CLIMATE-RISK VULNERABILITY ASSESSMENT FOR AGRICULTURE SECTOR IN REGION 5

(ADAPTATION AND MITIGATION INITIATIVE IN AGRICULTURE 4 PROJECT)

Lorenzo L. Alvina, Dr. Mary Grace DP. Rodriguez, Adelina A. Losa and Rodel P. Tornilla
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Message from the DA RFO 5 Regional Executive Director

It is one of the efforts of the Department of Agriculture RFO 5 to have the results of the Climate Risk Vulnerability Assessment for Agriculture Sector is available to our policy makers and program implementers. In the past years, billions of pesos have been wasted due to damages in the agriculture and fisheries sector especially those climate related hazard. Bicol Region alone is exposed to numerous hazards such as typhoons, drought, flood, landslide, sea level rise, storm surge and volcanic eruption.

Climate change has taken its toll to the agriculture in the past years costing billions of pesos in damages. Landscape of the agriculture in the current year can be different already by 2050. As the results of the crop models, majority of rice areas in Bicol Region may loss its suitability. Without effective adaptation and genetic improvement, each degree-Celsius increase in global mean temperature would reduce global yields by 3.2% and 7.4% or rice and corn, respectively. Food security is at risk. Loss in the suitability of rice may mean increase in suitability for other crops.

We could no longer be a mode of business as usual. Steps have to be taken in order for our clientele: the farmers and the fisher folks be able to adapt and mitigate the impacts of climate change. Furthermore, it is important to involve all other stakeholders for a more holistic, efficient and effective approach for a sustainable in agriculture. May this output serve as guide for effective program planning and legislation of necessary support to increase the agriculture sector's resilience.

RODEL P. TORNILLA
Regional Executive Director
Department of Agriculture RFO 5

Message from the AMIA Director

The Department of Agriculture Systems-Wide Climate Change Office has advocated for the completion of the Climate-Risk Vulnerability Assessment of all the provinces in the Philippines. In 2017, ten priority provinces have undergone the CRVA, including the province of Camarines Sur in Region 5. Results of the CRVA were used as baseline information in the selection of AMIA Villages.

With the completion of CRVA of the remaining 5 provinces (Albay, Camarines Norte, Catanduanes, Masbate and Sorsogon) and updating of CRVA of Camarines Sur , AMIA Villages can now be established in each province.

The Local Government Units in Bicol Region may adapt the results of the CRVA in their climate change adaptation plans and policies to support agriculture resiliency. Access to the data will be fully available on-line thru www.farmersguide.gov.ph website to ensure usability for all stakeholders. The CRVA will be integrated to other online decision-tools developed by the Department of Agriculture and its partners.

The CRVA bolsters our future actions in addressing climate change. Climate change is here. Building climate resilient agriculture and fishery sector while pursuing sustainable livelihoods will be our stronghold. And should take part from the beginning of planning among community and agricultural activities.

U-NICHOLS A. MANALO
Director
DA Systems-wide Climate Change Office

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EXECUTIVE SUMMARY

The Climate Risk Vulnerability Assessment for Agriculture Sector in Bicol Region will serve as a tool for policy makers and program implementers from the base year up to the projected year 2050. This can serve as reference for the future programs and projects for climate change adaptation and mitigation and food security.

Based on the results of the adaptive capacity, hazard exposure and sensitivity, the overall vulnerability of each municipality and city of Bicol Region was determined. Vvulnerability is function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. The following have very high vulnerabilities: Province of Albay: Municipalities of Tiwi, Malinao in District I, Rapu-Rapu in District II, and Jovellar and Pio Duran in District III; Province of Camarines Sur: Municipalities of Lupi, Cabusao in District I, Magarao, Bombon in District III, and Garchitorena and Siruma District IV; Province of Camarines Norte: Municipalities of Capalonga, Paracale, Vinzons and San Vicente; Province of Catanduanes: All towns except Virac have high to very high vulnerability; Province of Sorsogon: Municipality of Casiguran in District 1 and Prieto Diaz, Gubat, Castilla, Juban, Santa Magdalena and Matnog in District II; and Province of Masbate: District 1 especially from Burias Island, the municipalities of Monreal, San Jacinto, San Fernando; District 2: Mandaon; and District 3: Uson, Palanas, Placer and Mandaon.

Sensitivity of the crops were determined using the crop occurrence and climatological data provided by the International Center for Tropical Agriculture (CIAT). Based on the results, among provinces, only Camarines Norte has negative sensitivity (increase in suitable areas). As of 2018, only the province of Camarines Sur self-sufficiency greater than 100%, yet its rice area may be threatened in the near future. Impacts has risen of the hazards can be felt already as 2019 damages to rice crop alone has reached PhP 880M and 887M during the onslaught of El Nino and various tropical cyclones.

These highly vulnerable municipalities should be prioritized in the implementation of programs and projects to increase adaptive capacity and resilience. The results of the CRVA can be used in the updating of the Local Climate Change Action Plans, updating of the road maps and crop investment plans, promotion of climate-resilient agriculture (CRAs) practices promotion.

The agriculture needs support for infrastructure. While CRAs may help avert the negative impacts, the construction of flood control, water desalination plant, terraces, solar-powered and bio-gas powered equipment promotion, retrofitting of the existing infrastructure is critical as long term solutions. Gradual shifting from one crop to another that will maintain the comparative advantage of farmers.

The CRVA focus of the 3 components: Adaptive Capacity, Hazard Exposure and Sensitivity. Adaptive capacity refers to the aggregate of 9 capitals/indicators (anticipatory, economic, health, human, institutional, natural, physical, social). Analyses on the exposure to hazards utilized the data from various government agencies (DENR and DA). For sensitivity, MaxEnt, a widely-used modelling tool utilizing the crop occurrence points and various climatic data were used to determine the crop suitability of the crops from based year to 2050.

Adaptive capacity of each province and municipality/city differ significantly. Usually, the major/capital towns and cities have very high adaptive capacities. They have the ability to address the impact of climate change and build back better. Municipalities belonging to the 3rd to 5th Class usually have low to very low adaptive capacities. Meanwhile, exposure to hazard varies among territories.

CLIMATE-RISK VULNERABILITY ASSESSMENT OF AGRICULTURE IN REGION 5 (ADAPTATION AND MITIGATION INITIATIVE IN AGRICULTURE 4 PROJECT)

Lorenzo Alvina, Dr. Mary Grace DP. Rodriguez, Adelina A. Losa, Rodel P. Tornilla

1. Introduction

1.1. Rationale

Agriculture is one of the primary sources of livelihoods accounting to 9.28% of the GDP and 24.3% of the labor force in the Philippines (PSA, 2019). However, the country faces the challenges of the impacts of climate change in attaining food security and increasing competitiveness of the farmers and fisherfolks. In 2018, the Philippines ranked 3rd as most disaster-prone countries (UNFPA, 2019).

Bicol Region, located in the eastern seaboard of the country, it is prone to typhoons coming from the Western North Pacific Ocean. Furthermore, Philippines has perennially experiences the impact of climate risks such as typhoons, flood, drought, salt water intrusion, soil erosion, landslide, storm surge and sea level rise. Primary commodities of the six provinces are all affected. In 2019, damages from the El Niño and Typhoon has reached PhP 1.3B and PhP 1.5B, respectively.

In 2017, the Climate Risk Vulnerability Assessment (CRVA) of the province of Camarines Sur was completed and used as baseline for evaluating climate-resilient agriculture practices at the highly vulnerable communities. The importance of the CRVA in the planning for policies and implementing projects underscored the need to complete the CRVA of all the provinces in Region 5. Hence, this project.

1.2. Review of Literatures

1.2.1. Climate Trends and Projected Climate Change in the Philippines

The observed temperature in the Philippines is warming at an average rate of 0.1^{0}C/decade (PAGASA, 2018). It is projected that the country-averaged mean temperature could increase by as much as 0.9 ^{0}C – 1.9^{0}C (moderate scenario, RCP 4.5) and 1.2^{0}C – 2.3^{0}C (high emission scenario in the mid-21st century (2036-2065).

Increase trend in annual and seasonal rainfall were observed in many parts of the country. Multi-model projections suggest a range of increase and decrease in seasonal mean rainfall exceeding 40% of its historical values. Nevertheless, the multi-model central estimate of projected changes in rainfall could be within the natural rainfall variations, except for the projected rainfall reduction over central sections of Mindanao that are beyond the observed rainfall variations in the past.

In the past 65 years (1951-2015) a slight decrease in the number of tropical cyclones (TC) and a minimal decrease in the frequency of very strong TCs (>170kph) were observed over the Philippine Area of Responsibility (PAR). These trends are projected to continue in the future.

For sea level rise, Philippines has experienced nearly double the global average rate of sea level rise over certain parts of the Philippines from 1993-12015. Projections revealed that sea level in the country are expected to increase by approximately 20cm (RCP 8.5) by the end of the 21st century. This might worsen storm surge hazards particularly on coastal communities.

1.2.2. Climate Risk Vulnerability Assessment

Through the AMIA 1 component project in 2015-2016, the DA has undertaken vulnerability assessment focusing on key hotspots for risk and hazards in the country. Although this is a useful starting point for vulnerability assessment – representing exposure to climate risks - a combined analysis for sensitivity and adaptive capacity would result in a more comprehensive CRVA (CIAT, 2016).

A full CRVA is essential to enable not only AMIA, but also other stakeholders and policy makers, to achieve higher resolution and longer-term geographic targeting. This is because exposure (to hazard) is only one dimension of climate-risk vulnerability, while suitability analysis is only one step in the overall CRVA methodology (*ibid*).

1.2.3. Camarines Sur CRVA

The municipalities of Siruma, Tinambac, Garchitorena, Del Gallego, Ragay, Lupi, Pamplona, Milaor and Minalabac were identified as the *very highly vulnerable* areas in the province of Camarines Sur (Laureta 2017).

In terms of adaptive capacity, Del Gallego, Ragay, Lupi, Canaman, Magarao and Bombon recorded the very low adaptive capacity. Residents in these areas are highly vulnerable when it comes to the impacts of climate change. Likewise, an adaptation strategy on enhancing human and social capital needs to be undertaken to increase resilience. Naga City, on the other hand, has the highest adaptive capacity among the Local Government Units with people have access to various financial institutions, social and economic opportunities, health and infrastructure.

In the climatic suitability of crops, rice is *moderately positive sensitive* (i.e. moderately loss in suitable areas) in the municipalities of Magarao, Bombon, Canaman, Pili, Ocampo, parts of San Jose and Minalabac. For corn, it has a projected to have a negative suitability (i.e. Increase in the suitable areas) than the base year. It can be attributed to the projected less rainfall thus, making the conditions suitable for maize production.

B.3 Climate Change Act of 2009

Under the Climate Change Act of 2009 or Republic Act 9729, impact, vulnerability and adaptation should be included in the Framework Strategy and Program on Climate Change (Section 12-b). Furthermore, under the National Climate Change Action Plan, identification of the most vulnerable communities/areas, including ecosystems to impact climate change variability and extremes (Sec. 13-b) and assessment and management of risk and vulnerability (Sec. 13-d).

B. 4 Major climate-related risks and impacts for agrifisheries sector in the region

The Bicol Region has one of the highest risk environments in the country due to its geographic location and physical environment. The threats that affect the agriculture sector are tropical cyclones/typhoons, flood, continuous rain, landslide/soil erosion, saline water intrusion, drought/long dry spell, and pests and disease incidence.

B. 4.1 Tropical Cyclones/Typhoons

Tropical cyclones/storms are the most serious hazard to agriculture in Bicol region. Being in the "typhoon highway", mainland Bicol and the island-province of Catanduanes would usually experience the effects of typhoons when they enter the Philippine Area of Responsibility (PAR).

Typhoons would usually hit Bicol Region during the last quarter of the year. The latter part of the year (October-December) coincides with rice harvest season and early planting season in some parts of Bicol.

B. 4.2 Flood and Landslides/ Erosion

Some of the devastating floods and landslides in the region were triggered by typhoons and continuous rains brought by tail end of the cold front. The Bicol River Basin, which covers major rice areas in the provinces of Albay and Camarines Sur, is the most flood prone area in the region. It has a drainage area of about 3,156 sq. km., of which some 2,000 sq. km. are agricultural and the rest are forests, wetlands, rivers, and lakes. Urbanization and other human activities have accelerated flooding and caused permanent loss of prime agricultural lands. Sedimentation and soil erosion further aggravate flooding in the entire basin area including the rapid changes in the brackish water and morphology of the estuaries and riparian landscapes of major rivers in the basin area.

1.2.4. Continuous Rains

Annual monsoon season in the country has brought severe flooding in most areas. In 2011, most of the disasters that claimed the lives of people and affected properties and livelihoods of the most vulnerable were brought about by increased rainfall, which caused massive flash flooding in areas, which do not normally experience such.

Historical data from PAGASA would show that the province of Camarines Sur receives the highest amount of rainfall between the months of October and December. Based on the 16-year average monthly rainfall, November recorded the highest rainfall of 305.95 mm, followed by October with 294 mm.

1.2.5. El Niño/Drought

Since 1949, there have been 17 El Niño events based on the National Oceanic and Atmospheric Administration's classification, many of which have brought adverse socio-economic impacts in the Philippines. The Philippines previously experienced severe drought due to El Niño in 1982-1983, 1992-1993, 1997-1998 and 2019. Damage to agriculture during the period was estimated at PhP 700 million, PhP 4.1 billion, PhP 4.6 billion and P1.3 billion, respectively.

1.2.6. Pests and Disease Incidence

Aside from climate risks, pests and disease incidence also poses a serious hazard to agriculture in the region. The DA-RFO 5 reported a total damage valued at P 3,818,084.66 in 2010 due to armyworm infestation. Crops affected were rice in the provinces of Albay and Camarines Sur, corn in the provinces of Camarines Sur and Masbate, and High Value Commercial Crops in the provinces of Albay and Camarines Sur. Confirmed report on the trans-boundary pest like fall army worm but no significant damage were recorded due to immediate control measures set-up. Although African swine fever did not affect the region, it caused damages to hog raisers especially in Region 3 and NCR.

The fisheries sector was not also spared from pest infestation. In 2007, the city government of Sorsogon sounded the worsening condition of Sorsogon Bay which has affected more than 6,000 families after the Bureau of Aquatic and Fishery Resources imposed a shellfish ban since September 2006 due to presence of red tide organism.

2. Objectives

The project's overall objective is to develop the climate-risk vulnerability assessment of the six provinces of Bicol Region. Specifically, it aims to develop the adaptive capacity, crop occurrence, suitability and vulnerability maps of the region's agri-fisheries sector through geospatial and climate modelling tools.

3. Methodology

3.1. Conceptual Framework

The study requires detailed information on the hazards, adaptive capacities of the 114 M/CLGUs, crop occurrence and suitability projection in the future year (2050). It follows the framework shown in Figure 1.

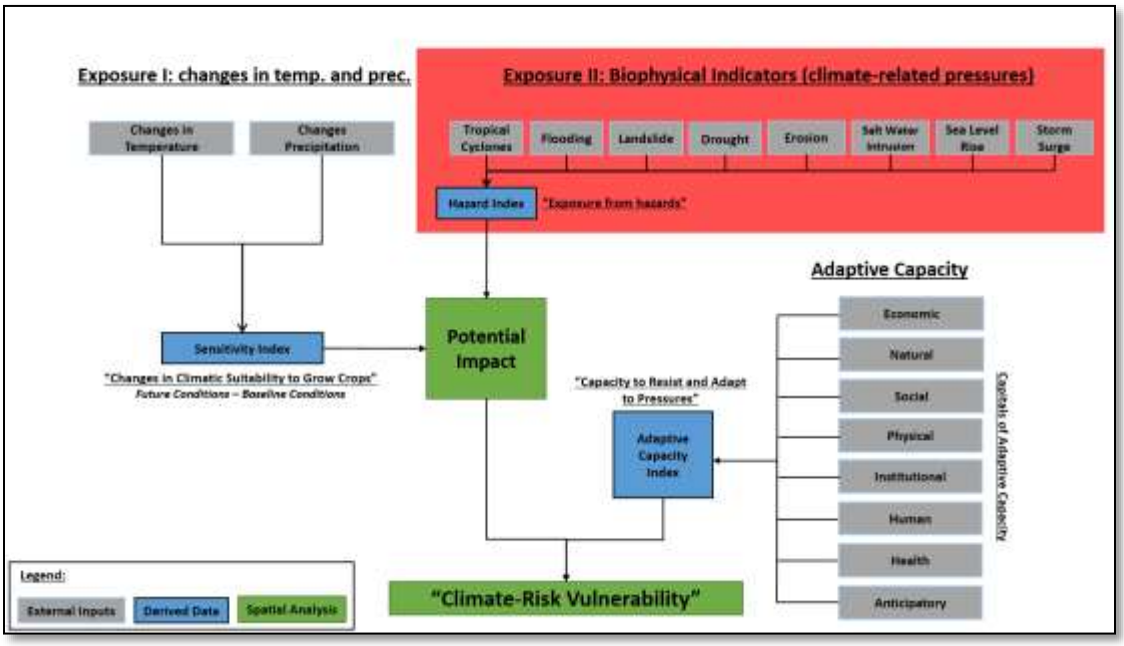


Figure 1 Conceptual Framework of the Climate Risk Vulnerability Assessment

3.2. Study Area

This is a region-wide study focusing on the six provinces: Albay, Camarines Sur, Camarines Norte, Catanduanes, Sorsogon and Masbate. The region is geographically located from 13^0 30'N 123^0 20'E land area of 18,155.82 km^2 ha (6%) of the total country area. It is composed of 114 Local Government Units (7 cities and 107 municipalities).

3.3. Data Collection and Analyses

Data collection and processing followed the protocol designed by the International Center for Tropical Agriculture (CIAT). The same methodology had been used in the AMIA 2 project implemented by the State Universities and Colleges.

3.3.1. Adaptive Capacity

Adaptive capacity is the ability of a system to adjust to climate change (Läderach et al. 2011). It is one the three components of the vulnerability assessment in addition to exposure and sensitivity. Adaptive capacity is directly correlated with resilience. Measured on a municipal scale in the context of climate change effects to agriculture, an AC index provides information on how resilient to climate change a particular area is. The AC parameters used are those that are relevant to the agricultural sector in the province. The indicators are summarized in 0.

Analysis of adaptive capacity in this study was contextualized for the agricultural sector. Several socioeconomic information from each municipality that are relevant to its agricultural situation was gathered from credible sources both local (various offices in the M/CLGU) and national (PSA, DPWH, DA RFO, etc.) and analyzed to generate a measure of adaptive capacity per municipality in form of an index. The formulation of an index involved the process of data standardization to bring the values of the different AC parameters to a common range that is 0-1. Five equal breaks were used to establish the thresholds for the following classes: 0-0.20 (Very Low), 0.2-0.40 (Low), 0.4-0.60 (Moderate), 0.6 0.80 (High), and 0.8-1.00 (Very High).

3.3.2. Exposure to Hazards

Exposure is the character, magnitude and rate of climate change and variation (Läderach et al. 2011 as cited by Paquit, et.al. 2018). Several biophysical indicators of exposure to climate change were factored-in as hazards (Appendix 2). All hazard data were sourced-out from CIAT who managed the pooling of datasets from different sources for distribution to different SUC and DA RFO partners. Flood and drought data were extracted from the AMIA 1 dataset. The factors were weighted based on its impact on agriculture on the national scale and then later downscaled to the provincial level. The rating process involved the analysis of the impact of these hazards to the economy, food security, household income and crop productivity for each municipality in Bicol Region. For each municipality, the mean value of aggregate weight was computed. Normalization was employed to generate an index from 0 to 1. Five equal breaks were used to establish the thresholds for the following classes: 0-0.20 (Very Low), 0.20-0.40 (Low), 0.40-0.60 (Moderate), 0.60- 0.80 (High), and 0.80-1.00 (Very High).

3.3.3. Species Occurrence Points (SOPs)

Species Occurrence Points (SOPs) were gathered from local experts specifically from the local agriculture office. A prior consultation meeting was conducted to all M/CLGUs to determine the crops grow in the province. Top priority commodities were identified and prioritized for mapping (Table 1). Other crops are shown in Appendix 2.

Table 1 Priority Crops in Bicol Region, 2019

Ref. No.	Albay	Camarines Sur	Camarines Norte	Catanduanes	Masbate	Sorsogon
1	Rice	Rice	Rice	Rice	Rice	Rice
2	Corn	Corn	Corn	Cassava	Corn	Banana
3	Ampalaya	Ampalaya	Banana	Abaca	Banana	Cassava
4	Pili	Cassava	Pineapple	Banana	Cassava	Eggplant
5	Sweet Potato	Eggplant	Sitao	Eggplant	Mango	Pili
6	Tomato	Sugarcane	Watermelon	Tiger Grass	Napier	String Beans

To expedite mapping, Google Earth was integrated. The map depicts grid representing the resolution of the environmental variable. It contains features that can assist in locating the occurrence of crops, such as road network, river networks, digital elevation model, municipal and barangay political boundaries. Rice and corn were plotted with ease due availability of clear satellite captures and farm boundaries. However, for other commodities such as vegetables and pineapples (which are generally intercropped with coconut), plotting was coordinated with the local experts to ensure correct digitization.

3.3.4. Climate Variables

Twenty (20) baseline and projected climate variables were sourced out from worldclim.org (Hijman et.al 2005 as cited by Paquit, et.al. 2018) were used in Maxent Modelling. These variables are derived from the monthly temperature and rainfall values for the purpose of producing variables that are biologically relevant. There variables represent annual, quarterly, monthly and even daily ranges in climate (Appendix 4).

Geographic distribution of plants is primarily regulated by climate (Woodward, 1987 as cited by Paquit, et.al. 2018) Variations in species richness, composition and diversity across latitudinal and altitudinal gradients are clearly dictated by climate. To analyze climate change impacts, we used a future downscaled climate data (year 2050) (IPCC, 2001). The 2050 data is the projected average for 2041-2060. Global Circulation Models (GCMs), which are important tools for projected climate data, were spatially downscaled using spatial statistical downscaling techniques to produce the 1-km resolution bioclimatic variables. Outputs of GCMs have coarse resolutions that require spatial downscaling for resolution enhancement. RCP 8.5 was used because of its relevance given the observed trends in greenhouse gas emissions at presen

3.3.5. Crop Modelling using Maxent

Maxent program was used to model the climatic suitability of the all the priority crops in Bicol Region (5) crops. The program uses environmental data to model the distribution of species (Galletti et al. 2013 as cited by Paquit, et.al. 2018). Compared with other tools, Maxent has been shown to perform better (Leathwick et al. 2006 as cited by Paquit, et.al. 2018). Most of the data preprocessing was done in GIS. A .csv file was prepared containing all needed information regarding the speciesMA occurrence points. The coordinate reference system for all environmental variables was set to WGS 1984. All environmental raster layers were formatted to American Standard Code for Information Interchange (ASCII) format. ASCII is the common file format in modeling. For model accuracy evaluation, the AUC-ROC that was produced as one of the Maxent outputs was used. The percent influence of each environmental variable on the distribution of the species was determined using jackknife test. The result of the test was automatically produced by Maxent.

3.3.6. Crop Climatic Sensitivity Analysis

Crop sensitivity was assessed by analyzing changes in climatic suitability of crops by the year 2050 in comparison with the baseline crop suitability. Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change (Läderach et al. 2011 as cited by Paquit, et.al. 2018). The change in climatic suitability of crops between baseline and future predictions was analyzed in ArcMap using a step-by-step process that involved the use of tools such as; raster calculation, reclassification and zonal analysis. Using this protocol the potential effect of climate change to crop suitability was analyzed. CIAT formulated a sensitivity index based on percent change as depicted in Appendix 5. An index of 1.0 means a very high loss in suitability while and index of -1.0 means very high gain. The index equal to 0 means there is no change in suitability detected from baseline to projected year.

The crop suitability did not factor in other parameters such as soil and slope, which are essential for plant growth and survival at the ground level.

3.3.7. Climate Risk Vulnerability Assessment (CRVA)

The index equal to 0 means there is no change in suitability detected from baseline to projected year. Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2001). Based on the definition, vulnerability is a function of sensitivity, exposure and adaptive capacity. A national workshop led by national experts was conducted with the objective of coming up with final weight of each factor. The CRV equation adopted in this study is presented below.

$$f(Haz, Sens, AC) = \sum_{n=i} ((Haz_{(wh)} + Sens_{(ws)}) + 1 - AC_{(wa)}$$

Where: *Haz* = hazard index, *Sens* = sensitivity index, *i* = crop, and *AC* = adaptive capacity index. *Wh* = weight given for hazard (15%), *Ws* = weight for sensitivity (15%) and *Wa* = weight for adaptive capacity (70%). The analysis of weights for each component of vulnerability has been assigned to a group of national experts.

4. Results and Discussion

Objective 1: Develop the adaptive capacity, crop occurrence, suitability and vulnerability maps of the region's agri-fisheries sector through geospatial and climate modelling tools

4.1. Impact to Food Security

Food security in the region may be at risk by 2050. Based on crop models, rice has positive sensitivity (loss/diminish in suitable areas) except for Camarines Norte (Table 2). Currently, Bicol Region has 108% rice self-sufficiency ratio (DA RFO 5, 2018). The province of Camarines Sur is the sole province with more production that what its residents can consume. The rest of the provinces have below 93% self-sufficiency ratio. (See discussions for all crops in the succeeding section under *Crop Climatic Sensitivity Analysis*)

Yellow and white corns are important for feed and as staple, especially in the province of Masbate. As of 2017, self-sufficiency for white and yellow corn is 168.82% and 155.88%, respectively. There is *no* to *slight decrease* in the suitability for corn in Albay, Camarines Norte and Masbate. However, the province of Camarines Sur may experience loss in suitable areas. Seventy four (74%) of the total yellow corn produced in Bicol Region comes from Camarines Sur (PSA, 2019). A shift in the production area from one province to another may occur. Furthermore, supply glut currently the Region enjoys may change and affect the industries that utilize yellow corn.

Table 2 Crop Suitability Modelling Results of Major Commodities

Item	Crop Modeling Results (2050)	
	Rice	Other Primary Commodities:
Bicol Region		
Albay	Loss in suitable areas	Corn: No significant change in suitability
Camarines Norte	Increase in suitable areas	Corn: Increase in suitable areas Pineapple: No significant change in suitability
Camarines Sur	Loss in suitable areas	Corn: Loss in suitable areas
Catanduanes	Loss in suitable areas	Abaca: Slight decrease in suitability in some municipalities
Masbate	Loss in suitable areas	Corn: Slight decrease in suitability in some municipalities
Sorsogon	Increase in suitable areas	Pili: Slight decrease in suitability in some municipalities

4.2. Albay

4.2.1. Adaptive Capacity

The aggregate capacity map revealed that the Municipalities of Malinao, Malilipot, Rapu-Rapu, Pio Duran and Jovellar have the very low adaptive capacities among M/CLGUS of Albay. Both Santo Domingo and Jovellar belong to the 4th Class Municipality while Rapu-Rapu and Pio Duran belong to the 3rd Class Municipality. Moderate to very low economic, anticipatory, human and natural capital played major roles in the results. Despite being a 1st Class Municipality and abundance of natural resources especially geothermal energy, the Municipality of Tiwi has low adaptive capacity partly due to the low anticipatory capital, sluggish economic activities, less developed human and social capital and treacherous terrains that will support accessibility and infrastructure development. These municipalities may have hard time in dealing on the impacts of climate change especially to its impact in the agriculture and fisheries sector.

Meanwhile, the City of Legazpi, the regional capital of Bicol, has the only very high adaptive capacity rating. This bustling and thriving city can support, finance and address the impacts of climate change. For breakdown of different capitals, see Appendix 6.

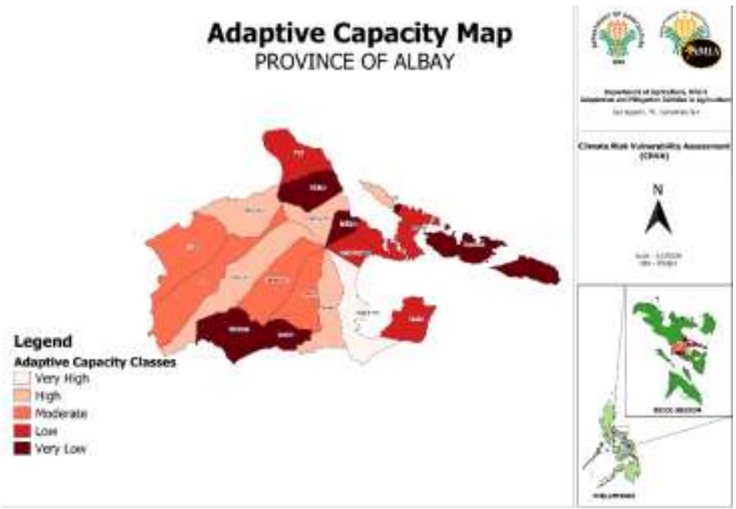


Figure 2 Aggregate Adaptive Capacity Map of Albay Province

4.2.2. Exposure to Hazard

The Municipalities of Malinao, Bacacay and Rapu-Rapu have the very high hazard index among the 18 M/CLGUs in Albay. Seven (7**)** hazards (flood, tropical cyclones, soil erosion, salt water intrusion, drought, landslide, storm surge and sea level rise) were aggregated to form the overall hazard map (Figure 3). These three municipalities, located in the First district, are specifically with high to very high level of exposure to tropical cyclone, storm surge and sea level rise. This implies that higher pressure to the agricultural sector is exerted by hazards. Furthermore, the island municipality of Rapu-Rapu and remoteness of some villages of Bacacay exacerbate the exposure of agricultural production not only to hazards but also to losses in quantity and quality of produce due to delayed in hauling caused by rains and cancellation of marine vehicle transportation.

Municipalities and cities surrounding the Mayon Volcano, factoring all the hazards, the City of Legazpi, Tabaco and the Municipality of Malilipot have high exposure. Joining the list are the Municipalities of Manito and Oas.

The presence of Bicol River, Mayon Volcano, rugged terrains and lowland flood-prone areas contribute to the total agricultural outputs of the province resources but these also strain agricultural production when hazards are triggered. For maps of different hazards, see Appendix 7.

In the future year, PAGASA (2018) projected that there could be less typhoons but an increase in the frequency of strong typhoons (>170kph). While the map shown in Figure 3 shows that here are cities/municipalities that have overall low-very low hazard index, this is in contrast to the tropical cyclone hazard and drought. In 2019, Albay incurred PhP 189M and PhP 230M worth of agricultural damage from El Nino and Typhoon Tisoy, respectively (DA RFO 5, 2019).

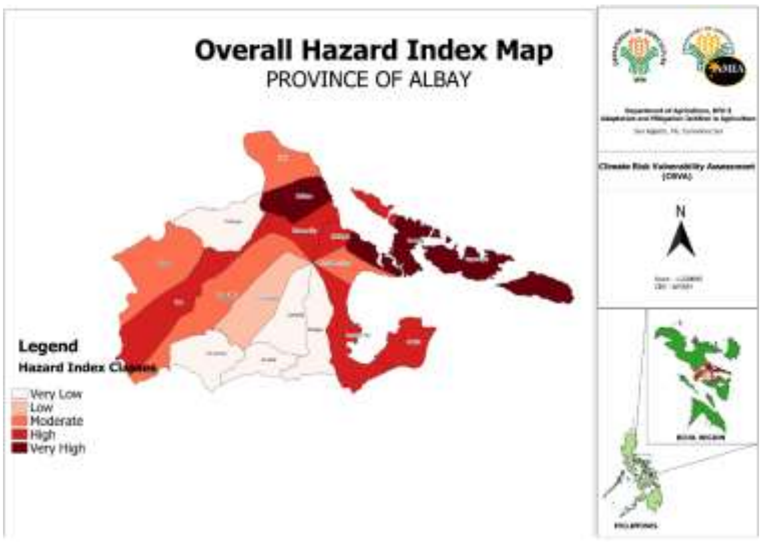


Figure 3 Aggregate Hazard Map of Albay Province

4.2.3. Crop Occurrence of Priority Crops

The crop occurrence points show where the commodities are bulky produced and intended for commercial production. Rice, sweet potato, pili, *Ampalaya* and tomato are generally grown in almost all municipalities and cities of Albay. For corn, these are mainly grown in the 2nd and 3rd District although there is one corn cluster located in Tabaco City in the 1st District. For maps of other commodities, see Appendix 8.

