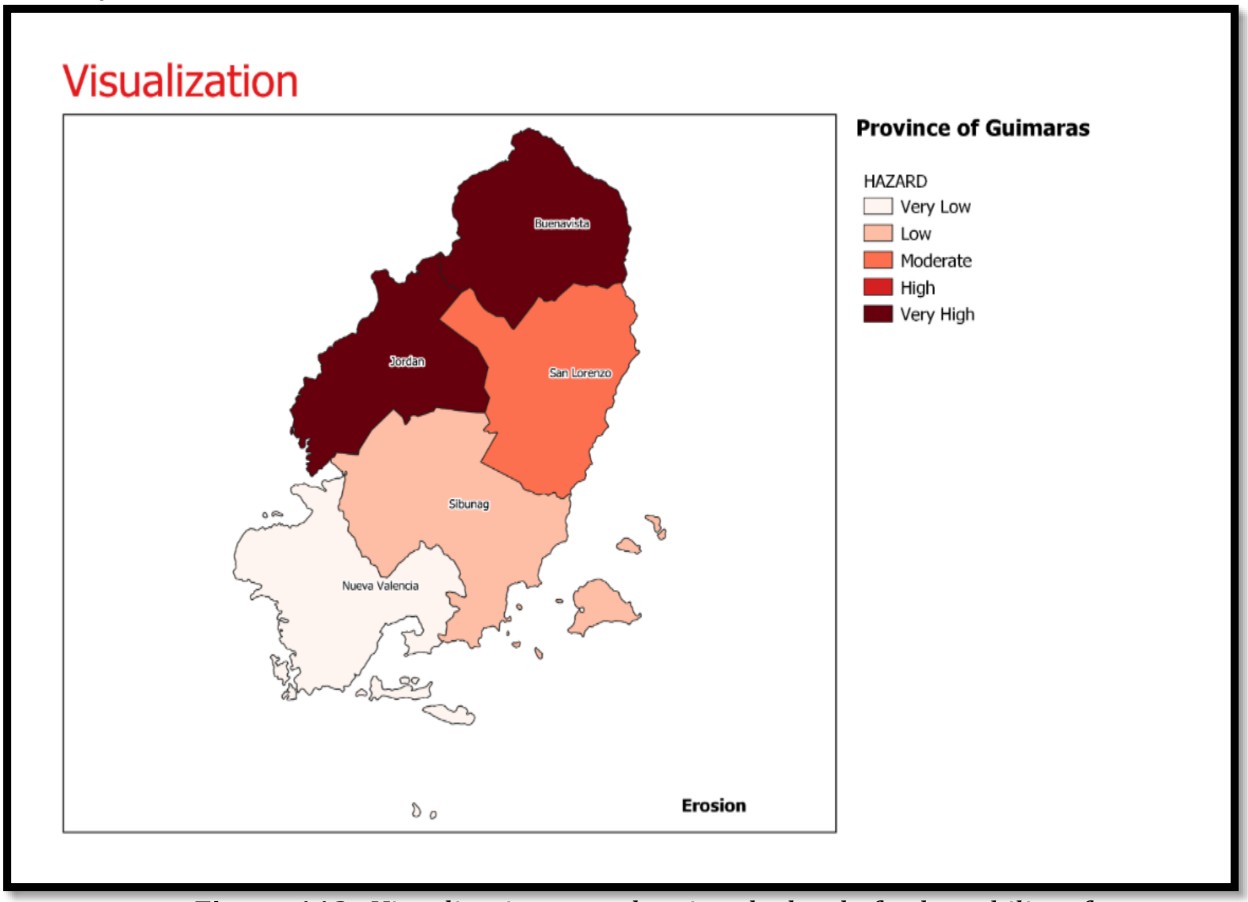



***Figure 112.** Visualization map showing the level of vulnerability of the Province of Guimaras to erosion.*

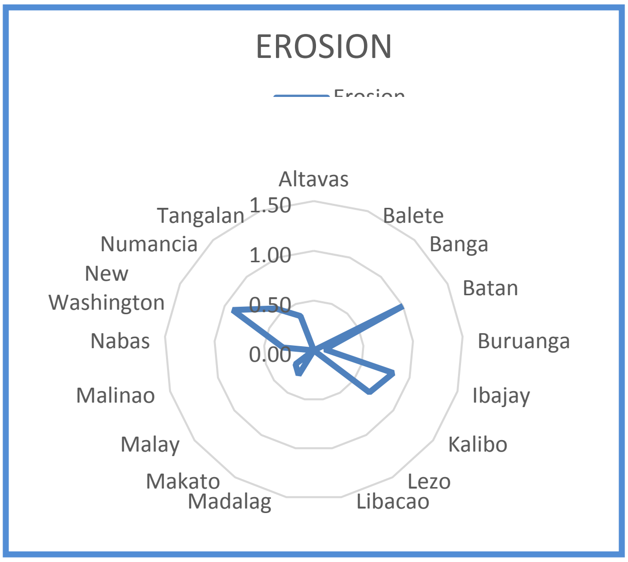



***Figure 37.*** *Radar chart showing the occurrence of erosion occurrence in the Province of Guimaras.*

***Storm surge.*** Similar to erosion, coastal areas are highly vulnerable to storm surge. In the Guimaras, the vulnerability of the municipalities to this climatic hazard ranged from moderate to very high. Sibunag and San Lorenzo which southwestern seaboards are fully exposed to the open sea and therefore highly vulnerable to storm surge This is particularly during the *habagat* season. These two municipalities were rated a *very high* risk to storm surge. Nueva Valencia, on the other hand, was rated ***high*** while Buenavista and Jordan got a ***low*** and ***very low*** rating on this climatic event, respectively (Figure 113).

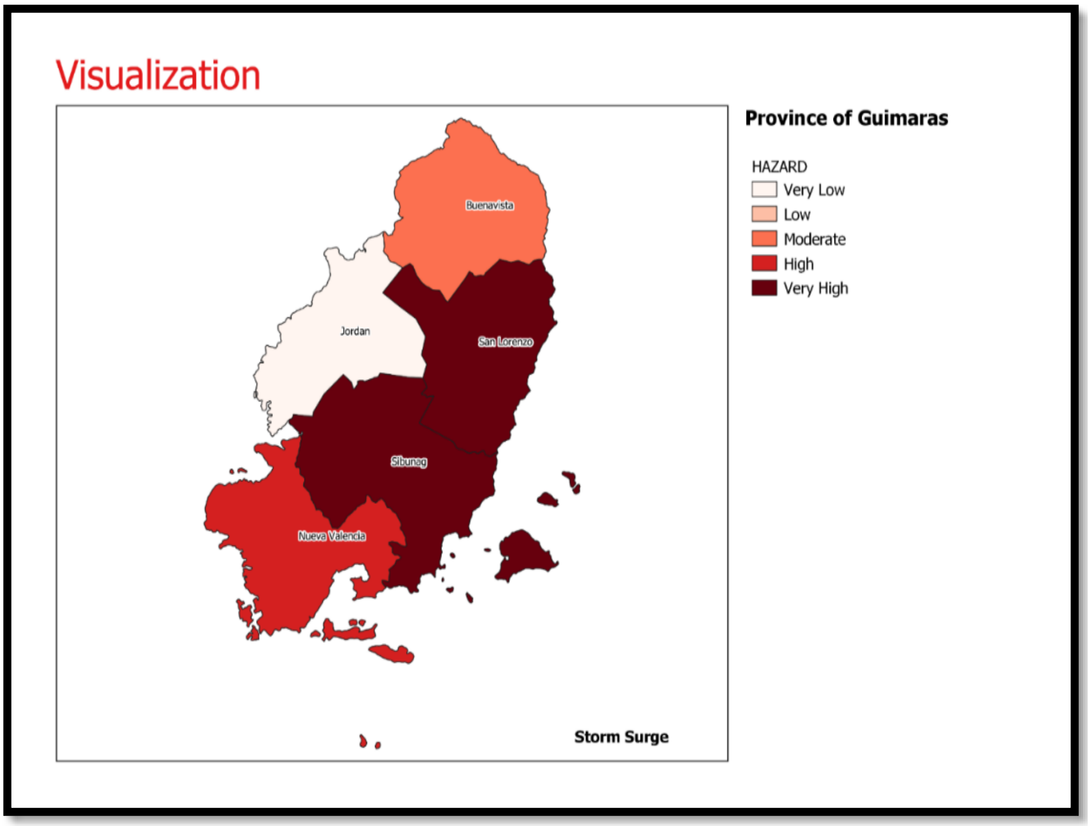



***Figure 113.*** *Visualization map showing the level of vulnerability of the province of Guimaras to storm surge.*

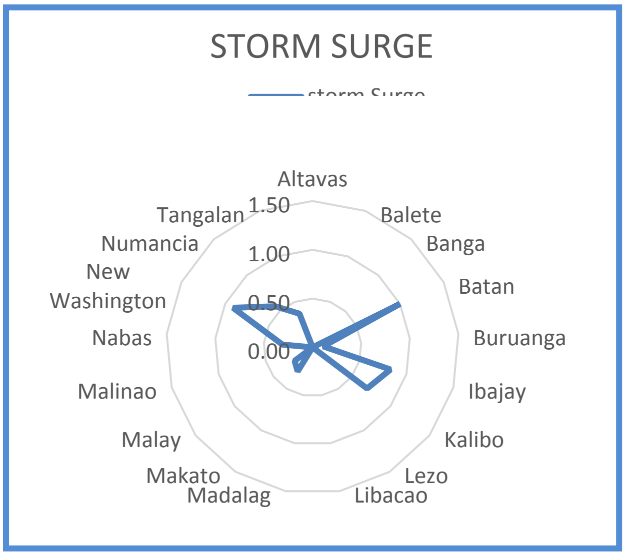



*Figure 39. Radar chart showing the occurrence of storm surge occurrence in the Province of Aklan.*

***Saltwater intrusion.*** As the visualization map in Figure 114 would suggest, the hazard or risk of saltwater intrusion in the five municipalities of Guimaras is almost absent or negligible (***very low***). That although the entire province is surrounded by bodies of saltwater, the risk of intrusion into the land is predicted to be insignificant in the near future. This must not therefore cause alarm to the inhabitants of the area.