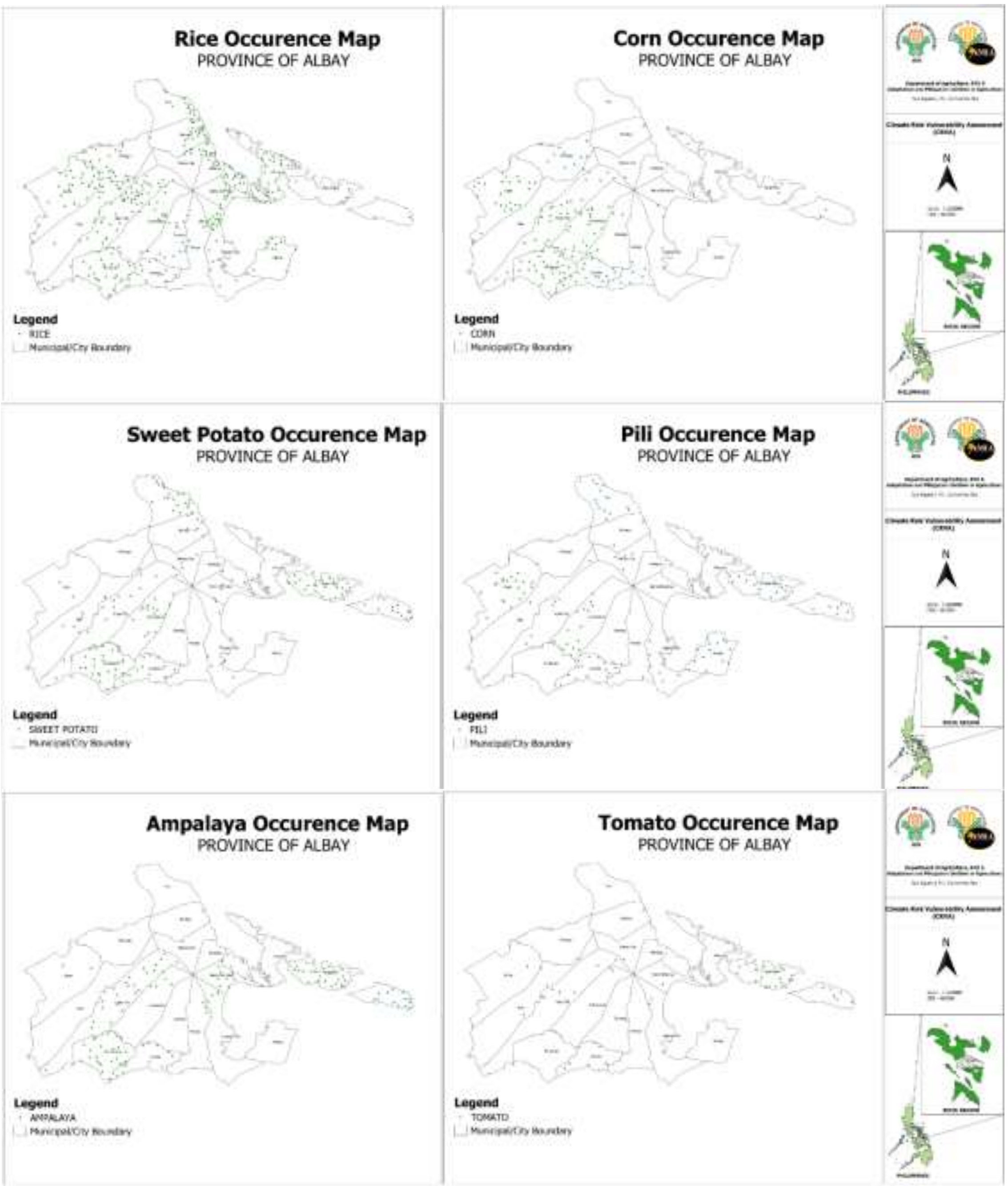


Figure 4 Top Priority Commodities in Albay Province (from *Left-Right: Rice, Corn, Sweet Potato, Ampalaya and Tomato)*

4.2.4. Crop Climatic Sensitivity and Suitability

4.2.4.1. Rice and Corn

Rice is more *positive sensitive* (loss/diminish in suitable areas) than corn. At current year, both commodities are moderately to very highly suitable in the 2^{nd} and 3^{rd} District of Albay (Figure 5). However, based on the crop model results, rice is likely to loss suitability in the future year (2050) especially in the 1^{st} and 3^{rd} District. Eighty-four percent of the total production areas of Albay are located in these districts (Rice Program/DA RFO 5, 2019). The lost in the crop suitability may affect the 16,735 farmers in the near future. The loss in the suitability can be attributed to the projected severity of climatic conditions (lack or abundance of rainfall). Furthermore, while the presence of Bicol River and its tributaries originating from Mayon Volcano may supply the needed irrigation water, the perennial flooding in a way or another, may negate the benefits derived from it. Meanwhile, the loss of suitable rice areas in the Municipality of Libon can be a boon to the production of corn area by 2050.

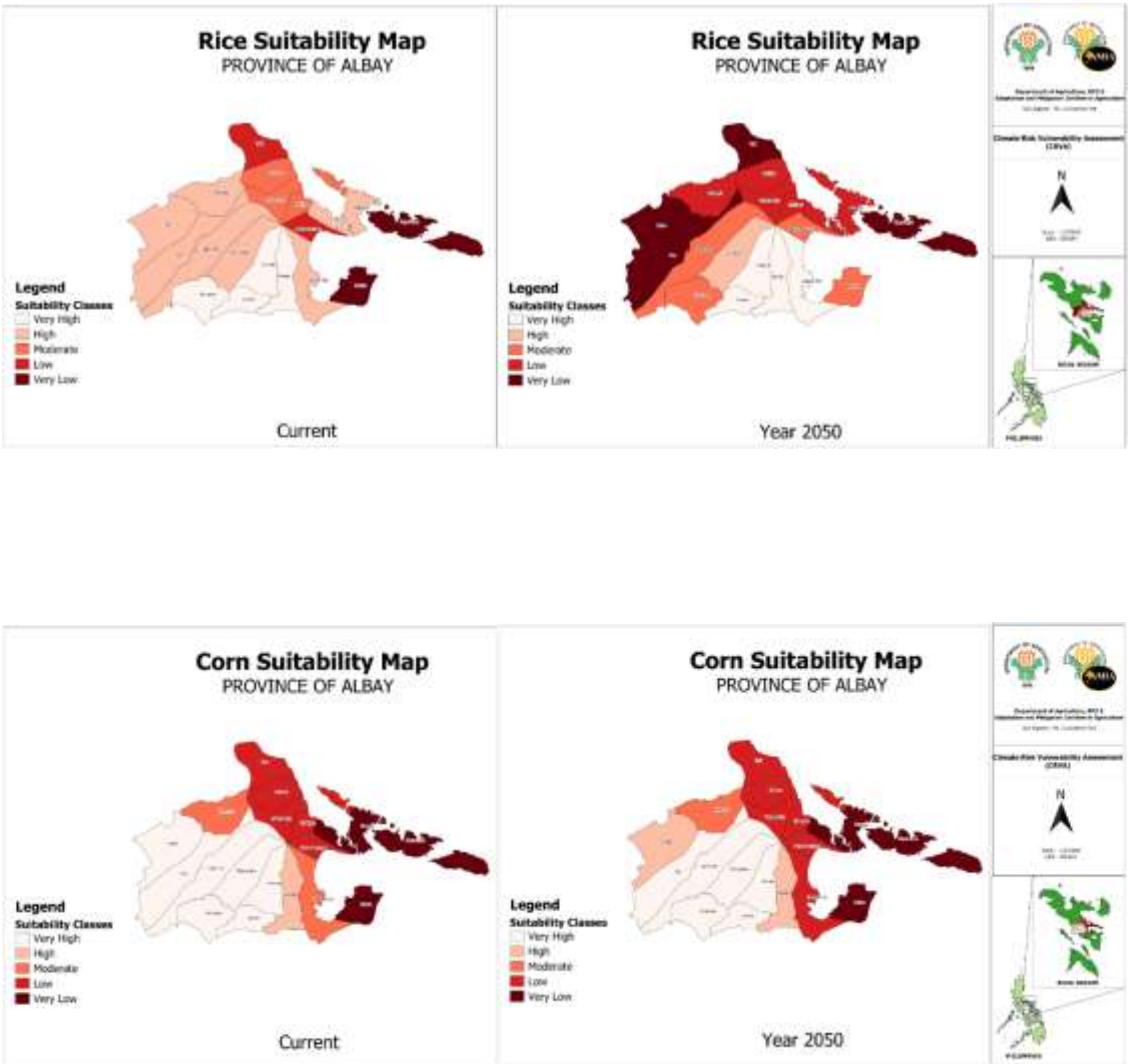


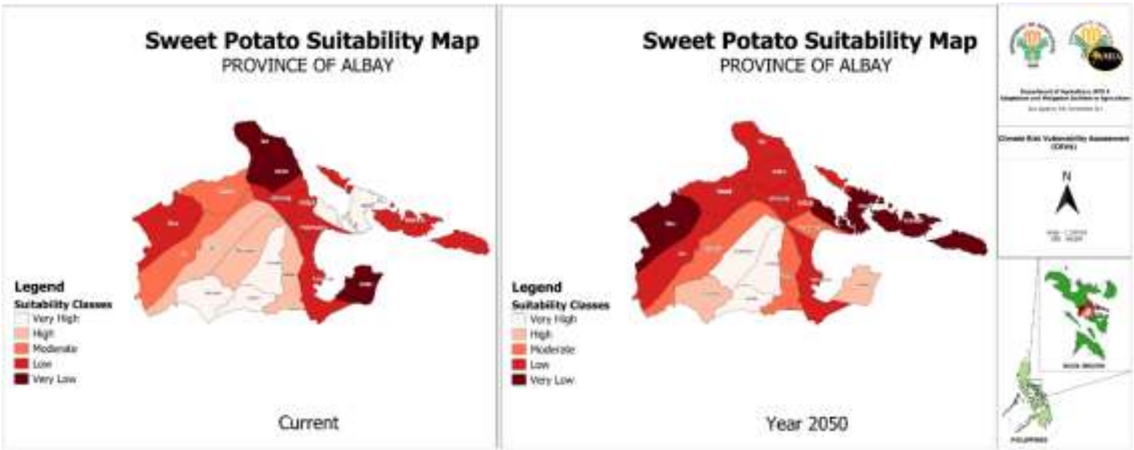
Figure 5 Rice and Corn Suitability from Current Year and Future Year (2050) in Albay Province

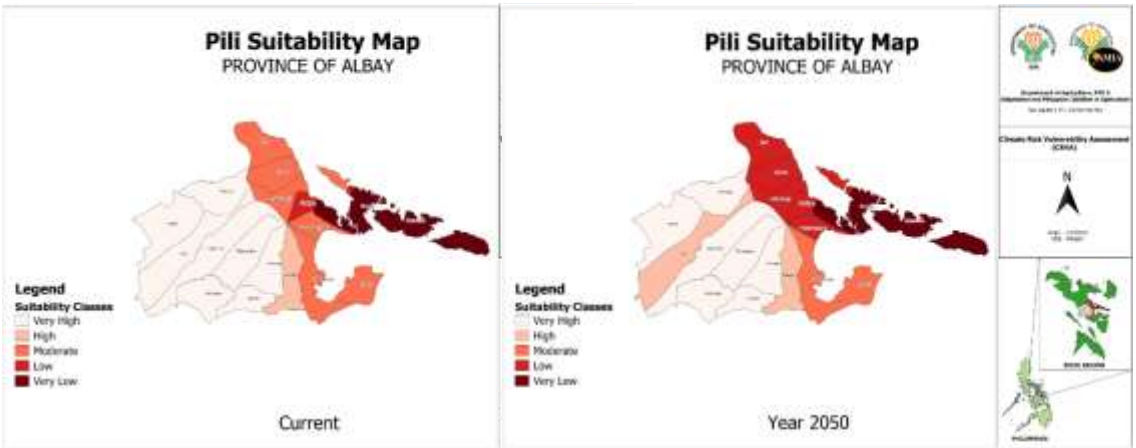
4.2.5.1. Sweet Potato, Pili, Ampalaya and Tomato

Sweet potato is being promoted by the Department of Agriculture and the Provincial Local Government Unit of Albay as a potential cash crop and alternative to rice and corn. The Philippine Rural Development Program (PRDP) of the DA is investing in the island barangay of Tabaco City to improve the competitiveness of the product. Likewise, in 2017, the program approved the support the Camote Creations Sweet Potato-Based Products Processing Enterprise to be established in Daraga, Albay. Currently, the enterprise is already producing products from camote.

The future for sweet potato production may be erratic as its suitability may reduce overtime specially in the aforementioned areas with investments already. Only the municipalities of Guinobatan and Manito showed *negative sensitivity* (increase in suitable areas).

For *ampalaya*, suitability in 2050 is very high and remarkable in the Municipalities of Manito, Camalig, Guinobatan, Jovellar and Pio Duran. For suitability maps of other commodities, see Appendix 9.





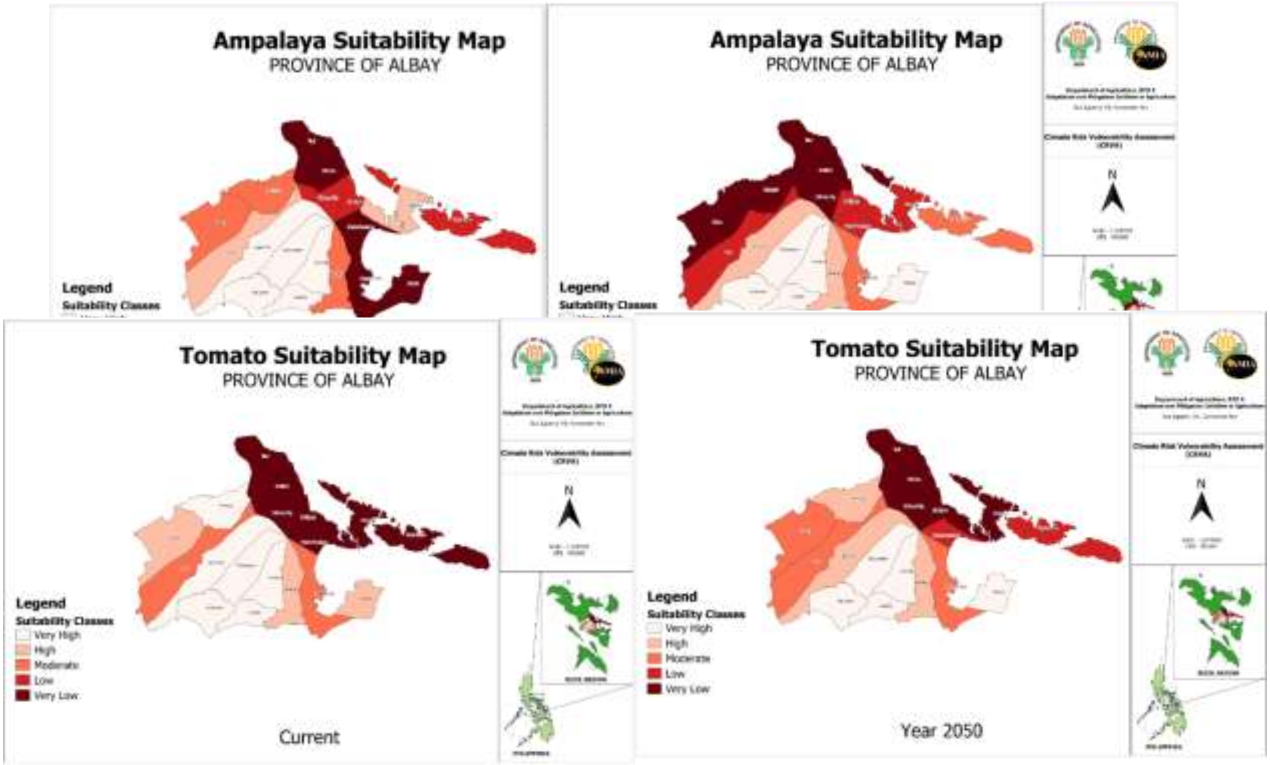


Figure 6 Sweet Potato, Pili, Ampalaya and Tomato Suitability from Current Year and Future Year (2050) in Albay Province

4.2.6. Vulnerability

The final climate risk vulnerability map for the year 2050 is the integration of the exposure, sensitivity, and adaptive capacity components. The weights used in coming up with the CRV map was 15% for exposure, 15% for sensitivity and 70% for adaptive. Since adaptive capacity has the highest share in the digitization, the resulting vulnerability map is closely correlated to the adaptive capacity map.

The Municipalities of Tiwi, Malinao, Malilipot, Rapu-Rapu, Jovellar and Pio Duran recorded the very high vulnerability among LGUs of Albay. These Municipalities should be prioritized in implementing programs and projects, especially infrastructure, to increase capacity and resilience. Furthermore, adaptation strategies in agriculture through use of climate-resilient agriculture practices should be promoted. AMIA Villages may also be established in a community where agro-tourism can be promoted. For climate risk vulnerability map per commodity, see Appendix 10.

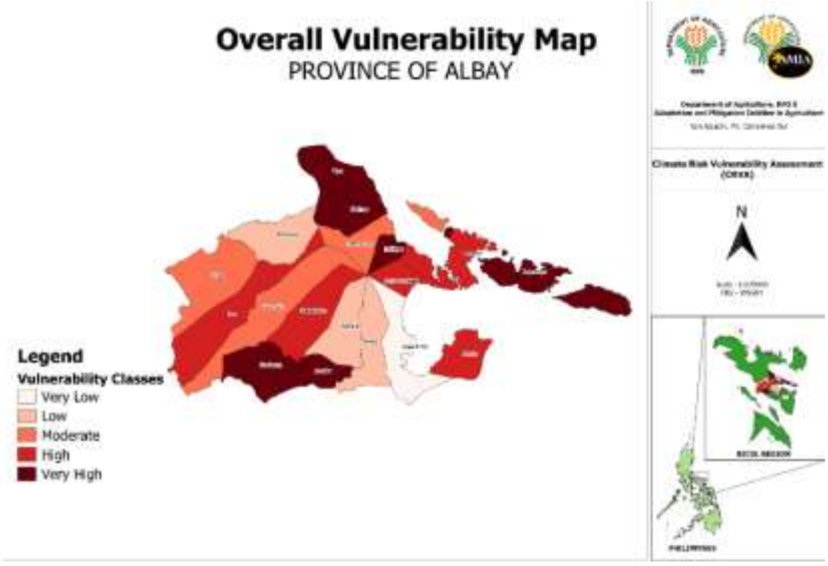


Figure 7 Overall Vulnerability by 2050 of Albay Province

4.3. Camarines Sur

4.3.1. Adaptive Capacity

The following municipalities recorded very low adaptive capacities: District 1: Del Gallego, Lupi and Cabusao; District 2: Magarao; and District 5: Siruma, Garchitorena and Presentation. Some of the these Municipalities with very low adaptive capacities did not change overtime in reference to the 2017 CRVA conducted by the Partido State University.

Majority of the municipalities have vulnerability ranging from moderate to low vulnerability. Contributory to these are underdeveloped the economic, health, human and natural capitals. On the other hand, the Cities of Naga and Iriga and the town of Pili, posted very high adaptive capacities. Economic activities, access to financial institutions, policy support in the anticipatory capital play an important role in increasing the LGU's capacity. For breakdown of different capitals, see Appendix 11.

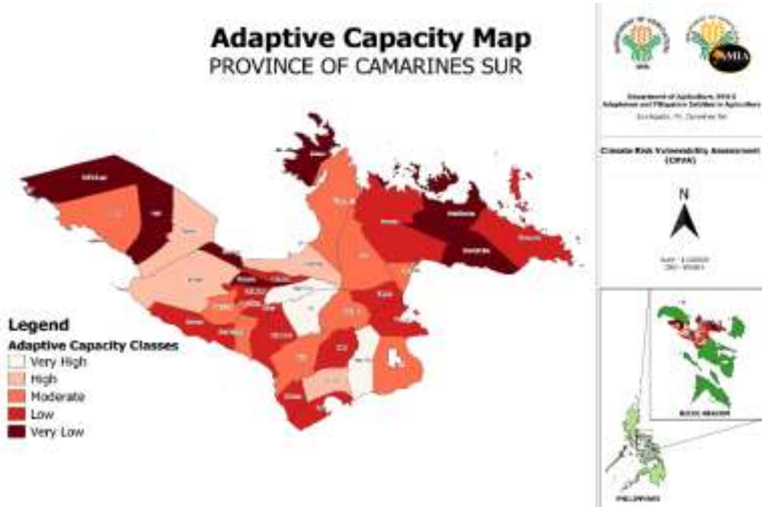


Figure 8 Aggregate Adaptive Capacity Map of Camarines Sur Province

4.3.2. Exposure to Hazard

The Municipalities of Libmanan, Tinambac, Lagonoy, and Caramoan have the very high hazard index among the 37 M/CLGUs in Camarines Sur. The Municipality of Libmanan has one of the largest physical areas, thus exposure to various hazards is detrimental to the municipality's operations. For other LGUs, area along seashores and riverbanks are more affected by various natural calamities with tripled impact of typhoons, flooding and saltwater intrusion. This is evident with the municipalities situated along Bicol River, and coastal municipalities found in Lagonoy Gulf, Maqueda Challe, Ragay Gulf and San Miguel Bay (Laureta, 2017). For maps of different hazards, see Appendix 17.

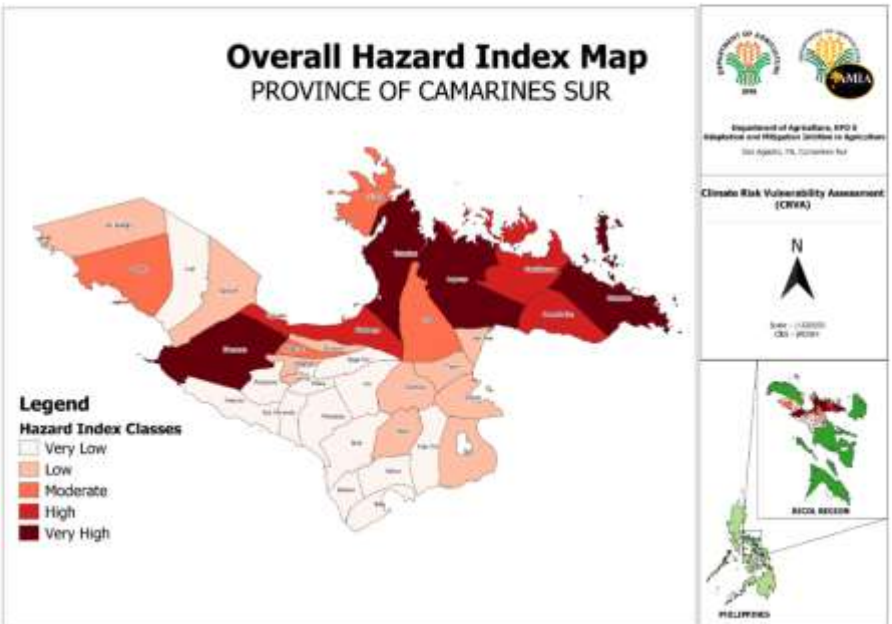
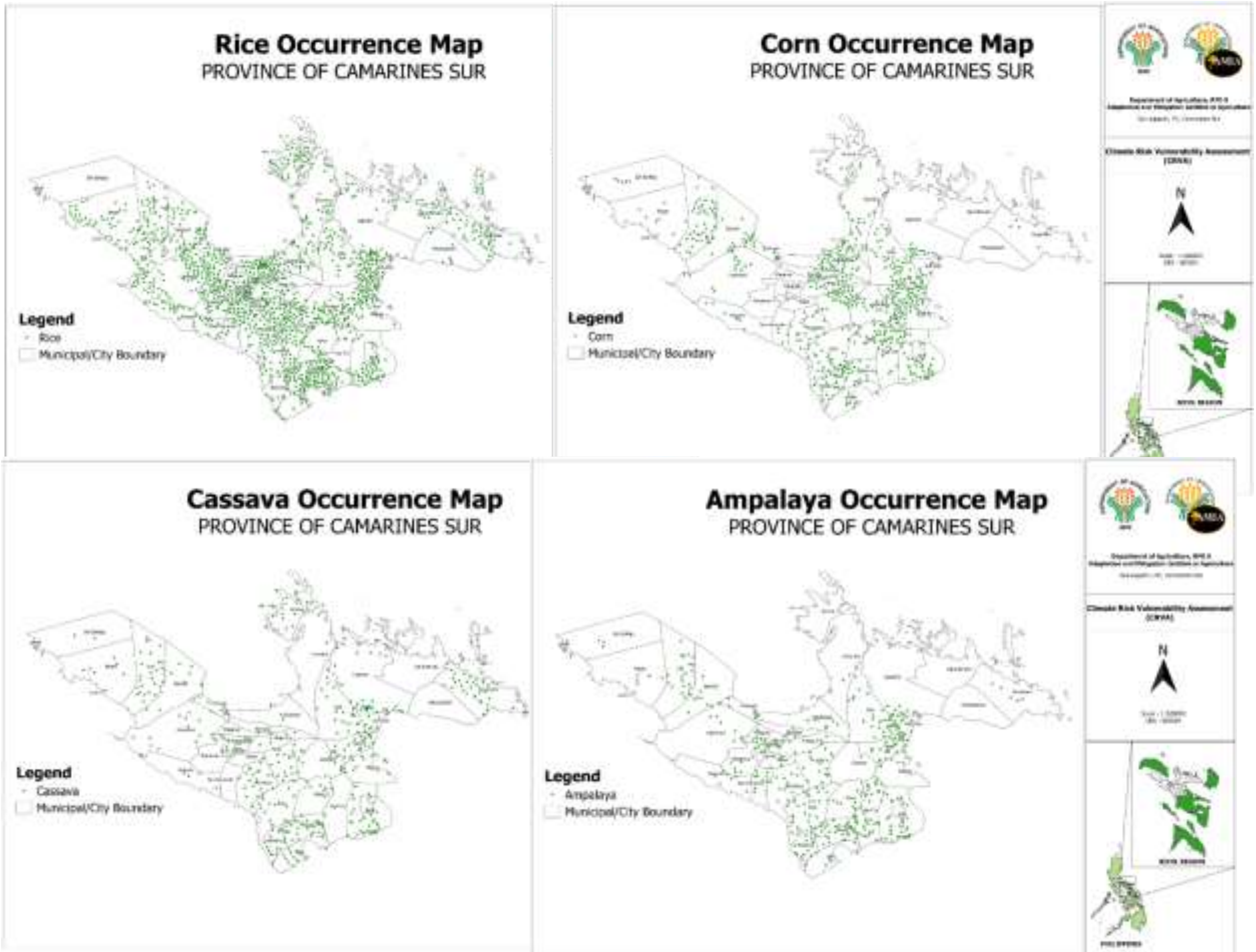


Figure 9 Aggregate Hazard Map of Camarines Sur Provin

4.3.3. Crop Occurrence of Priority Crops

The crop occurrence points show where the commodities are bulky produced and intended for commercial production. Rice, corn, cassava, Ampalaya and eggplant are generally grown in almost all municipalities and cities of Camarines Sur. For sugarcane, this is mainly grown in a number of municipality/city such as Pili, Naga City and Partido Areas. For maps of other commodities, see Appendix 18.



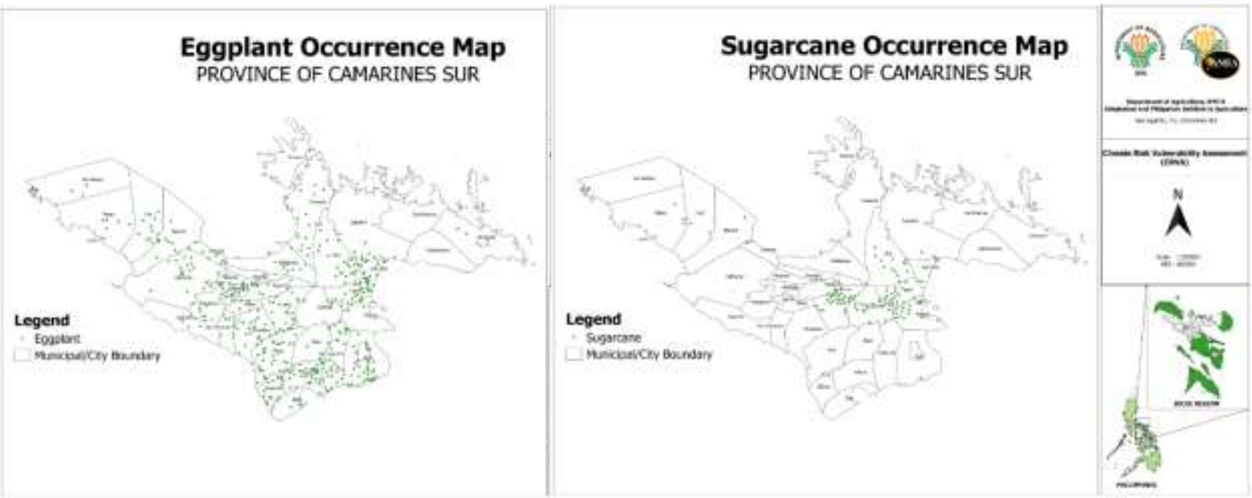


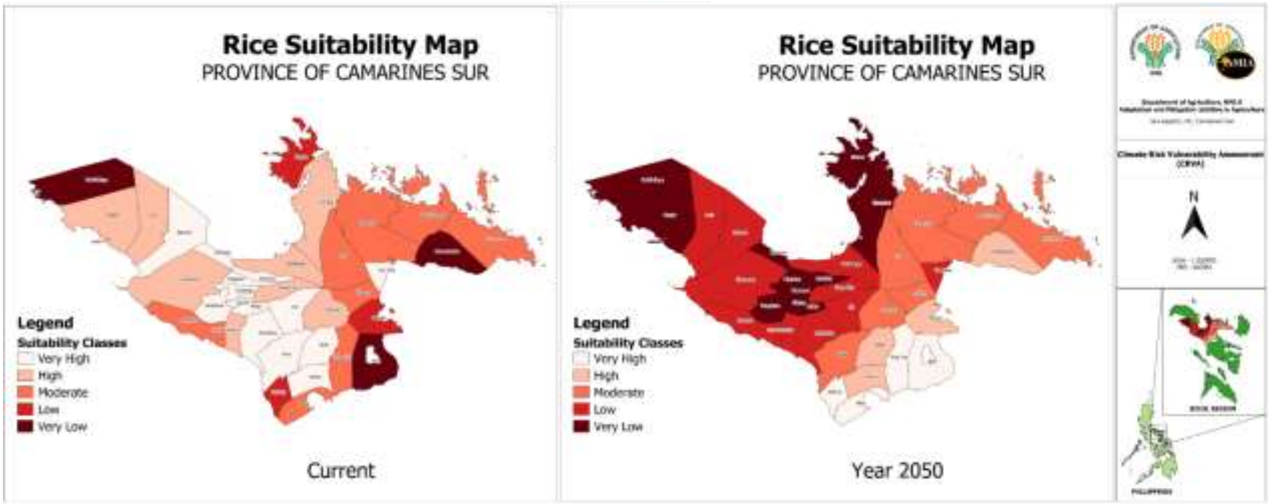
Figure 10Top Priority Commodities in Camarines Sur Province (from *Left-Right: Rice, Corn, Cassava, Ampalaya, Eggplant and Sugarcane*

4.3.4. Crop Climatic Sensitivity and Suitability

4.3.4.1. Rice and Corn

More than half of the rice in Bicol Region is produced in the province of Camarines Sur. However, based on the crop model, rice is highly *positive sensitive* (loss/diminish in suitable areas). This is very glaring especially in areas located along the Bicol River Basin and extending to other rice-producing municipalities of Del Gallego, Ragay, Tinambac and Siruma. Still, there are areas with negative sensitivity (increase in suitable areas) in Buhi, Iriga City, Baao and Balatan area (Figure 11).

Corn areas may experience shift in suitability from high to moderate to low suitability in some areas currently producing corn. In the 5th District, where corn clustering and sorghum is currently being introduced, the future scenario is unlikely for corn production. Rugged terrains, constant exposure to strong winds, exposure to soil erosion and landslide contribute to the uncertainties (Figure 11).



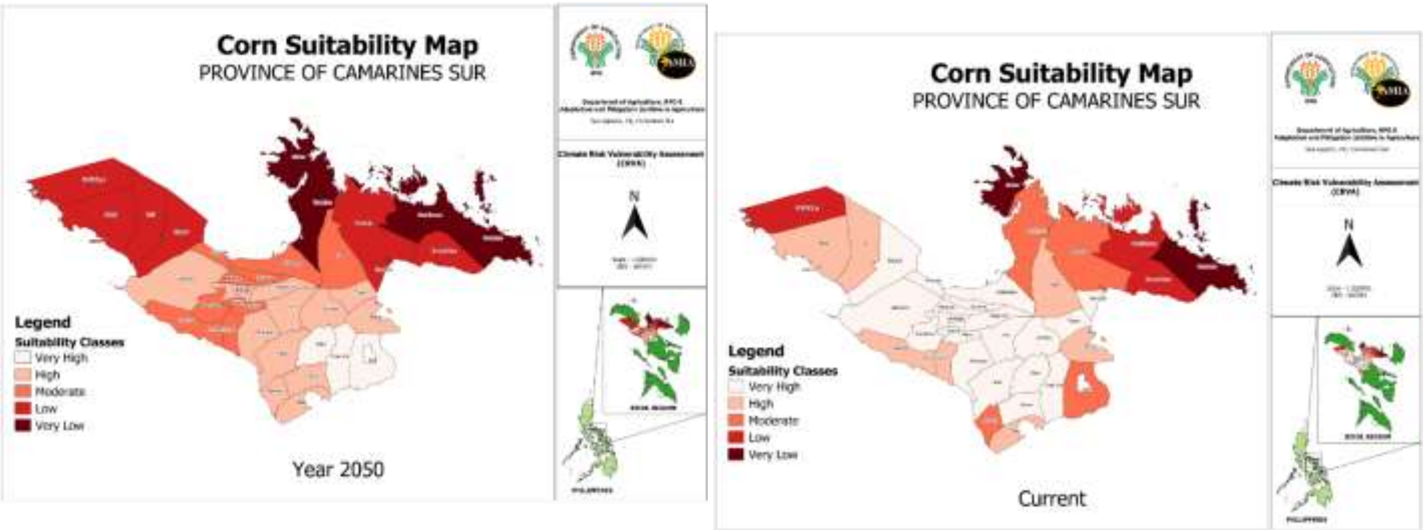
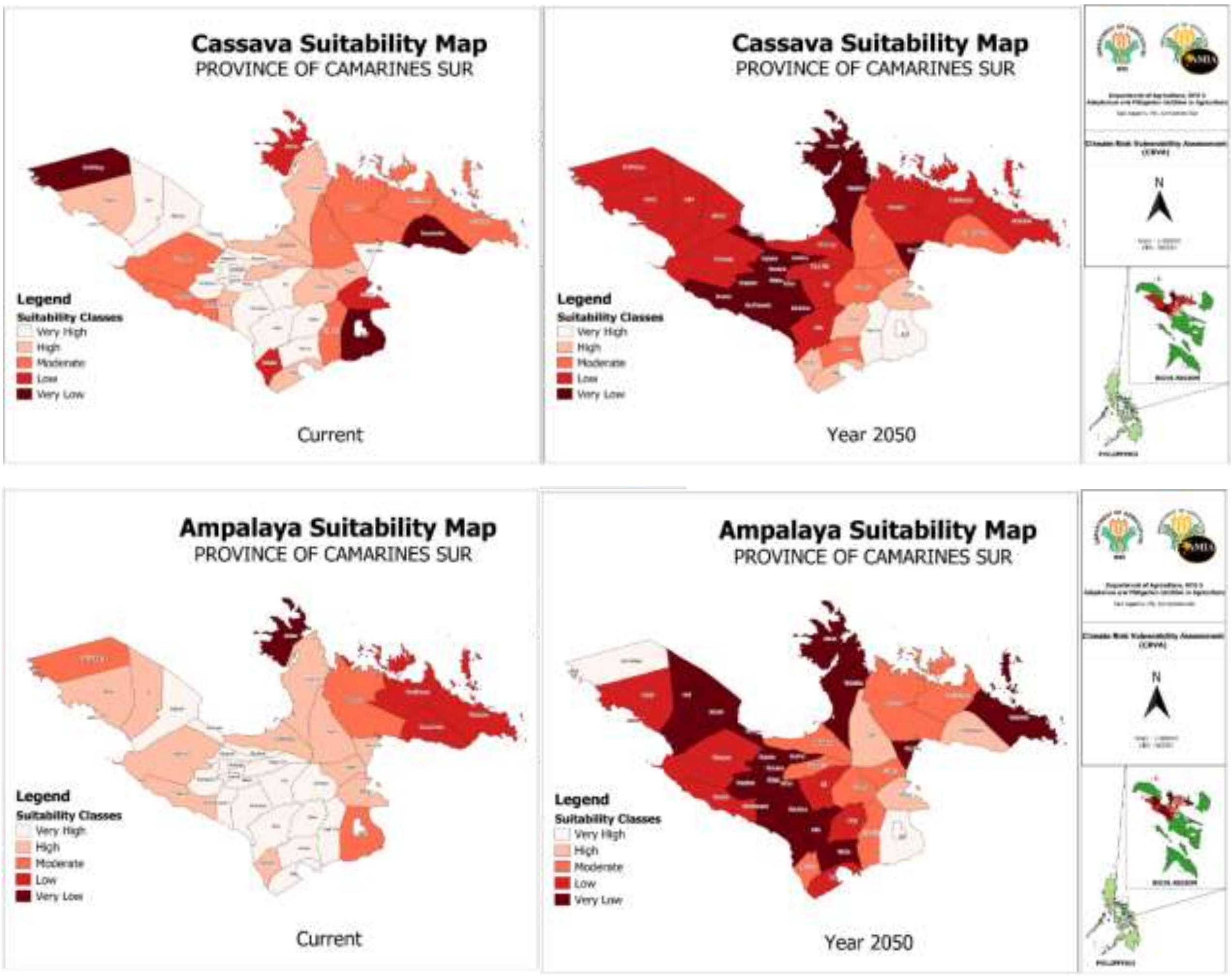
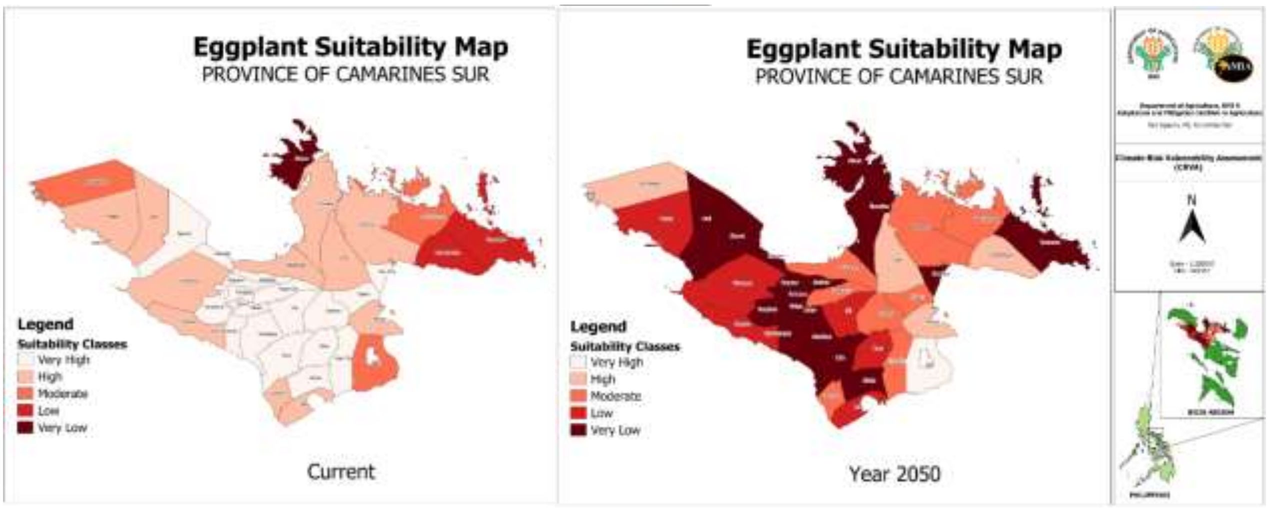


Figure 11 Rice and Corn Suitability from Current Year and Future Year (2050) in Camarines Sur Province

4.3.4.2. Other Priority Commodities

Cassava, Ampalaya and eggplant were found to be positive sensitive (loss in suitable areas) as compared to sugarcane (Figure 12). This can have a significant impact on the food security of the families whose livelihoods depend on vegetable production.





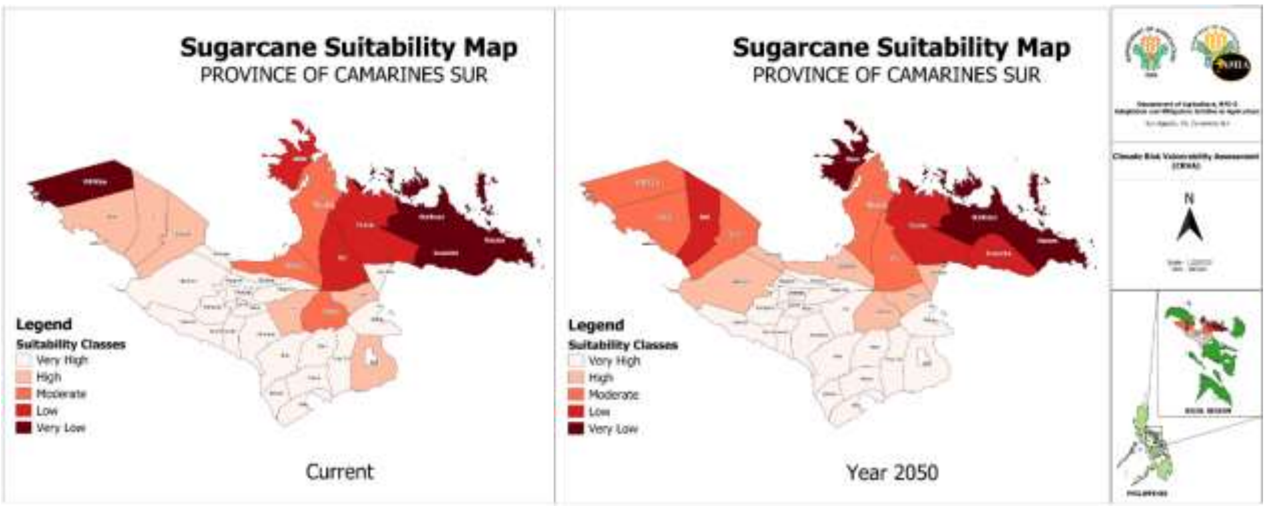


Figure 12 Cassava, Ampalaya, Eggplant and Sugarcane Suitability from Current Year and Future Year (2050) in Camarines Sur Province

4.3.5. Vulnerability

The Municipalities of Lupi, Cabusao, Magarao, Bombon, Garchitorena, Caramoan and Siruma recorded the very high vulnerability among LGUs of Camarines Sur (Figure 14). These Municipalities should be prioritizing in implementing programs and projects, especially infrastructure, to increase capacity and resilience. Furthermore, adaptation strategies in agriculture through use of climate-resilient agriculture practices should be promoted. LGU-initiated expansion of AMIA Villages with assistance from the DA RFO should be taken into consideration. For climate risk vulnerability map per commodity, see Appendix 20.

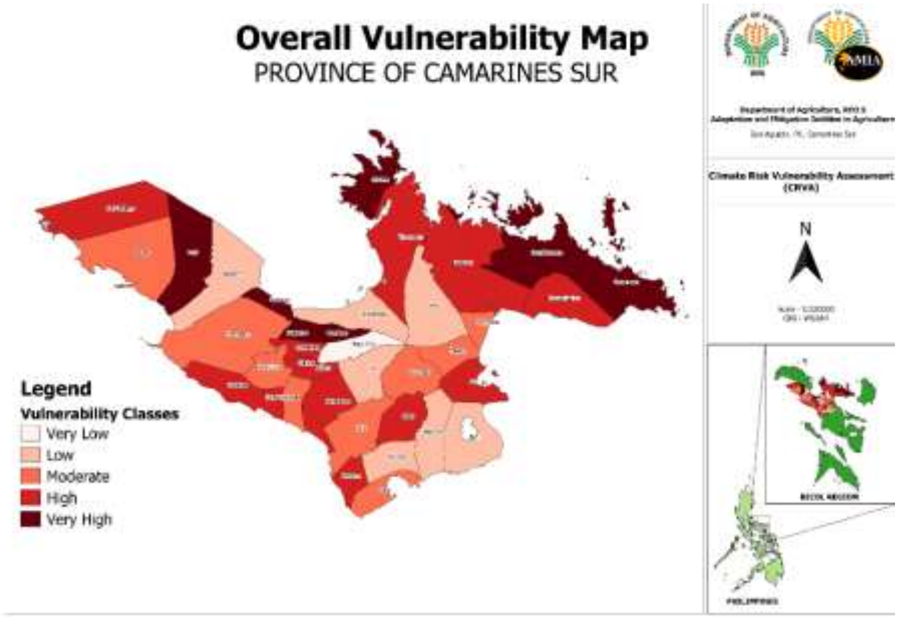


Figure 13 Overall Vulnerability by 2050 of Camarines Sur Province

4.4. Camarines Norte

4.4.1. Adaptive Capacity

Seven out of twelve municipalities or equivalent to 58% of the total municipalities have low to very low adaptive capacity. For very low adaptive capacity, there are from: District 1: Santa Elena, Capalonga and San Vicente. They belong primarily to 3rd to 5th Class Municipalities (Figure 14). In general, lack of economic activities, least developed human capital, institutional capitals and underdeveloped natural capitals plague these municipalities. Rugged terrains and limited infrastructure, especially road networks, hinder the potential of these municipalities (i.e. Capalonga has only 114 km of road network as compared to 2,104 km of Daet). Natural resources such as the gold being mined in Paracale were not able to contribute significantly to improve adaptive capacities.

Only the Municipalities of Labo and Daet, the Capital Town, have high adaptive capacity. For breakdown of different capitals, see Appendix 11.

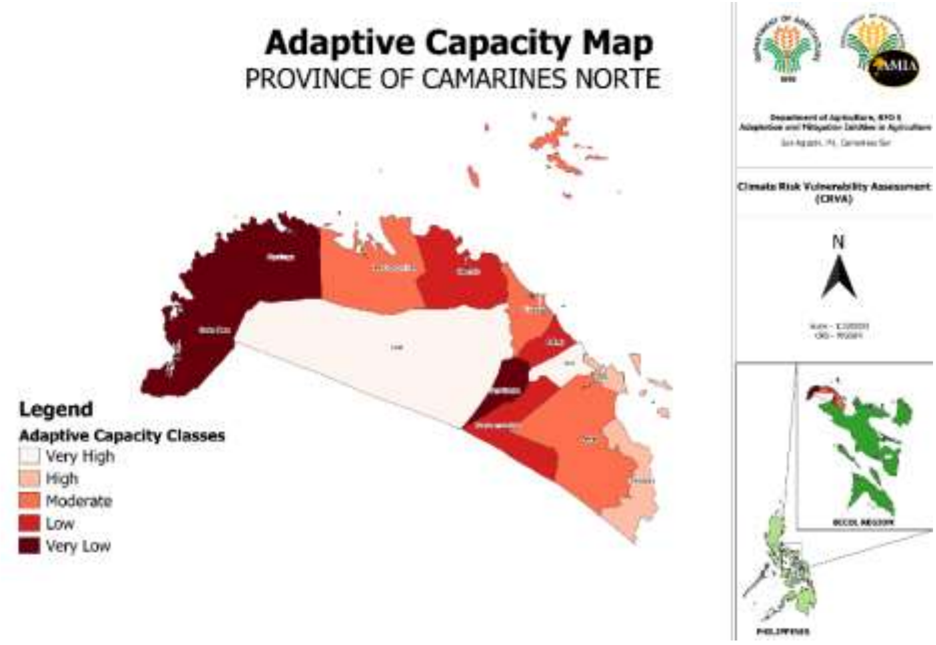
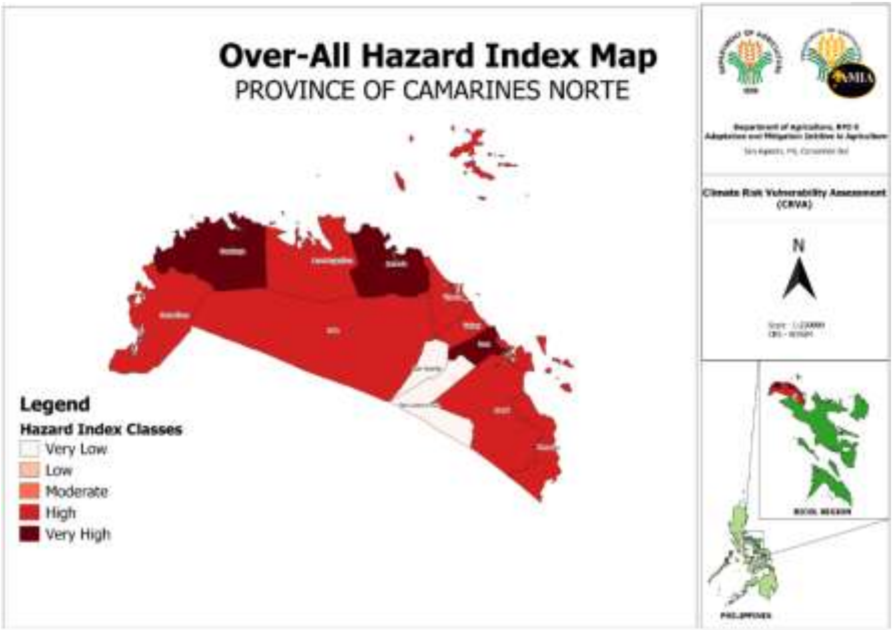


Figure 14 Aggregate Adaptive Capacity Map of Camarines Norte Province

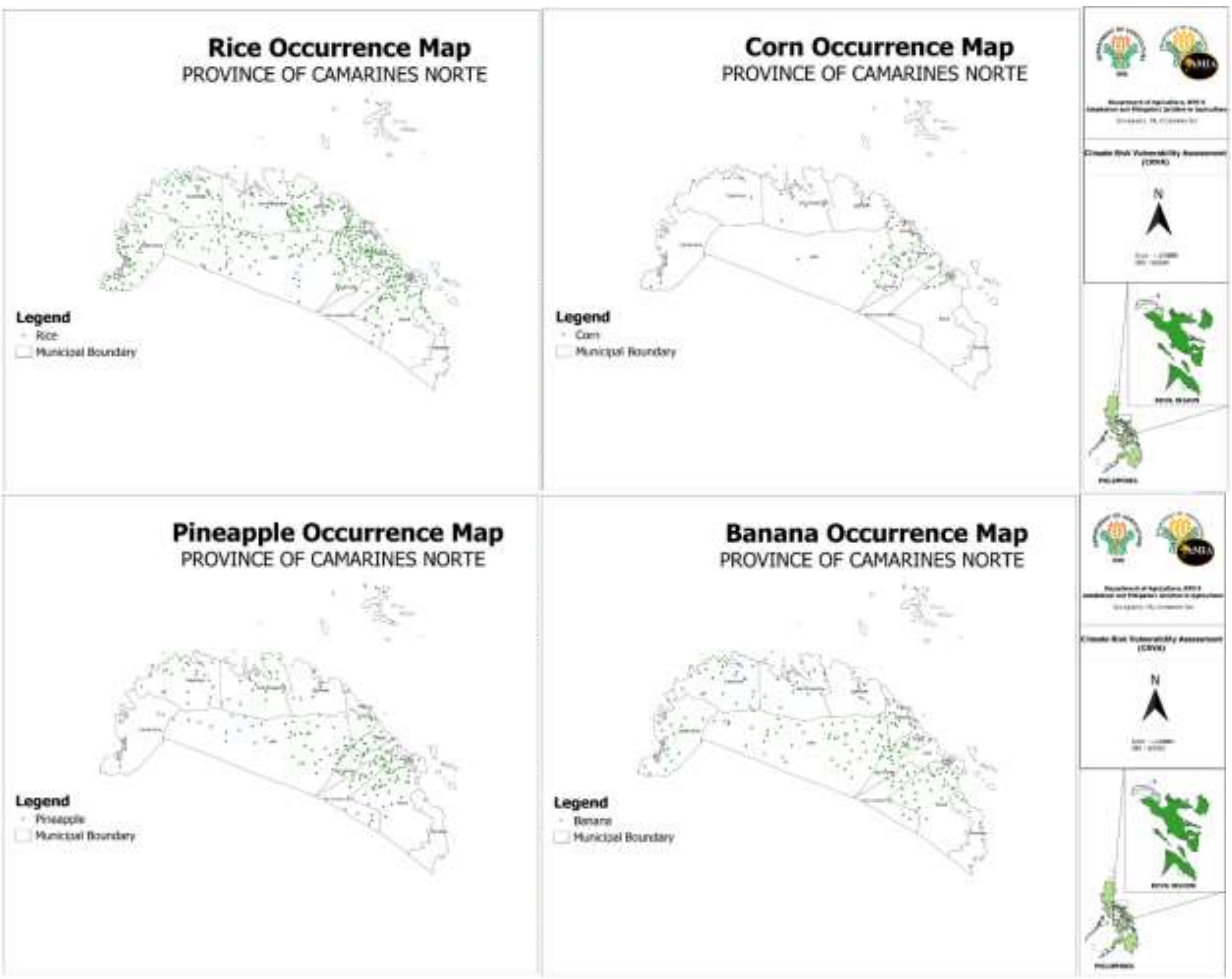
4.4.2. Exposure to Hazard

Generally, the province of Camarines Norte has high to very high exposure to hazards (Figure 15). The Municipalities of Capalonga, Paracale and Daet have very high hazard exposure. Tropical cyclones, drought, soil erosion and landslide are the top contributory hazards. For areas near the San Miguel Bay and Lamon Bay, these are affected by sea level rise and salt-water intrusion. Two of major agricultural products of the province: Coconut and pineapple are perennially exposed to these hazards. For maps of different hazards, see Appendix 12.



4.4.3. Crop Occurrence of Priority Crops

The crop occurrence points show where the commodities are bulky produced and intended for commercial production. Rice, pineapple, banana, and string beans (Sitao) are generally grown in almost all municipalities and cities of Albay. Corn is concentrated in the corn cluster areas in Daet, Labo, Mercedes and Paracale. Green corn and watermelon is popular also among farmers (Figure 16). For maps of other commodities, see Appendix 13.



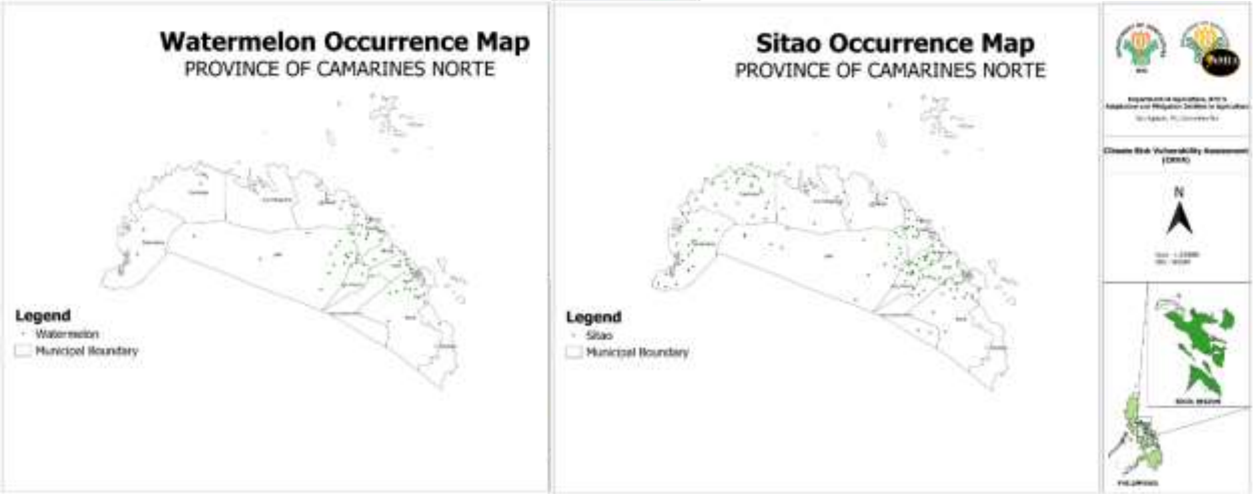
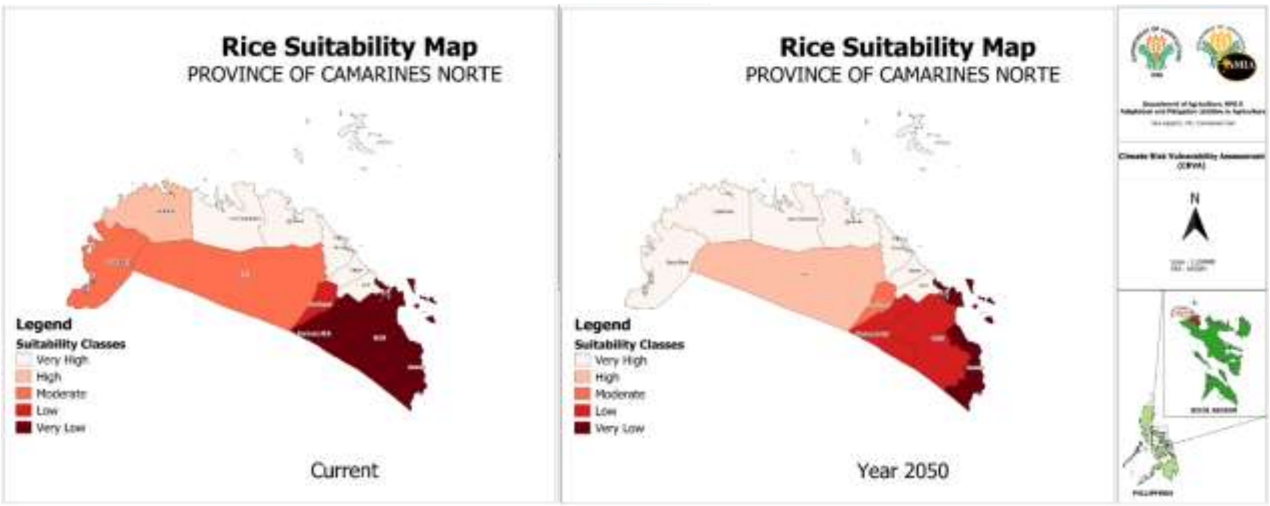


Figure 16 Top Priority Commodities in Camarines Norte Province (from *Left-Right: Rice, Corn, Pineapple, Banana, Watermelon and String beans)*

4.4.4. Crop Climatic Sensitivity and Suitability

4.4.4.1. Rice and Pineapple

Rice is highly *negative sensitive* (increase in suitable areas). Currently, the 1st District supplies 49% of the total rice area in the province. The presence of irrigation facilities in these areas may further boost the production. Meanwhile, (Figure 17). For pineapple, it remains moderate to very high suitable by 2020 in large part of the province.



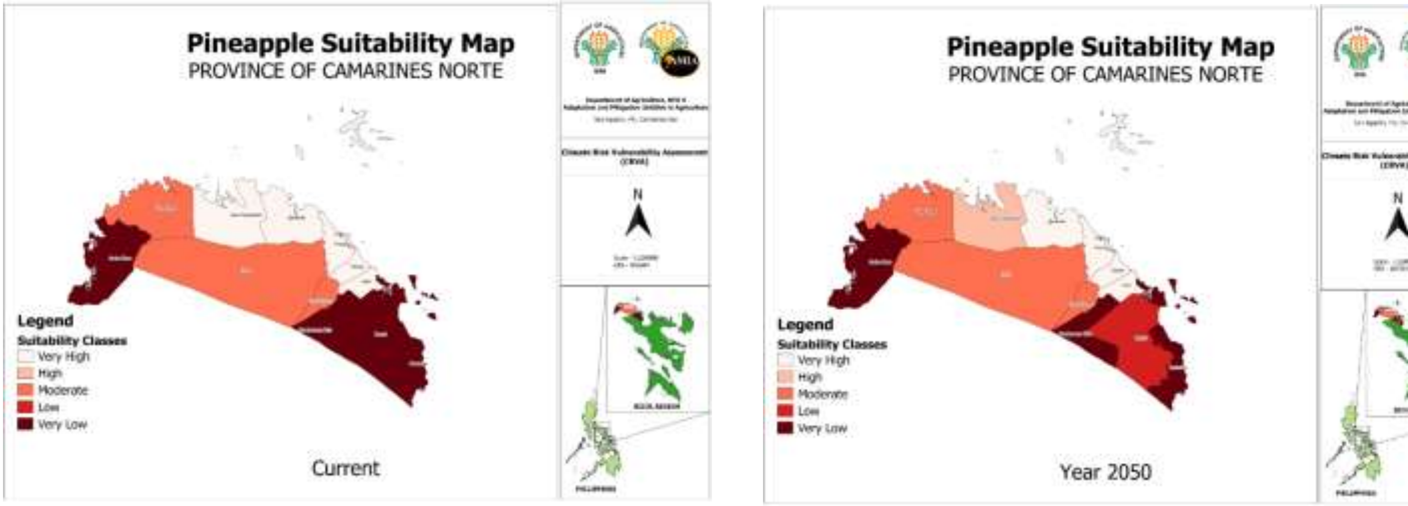
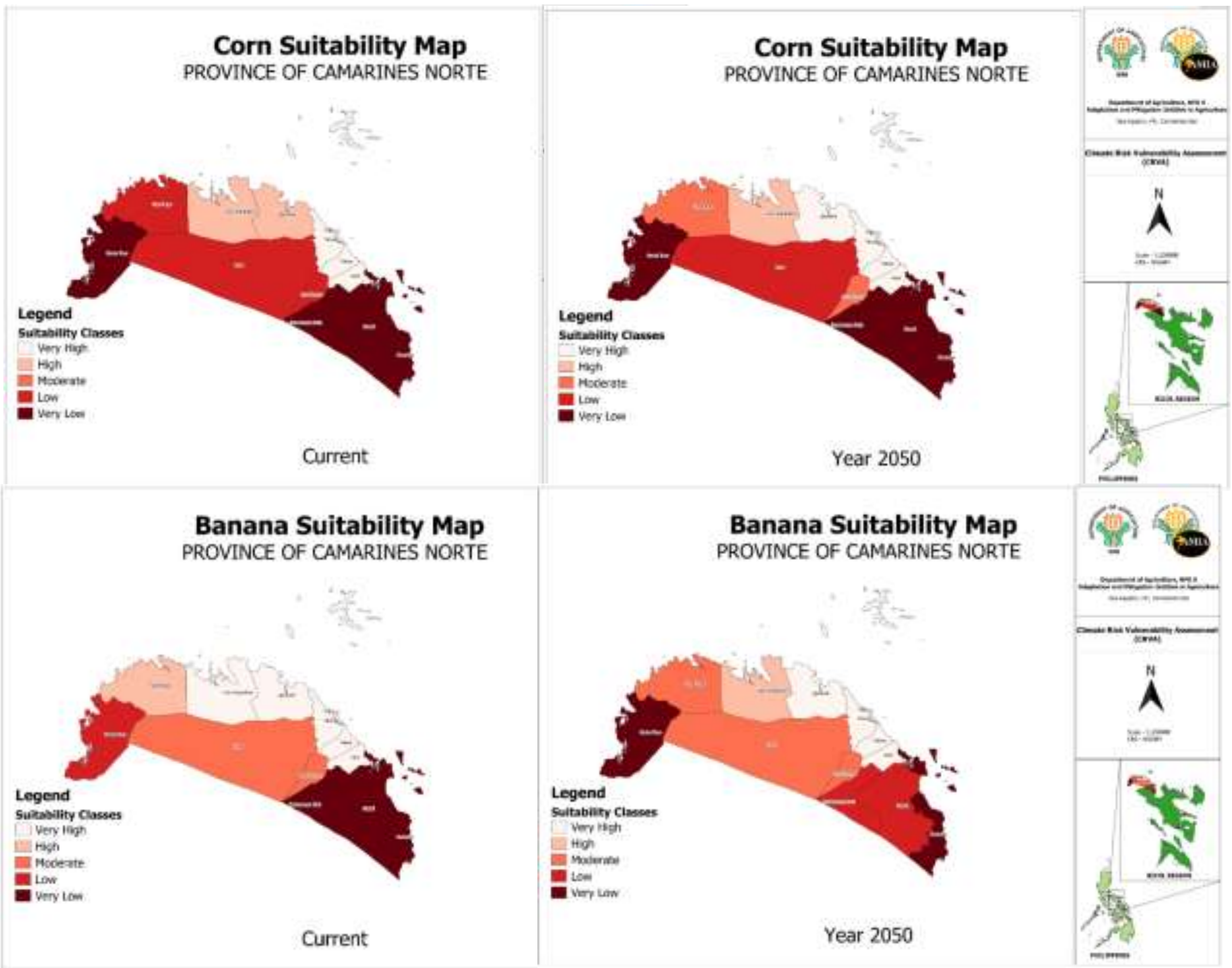


Figure 17 Rice and Pineapple Suitability from Current Year and Future Year (2050) in Camarines Norte Province

4.4.4.2. Other Priority Commodities

Corn production areas may be concentrated in the other municipalities except Sta. Elena, Daet, Mercedes and San Lorenzo Ruiz



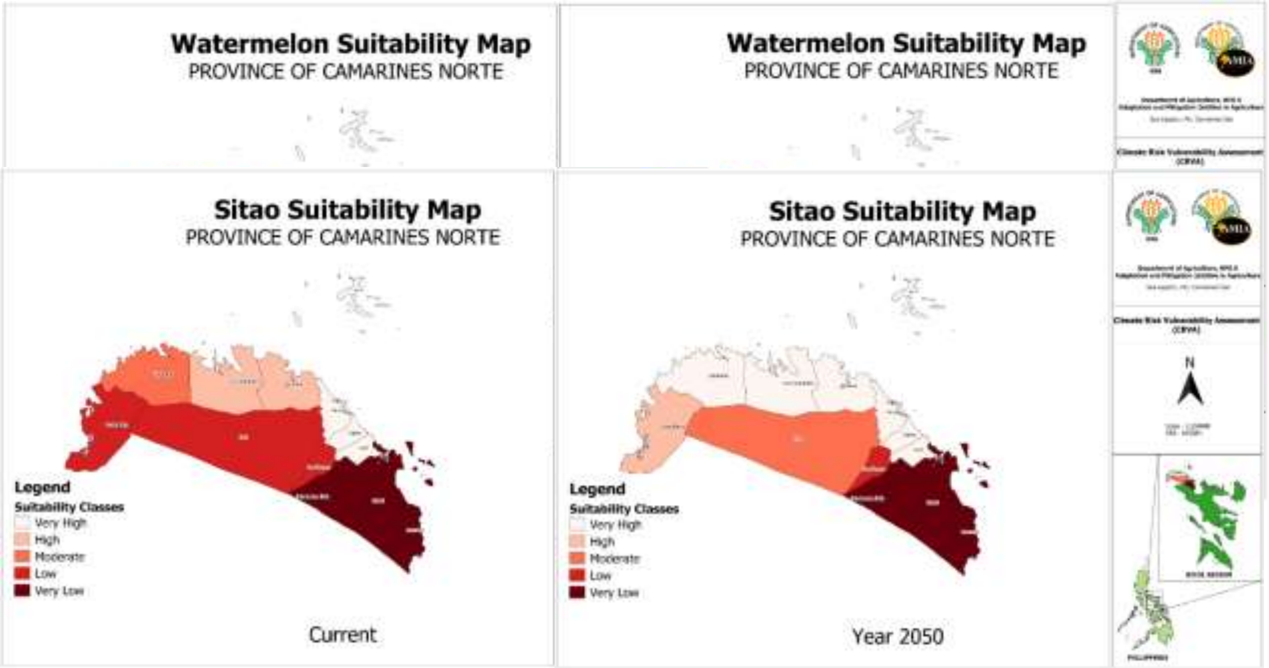


Figure 18 Corn, Banana, Watermelon and String Beans Suitability from Current Year and Future Year (2050) in Camarines Norte Province

4.4.5. Vulnerability

The Municipalities of Capalonga, Paracale and San Vicente recorded very high vulnerability among LGUs of Camarines Norte. These Municipalities should be prioritized in implementing programs and projects, especially infrastructure, to increase capacity and resilience. Furthermore, adaptation strategies in agriculture through use of climate-resilient agriculture practices should be promoted. Establishment of AMIA Village should be taken into consideration. For climate risk vulnerability map per commodity, see Appendix 15.