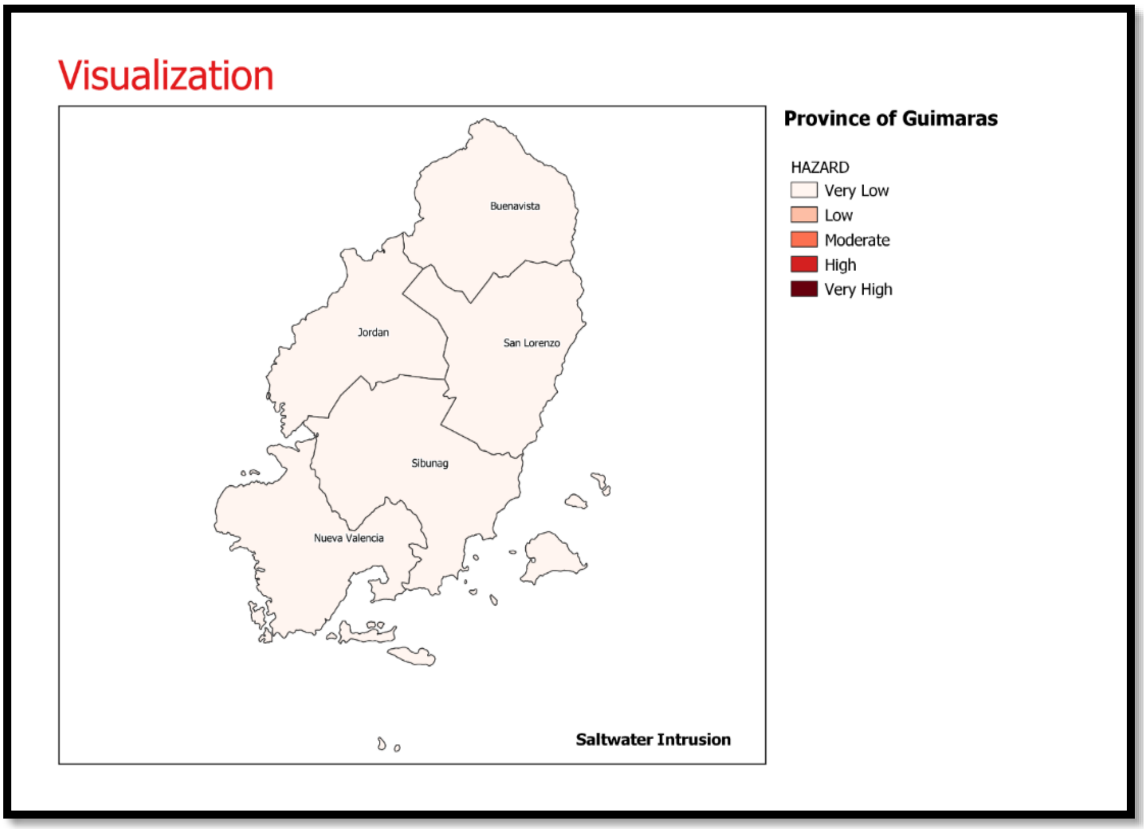



***Figure114.*** *Visualization map showing the level of vulnerability of the province of Guimaras to saltwater intrusion.*

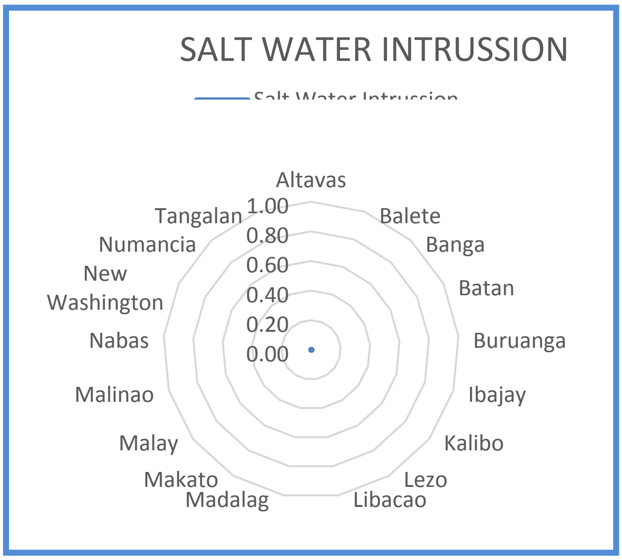



***Figure 41.*** *Radar chart showing the occurrence of salt water intrusion in the Province of Aklan.*

***Over-all hazard index.*** Figure 115 presents the maps showing the comparative level of risks of the municipalities of Guimaras to the eight common natural climatic hazards. The levels at which the municipalities are exposed to these hazards were already discussed above.

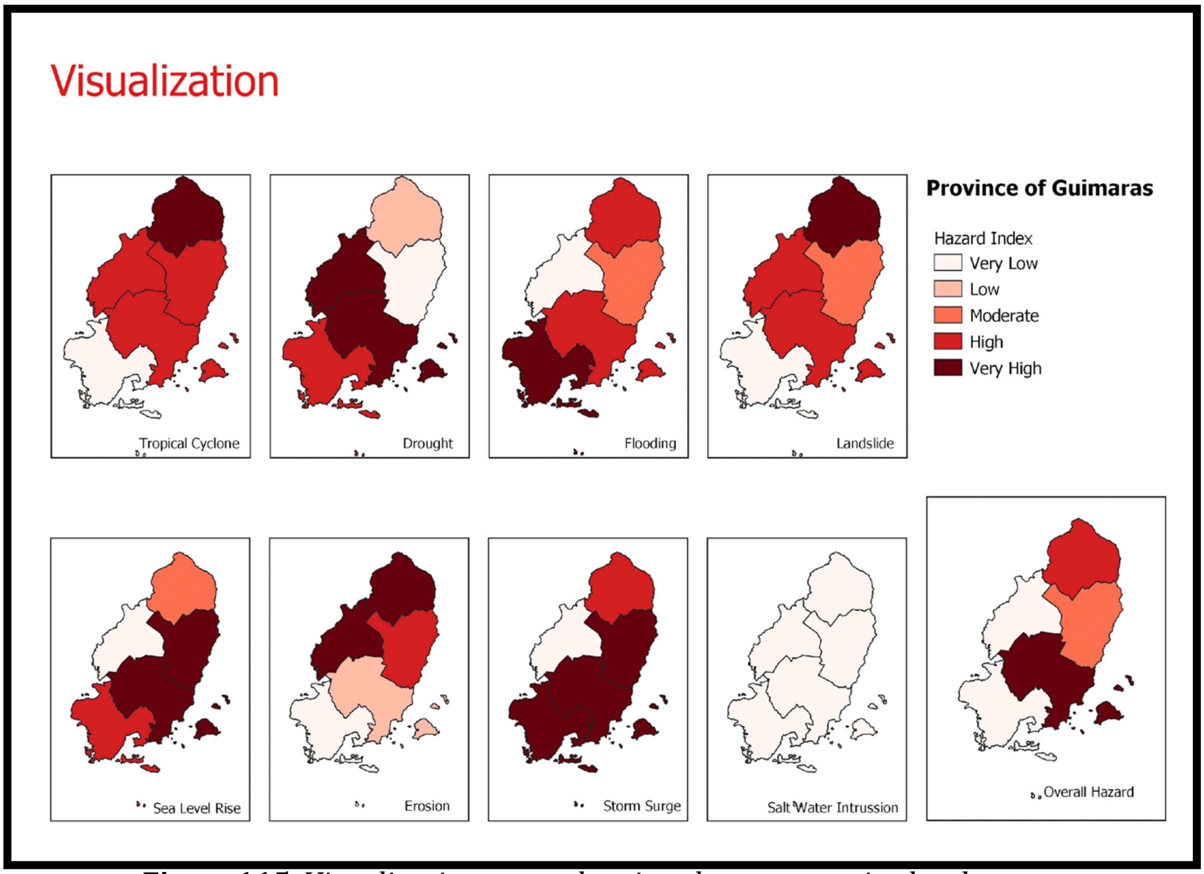



***Figure115.*** *Visualization maps showing the comparative level of hazards of the Province of Guimaras to the eight climatic events.*

## Over-all Hazard Index of the Province of Guimaras to the Eight Natural Hazards

The visualization map on the overall hazard index of vulnerability of the province of Guimaras to climatic hazards is shown in Figure 116. These summarized results are arrived at by considering the eight common natural hazards of climate change and the combination of their corresponding hazard weights.

The hazard index indicates that Buenavista was assessed to have a ***very high*** index - highly vulnerable to natural climatic events. Sibunag likewise had a ***high*** index; Jordan had ***moderate*** while San Lorenzo and Nueva Valencia had ***low*** and ***very low*** index, respectively. As may be understood, the higher the hazard index, the higher is its vulnerability to climatic events; the lower the index, the lower also is its vulnerability to these events.

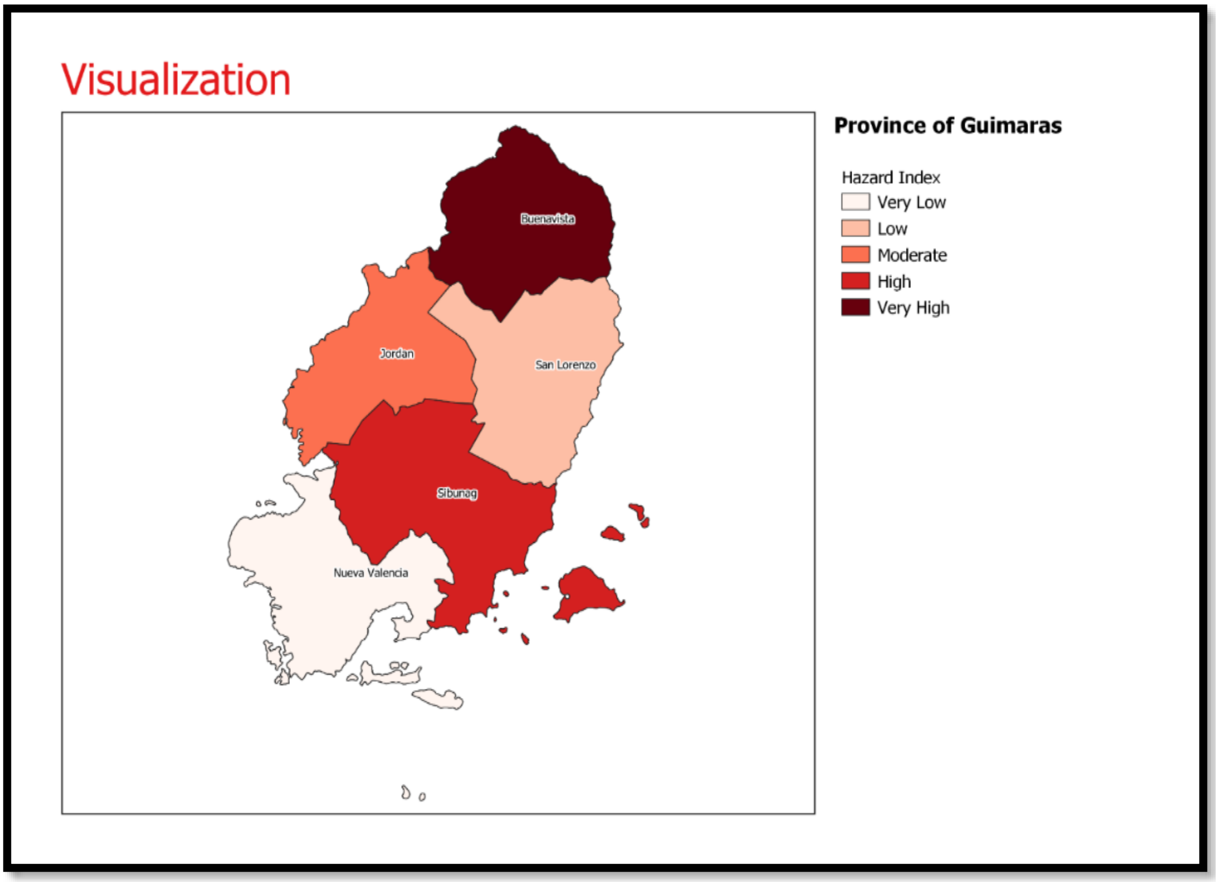



***Figure 116.*** *Visualization map showing the over-all hazard index of the province of Guimaras to the eight common natural hazards.*

## Adaptive Capacity Assessment

Similar to what were done in the other provinces, adaptive capacity of the municipalities studied were basically based on the eight adaptive capitals. These capitals were natural, economic, social, human, anticipatory, institutional, and physical. The results of the assessments of these capitals are separately discussed below.

***Natural, economic, anticipatory and human capitals.*** Based on the indicators for the evaluation of natural, economic, anticipatory and human capitals enumerated in the methodology, these four adaptive capitals yielded the same results. This is shown in the visualization map in Figures 115-118. The corresponding maps for the four capitals revealed that the municipality of San Lorenzo got ***very high*** rating. This is the municipality that has the most resources both human and material that could make the inhabitants quickly respond, mitigate and adapt to the challenges brought about by climate change. Compared with other municipalities, San Lorenzo is the least vulnerable town to climatic pressures in the province based on the four capitals mentioned. Sibunag had ***moderate*** rating while the rest of the remaining municipalities got ***very low*** rating. A greater majority of the municipalities then are vulnerable to the risks of climate change based on the four capitals. The assessment means that the higher the rating on specific adaptive capital a municipality gets, the more it is capable of responding and adapting to climate-caused adversities.

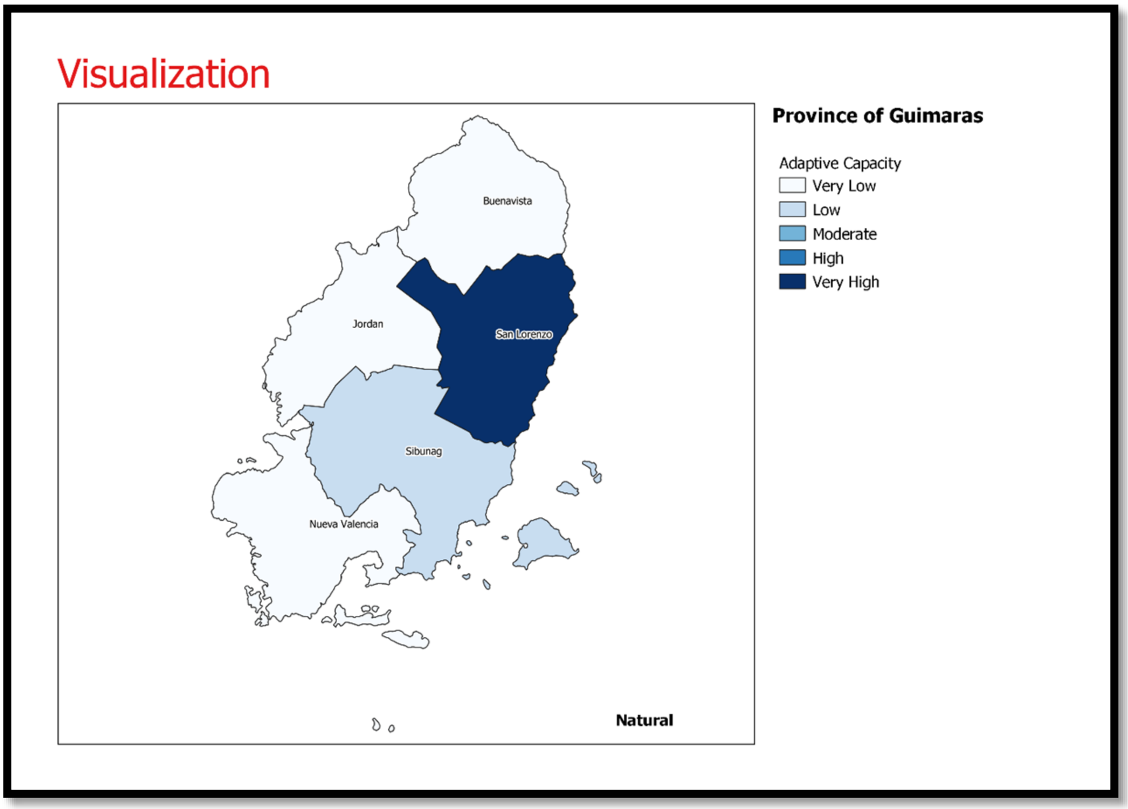



***Figure 115****. Visualization map showing the adaptive capacity of the Province of Guimaras against climate change based on its natural capital.*

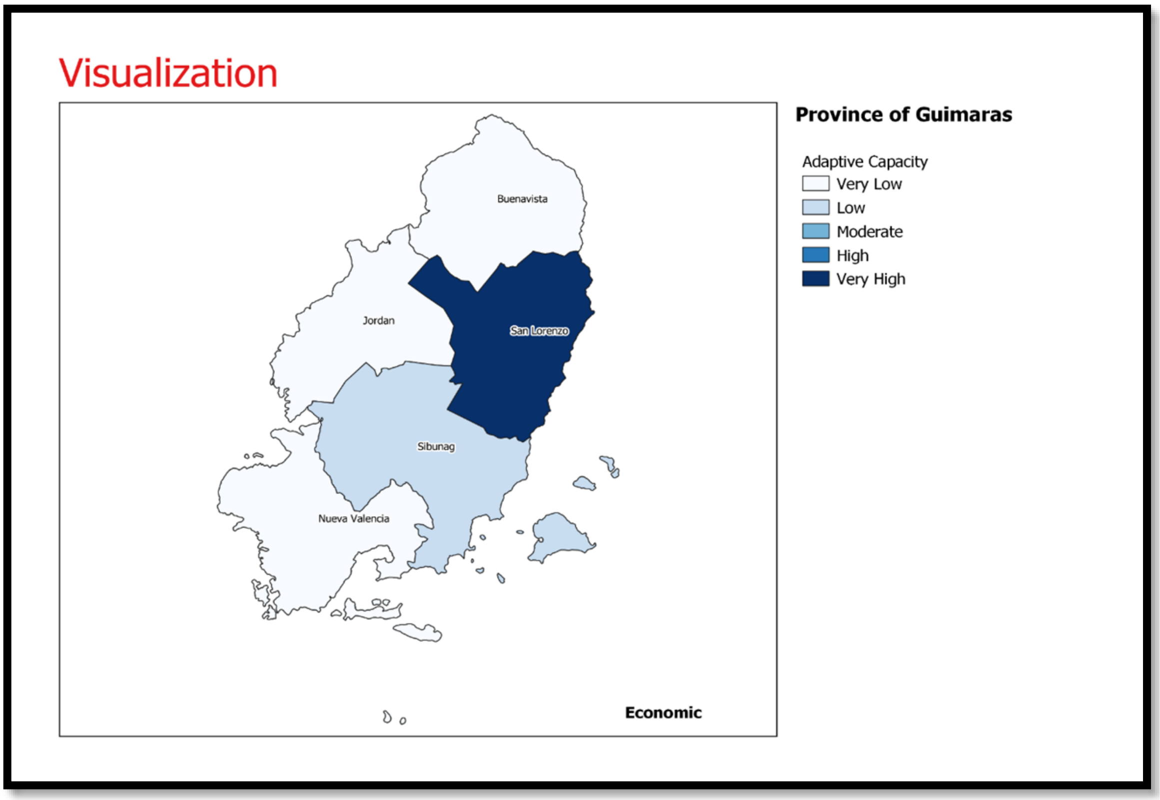



***Figure 116.*** *Visualization map showing the adaptive capacity of the Province of Guimaras against climate change based on its economic capital.*