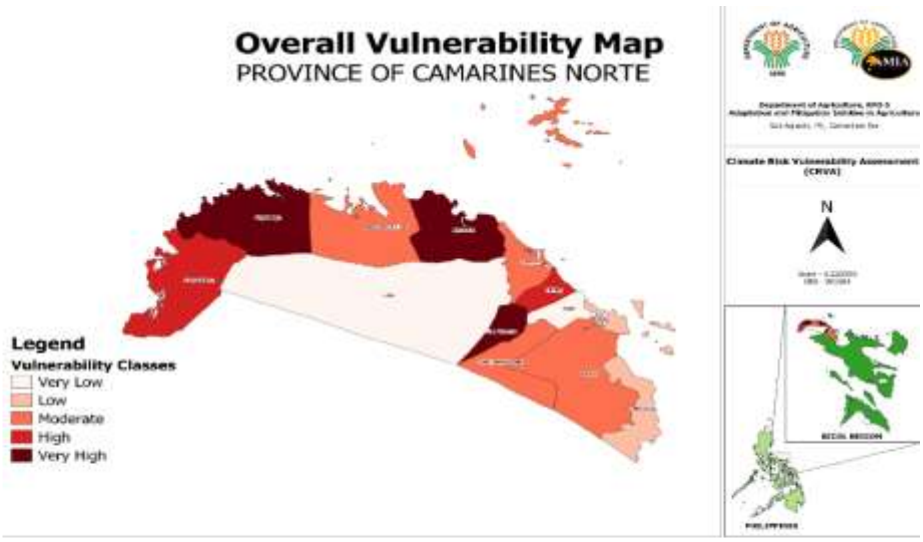


Figure 19 Overall Vulnerability by 2050 of Camarines Norte Province

4.5. Catanduanes

4.5.1. Adaptive Capacity

Generally, adaptive capacity of the province of Catanduanes is very low. The capital town, Virac, has very high scale of adaptive capacity, but mostly of the municipality has a very low adaptive capacity (Figure 20). This can be traced from sluggish economic activities, underdeveloped human capital, lack of health facilities and physical capital. Majority of the MLGUs belong to the 3rd to 5th class municipalities. Years of being a typhoon-highway, funds that could have been devoted to new projects goes to unending rehabilitation of damages, especially the agriculture sector.

With the completion of the circumferential road, this may boost the economic activity, intercommunication, mobility and accessibility. Agriculture sector will benefit from it especially since the province is rich in natural resources with its world-renowned abaca fiber. Tourism may play an important role to increase revenue as the province is relatively lots to offer. For breakdown of different capitals, see Appendix 21.

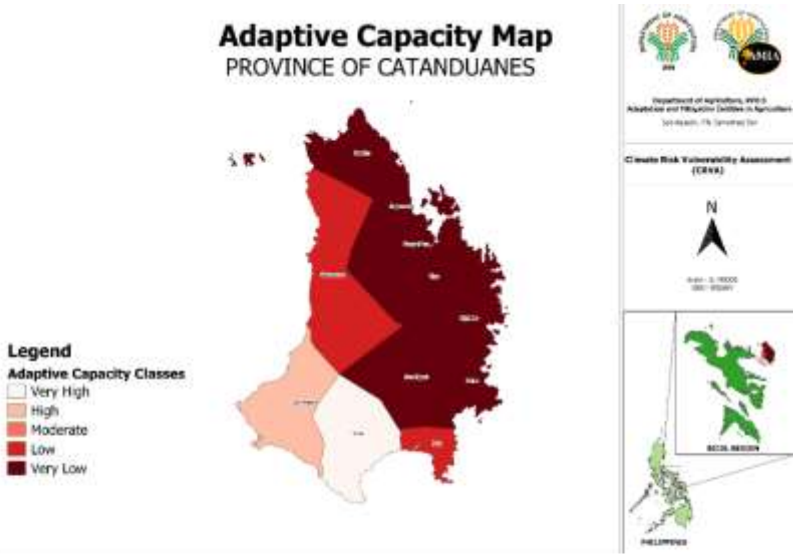


Figure 20 Aggregate Adaptive Capacity Map of Catanduanes Province

4.5.2. Exposure to Hazard

The Municipality of Viga has very high exposure to hazards (Figure 21). On the other hand, the Municipalities of San Andres, Caramoran and Bagamanoc have high exposure to hazards. The Municipality of San Andres is one of the gateways in the province where a seaport is operational. Landslide, drought and tropical cyclones are the major contributory.

Catanduanes is generally an agricultural province. Abaca, tiger grass and fishery products are the major commodities. There is a limited area for rice production due to rugged terrains. Exposure to hazards, especially for abaca, will cost severe economic downturn. The perennial occurrence of torrential rains brought by weather systems compounds the effect to the agriculture sector. For maps of different hazards, see Appendix 22.

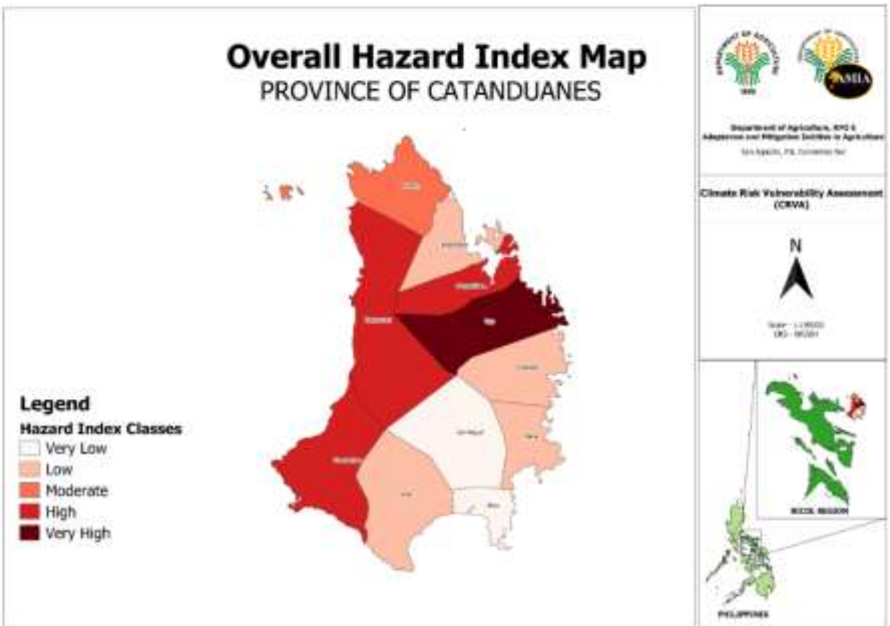
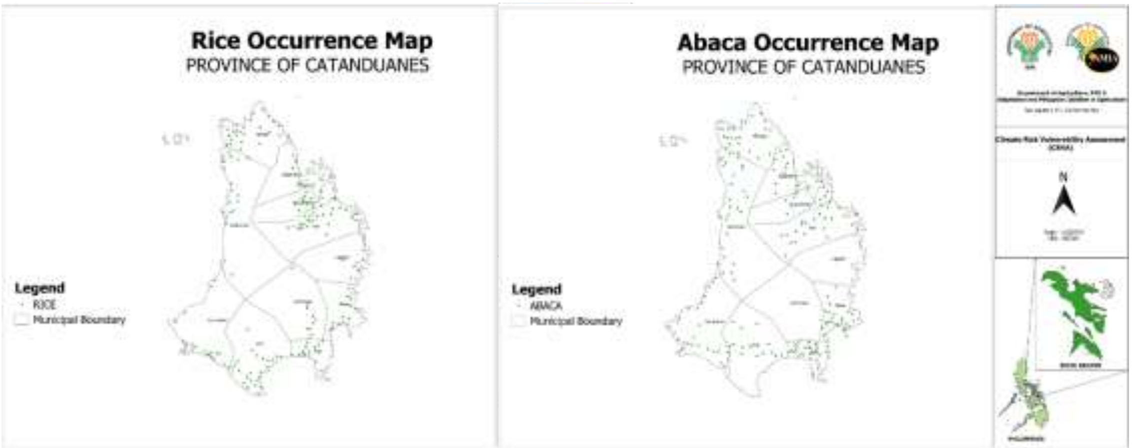


Figure 21Aggregate Hazard Map of Catanduanes Province

4.5.3. Crop Occurrence of Priority Crops

Rice, abaca, eggplant and banana are crops that can be found generally in almost all Municipalities of Catanduanes. Tiger grass, the raw material used for softbroom, is mainly grown in the contiguous municipalities of San Andres, Caramoran and Pandan. Cassava, which is being processed into KUPING a native food snack, is grown in Bagamanoc, San Andres, Virac and Panganiban. For maps of other commodities, see Appendix 23.



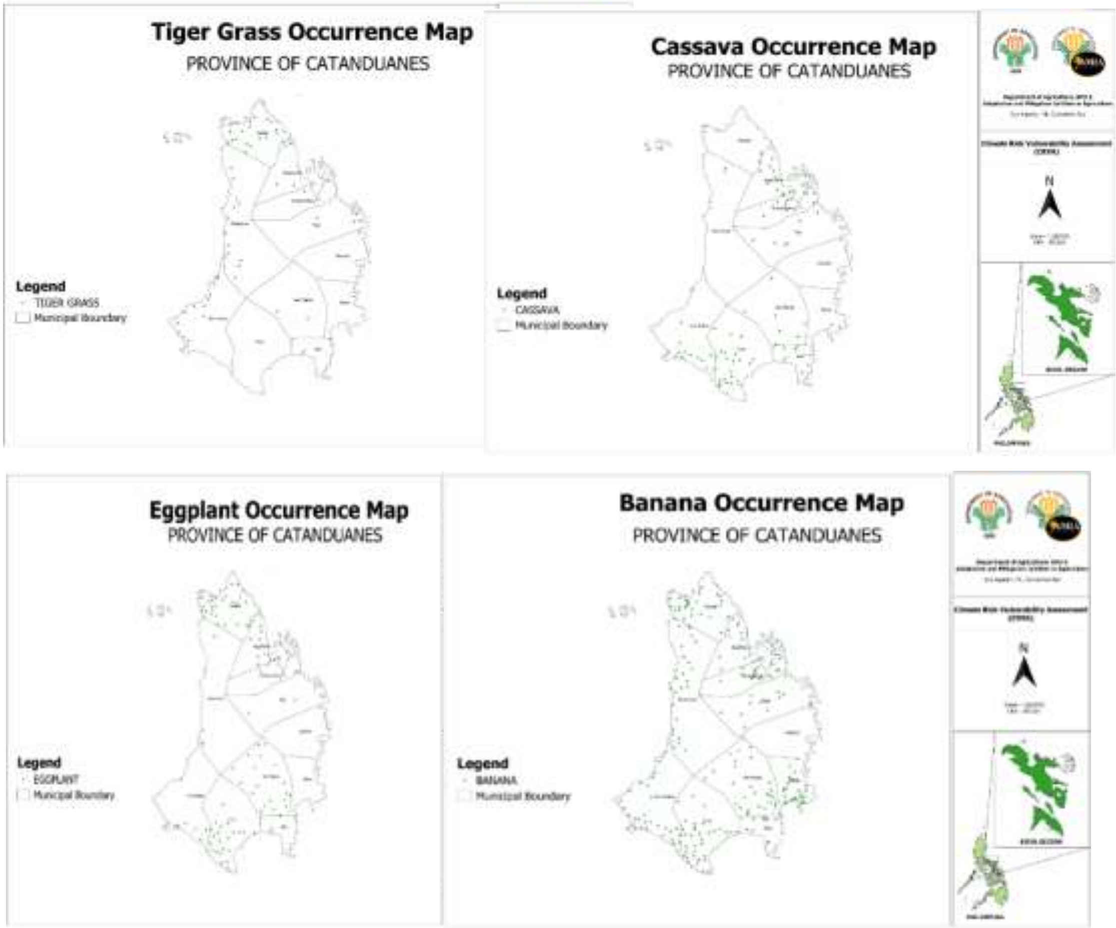


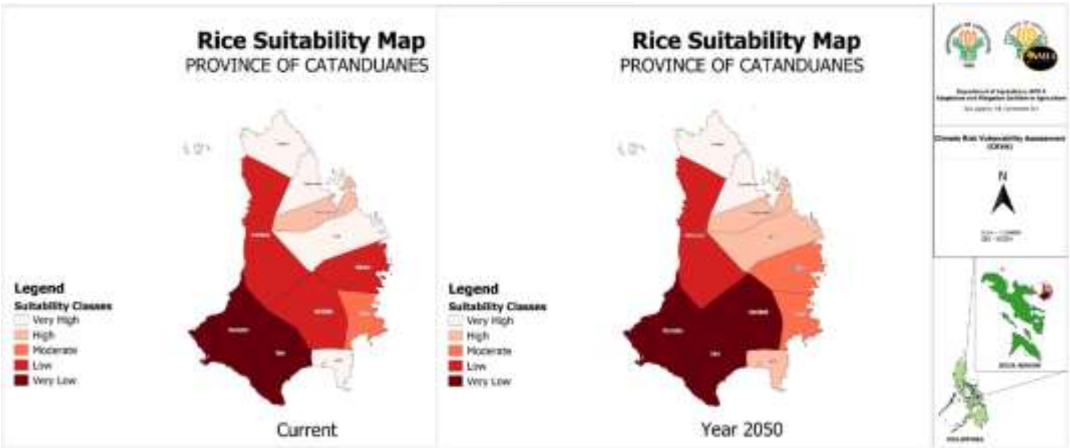
Figure 22Top Priority Commodities in Catanduanes Province (from *Left-Right: Rice, Abaca, Eggplant, Banana, Tiger Grass and Cassava)*

4.5.4. Crop Climatic Sensitivity and Suitability

4.5.4.1. Rice and Abaca

Rice is more *positive sensitive* (loss/diminish in suitable areas) than abaca. Currently, both Virac and Viga have 21% share in total rice area but it is projected that Virac will still have a very low suitability for rice by 2050. For abaca, while there are reductions in the suitable areas, only the Municipality of San Miguel slid to the low vulnerability class. The rest more or less has retained their suitability/non-suitability.

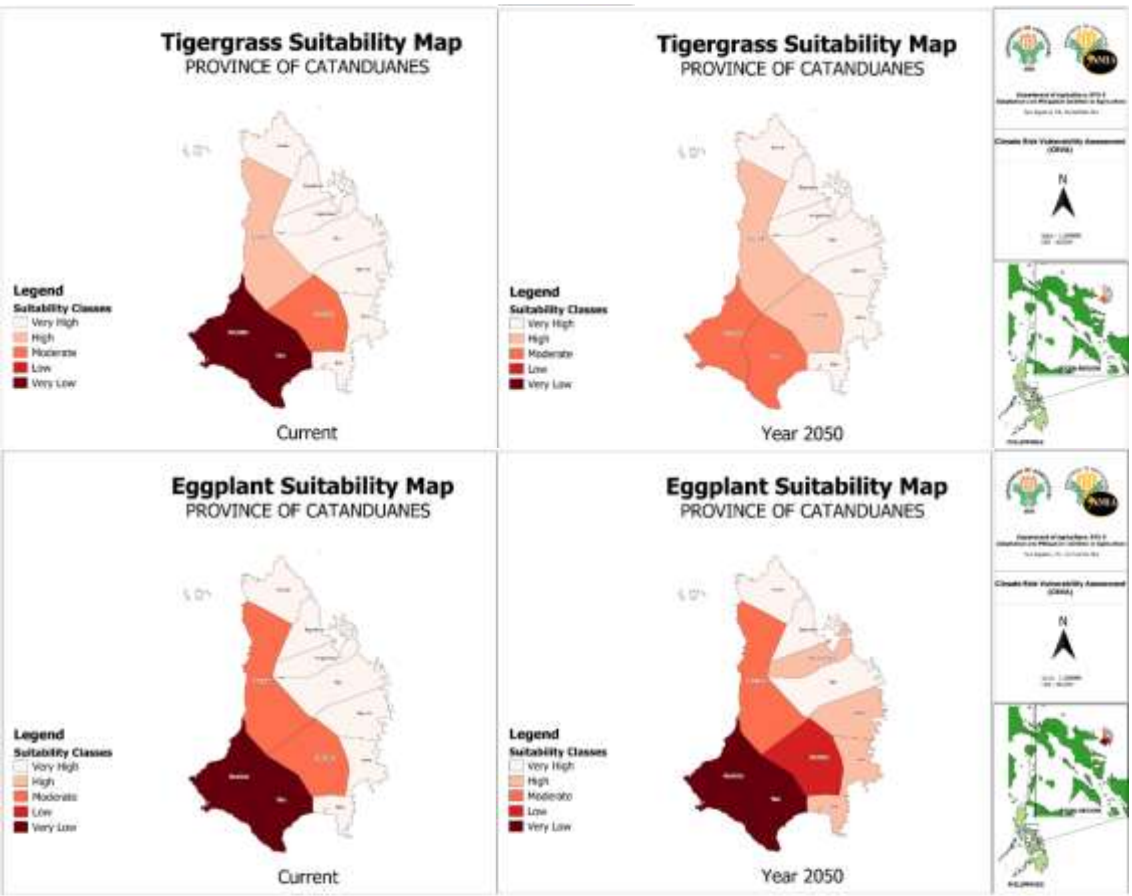
Abaca will still be an important commodity in the Catanduanes. An investment from the DA- Philippine Rural Development Project on fiber trading will be of help to ensure profitability of the commodity. However, due to exposure to hazards of the production area, programs to maintain the best abaca species or an improved variety should be developed to withstand hazards.



4.5.4.2. Tiger Grass, Eggplant, Banana and Cassava

Tiger grass has negative suitability (increase in suitable areas). Banana and eggplant has retained its suitability to areas already suitable at current areas except for San Miguel. For cassava, most of the interventions of DA is located in the Municipality of Bagamanoc, where its suitability is projected to backtrack from very high to very low vulnerability.

For areas with changes in the suitability, there is a need to develop new varieties with tolerance to some degree of climate extremes. For suitability maps of other commodities, see Appendix 24.



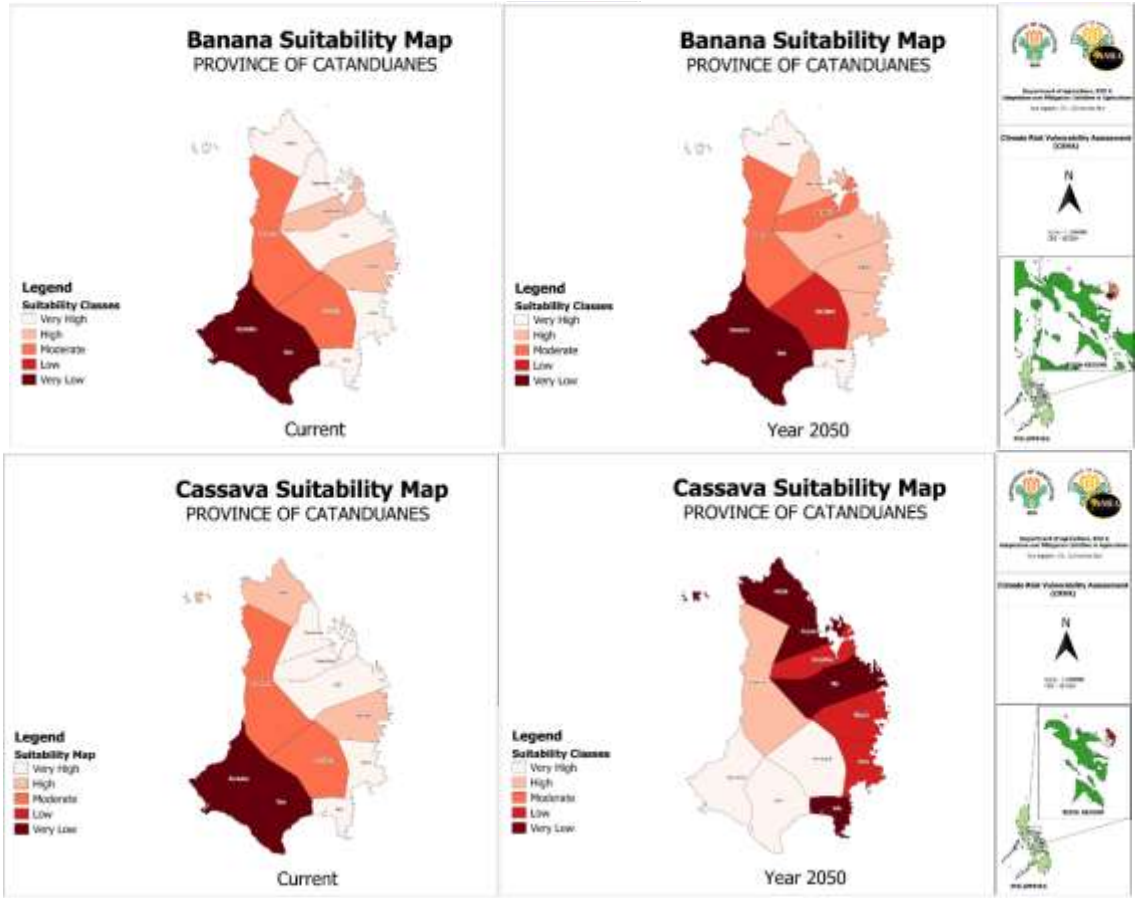


Figure 23 Tiger Grass, Eggplant, Banana and Cassava Suitability from Current Year and Future Year (2050) in Catanduanes Province

4.5.5. Vulnerability Assessment

The final climate risk vulnerability map for the year 2050 is analysis the function of the exposure, sensitivity, and adaptive capacity components. Almost all Municipalities of Catanduanes have high to very high vulnerability, except for the Capital Town, Virac.

These Municipalities with high to very high municipalities should be prioritize in implementing programs and projects, especially infrastructure, to increase capacity and resilience. Furthermore, adaptation strategies in agriculture through use of climate-resilient agriculture practices should be promoted. AMIA Villages may also be established in a community where agro-tourism can be promoted. Current agriculture products, especially abaca and millet (an heirloom crop found in Pandan and Caramoran) should be given utmost importance as the provinces have the comparative advantage in producing these. For climate risk vulnerability map per commodity, see Figure 24

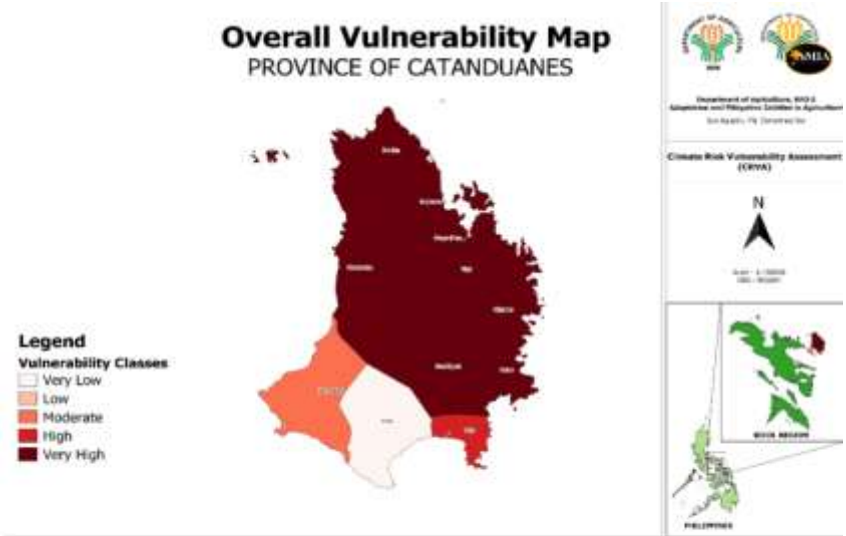


Figure 24Overall Vulnerability by 2050 of Catanduanes Province

4.6. Sorsogon

4.6.1. Adaptive Capacity

The aggregate capacity map revealed that the Municipalities of Juban and Santa Magdalena have the very low adaptive capacities among M/CLGUS of Sorsogon (Figure 25). Juban at 4th Class; and Santa Magdalena at 5th Class Municipality. Economic, human and social capitals have impacts to the ranking. These municipalities may have hard time in dealing on the impacts of climate change especially to its impact in the agriculture and fisheries sector.

The Municipality of Donsol has the peculiarity of attracting tourists thru the annual migration of *butanding* (whale shark). This opportunity can be tapped to develop other attractions. The Department of Social Welfare and Development RO 5 and DA RFO 5 has established numerous agriculture-related livelihood projects such as coffee, cacao and dragon fruit plantations. These can be further developed into an agro-ecosystem as new offering to the seasonal tourists arriving at the municipality.

Meanwhile, the City of Sorsogon, the provincial capital, has the only very high adaptive capacity rating. This bustling and thriving city can support, finance and address the impacts of climate change. For breakdown of different capitals, see Appendix 25

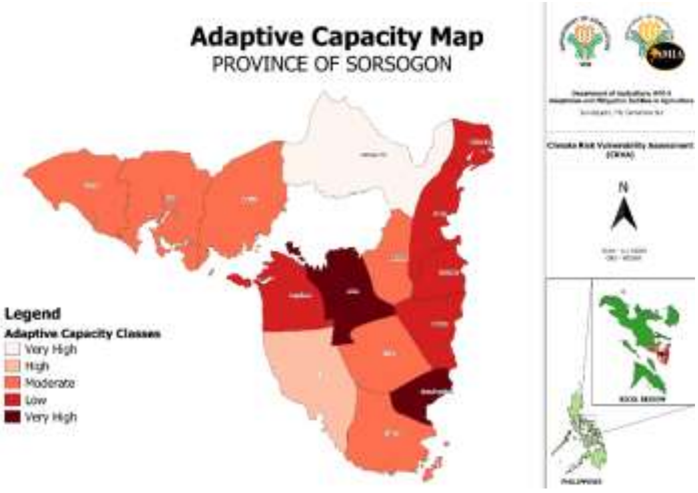


Figure 25 Aggregate Adaptive Capacity Map of Sorsogon Province

4.6.2. Exposure to Hazard

The Municipality of Prieto Diaz has the very high hazard index among the 15 M/CLGUs in Sorsogon. This is followed by the City of Sorsogon and Municipality of Gubat. 7 hazards (flood, tropical cyclones, soil erosion, salt water intrusion, drought, landslide, storm surge and sea level rise) were aggregated to form the overall hazard map (Figure 26). This implies that higher pressure to the agricultural sector is exerted by hazards. For maps of different hazards, see Appendix 26.

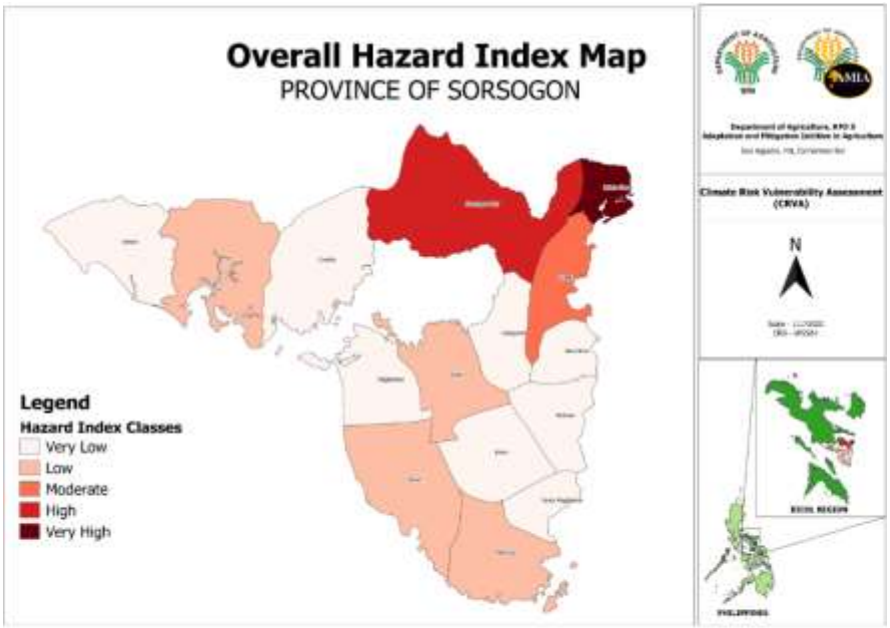


Figure 26Aggregate Hazard Map of Sorsogon Province

4.6.3. Crop Occurrence of Priority Crops

The crop occurrence points show where the commodities are marjority produced and intended for commercial production. Rice, pili, banana, eggplant, cassava and string beans are generally grown in almost all municipalities and cities of Albay. The province is a net producer of pili nuts in Region 5. For maps of other commodities, see Appendix 27.

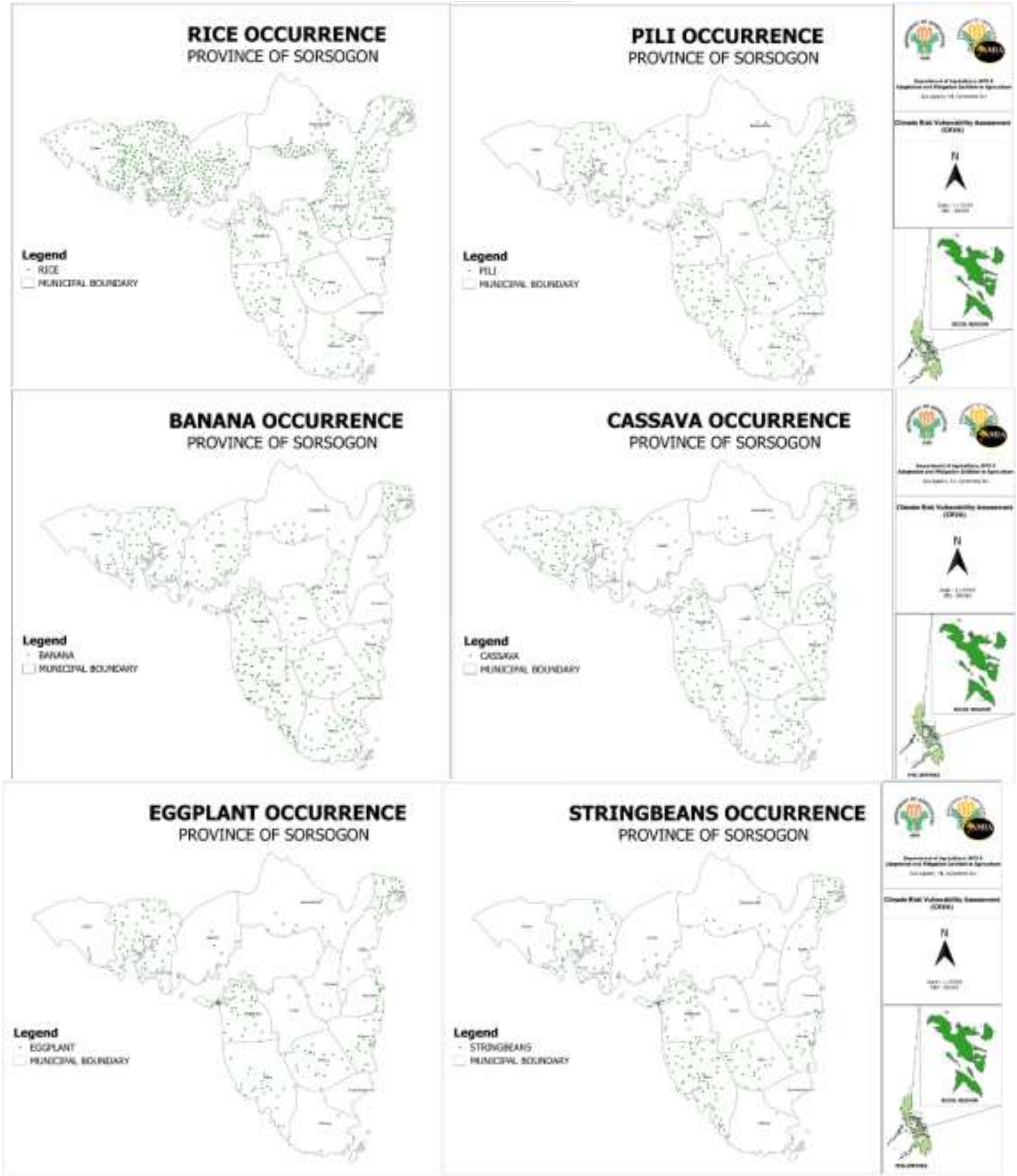


Figure 27 Top Priority Commodities in Sorsogon Province (from *Left-Right: Rice, Pili, Banana, Eggplant, Cassava and String Beans)*

4.6.4. Crop Climatic Sensitivity and Suitability

4.6.4.1. Rice and Pili

Rice has various sensitivity (loss/increase in suitable areas) among the municipalities and city. The most **positive sensitive** (loss/diminish in suitable areas) are the: City of Sorsogon, Castilla, Juban, and Santa Magdalena. A third of the production area (equivalent of 5,965 ha as per 2019 data of production) may be affected by 2050. Farm holdings in the province is relatively lower at 0.78ha/farmer (DA RFO 5, 2019). This will further put pressure on the food production and food security among small-scale landowners.