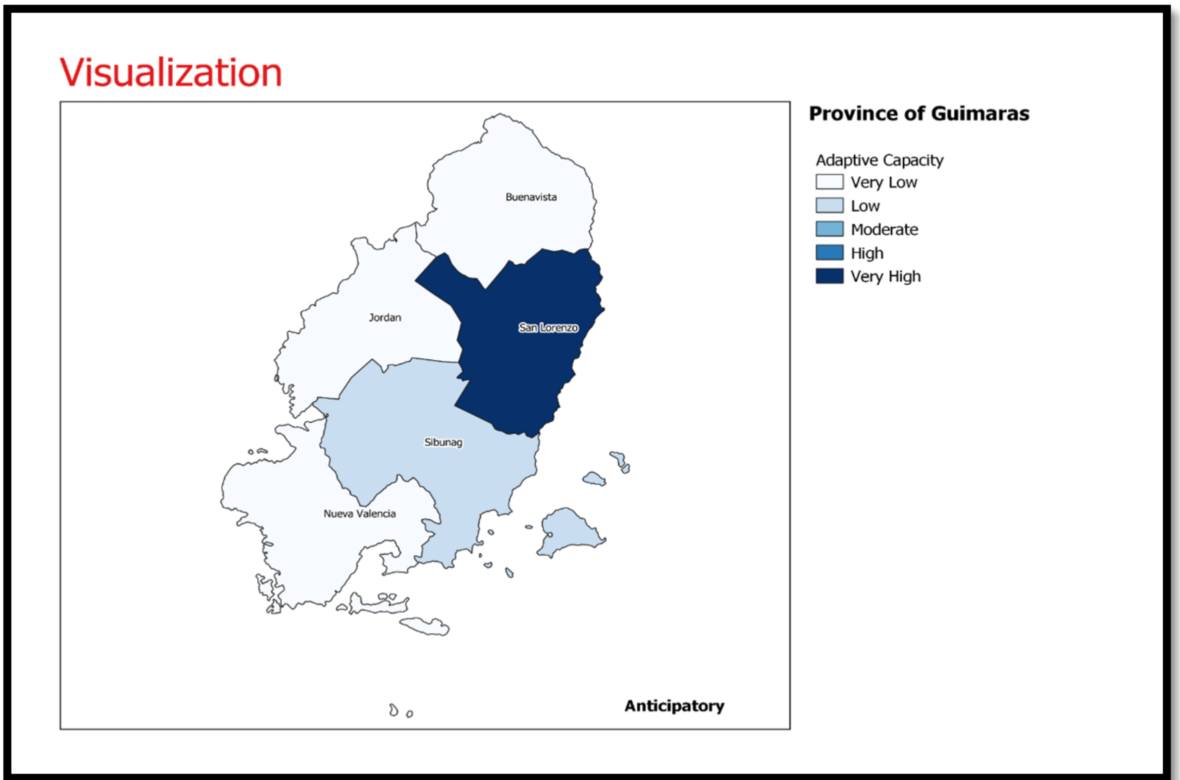



***Figure 117****. Visualization map showing the adaptive capacity of the Province of Guimaras against climate change based on its anticipatory capital.*

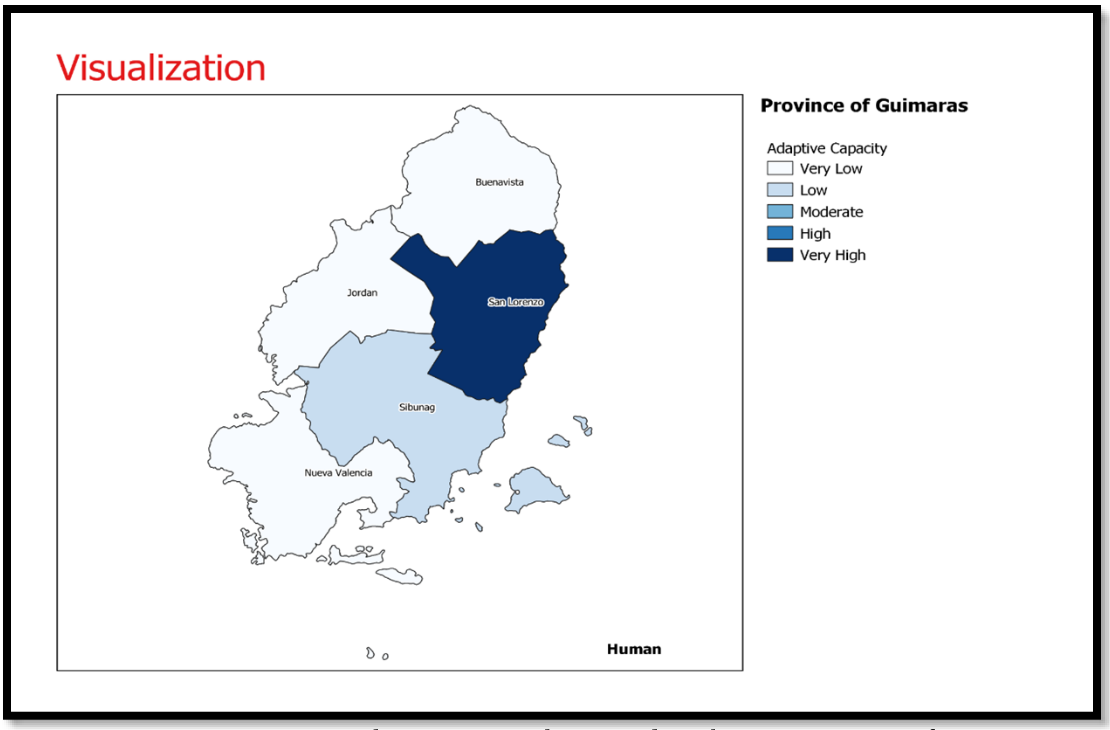



***Figure 118.*** *Visualization map showing the adaptive capacity of the Province of Guimaras against climate change based on its human l capital.*

***Social capital.*** In terms of social capital, the municipality of Nueva Valencia got a ***very high*** rating; San Lorenzo obtained a low while Jordan and Sibunag had a ***very low*** adaptive capacity rating (Figure 119).

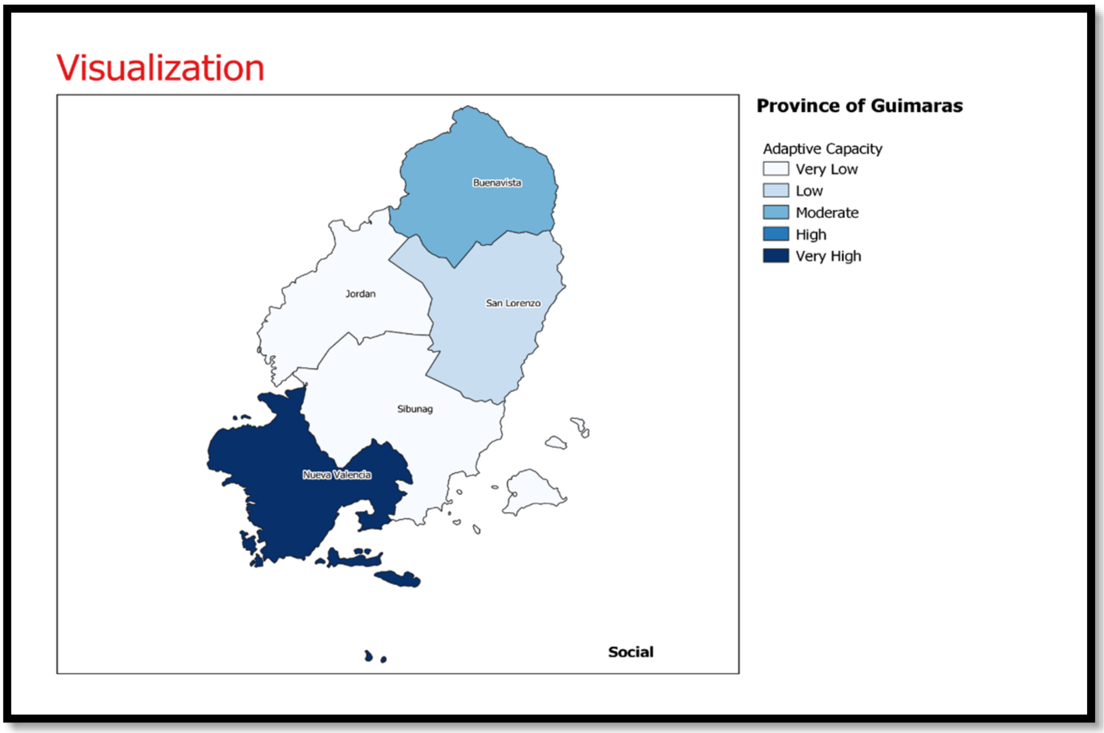



***Figure 119.*** *Visualization map showing the adaptive capacity of the Province of Guimaras against climate change based on its social l capital.*

***Institutional capital.*** The municipality of Jordan got a ***very high*** adaptive capacity in terms of its institutional capital as shown by visualization map in Figure 120; Buenavista had ***moderate*** rating. On the other hand, Sibunag and Nueva Valencia got a ***low*** rating while San Lorenzo had ***very low*** rating.

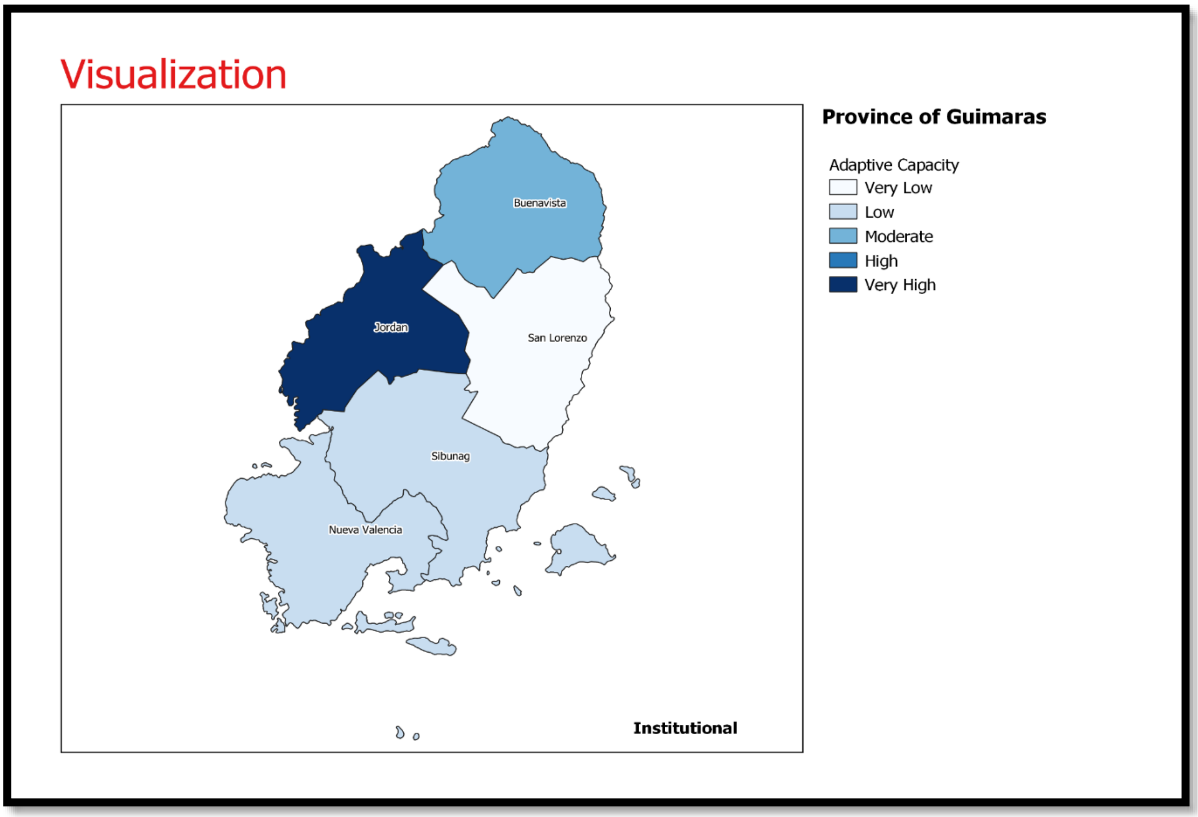



***Figure 120.*** *Visualization map showing the adaptive capacity of the Province of Guimaras against climate change based on its institutional capital.*

***Physical capital.*** As shown by visualization map in Figure 121, Sibunag got a ***very high*** rating in physical capital while Buenavista had **high** and San Lorenzo ***moderate***, On the other hand, Jordan got ***low*** rating while Nueva Valencia obtained a ***very low*** rating in this adaptive capacity capital.

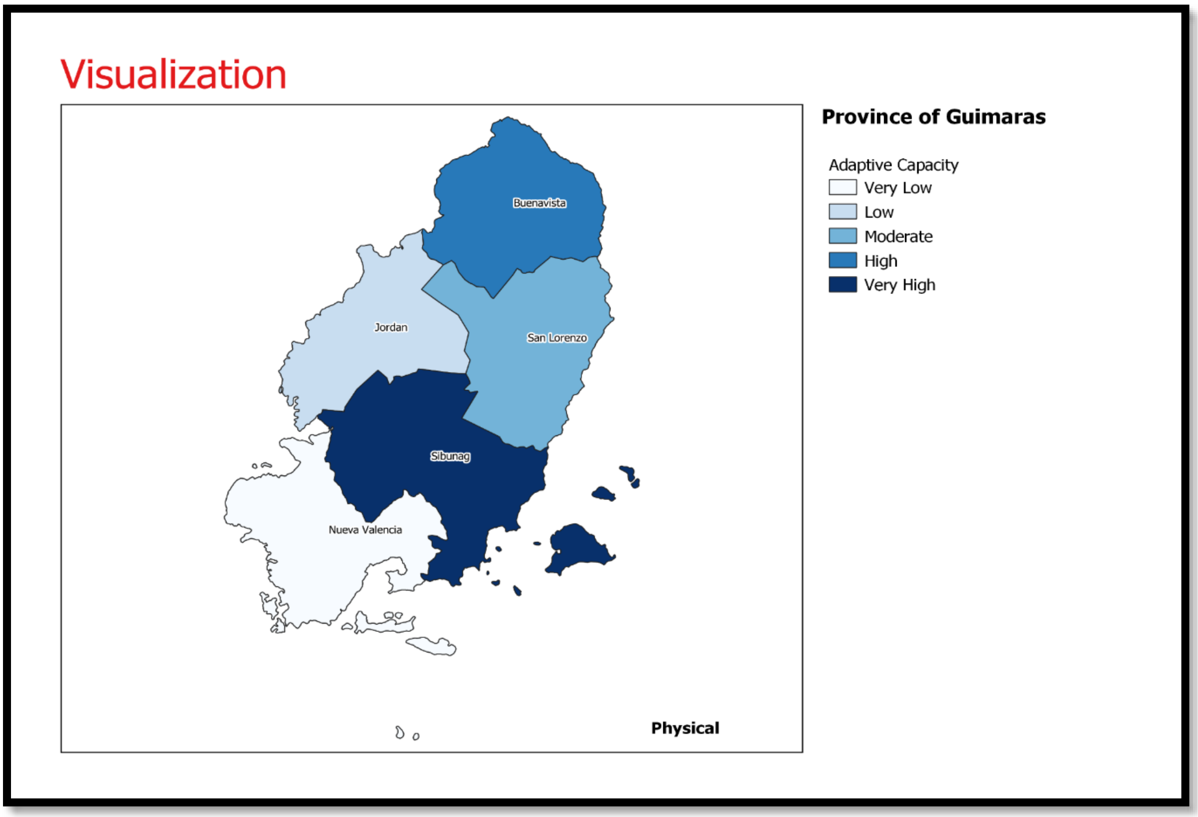



***Figure 121.*** *Visualization map showing the adaptive capacity of the Province of Guimaras against climate change based on its physical capital.*

## Adaptive Capacity assessment for the Province of Guimaras

On the over-all adaptive capacity of the Province of Guimaras to climate change based on the eight adaptive capitals, the visualization map in Figure 123 revealed that Nueva Valencia and Buenavista had ***very high*** adaptive capacity together with Jordan which got a ***high*** rating. Sibunag and San Lorenzo, on the other hand, got a ***very low*** capacity. In the province of Guimaras, therefore, the two municipalities which obtained very high rating on adaptive capacity, could be characterized as having the capacity or capability to adapt to the adverse effect of climate change through mitigation efforts and coping activities that could improve resiliency.