Pili crop may be more adaptable in southern part of Sorsogon. With more municipality having a positive sensitivity (loss/diminish in suitable area), the supply of pili nut may be affected in the future year. Pili is considered a climate-change adaptable crop. Despite frequently being damaged by tropical cyclones, not all pili fruits are fell by the strong winds. This may change by 2050. Thus, varietal improvement and distribution of asexually propagated plants should be undertaken to maximize yield. A pili seedling can take 5-6 years before fruiting starts as compared to 3 years of asexually propagated seedlings.

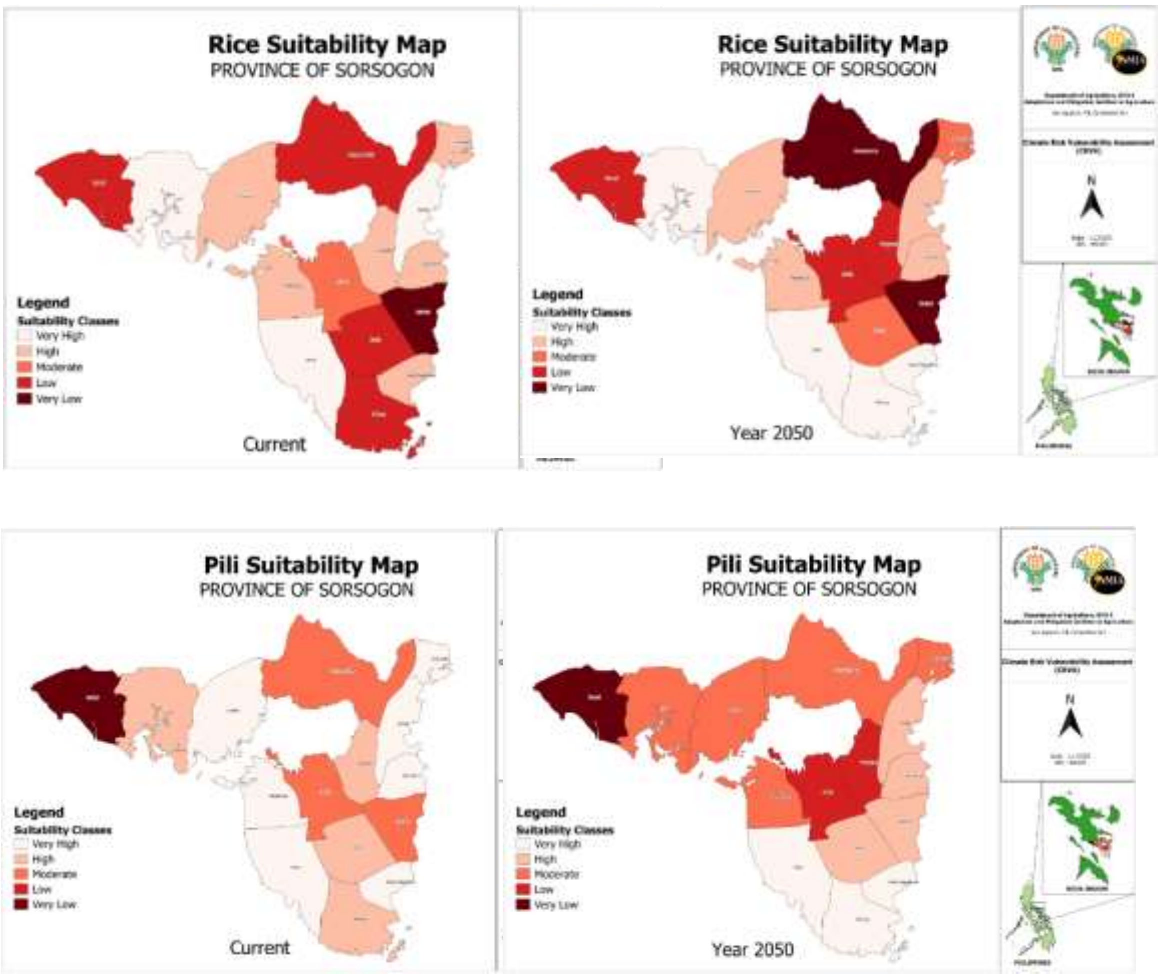
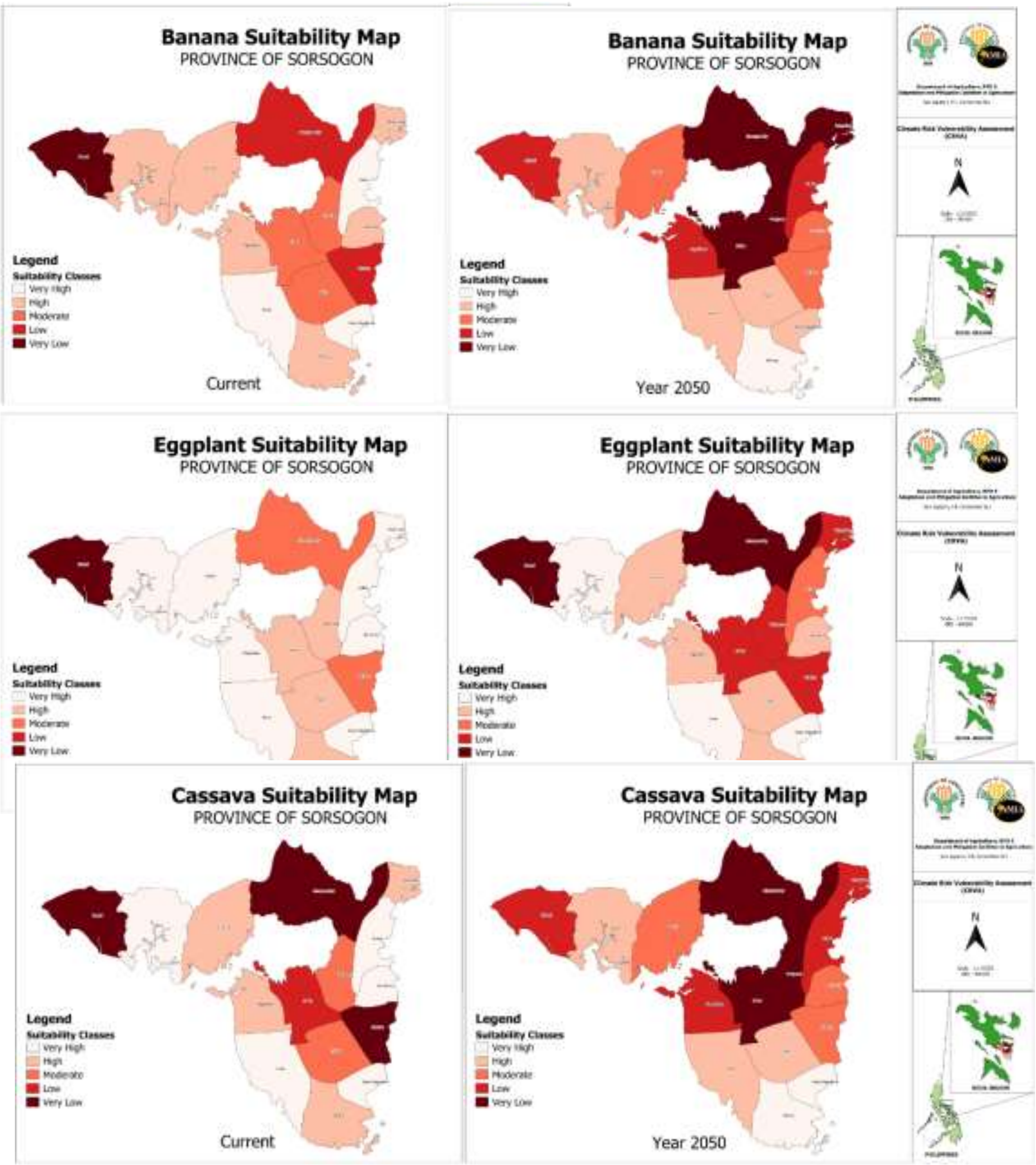


Figure 28 Rice and Pili Suitability from Current Year and Future Year (2050) in Sorsogon Province

4.6.4.2. Banana, Eggplant, Cassava, and String beans

Vegetable and fruit production has various suitability by 2050 (Figure 29). The essence of these is to prioritize crops which will be more suitable in the locality or adapt climate-resilient agriculture practices that will help sustain production. For suitability maps of other commodities, see Appendix 28.



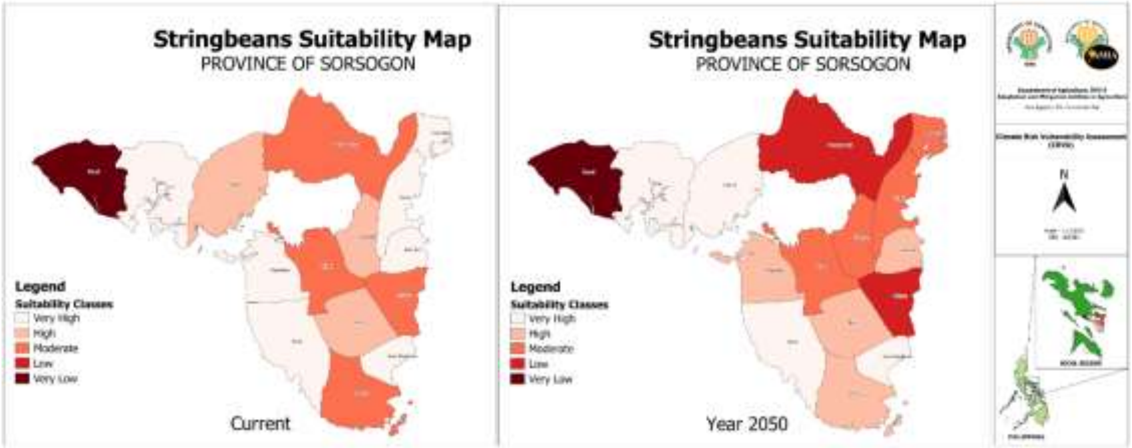


Figure 29 Banana, Eggplant, Cassava, and String beans Suitability from Current Year and Future Year (2050) in Sorsogon Province

4.6.5. Vulnerability

The final climate risk vulnerability map for the year 2050 is the integration of the exposure, sensitivity, and adaptive capacity components.

The Municipality of Prieto Diaz, Gubat, Juban, and Santa Magdalena have the very high vulnerability among LGUs of Sorsogon. These Municipalities should be prioritizing in implementing programs and projects, especially infrastructure, to increase capacity and resilience. Furthermore, adaptation strategies in agriculture through use of climate-resilient agriculture practices should be promoted. AMIA Villages may also be established in a community where agro-tourism can be promoted. For climate risk vulnerability map per commodity, see Appendix 29

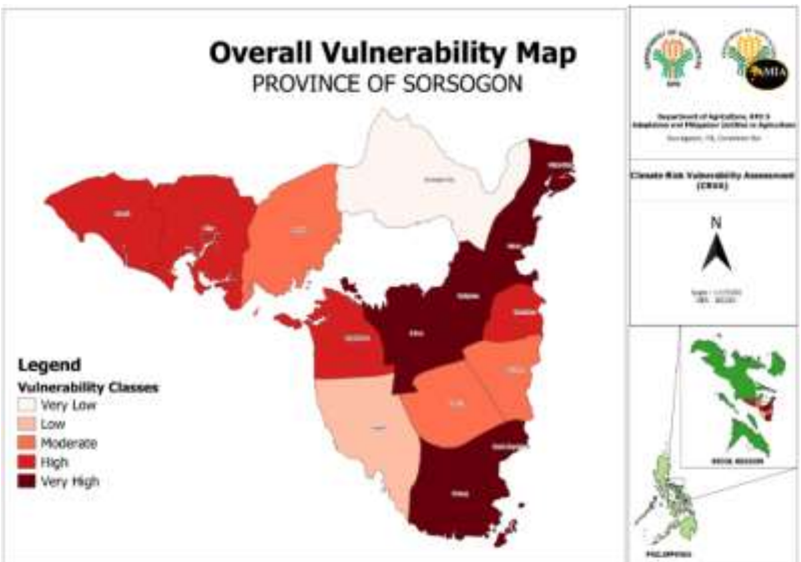


Figure 29. Vulnerability Map Province of Sorsogon

4.7. Masbate

4.7.1. Adaptive Capacity

The aggregate capacity map revealed that the Municipalities of Balud from District 3, Baleno and Esperanza have the very low adaptive capacities among M/CLGUS of Masbate (Figure 30). Majority of these belong to the 4th Class Municipality. Contributory to these are the sluggish economic activities resulting from conflicts, low human development, underdeveloped natural capital, low physical capital and low socio-economic indicators.

Meanwhile, the City of Masbate, the provincial capital, has the only very high adaptive capacity rating. This bustling and thriving city can support, finance and address the impacts of climate change. Joining the group with high adaptive capacity are the municipalities of Aroroy, Milagros, Cawayan, Dimasalang and Cataingan. For breakdown of different capitals, see Appendix 30.

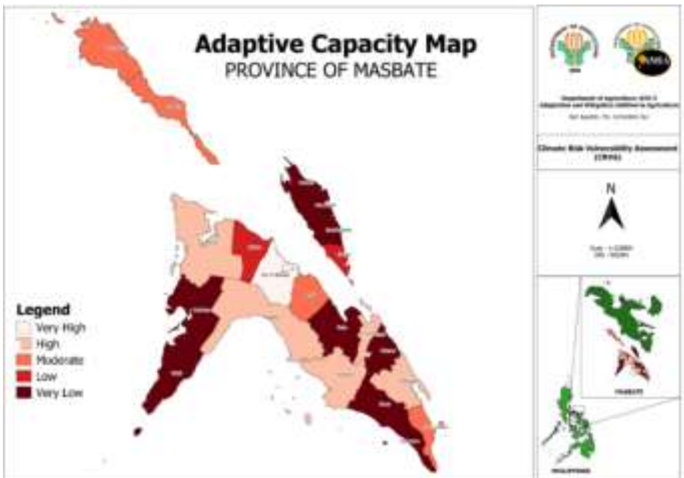


Figure 30. Aggregate Adaptive Capacity Map of Masbate Province

4.7.2. Exposure to Hazard

The Municipalities of San Pascual and Claveria in District 1 have the very high exposure to hazard. This municipality forming an island is heavily secluded from the Masbate Mainland. Its exposure to soil erosion, sea level rise and tropical cyclones put these municipalities at higher risk. This implies that higher pressure to the agricultural sector is exerted by hazards. While regular marine vessels are plying the Masbate-Camarines Sur route, remoteness of some villages of exacerbate the exposure of agricultural production not only to hazards but also to losses in quantity and quality of produce due to delayed in hauling caused by rains and cancellation of marine vehicle transportation. For maps of different hazards, see Appendix 32.

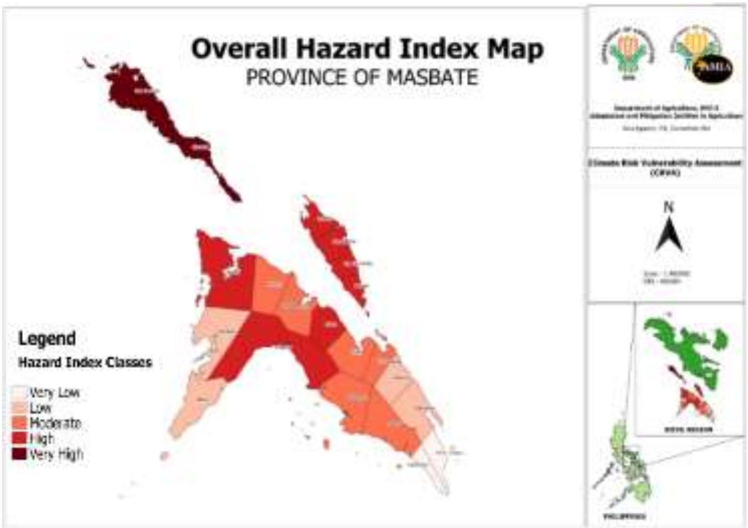
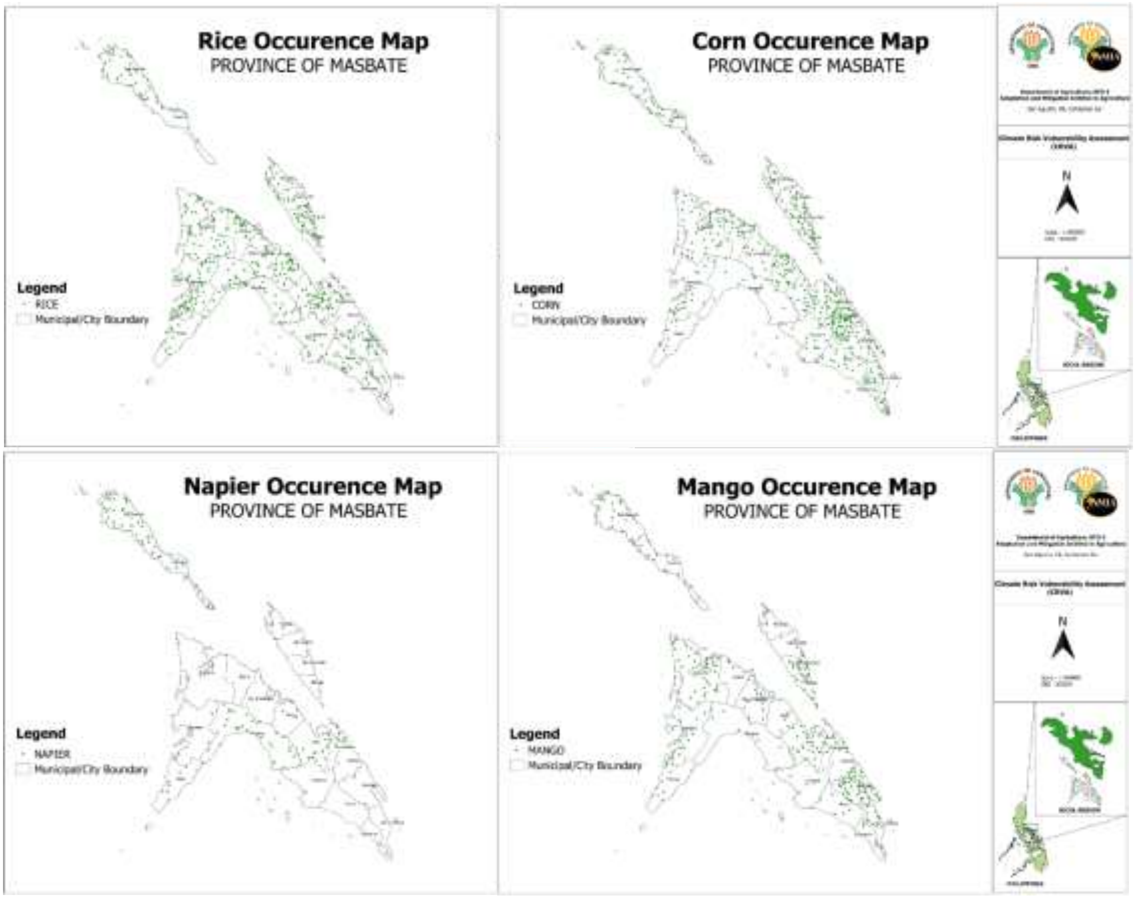


Figure 31 Aggregate Hazard Map of Masbate Province

4.7.3. Crop Occurrence of Priority Crops

The crop occurrence points show where the commodities are majority produced and intended for commercial production. Rice, corn, napier, mango, cassava and banana grown in almost all municipalities and city of Masbate. Napier is for forage of ruminants, which Masbate is known for. Meanwhile, white corn is an alternative for rice. Cassava and yellow corn are currently being promoted for feed processing. For maps of other commodities, see Appendix 32.



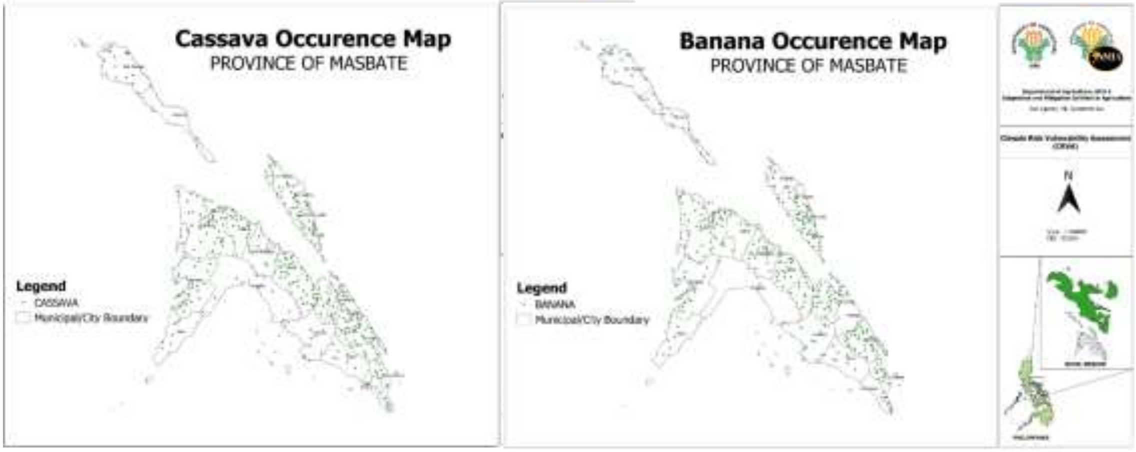


Figure 32 Top Priority Commodities in Masbate Province (from *Left-Right: Rice, Corn, Napier, Mango, Cassava and Banana)*

4.7.4. Crop Climatic Sensitivity and Suitability

4.7.4.1. Rice and Corn

The top rice-producing municipalities of Balud, Milagros and Placer will still experience a moderate to very high suitability (Figure 33). Forty-six percent (46%) of the rice production areas are concentrated in these municipalities. However, different scenario is project for San Pascual, Monreal and San Jacinto. Climate factors will lead to very low suitability for rice growth.

Corn, being a staple, has a positive sensitivity (loss/diminish in suitable areas). However, this scenario is particularly concentrated in the 1st district of Masbate.

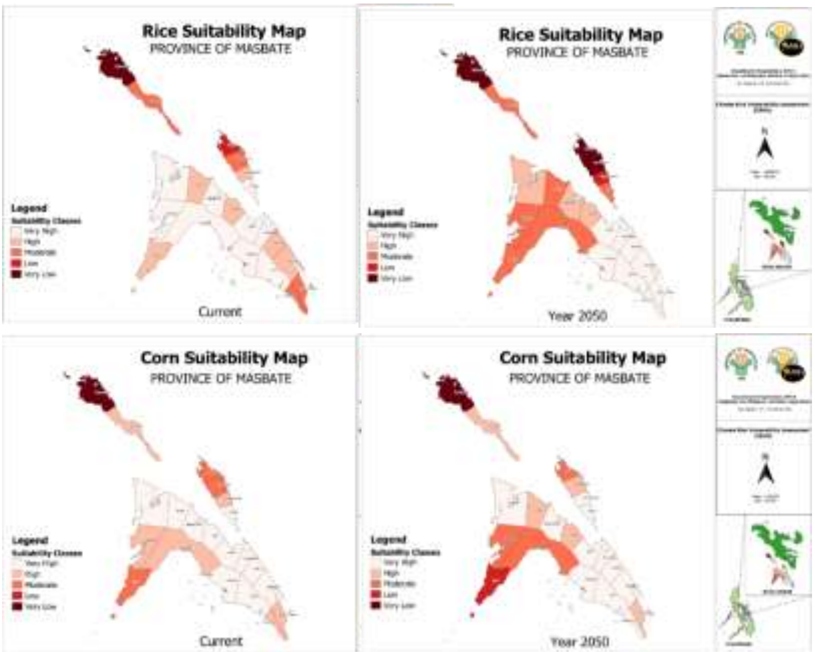
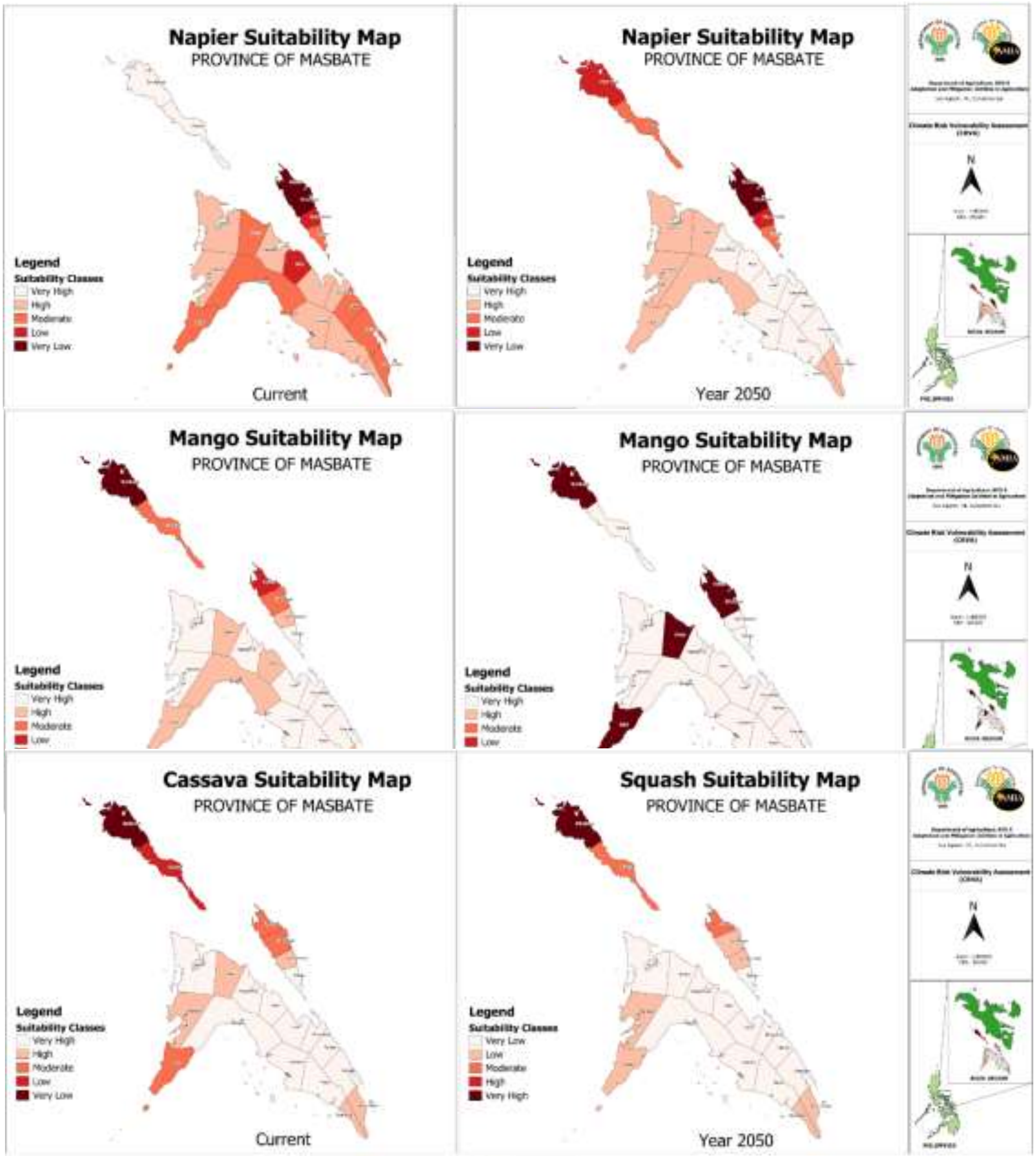


Figure 33 Rice and Corn Suitability from Current Year and Future Year (2050) in Masbate Province

Food security is very crucial for Masbate. Rugged terrain, limited land transportation available connecting the different municipalities and villages, arm conflict and climate risks challenge the fragile condition of Masbate. With its scenic island, its natural resources should be tapped to augment income to existing industries, such as cattle farming, Furthermore, establishment of feed mill, mango processing, and branding the province as a reliable source of healthy rice-corn blend should be taken into consideration.

4.7.4.2. Napier, Mango, Cassava and Banana

Napier is projected to be very highly suitable in almost all territories of Masbate except Ticao and Burias Islands. For mango, it's highly suitable to plant except for project unsuitability in San Pascual, Monreal, San Jacinto, Baleno and Balud. Squash will still have a very high suitability while banana may experience changes in geographical suitability (Figure 34). For suitability maps of other commodities, see Appendix 33.



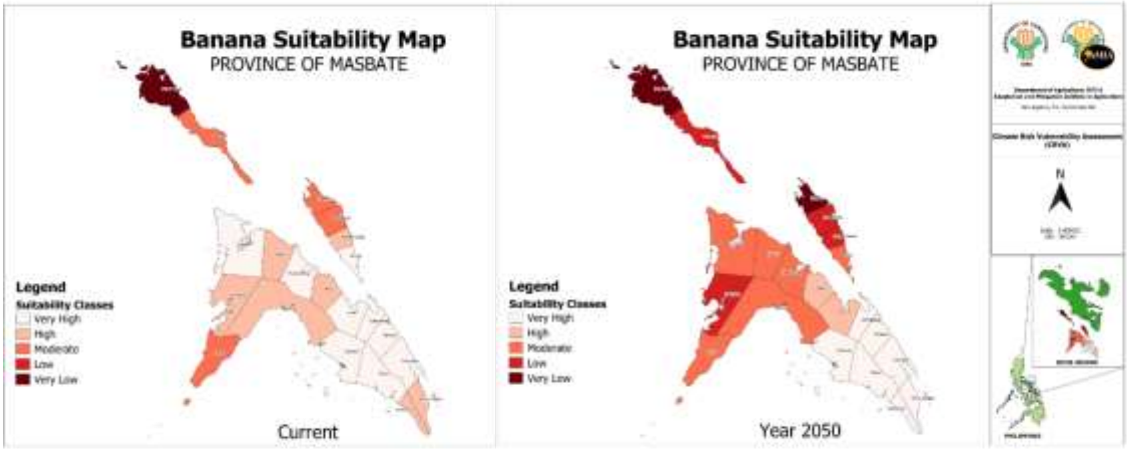


Figure 34 Napier, Mango, Cassava and Banana Suitability from Current Year and Future Year (2050) in Masbate Province

4.7.5. Vulnerability

The final climate risk vulnerability map for the year 2050 is the integration of the exposure, sensitivity, and adaptive capacity components. The following municipalities have very high vulnerability: District 1 especially from Burias Island, the municipalities of Monreal, San Jacinto, Batuan; District 2: Mandaon, Balud, Baleno; and District 3: Esperanza, Palanas, and Placer. These Municipalities should be prioritized in implementing programs and projects, especially infrastructure, to increase capacity and resilience. Furthermore, adaptation strategies in agriculture through use of climate-resilient agriculture practices should be promoted. AMIA Villages may also be established in a community where agro-tourism can be promoted. For climate risk vulnerability map per commodity, see Appendix 34.