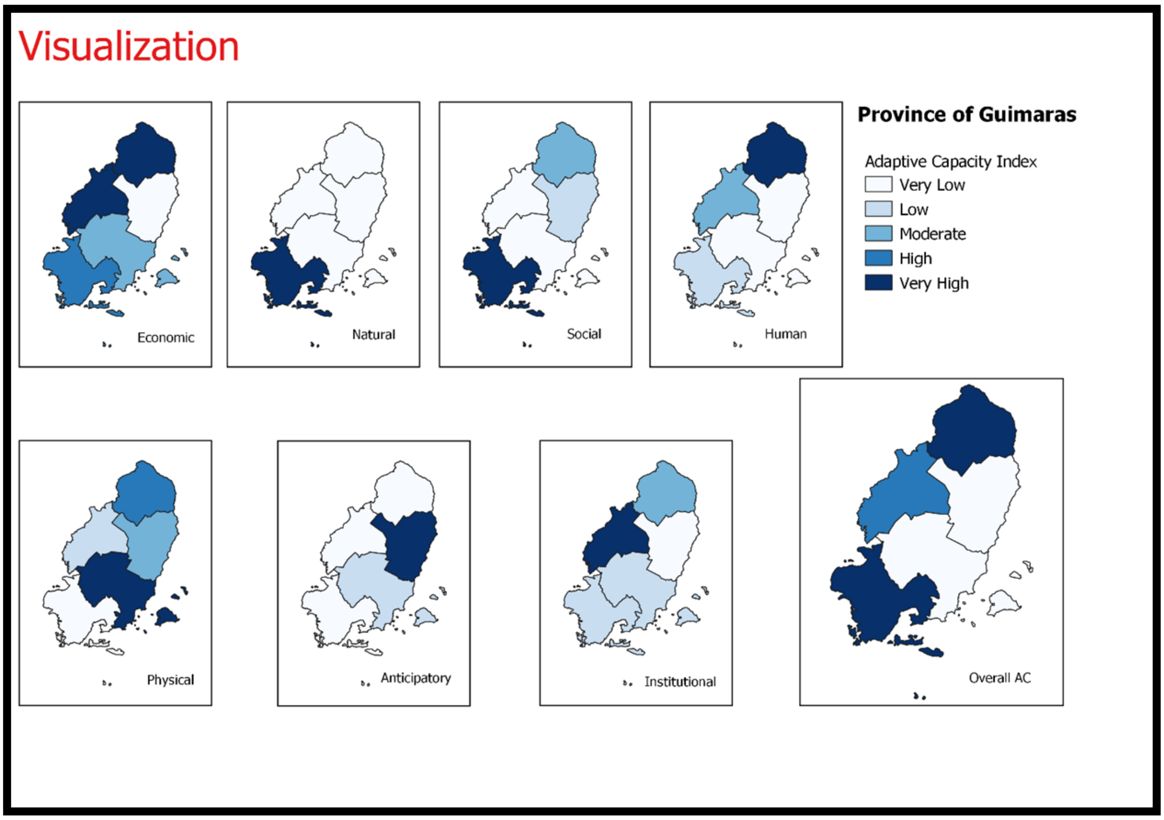



***Figure 123.*** *Visualization map showing the adaptive capacity of the province of Guimaras against climate change based on the eight capitals used as indicators.*

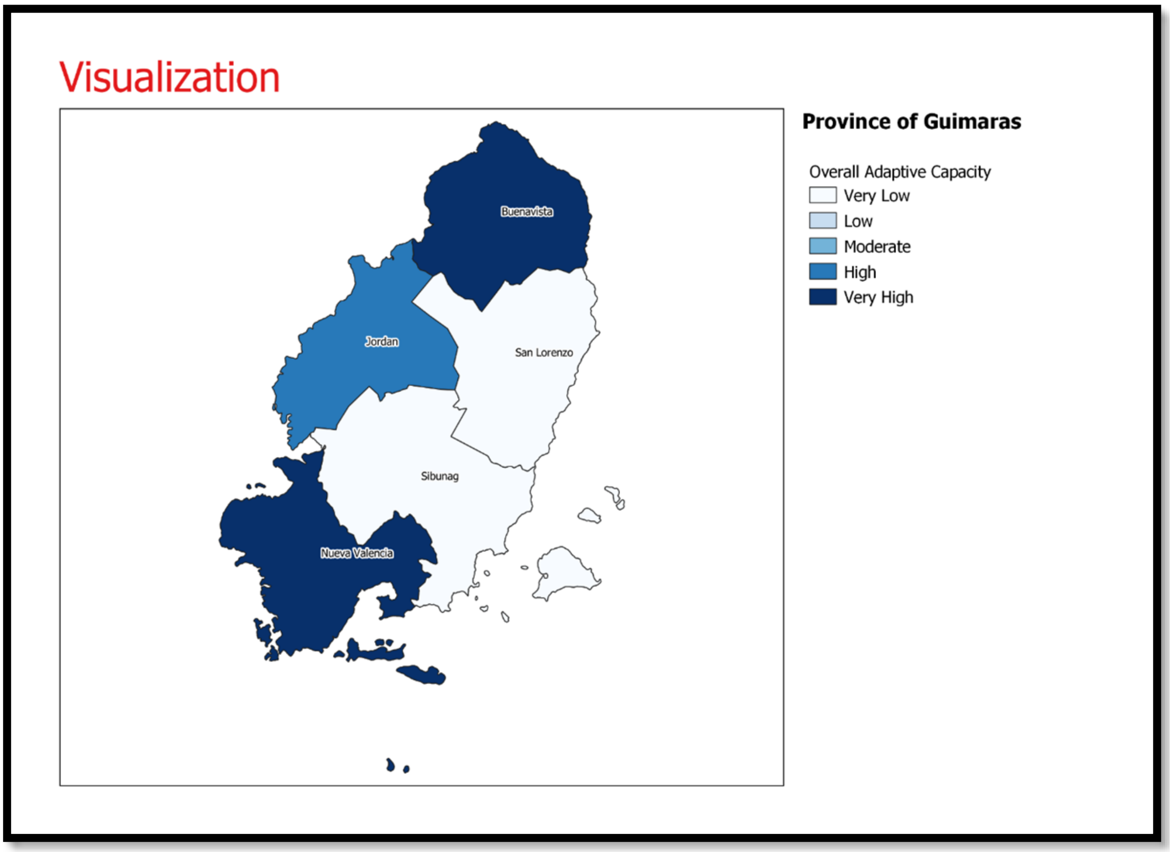



***Figure 123****. Visualization map showing the over-all adaptive capacity of the province of Guimaras against climate change based on the eight capitals used as indicators.*

## Adaptive Capacity index for the Province of Guimaras.

Similar to the over-all adaptive capacity of the province of Guimaras, Sibunag and San Lorenzo had ***very high*** adaptive capacity index; Nueva Valencia and Jordan had ***low*** while Buenavista got ***very low*** index (Figure 124). As explained in the over-all rating, the two municipalities have resources that would enable them to cope, withstand and adapt to the harsh climatic events that may strike the province.

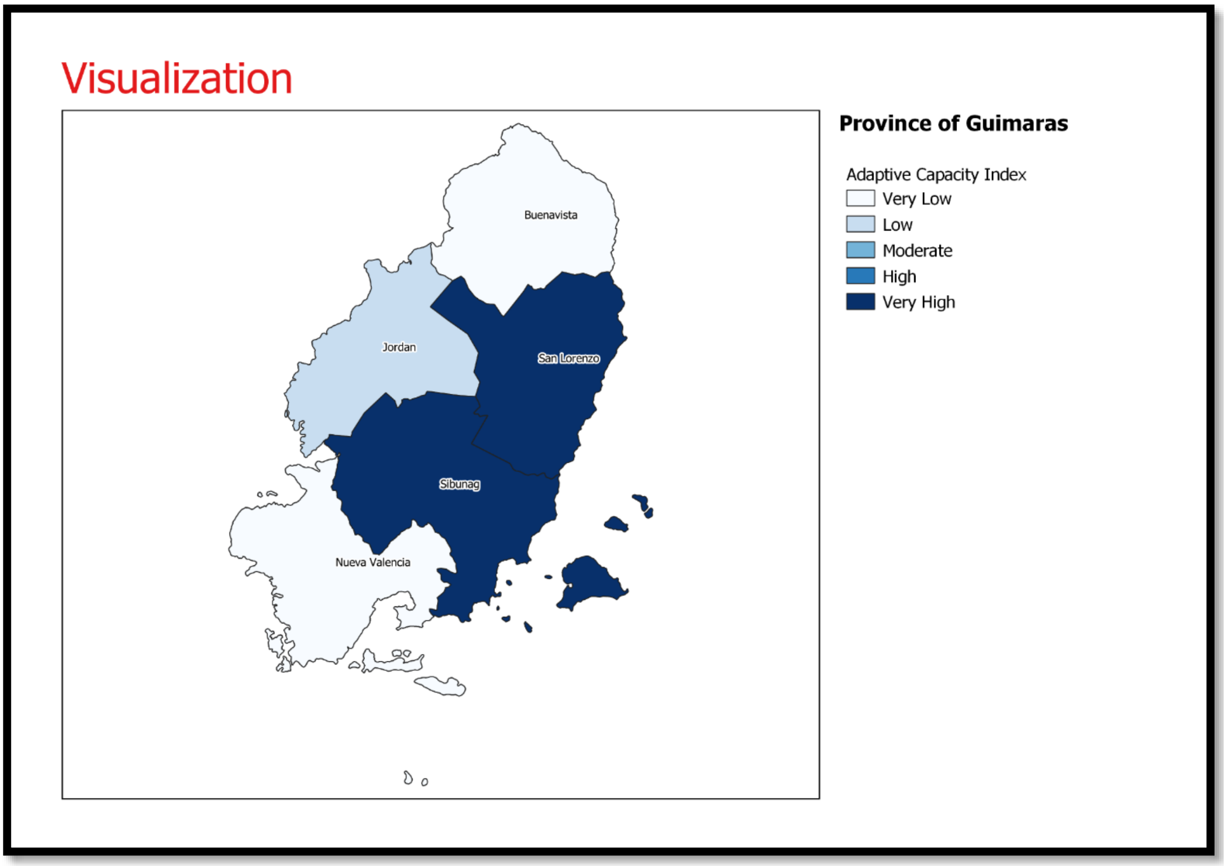



***Figure 124.*** *Adaptive Capacity index of the Province of Guimaras.*

## Over-all Climate Vulnerability Assessment For the Province of Guimaras

The municipalities of Sibunag and San Lorenzo for the Province of Guimaras were found to be the most vulnerable to climate change (***very high***). The assessment result further revealed that Jordan and Buenavista have a low vulnerability; however, Nueva Valencia ranked the lowest (***very low rating***) among all the municipalities in the province. Thus, it is strongly suggested that concerned agencies must intercede by introducing climate change-related interventions in the municipalities of Sibunag and San Lorenzo to abate and mitigate the possible impacts of climate change.

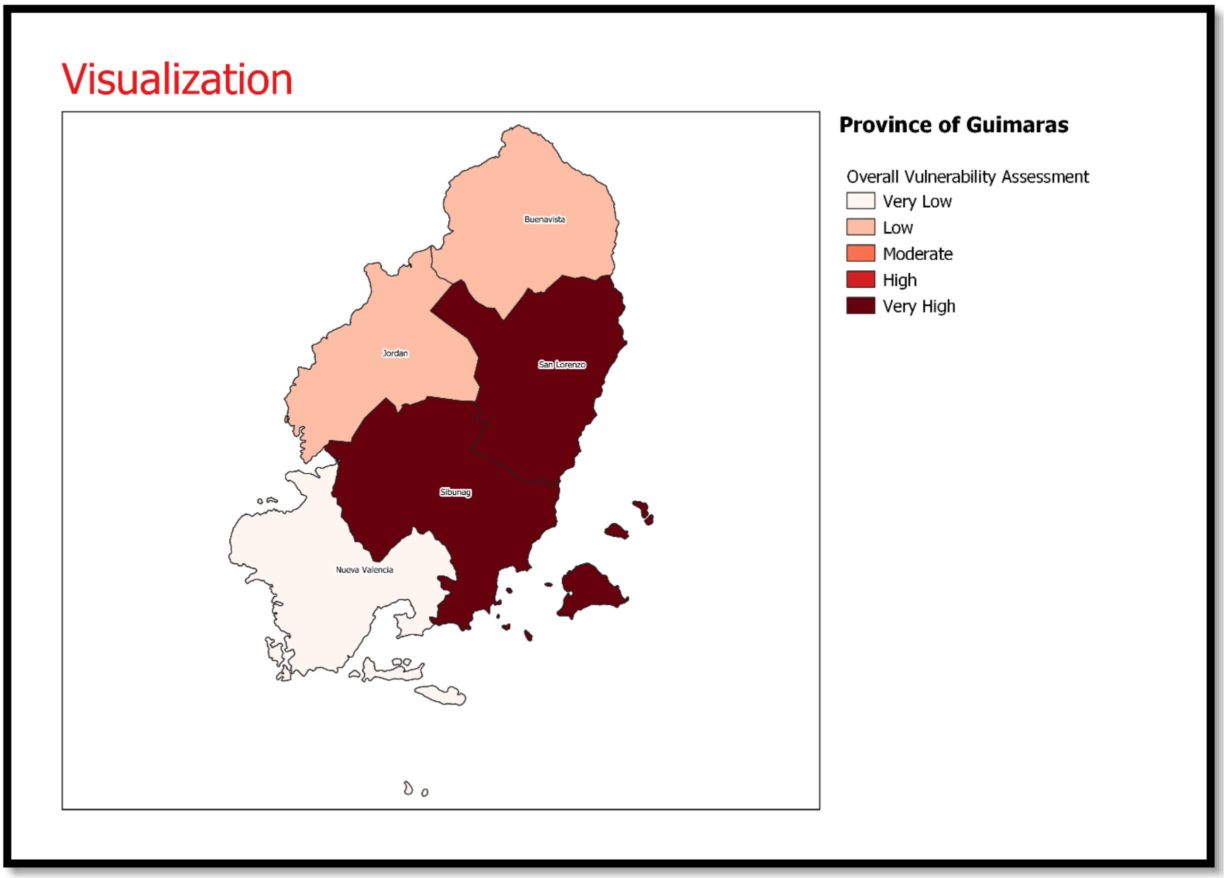



***Figure 125.*** *Over-all Climate Vulnerability Assessment of the Province of Guimaras.*

## Climate Risk Vulnerability

The weights assigned to each of the components were adopted from the study of CIAT (International Center for Tropical Agriculture), as an expert's opinion which indicates 15% (exposure), 15% (sensitivity), and 70% (adaptive capacity). Figure 15 exhibited overall vulnerability assessment results of Aklan, Antique, Capiz, and Guimaras in Western Visayas classified into five levels --very low, low, moderate, high, and very high. The results were presented to Local Government Units (LGUs) face to face (once) and virtual (twice). Before drafting the technical paper, all the amendments made by all LGUs involved concerning the data, comments, and suggestions were integrated.

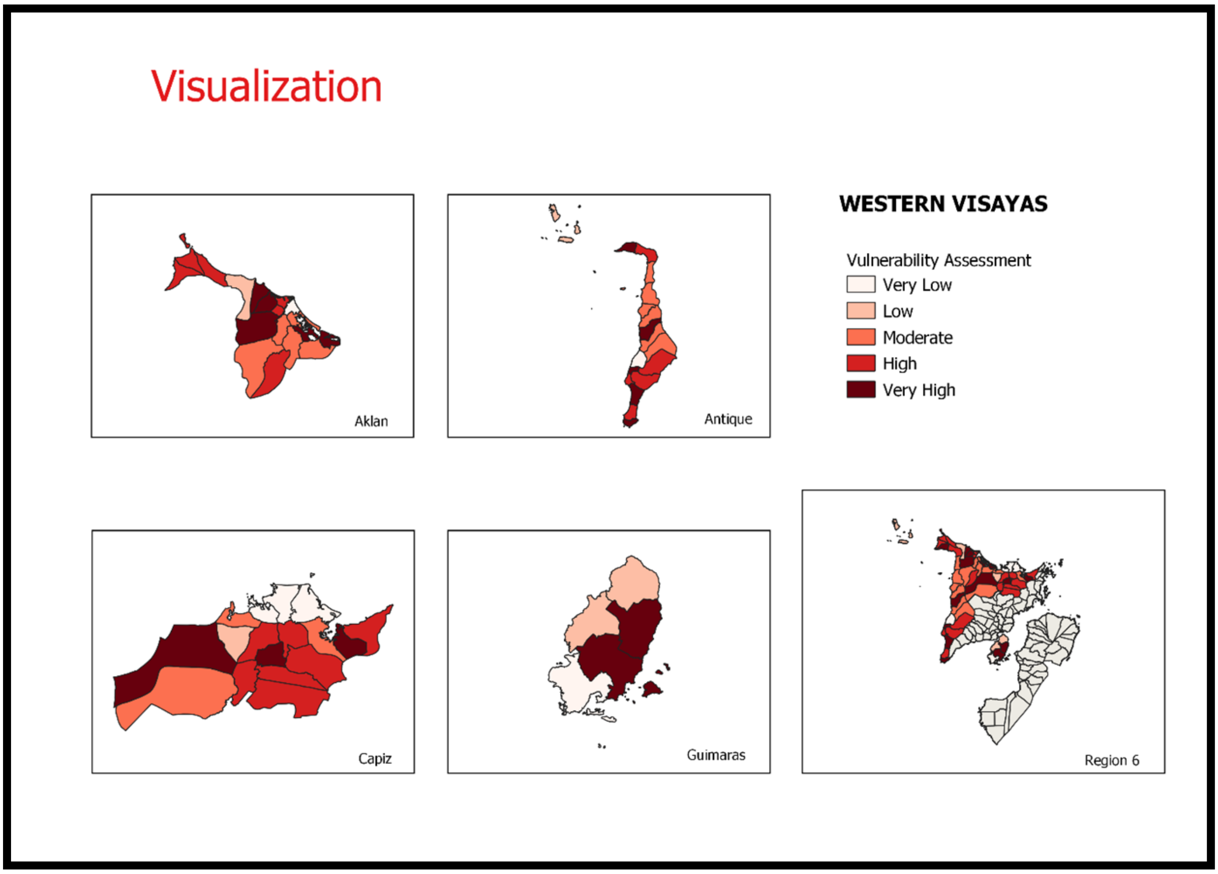



**Figure 15.** Climate Risk Vulnerability Assessment Result in the Western Visayas

Given the standard weights adopted from CIAT, the result of CRVA shows that in the Province of Aklan, the municipalities of Batan, Malinao, Makato, Tangalan are the most vulnerable to the impacts of climate change, followed by Lezo, Nabas, Malay, respectively. Moreover, municipalities of Altavas, Balete, Kalibo, and Ibajay obtained the lowest vulnerability scores. This scenario further recommends that the municipalities of Batan, Malinao, Makato, and Tangalan are in much need of climate change intervention and mitigation projects.

Using the component weights, the result of CRVA in the Province of Antique determined that the municipalities of Anini-y, Hamtic, Belison, Laua-an, and Libertad are the most vulnerable to the impacts of climate change. It concludes that the delivery of climate change interventions is much needed in said municipalities so that effects of climate change can be mitigated and vulnerability can be minimized.

Vulnerability assessment for the Province of Capiz using the same standard weight showed that the municipalities of Jamindan, Dao, and President Roxas as the most vulnerable to climate change. However, municipalities of Panay and Ivisan, including Roxas City, got the lowest vulnerability score. Thus, it is concluded that purveying climate change interventions is much needed in Jamindan, Dao and President Roxas to mitigate climate change and minimize vulnerability.

The municipalities of Sibunag and San Lorenzo for the Province of Guimaras are the most vulnerable to climate change. The assessment result further revealed that Jordan and Buenavista have a low vulnerability; However, Nueva Valencia ranked the lowest among all the municipalities in the province. Thus, it is concluded that pour out of climate change interventions are much needed in Sibunag and San Lorenzo so that impacts of climate change will be mitigated and vulnerability will be minimized.