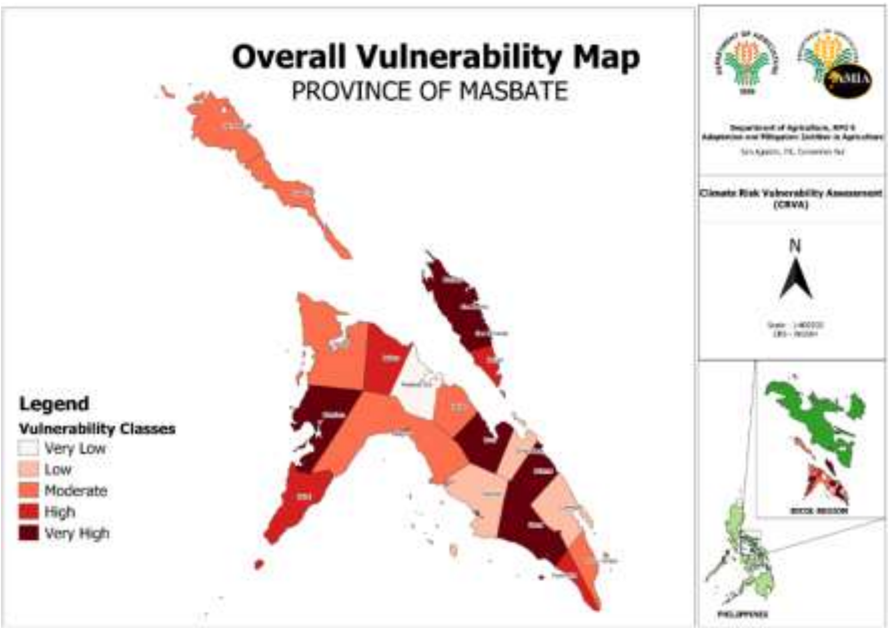


Figure 35. Overall Vulnerability Masbate Province

5. Regional Map

5.1 Aggregate Adaptive Capacity

Bicol Region, based on the result in Aggregate Adaptive Capacity, 5.26% (Naga City(2nd component city), Masbate City and Sorsogon City (both 4th class city), Virac and Daet (both 1st class municipality) and Legazpi City(1st class component city) of 114 LGUs has a Very High capacity to adapt while 27.19% are very low, this municipality are also very low in terms in economic capital, human capital, institutional capital and vulnerable to hazard (see Appendix 35). The remaining municipality were 7.02% High, 18.42% Moderate and 43.86% low adaptive capacity.

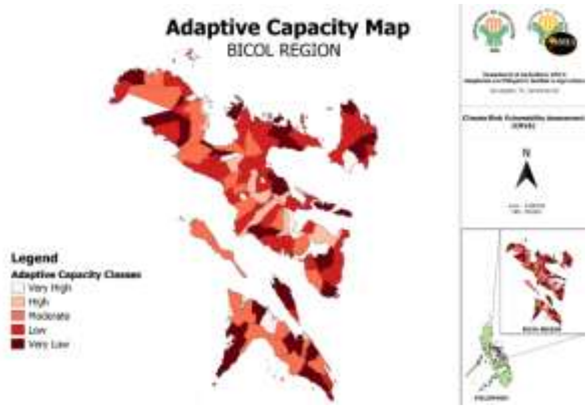


Figure 36. Regional Aggregate Adaptive Capacities

5.2 Overall Exposure to Hazard

The municipalities of Libmanan, Lagonoy and Caramoan have the very high hazard index among 114 M/CLGUs in Bicol Region. These municipalities are area along seashores and riverbanks that more affected by typhoons, flood and salt water intrusion. This is evident that the municipalities situated in Bicol River Basin, Lagonoy Gulf, San Miguel Bay and Ragay Gulf.

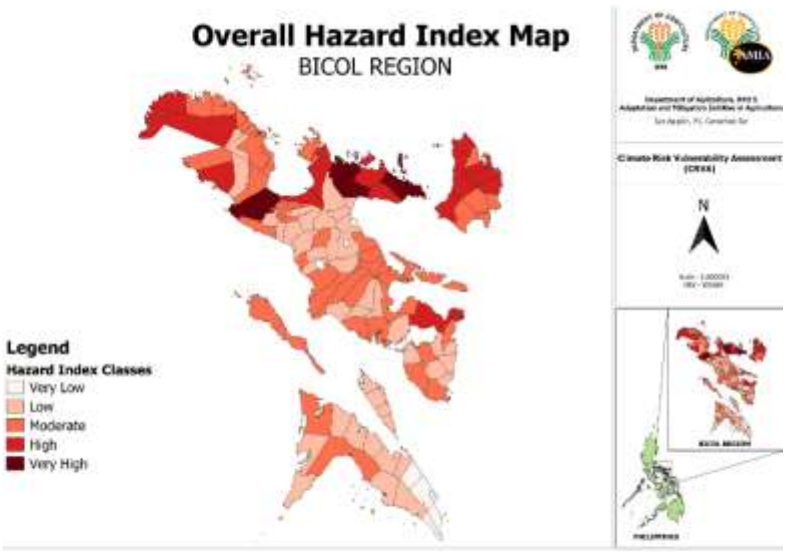


Figure 37. Regional Overall Hazard Index Map

5.3 Crop Climatic Sensitivity and Suitability

Rice, Corn, Banana and Coconut, are the major priority crops of Bicol Regions. Rice Suitability in the region in has a loss/increase in suitable areas for rice among the province of Camarines Sur, Sorosgon, Albay and Camarines Norte. Where areas, Camarines Sur has a prevalent contribution in Rice production irrigated and rain fed with a total of 174,130 areas harvested (PSA, 2019). While other province, Masbate for year 2050 projection, crop suitability has have a positive increase in rice production.

For Corn, being a staple has a positive loss/increase in Canarines Norte, Sorsogon and Catanduanes with Very low, Moderate to High Suitability. Masbate, Camarines Sur and Albay were, has an immense share in areas harvested of 103,205 ha (PSA, 2019) has a positive high suitability for corn production future 2050.

Coconut remained the major permanent crop in Bicol Region. Camarines Norte,Camarines Sur and Catanduanes is very low to low the suitability for coconut for the next 30 years. Masbate, Albay and Sorsogon, is highly suitable for 2050 projection. Rugged terrain, farm to market road and industrialization establishment in Masbate of other industries affects. While in banana, Camarines Norte, Camarines Sur and Catanduanes is loss/negative diminish for crop suitability projection for 2050, the essence of this is to give priority to the crops which will be more suitable for next 30 years but apply the climate resilient agriculture practices to sustain the food security, see Appendix 35.

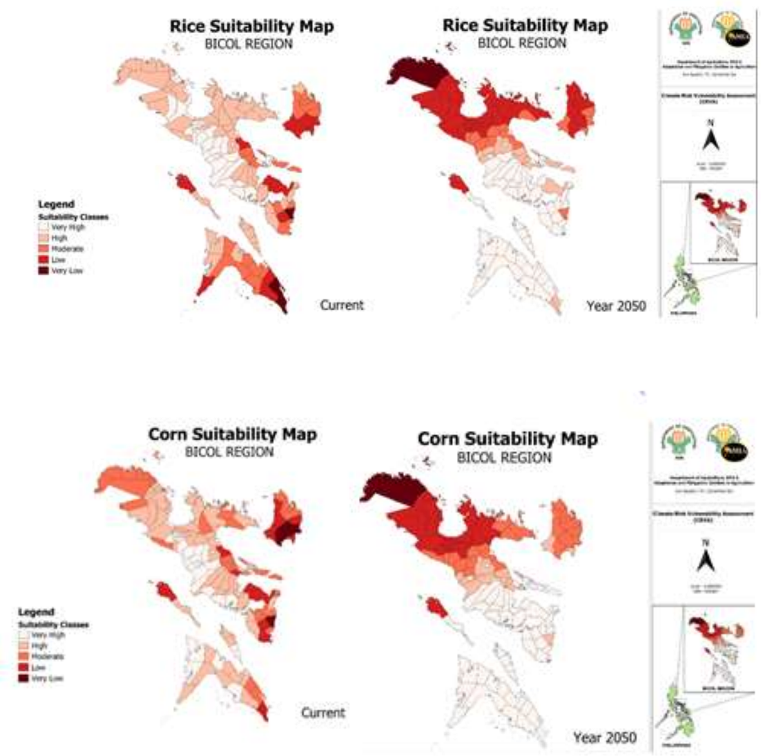


Figure 38.Regional Overall Hazard Index Map

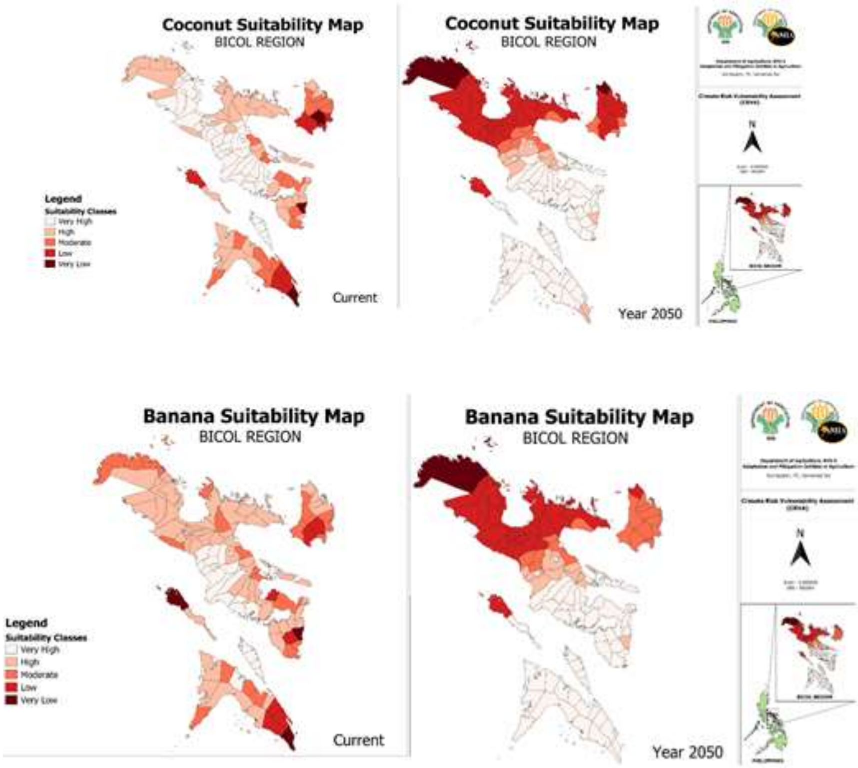


Figure 39.Regional Overall Hazard Index Map

5.4. Overall Vulnerability

Bicol Region final map for climate risk vulnerability for 2050 is the integration of the exposure, sensitivity, and adaptive capacity components.

Eighteen municipalities have a very high vulnerability among of 114 LGU's of Bicol Region. These municipalities should prioritize in implementing programs and projects, especially infrastructure, to increase capacity and resilience. Climate Resilient Agricultural practices should be promoted. AMIA Villages maybe also established in a community where agro-tourism can be promoted (eq. Camarines Norte,Albay, Catanduanes,Masbate and Sorsogon).

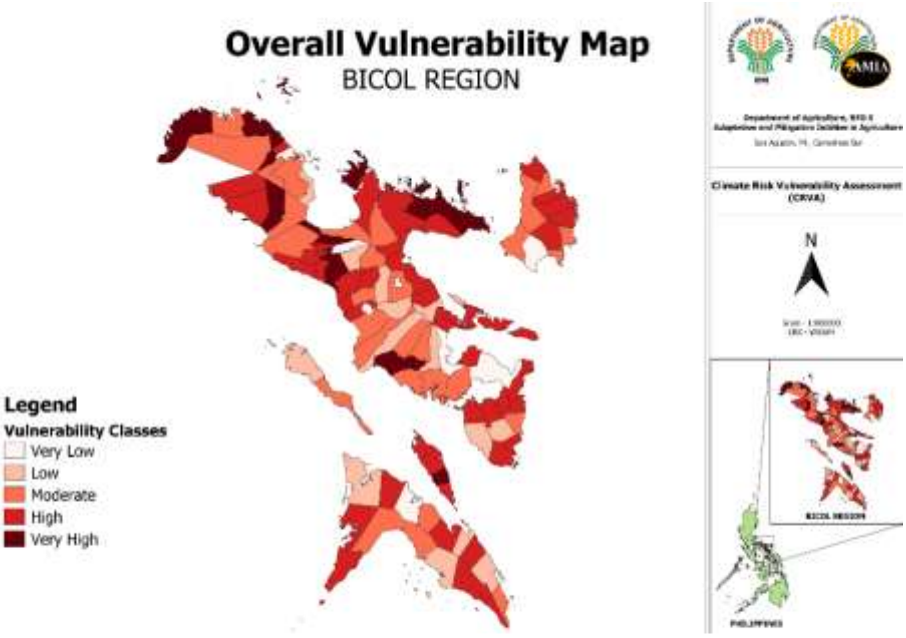


Figure 40.Regional Overall Hazard Index Map

6. Conclusion and Recommendation

6.1. Conclusion

1. Adaptive capacities of each Municipality of Bicol Region are highly affected by economic capital. Municipalities belonging to the 3rd to 5th Class have generally low to very low adaptive capacities.
2. Exposure to hazards of the municipalities and cities directly affect agriculture and fishery sector.
3. Crop climatic suitability of selected commodities showed positive and negative sensitivity. For rice, it has positive sensitivity (loss in suitable areas) except for Camarines Norte. It may have a negative effect in the food security in the near future. The loss of suitability of rice may open opportunities for growing other crops with economic importance.
4. The overall vulnerability determines the municipalities that will need interventions to increase capacity and resiliency. These are closely related to the results of the adaptive capacity.

6.2. Recommendations

The following policies are hereby recommended:

1. Prioritization of highly vulnerable municipalities in the implementation of programs and projects to increase capacity and resilience
2. Updating of the Local Climate Change Action Plans based on the CRVA results
3. Updating of the roadmaps and crop investment plans utilizing the results of the study
4. Climate-resilient agriculture practices promotion
5. Infrastructure and climate-resilient infrastructure development (i.e. flood control, water desalination plant, terracing, solar-powered and bio-gas powered equipment promotion, retrofitting of the existing infrastructure)
6. Gradual shifting from one crop to another that will maintain the comparative advantage of farmers

7. References

Department of Agriculture Regional Field Office V
Website: http://bicol.da.gov.ph/ Date Accessed: January 6, 2020

DOST-PAGASA, 2018. Observed and Projected Climate Change in the Philippines. Philippine Atmospheric, Geophysical and Astronomical Services Administration, Quezon City, 36pp.

Farmer's Guide Map
Website: *www.farmersguidemap.gov.ph* Date Accessed: January 6, 2020

International Center for Tropical Agriculture (CIAT).
https://ciat.cgiar.org/ciat-projects/climate-risk-vulnerability-assessment-crva-to-support-regional-targeting-and-planning-for-the-adaptation-and-mitigation-initiative-in-agriculture-amia/02 January 2020
Date accessed: December31, 2019

Laureta, R.P. 2017. Regional Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting & Prioritization for the Adaptation and Mitigation Initiative (AMIA) Phase 2, Region V (Bicol)- Camarines Sur. Partido State University. Goa, Camarines Sur.

Paquit, J.C., AG. Bruno, TA Rivera and R.O. Salingay, 2018. Climate-risk vulnerability assessment of the Agriculture Sector in the Municipalities and Cities of Bukidnon, Philippines. Bukidnon, Philippines.

Philippine Atmospheric, Geophysical and Astronomical Services Administration
Website: www.pagasa.dost.gov.ph Date accessed January 6, 2020

UNFPA
https://philippines.unfpa.org/en/node/15308
January 6, 2020

Zhao C., B. Liu, S. Piao, X. Wang, D. Lobell, Y. Huang, M. Huang, Y. Yao, S. Bassu, P. Ciais, J. Durand, J. Elliott, F. Ewert, I. Janssens, T. Li, E. Lin, Q. Liu, P. Martre, C. Müller, S. Peng, J. Peñuelas, A.C. Ruane, D. Wallach, T. Wang, D. Wu, Z. Liu, Y. Zhu, Z. Zhu, S. Asseng. 2017. Temperature Increase Reduces Global Yields. Proceedings of the National Academy of Sciences Aug 2017, 114 (35) 9326-9331; DOI: 10.1073/pnas.1701762114

APPENDICES

Appendix 1 Adaptive Capacity Indicators

Indicator	Sub-indicators	Weight
Anticipatory capital	Presence of MDRRMC, Early warning systems, Radio/TV stations, Telecommunications	12.5
Economic capital	Income level, water and sanitation, electricity, banks and financial institutions, commodity prices, farm income, agricultural insurance, employment in agriculture.	12.5
Health Capital	health services, nutrition sufficiency and sanitation	12.5
Human capital	School enrolment, student teacher ratio, number of class rooms, number of school buildings	12.5
Institutional capital	CSO programs, government response to calamities	12.5
Natural capital	Forest cover, groundwater availability, irrigation system	12.5
Physical capital	Land tenure, farm size, farm equipment, value of livestock, irrigated area, access to quality seeds, roads, market access	12.5
Social capital	Farmer unions, farmer cooperatives	12.5

Appendix 2 Hazard Weight

Hazard	Source	Unit of measurement, spatial and temporal resolution	Weight for Luzon (%) Source: CIAT
Typhoon	UNEP/UNISDR,2013	1km pixel resolution. Estimate of tropical cyclone frequency based on Saffir-Simposon Category 5 and higher from year 1990-2009	20.00
Flood	AMIA Multi-hazard map/baseline data from MGB-DENR	1:10,000 scale. Susceptibility of flood risk for Philippines from the past 10 years	19.05
Drought	AMIA Multi-hazard map/baseline data from National Water Resources Board	Groundwater potential from the past 10 years	14.25
Erosion	AMIA Multi-hazard map/baseline data from BSWM	1:10,000 scale. Soil erosion classified from low to high susceptibility	11.43
Landslide	AMIA Multi-hazard map/baseline data from MGB-DENR	1:10,000 scale. Landslide classified from low to high susceptibility	8.57
Storm Surge	AMIA Multi-hazard map/baseline data from Exposure, Assessment for Mitigation (DREAM-DOST)		9.52
Sea Level Rise	AMIA Multi-hazard map		5.71
Saltwater Intrusion	AMIA Multi-hazard map/ baseline data from NWRB	Ground water potential for the Philippines	11.43

Appendix 3 Top Commodities per Province

Ref. No.	Albay	Camarines Sur	Camarines Norte	Catanduanes	Masbate	Sorsogon
1	Abaca	Mango	Coconut	Cacao	Sweet Potato	Cacao
2	Banana	Abaca	Ampalaya	Calamansi	Ampalaya	Coconut
3	Cacao	Banana	Cacao	Coconut	Bangus	Coffee
4	Coconut	Cacao	Cassava	Corn	Blue Crab	Corn
5	Napier	Coconut	Eggplant	Millet/Dawa	Coconut	Mango
6	Okra	Napier	Napier	Mud crab	Eggplant	Napier
7	Papaya	Pili	Okra	Napier	Mud Crab	Okra
8	Squash	Sweet Potato	Pechay	Pili	Peanut	Pineapple
9	Taro	Taro	Pili	Pineapple	Seaweeds	Seaweeds
10	Tilapia	Tilapia	Sugarcane	Sweet Potato	Squash	Siling Haba
11	Water Melon	Tomato	Taro	Taro	Tilapia	Squash
12			Tilapia	Tilapia		Sweet Potato
13			Tomato	Watermelon		Tilapia

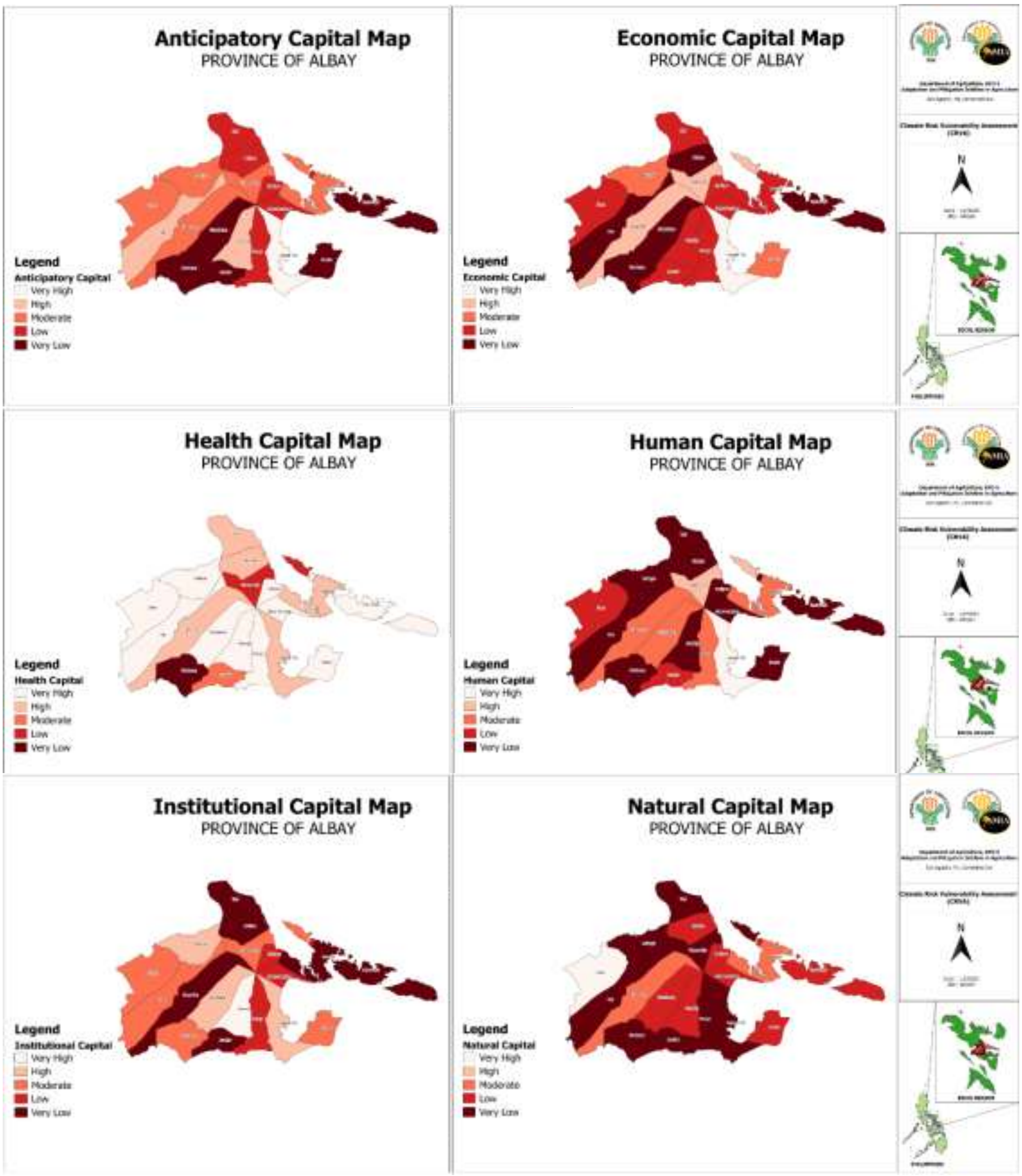
Appendix 4 List of Bioclimatic Variables

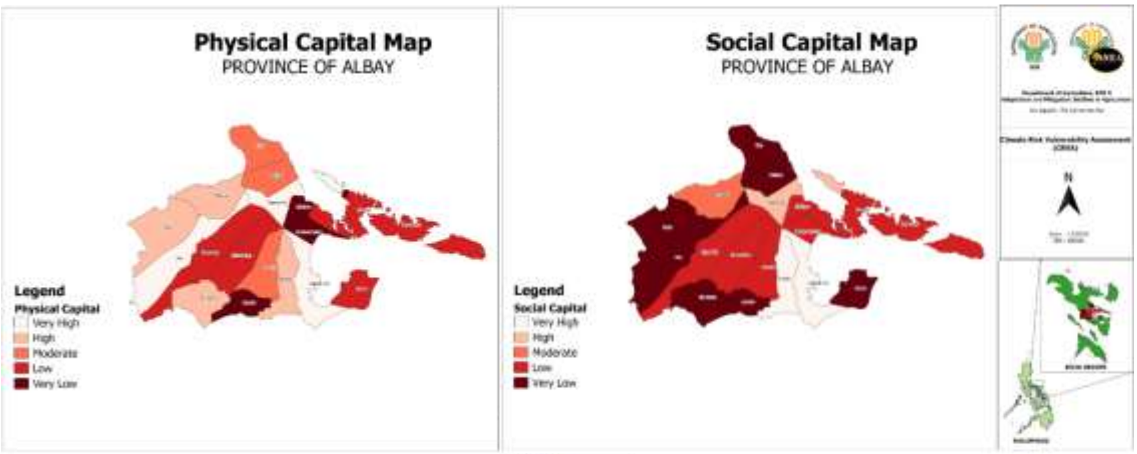
Code	Variable
BIO1	Annual Mean Temperature
BIO2	Mean Diurnal Range (Mean of monthly(max temp - min temp))
BIO3	Isothermality (BIO2/BIO7)*(100)
BIO4	Temperature Seasonality (standard deviation *100)
BIO5	Max Temperature of Warmest Month
BIO6	Min Temperature of Coldest Month
BIO7	Temperature Annual Range (BIO5-BIO6)
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 (Coefficient of Variation)
BIO16	Precipitation of Wettest Quarter
BIO17	Precipitation of Driest Quarter
BIO18	Precipitation of Warmest Quarter
BIO19	Precipitation of Coldest Quarter
BIO20	Number of consecutive dry days

Appendix 5 Sensitivity index based on percent change in crop suitability from baseline to future condition

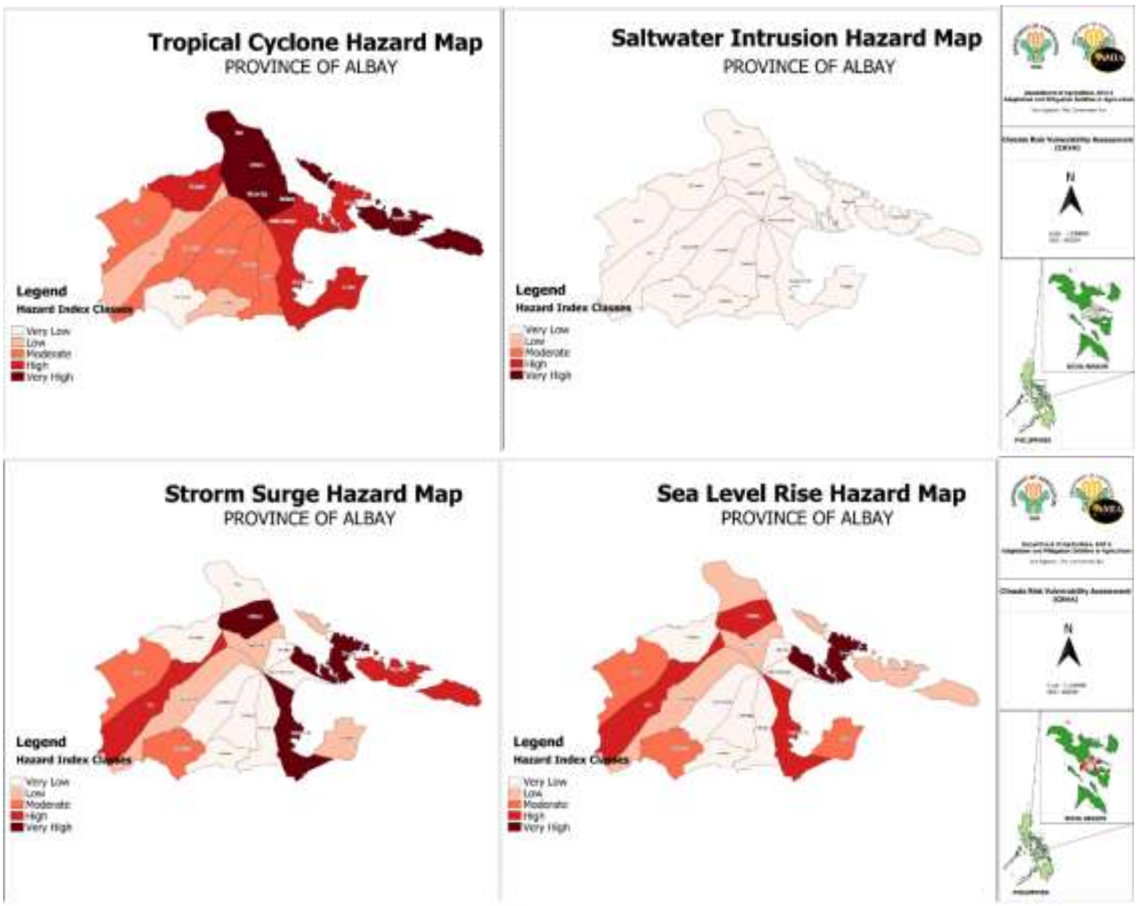
Percent Change in Suitability (Range in %)	Index	Description
<= -50 (Very high loss)	1.00	
> Loss -50 &<= -25 (High loss)	0.50	Loss
> -25 &<= -5 (Moderate loss) 0	0.25	
> -5 &<= 5 (No change)	0.00	No Change
> 5 &<= 25 (Moderate gain)	-0.25	
> 25 &<= 50 (High gain)	-0.50	Gain
> 50 (Very high gain)	-1.00	

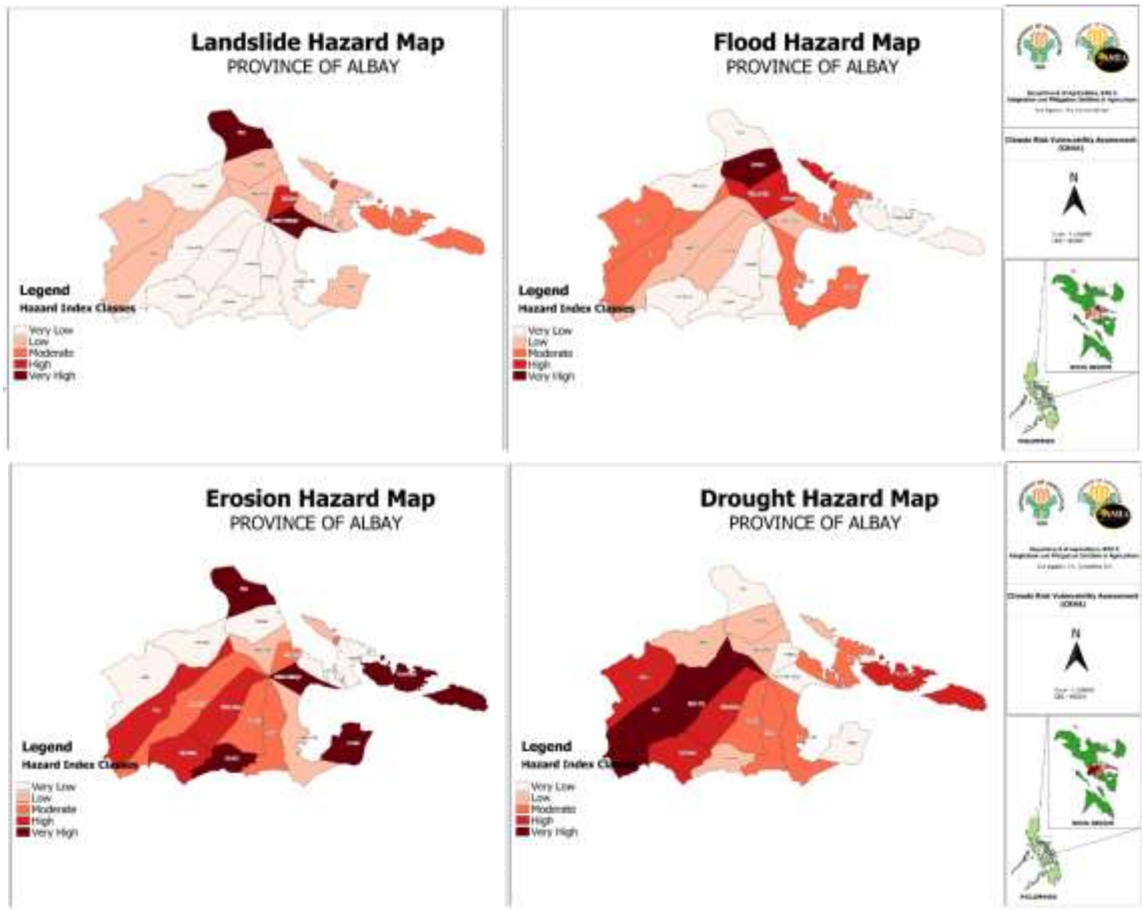
Appendix 6 Adaptive Capacity Maps of the Province of Albay (Per Capital)