## CONCLUSIONS AND RECOMMENDATIONS

### Conclusions

Based on the findings of this study, the following conclusions are drawn:

1. The agricultural vulnerabilities to climate change of the provinces Aklan, Antique, Capiz and Guimaras were objectively assessed, GIS-produced visualization maps were generated using the models and statistical analysis of climate impacts, climate variabilities, and socio-economic variables.
2. The vulnerability of the four provinces studies determined in terms of sensitivity, hazard and adaptive capacity index were attained and described.
3. In terms of sensitivity, hazard and adaptive capacity index, the findings likewise revealed that:

   a In Aklan, the sensitivity index was found very high in the municipalities of Malinao and Nabas but very low for Ibajay, Kalibo, New Washington, Altavas, Batan, and Libacao; the hazard index was very high in Batan, New Washington, and Ibajay but very low in Altavas, Madalag, Banga, Balete and lLezo while the adaptive capacity index was very high in Batan, Libacao, Tangalan, Makato, Lezo, and Malinao but very low for Kalibo.

   b In Antique, the sensitivity index was found to be very high in the municipalities Anini-y, Belison, Caluya, Hamtic, and Tobias Fornier but very low in Pandan. For hazard index, Pandan had a very high while San Jose got very low index. On adaptive capacity the municipalities of Libertad, Laua-an, Belison and Anini-y had very high index but very low in Sebaste, Culasi, Barbaza, Bugasong and Valderama.

c In Capiz, the sensitivity index was very high in Jamindan and Pontevedra but was found very low in Dao, Panitan, and Roxas City. On hazard index the municipality of Panay got very high index but very low in Mambusao, Sapian, Dao, Dumalag and Dumarao. On adaptive capacity index, the municipalities of Jamindan, Dao, Cuartero and Pres. Roxas had very high but very low in Roxas City and Panay.

d In Guimaras, the sensitivity index was found very high in the municipality of Buenavista but very low in Nueva Valencia. On hazard index, the municipality of Buenavista got a very high index but very low in Nueva Valencia while on adaptive capacity index, the towns of Sibunag and San Lorenzo had very high while Buenavista got very low index.

4. On the over-all vulnerability assessment, the findings of the study revealed that:

   a In Aklan, the municipalities of Batan, Malinao, Makato, Tangalan were the most vulnerable to climate change while Ibajay and Kalibo were rated the least vulnerable municipalities.

   b In Antique, Anini-y, Hamtic, Belison, Laua-an, and Libertad were the municipalities predicted to be most vulnerable to climate change while Patnongon was considered least vulnerable.

   c In Capiz, Jamindan, Dao, and President Roxas were found to be the most vulnerable municipalities while Panay and Ivisan, were rated to have the least vulnerability risk.

   d In Guimaras, it was predicted that the municipalities of Sibunag and San Lorenzo would be most vulnerable while Nueva Valencia was found least vulnerable to climate change.

5. The impacts of climate change on crop suitability or sensitivity had been objectively identified and described accordingly using crop distribution models (baseline and future scenarios).
6. The climatic crop suitability scenarios in the study areas were explored and explained; they can be important components of CRVA and also essential in preparing research interventions to enhance crop production practices and management as a response to the demands of climate change.
7. The study results highlighted appropriate interventions and CRA options aimed at addressing localized climatic vulnerabilities and risks;
8. The results were able to prioritize needs for adaptive capacity of communities through designing and planning appropriate interventions and mitigation measures.

## Recommendations

Based on the conclusions arrived at in this study, the following recommendations are forwarded:

1. Disseminate the salient findings of this study to all government agencies and private organizations directly or otherwise involved in intervening and mitigating the devastating impacts of climate change.
2. Utilize these CRVA outputs to guide and assist decision-makers from government agencies, extension staff, and private sectors on geographic areas exposed to climate-related vulnerabilities and risks that are in need of interventions to effectively cushion the present impacts and impending destructions of adverse weather conditions;
3. Utilize the results of the study in planning and decision-making among climate change planners and project implementors in the agricultural sector at the municipal level;
4. Conduct post-study seminars and workshops to present the findings, orient and guide participants on how to exploit to the maximum the results obtained in addressing impacts of adversities brought about by changing climate in their respective are;
5. Apply the results at the LGU level consistent with locally prevailing conditions and realities, particularly for long-ranged planning and in the development of immediately-needed initiatives and innovations;
6. Utilize the results in generating research-based innovations essential to farm workers and stakeholders to modify farming practices and improve crop management to cope with climate change hazards; and
7. Maximize the results obtained for open and multi-sectoral collaboration between and among government agencies and the private sectors.

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## ANNEXES

**ANNEX 1:** Bioclimatic variables used in crop distribution modeling

| **Parameters** | **Description (**O'Donnell, M, and Ignizio, D., 2012**)** |
|---|---|
| ***Temperature Related*** | |
| Bio_1 - Annual mean temperature | The annual mean temperature is derived from the average monthly temperature. |
| Bio_2 - Mean diurnal range | The mean of the monthly temperature ranges (monthly maximum minus monthly minimum). |
| Bio_3 – Isothermality | Oscillation in day-to-night temperatures. |
| Bio_4 - Temperature seasonality | The amount of temperature variation over a given year based on standard deviation of monthly temperature averages. |
| Bio_5 - Maximum temperature of warmest month | The maximum monthly temperature occurrence over a given year (time-series) or averaged span of years(normal). |
| Bio_6 - Minimum temperature of coldest month | The minimum monthly temperature occurrence over a given year (time-series) or averaged span of years (normal). |
| Bio_7 - Temperature annual range | A measure of temperature variation over a given period. |
| Bio_8 - Mean temperature of wettest quarter | This quarterly index approximates mean temperatures that prevail during the wettest season. |
| Bio_9 - Mean temperature of driest quarter | This quarterly index approximates mean temperatures that prevail during the driest quarter. |
| Bio_10 - Mean temperature of warmest quarter | This quarterly index approximates mean temperatures that prevail during the warmest quarter. |
| Bio_11 - Mean temperature of coldest quarter | This quarterly index approximates mean temperatures that prevail during the coldest quarter. |
| ***Precipitation Related*** | |
| Bio_12 - Annual precipitation | This is the sum of all total monthly precipitation values. |
| Bio_13 - Precipitation of wettest Month | This index identifies the total precipitation that prevails during the wettest month. |
| Bio_14 - Precipitation of driest month | This index identifies the total precipitation that |

| | |
|---|---|
| | prevails during the driest month. |
| Bio_15 - Precipitation seasonality | This is a measure of the variation in monthly precipitation totals for the year. This index is the ratio of the standard deviation of the monthly total precipitation to the mean monthly total precipitation and is expressed as a percentage. |
| Bio_16 - Precipitation of wettest quarter | This quarterly index approximates the total precipitation that prevails during the wettest quarter. |
| Bio_17 - Precipitation of driest quarter | This quarterly index approximates the total precipitation<br>that prevails during the driest quarter. |
| Bio_18 - Precipitation of warmest quarter | This quarterly index approximates the total precipitation that prevails during the warmest quarter. |
| Bio_19 - Precipitation of coldest Quarter | This quarterly index approximates the total precipitation<br>that prevails during the coldest quarter. |
| Bio_20 - Number of consecutive dry days | Consistent number considered dry days. |

**ANNEX 2:** Hazard weights by island group

| **Hazards** | **Island Group** | | |
|---|---|---|---|
| | Luzon | Visayas | Mindanao |
| Tropical Cyclones | 20 | 18.21 | 16.95 |
| Flood | 19.05 | 16.4 | 15.25 |
| Landslide | 8.57 | 10.72 | 14.41 |
| Erosion | 11.43 | 12.57 | 12.71 |
| Drought | 14.25 | 16.17 | 16.95 |
| Saltwater Intrusion | 11.43 | 7.21 | 10.17 |
| Sea Level Rise | 5.71 | 8.33 | 5.08 |
| Storm Surge | 9.52 | 10.39 | 8.48 |

**ANNEX 3:** Selected list of indicators and sub-indicators for Adaptive Capacity

| **Attribute Capital** | **Indicator** | **Sub-indicator** | **Source** |
|---|---|---|---|
| Economic Capital | 1. Poverty | | Philippine Statistics Authority (2012) |
| | 2.Inflation Rate | | National Competitiveness Council (2015) |
| | 3.Minimum wage (agriculture) | 3.1 Ag. minimum wage non-plantation, and 3.2 ag minimum wage plantation | National Competitiveness Council (2015) |
| | 4.Financial Institutions and Cooperative | 4.1 Total banks & financial institutions, and 4.2 Number of finance cooperatives | National Competitiveness Council (2015) |
| Natural Capital | 5.% of area irrigated | | International Water Management Institute (IWMI) |
| | 6.% of closed forest and mangrove forest | | National Mapping and Resource Information Authority |
| Human Capital | 7.Health | Ratio to population: 7.1 Public health services, 7.2 Private doctors, 7.3 Private health services, 7.4 Health services manpower, 7.5 Public doctors, and 7.6 Local citizens with PhilHealth | National Competitiveness Council (2015) |

| | | | |
|---|---|---|---|
| | 8.Education | 8.1 Number of secondary schools (public and private), and 8.2 ratio of public school teachers to students | National Competitiveness Council (2015) |
| Physical Capital | 9.Infrastructure investment | | National Competitiveness Council (2015) |
| | 10.Infrastructure Network | | National Competitiveness Council (2015) |
| | 11.Access to services | 11.1 % of households with access to electricity services, and 11.2 % of households with access to water services | National Competitiveness Council (2015) |
| | 12. Number of Public Transport | | National Competitiveness Council (2015) |
| | 13.Telephone Companies and Mobile Services | | National Competitiveness Council (2015) |
| Anticipatory Capital | 14. Number of trainings held relating to climate change | | Municipal/City Agricultural Office |
| | 15. Access to communication technology i.e., cellphone, internet | | Municipal/City Agricultural Office |

# Photo Documentation during the conducted workshop