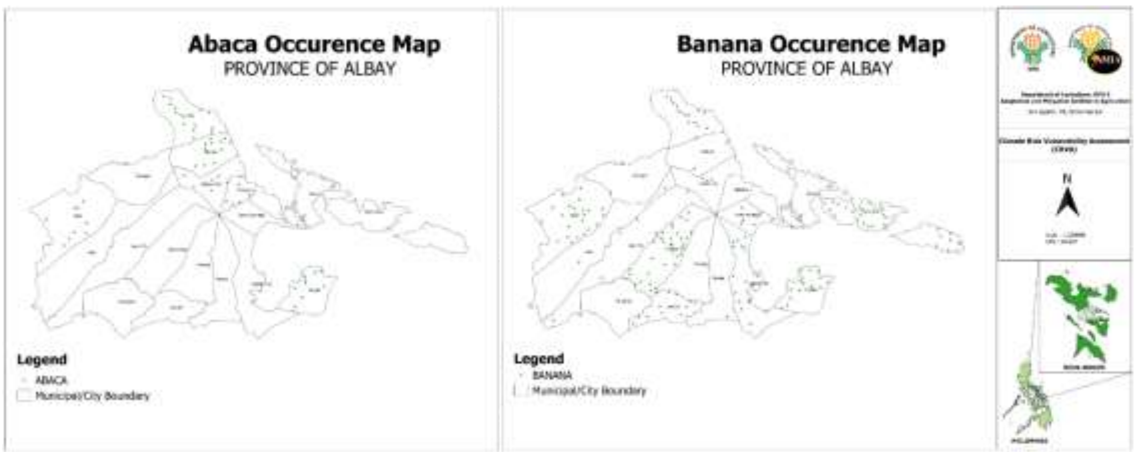


Appendix 7 Hazard Map of Albay Province

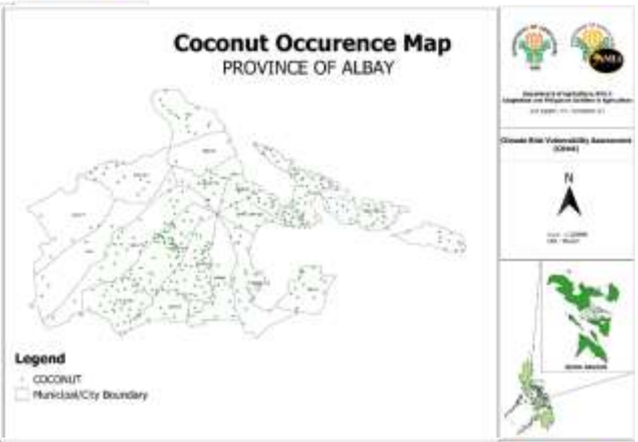




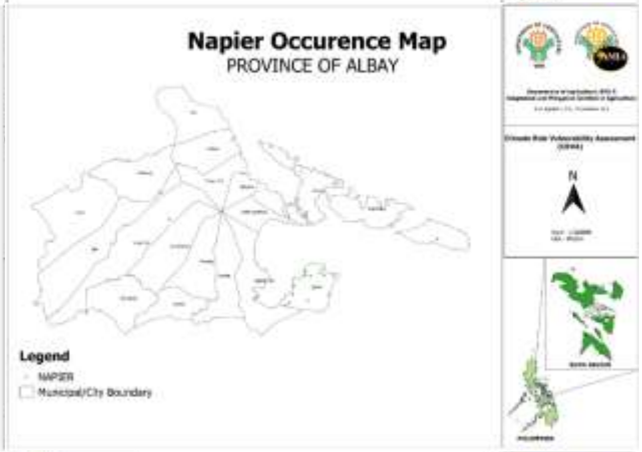
Appendix 8 Crop Occurrence map of other crops commodities in Albay Province

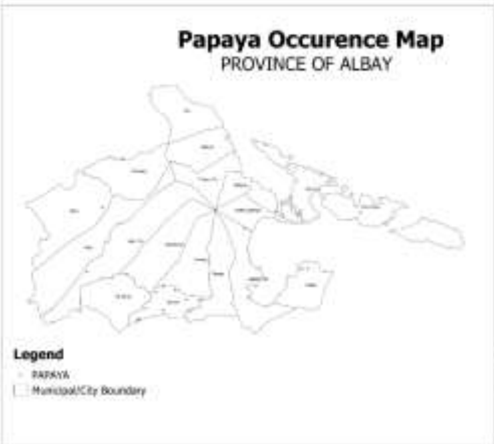


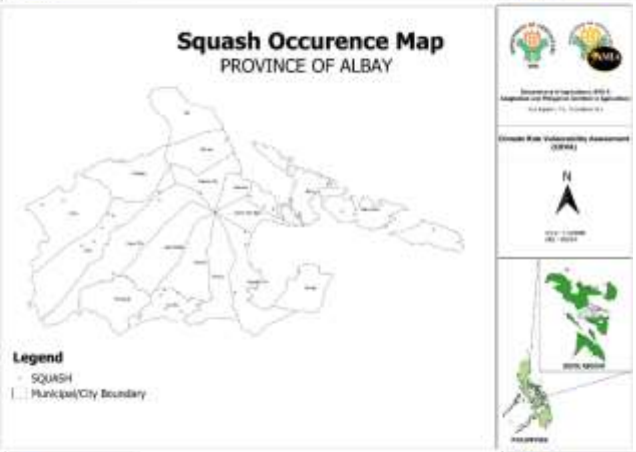

Cacao Occurence Map
PROVINCE OF ALBAY
Legend
CACAO
Municipal/City Boundary


Coconut Occurence Map
PROVINCE OF ALBAY
Legend
COCONUT
Municipal/City Boundary
N

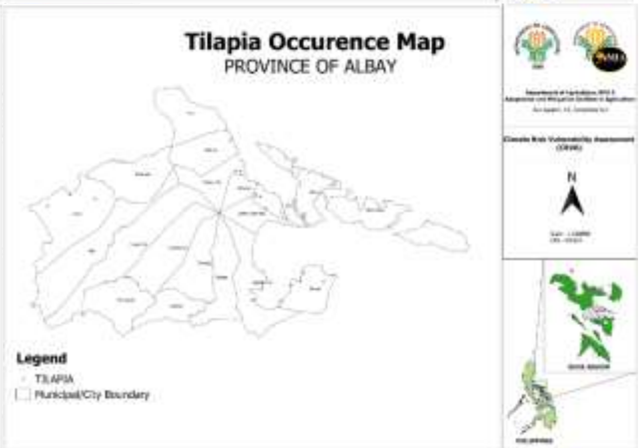

Ladyfinger Occurence Map
PROVINCE OF ALBAY
Legend
LADYFINGER
Municipal/City Boundary


Napier Occurence Map
PROVINCE OF ALBAY
Legend
NAPIER
Municipal/City Boundary
N


Papaya Occurence Map
PROVINCE OF ALBAY
Legend
PAPAYA
Municipal/City Boundary


Squash Occurence Map
PROVINCE OF ALBAY
Legend
SQUASH
Municipal/City Boundary
N


Taro Occurence Map
PROVINCE OF ALBAY
Legend
TARO
Municipal/City Boundary


Tilapia Occurence Map
PROVINCE OF ALBAY
Legend
TILAPIA
Municipal/City Boundary
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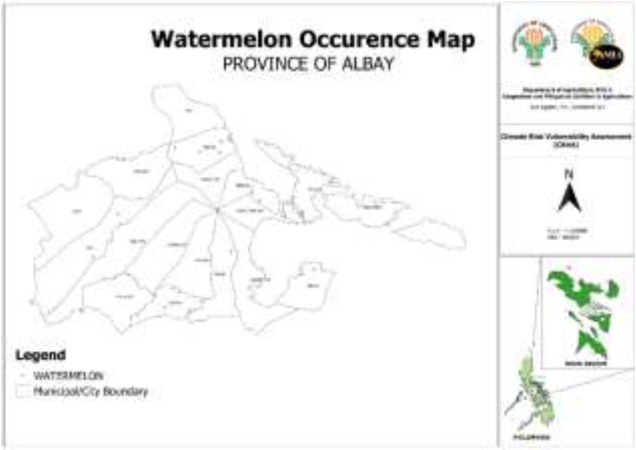
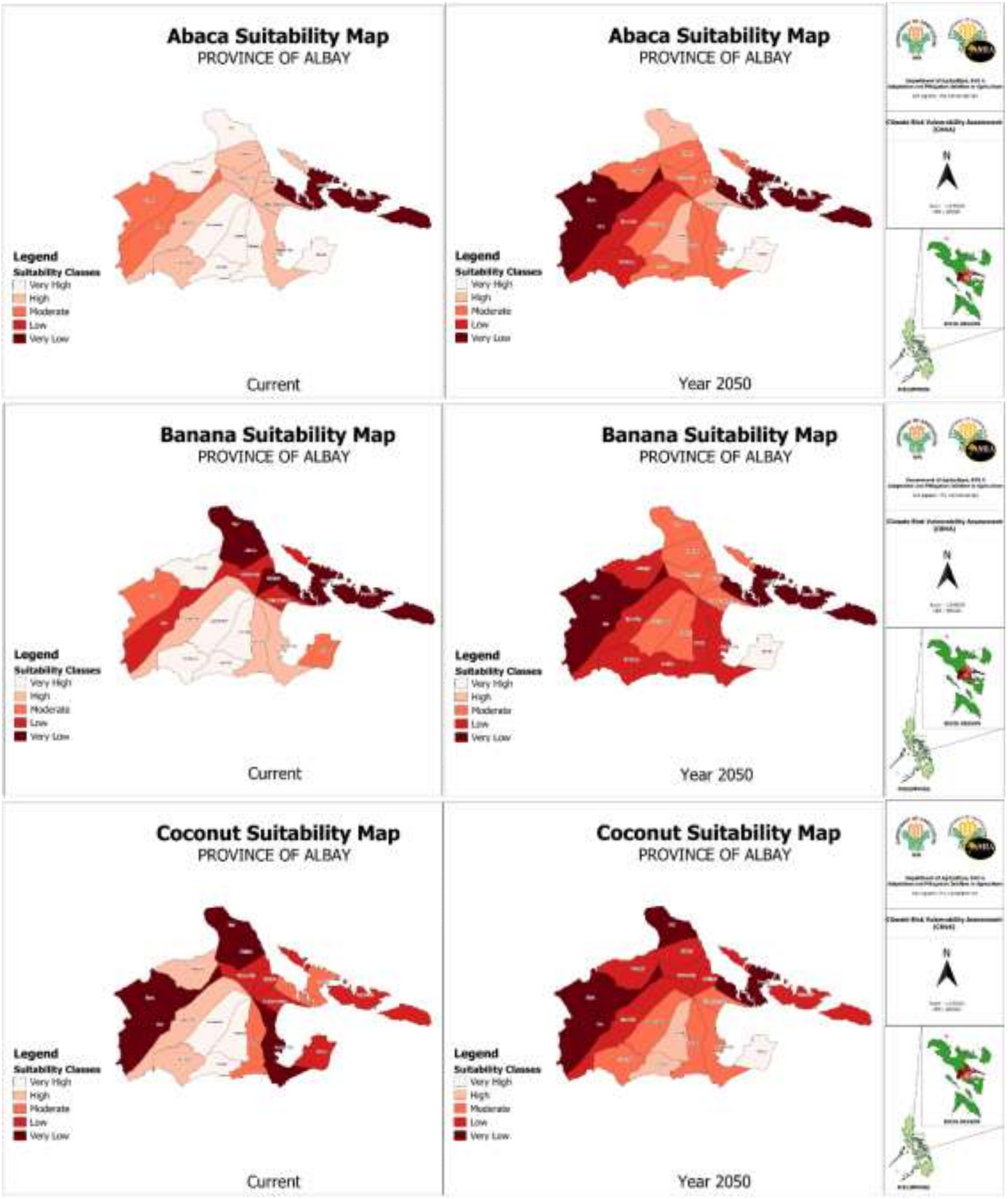
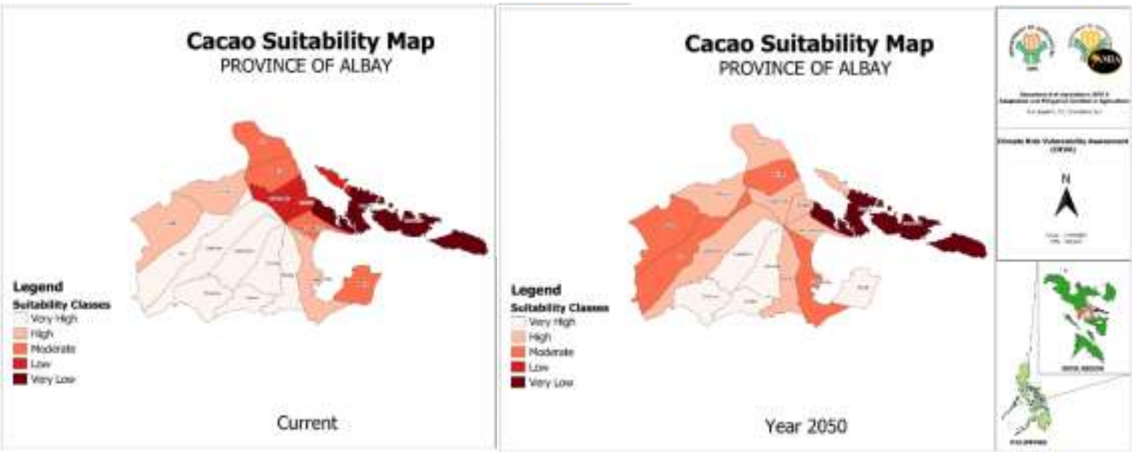
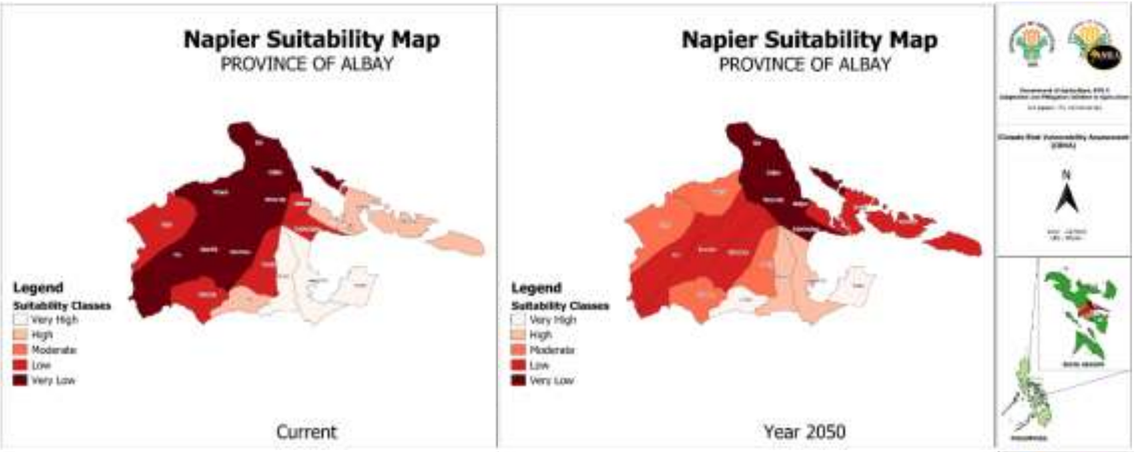
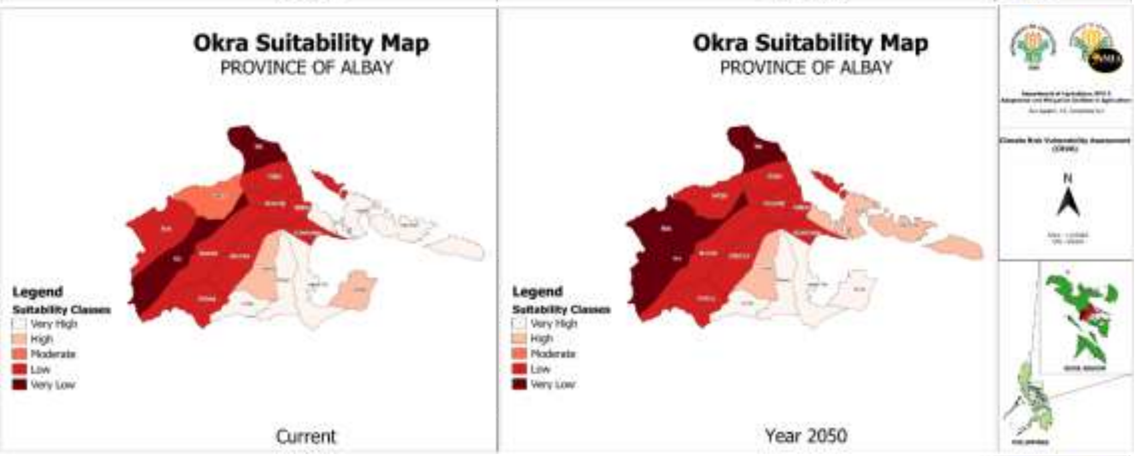


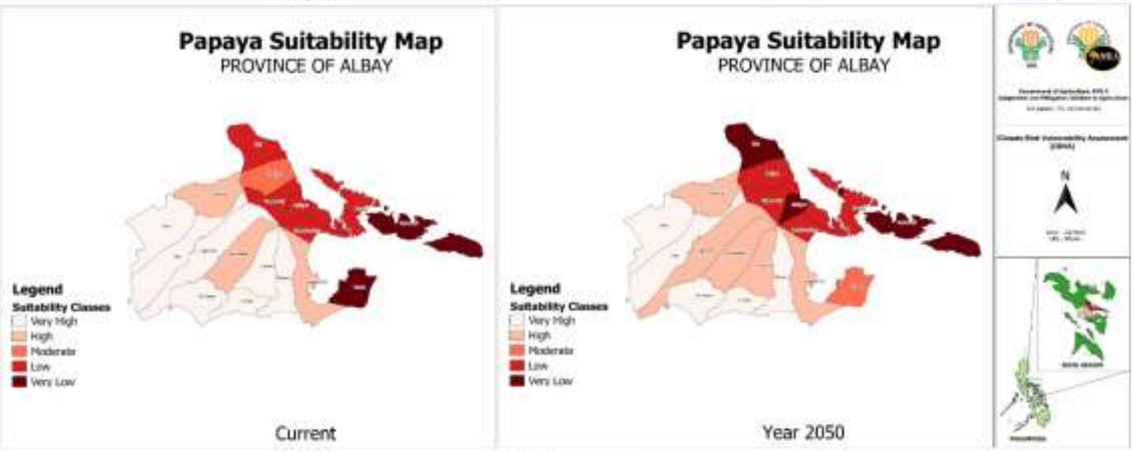
Appendix 9 Crop Climatic Sensitivity and Suitability of Other Crops in Albay Province

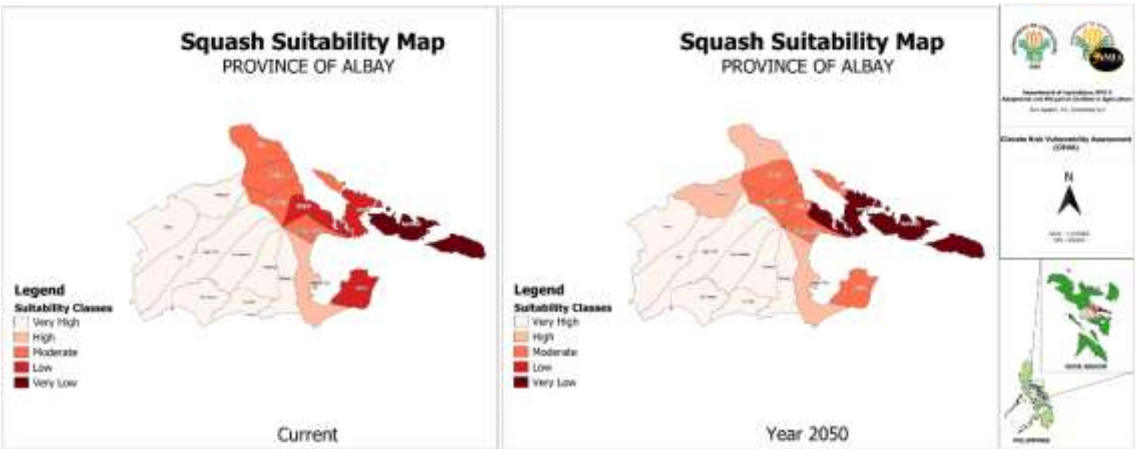


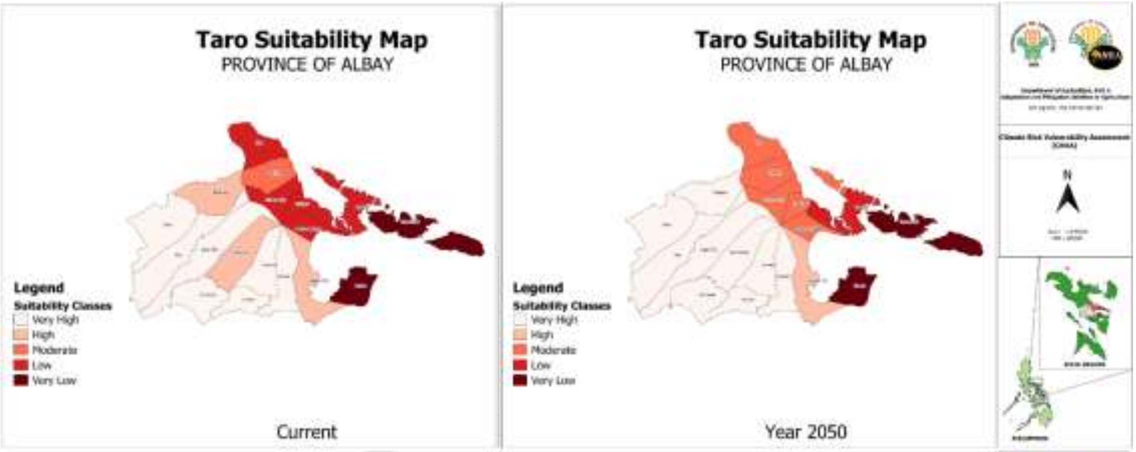

Cacao Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Cacao Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

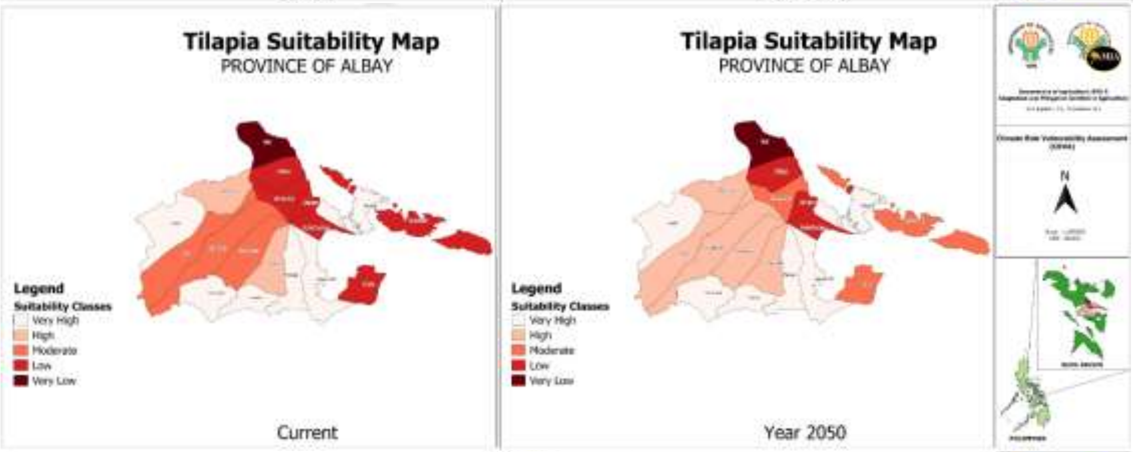

Napier Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Napier Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

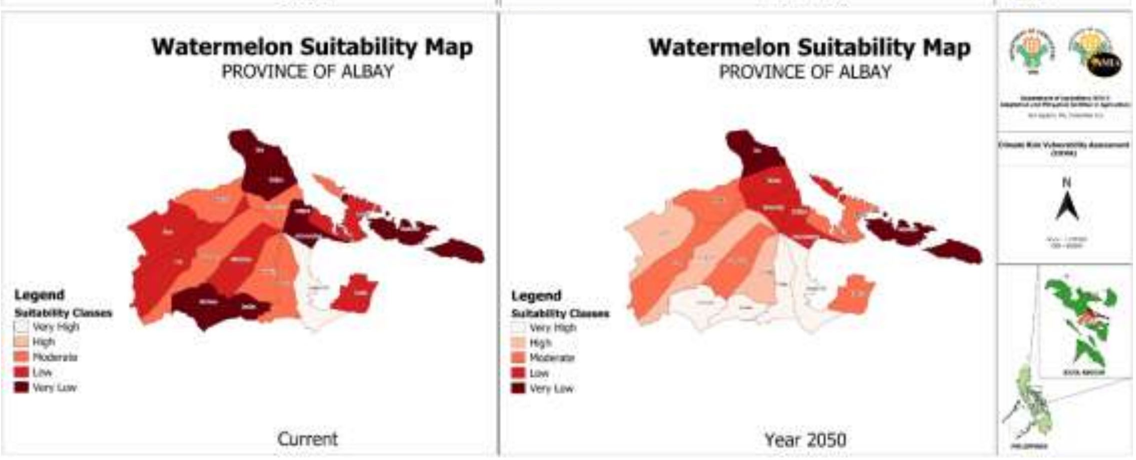

Okra Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Okra Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N


Papaya Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Papaya Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

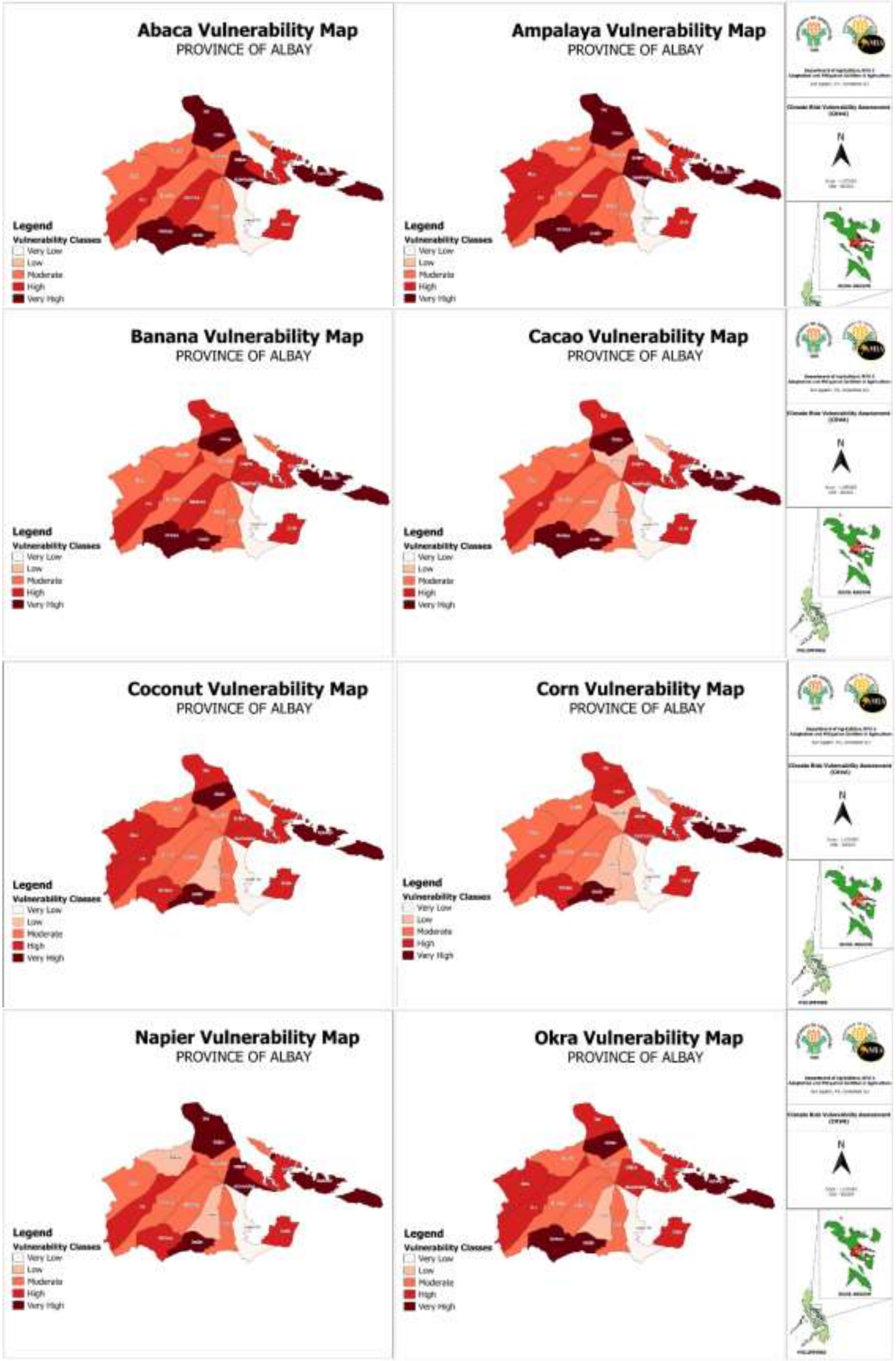

Squash Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Squash Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

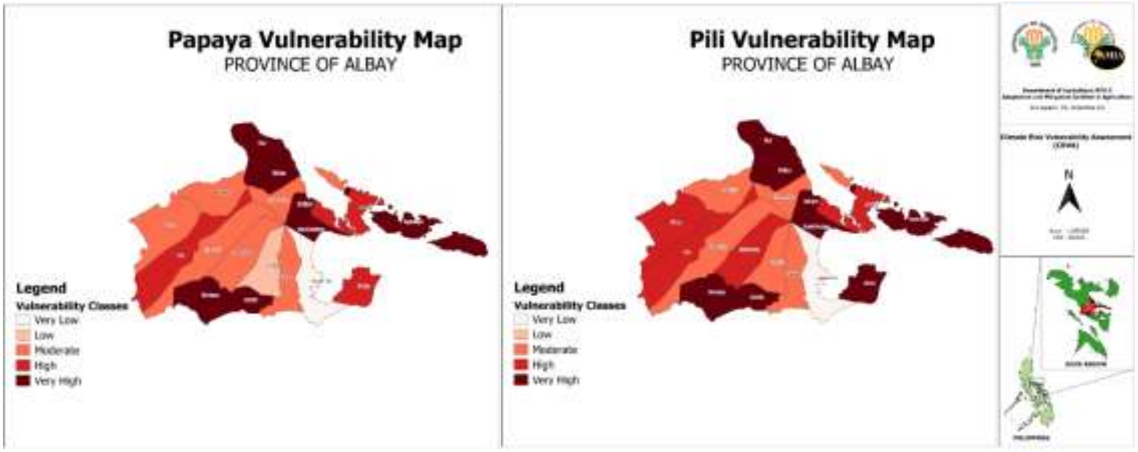

Taro Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Taro Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N


Tilapia Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Tilapia Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

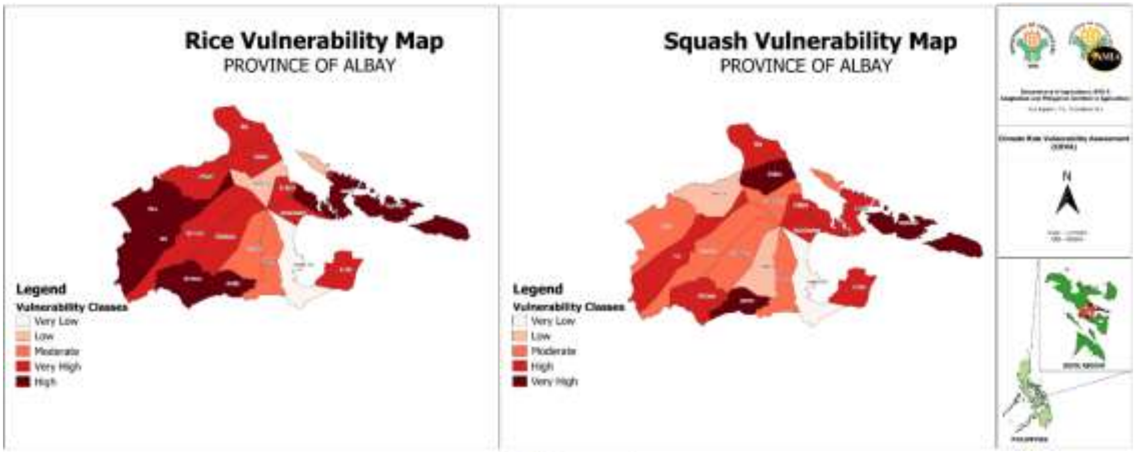

Watermelon Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Watermelon Suitability Map
PROVINCE OF ALBAY
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

Appendix 10 Crop Vulnerability by 2050 in Albay Province

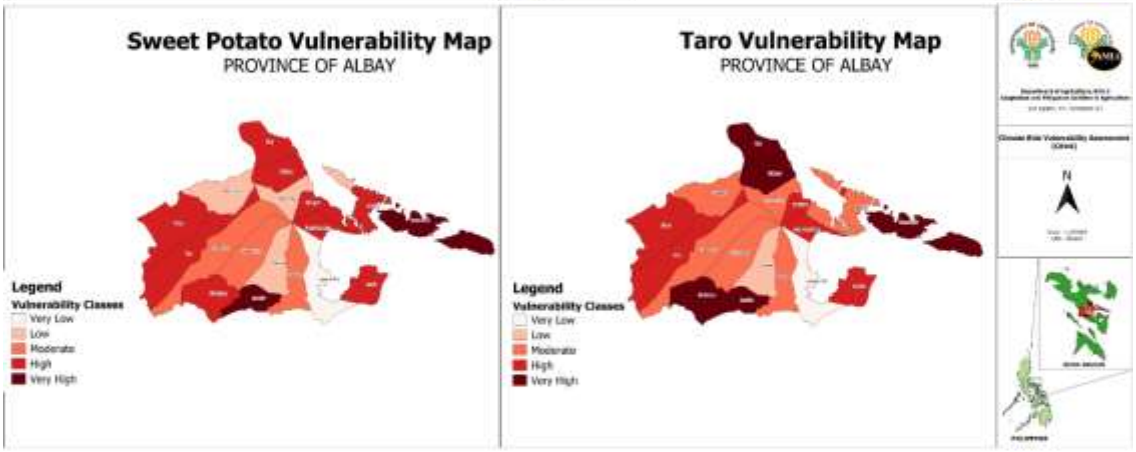




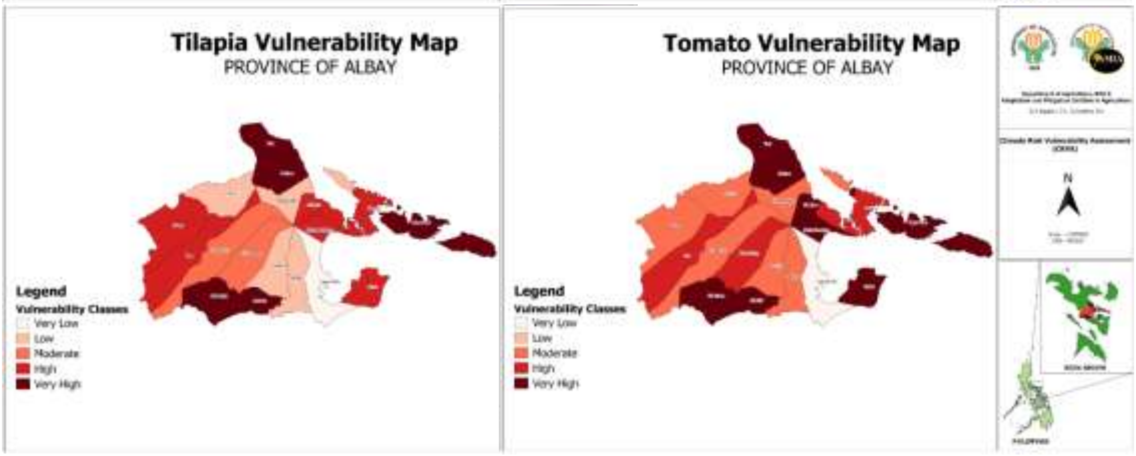
Papaya Vulnerability Map
PROVINCE OF ALBAY
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
Pili Vulnerability Map
PROVINCE OF ALBAY
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N



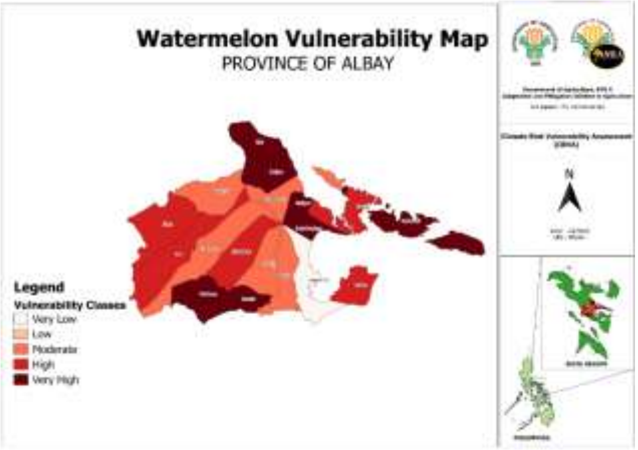
Rice Vulnerability Map
PROVINCE OF ALBAY
Legend
Vulnerability Classes
Very Low
Low
Moderate
Very High
High
Squash Vulnerability Map
PROVINCE OF ALBAY
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N



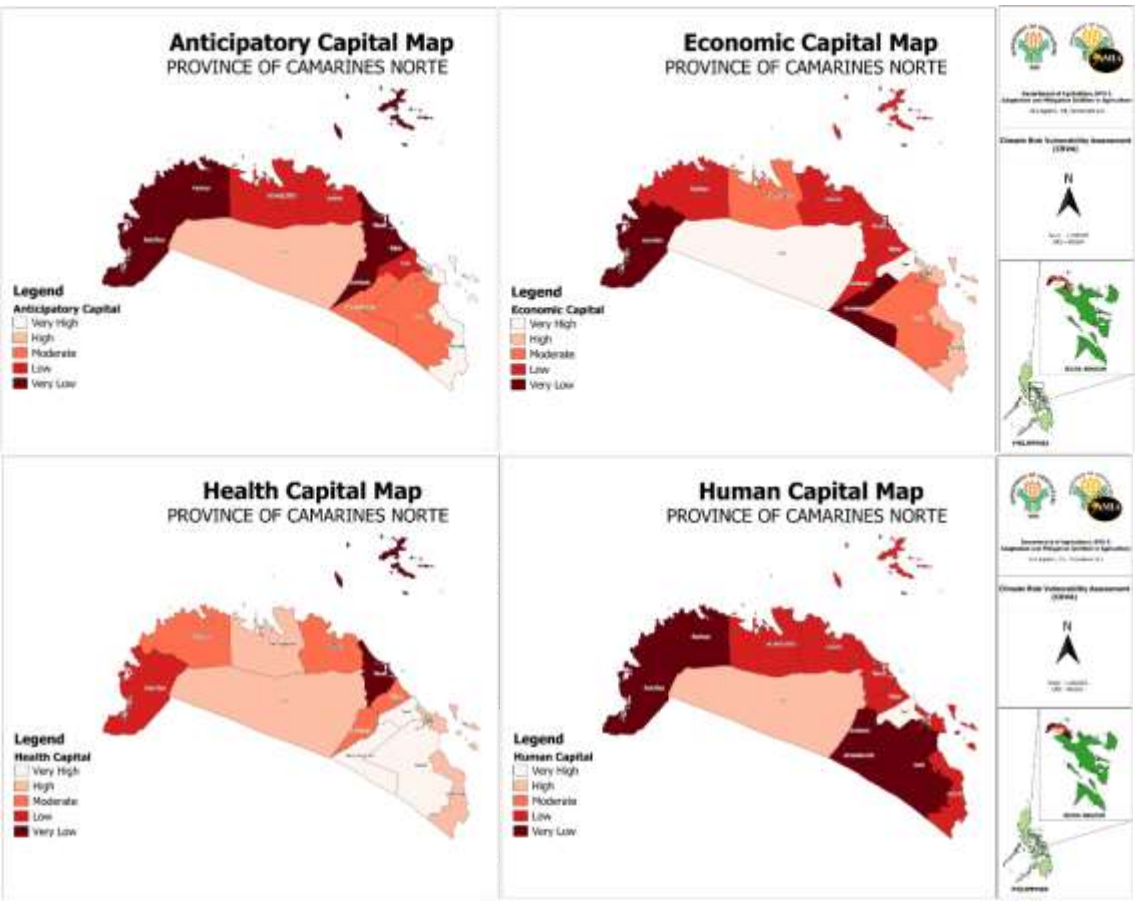
Sweet Potato Vulnerability Map
PROVINCE OF ALBAY
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
Taro Vulnerability Map
PROVINCE OF ALBAY
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N

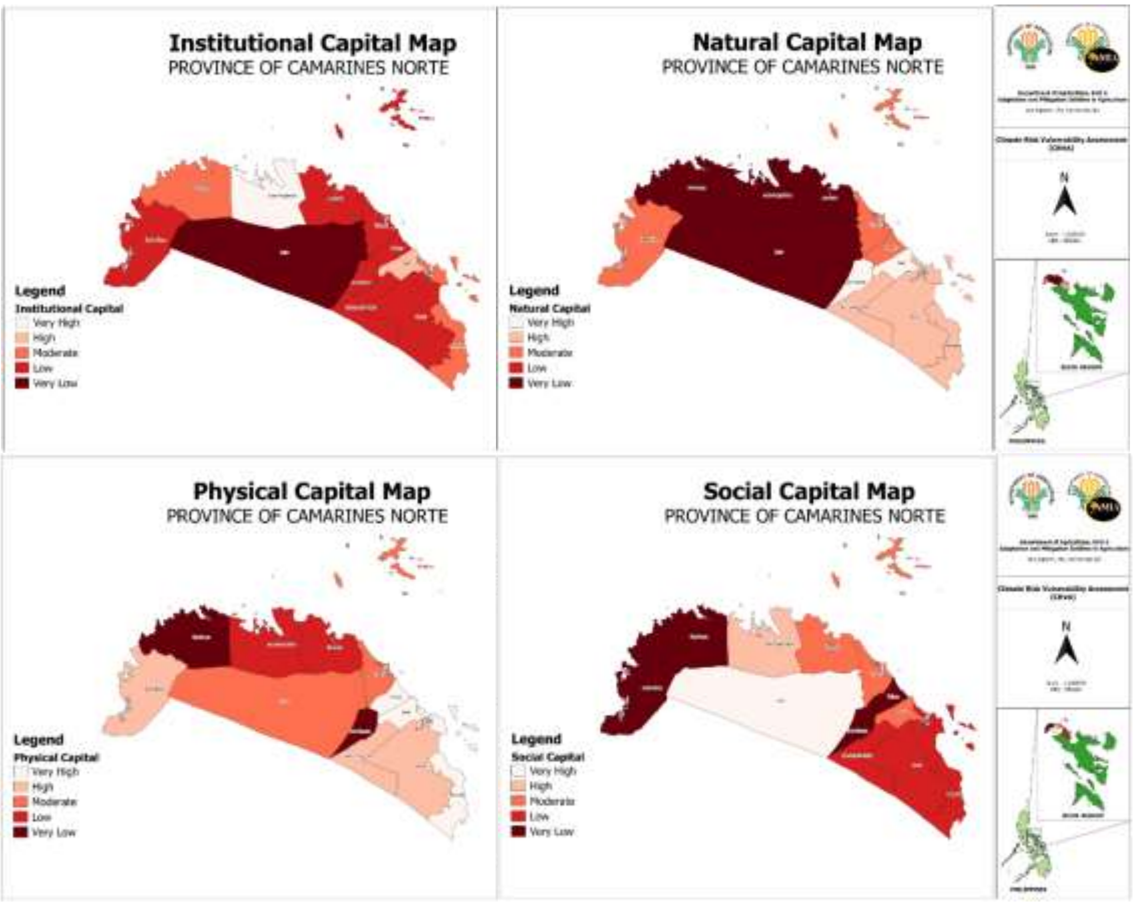


Tilapia Vulnerability Map
PROVINCE OF ALBAY
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
Tomato Vulnerability Map
PROVINCE OF ALBAY
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N

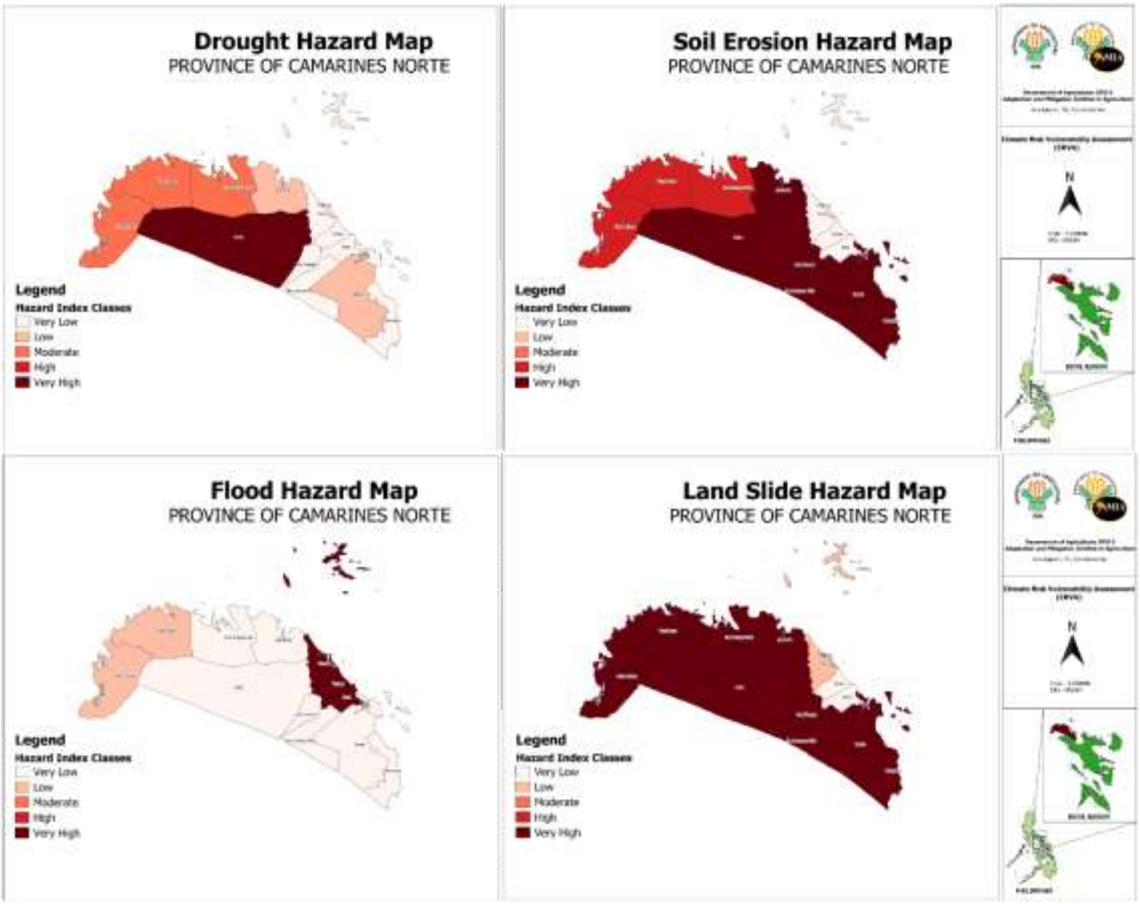


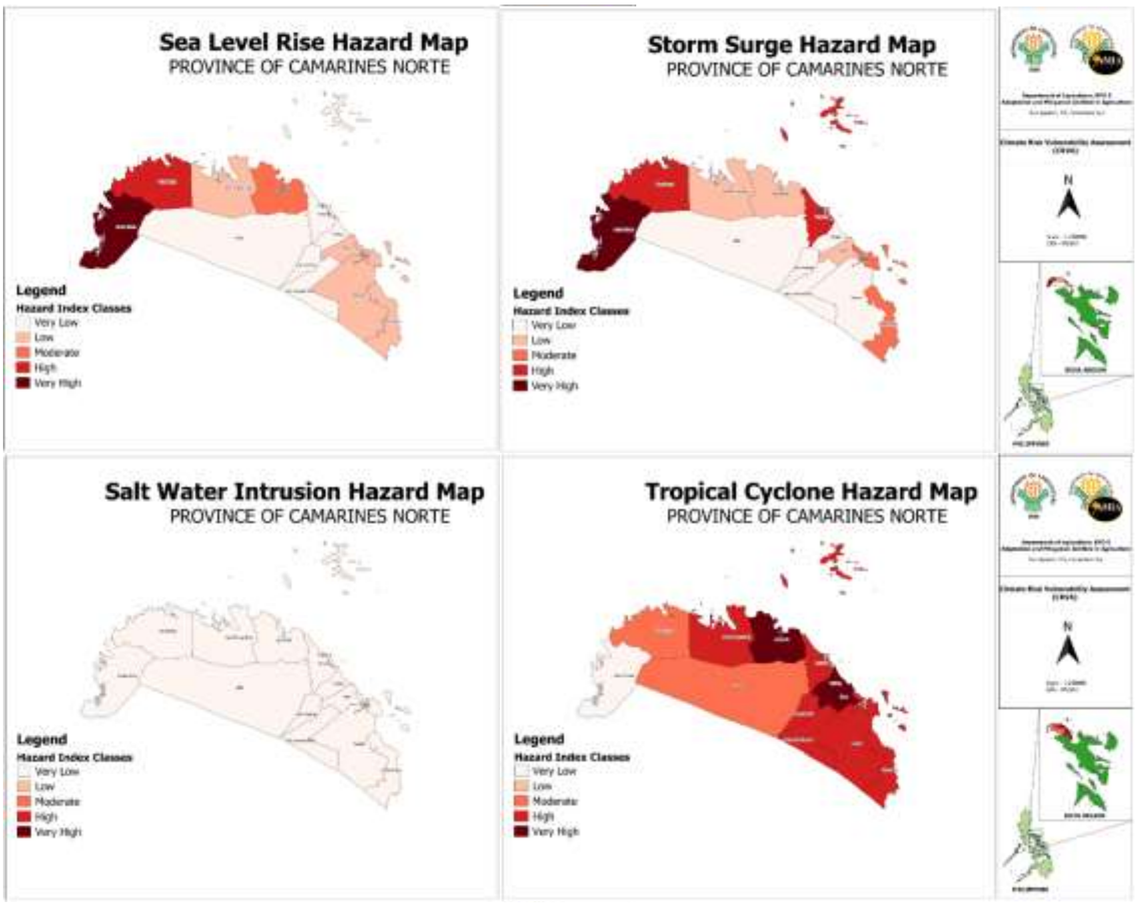
Appendix 11 Adaptive Capacity Maps of the Province of Camarines Norte (Per Capital)



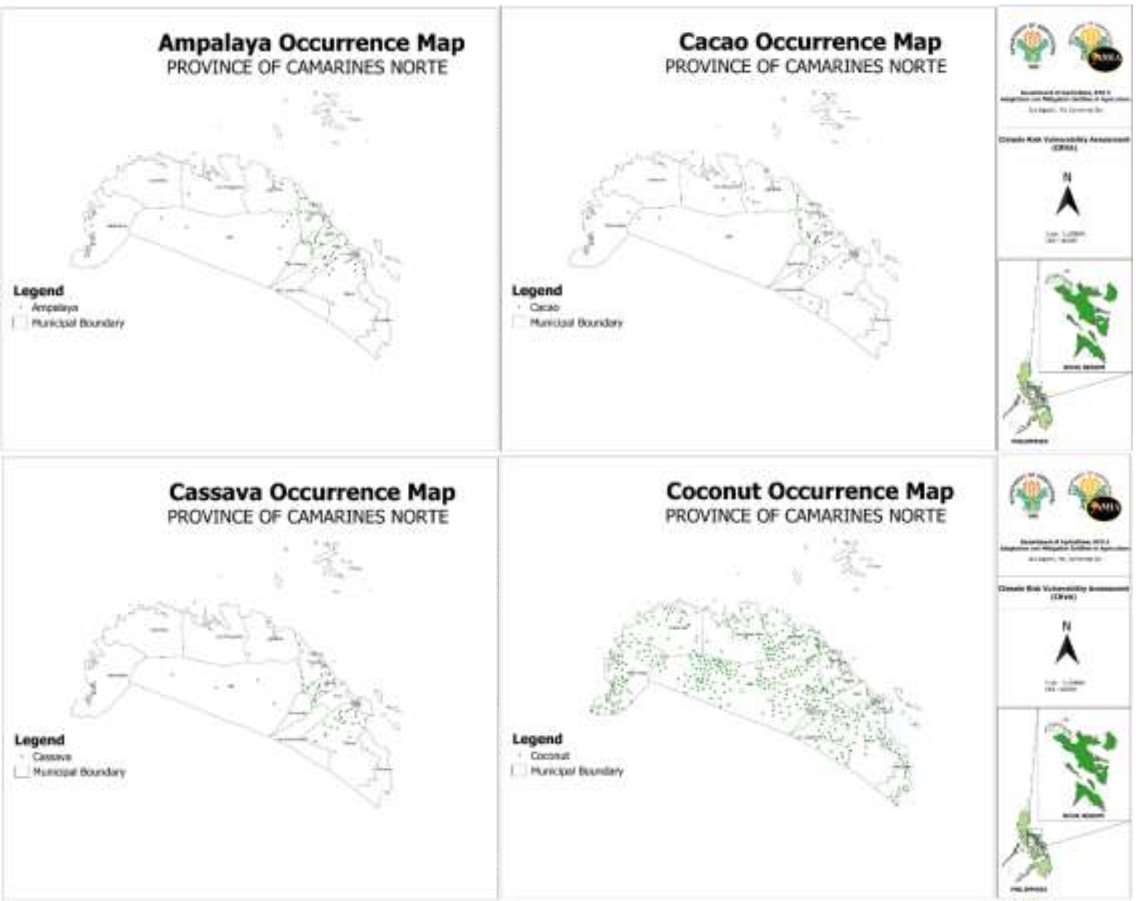


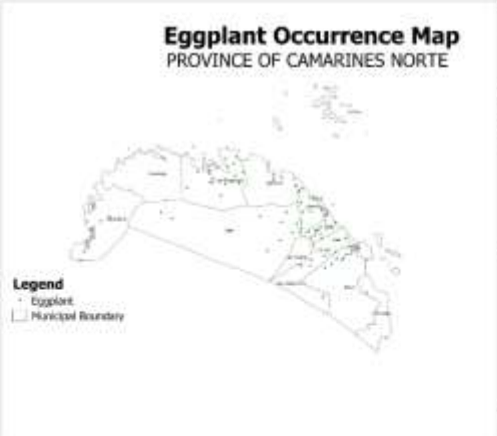
Appendix 12 Hazard Map of Camarines Norte Province

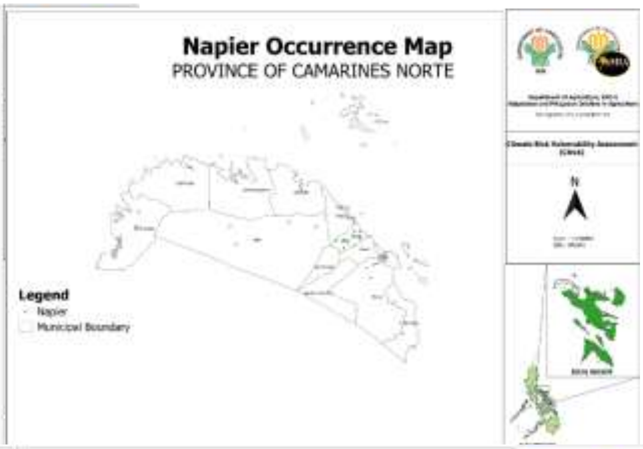




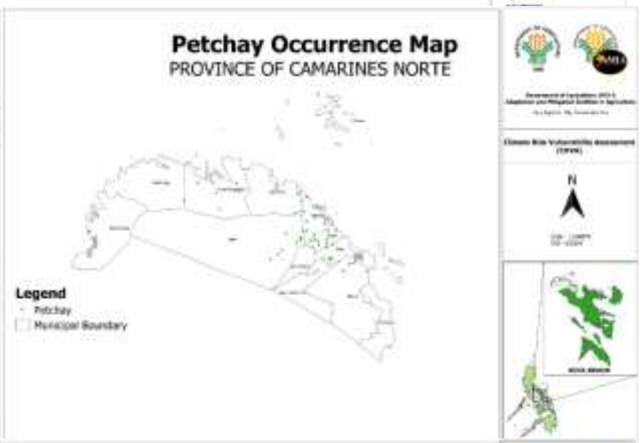
Appendix 13 Crop Occurrence of other crops in Camarines Norte Province

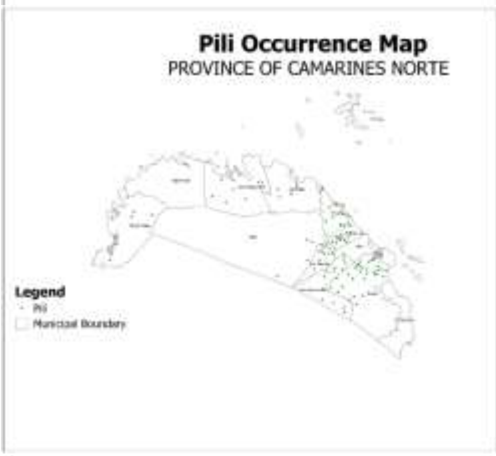


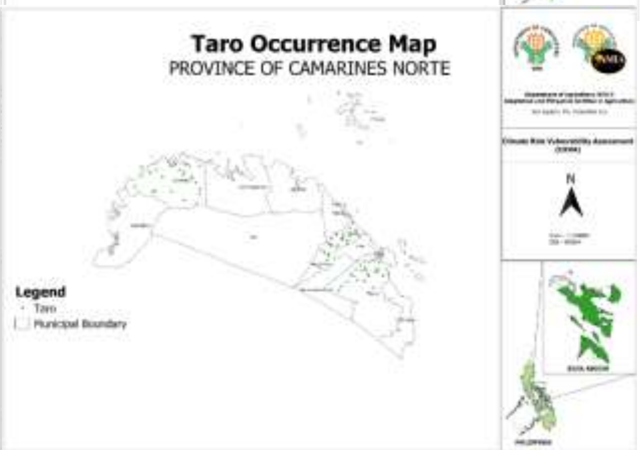

Eggplant Occurrence Map
PROVINCE OF CAMARINES NORTE
Legend
Eggplant
Municipal Boundary


Napier Occurrence Map
PROVINCE OF CAMARINES NORTE
Legend
Napier
Municipal Boundary
N

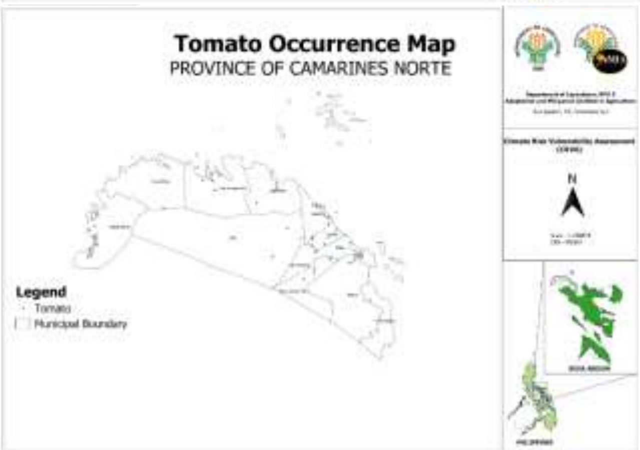

Okra Occurrence Map
PROVINCE OF CAMARINES NORTE
Legend
Okra
Municipal Boundary


Petchay Occurrence Map
PROVINCE OF CAMARINES NORTE
Legend
Petchay
Municipal Boundary
N

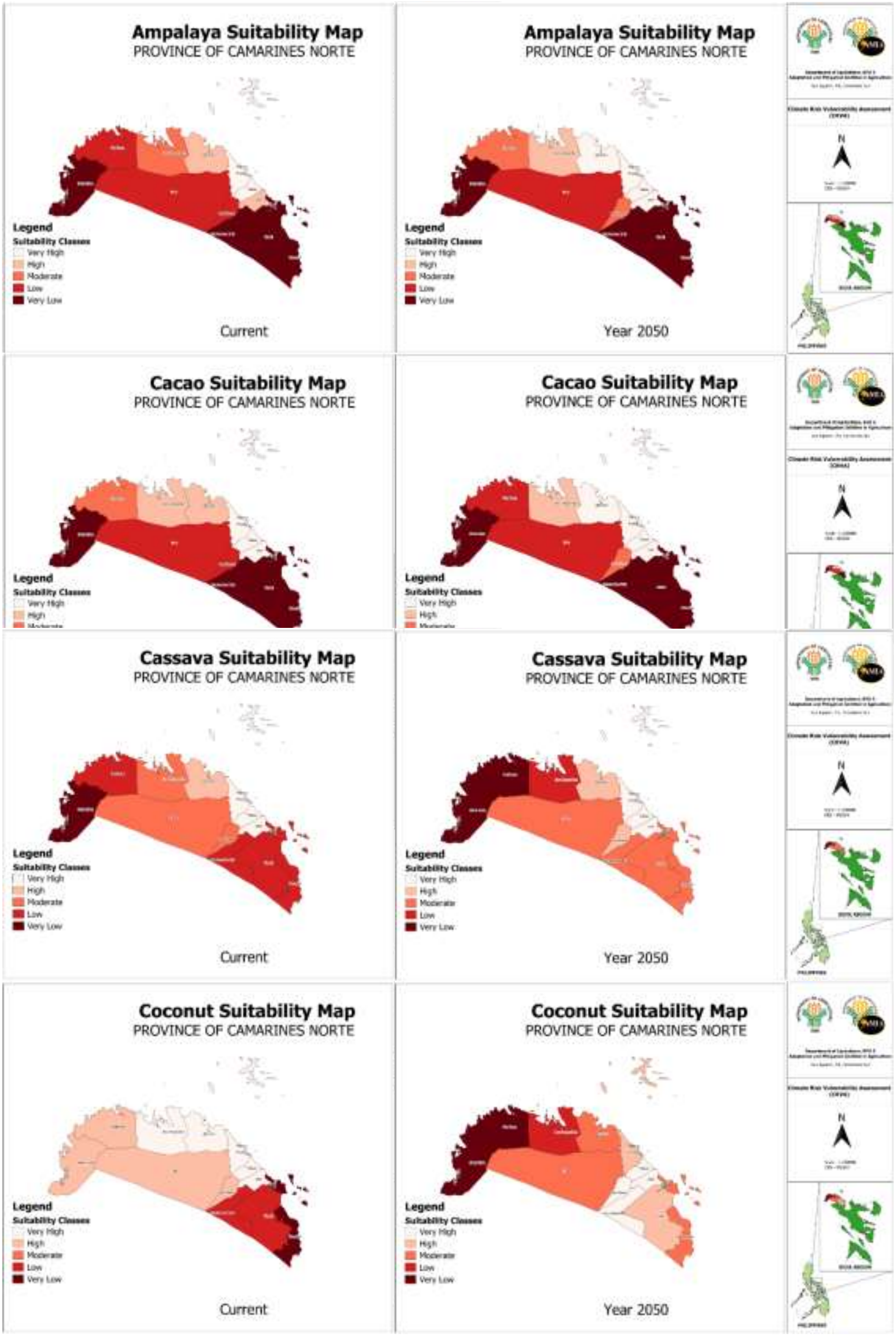

Pili Occurrence Map
PROVINCE OF CAMARINES NORTE
Legend
Pili
Municipal Boundary

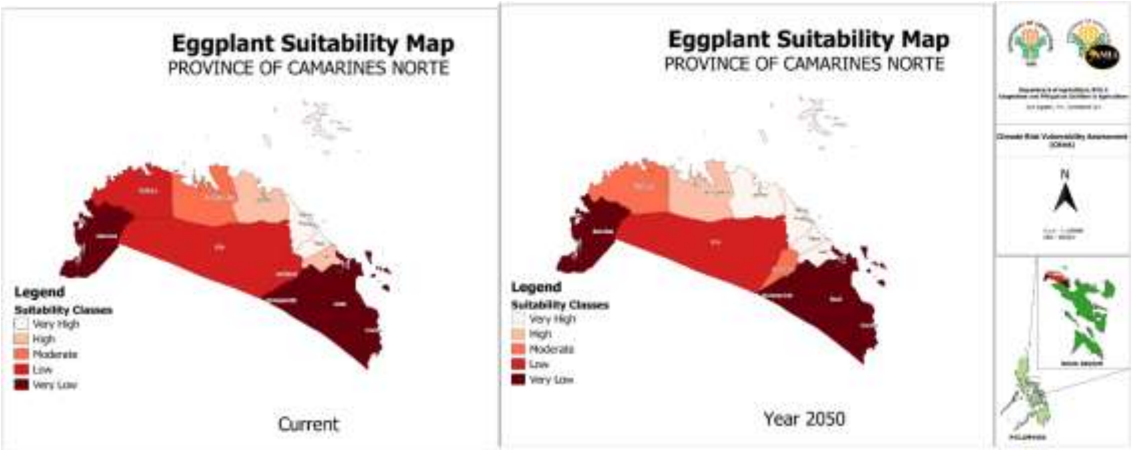

Taro Occurrence Map
PROVINCE OF CAMARINES NORTE
Legend
Taro
Municipal Boundary
N

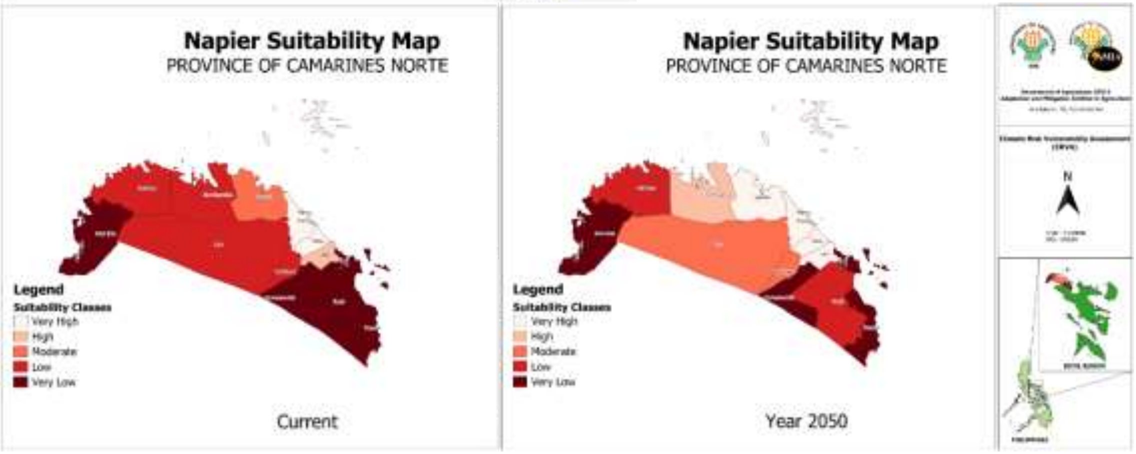

Tilapia Occurrence Map
PROVINCE OF CAMARINES NORTE
Legend
Tilapia
Municipal Boundary

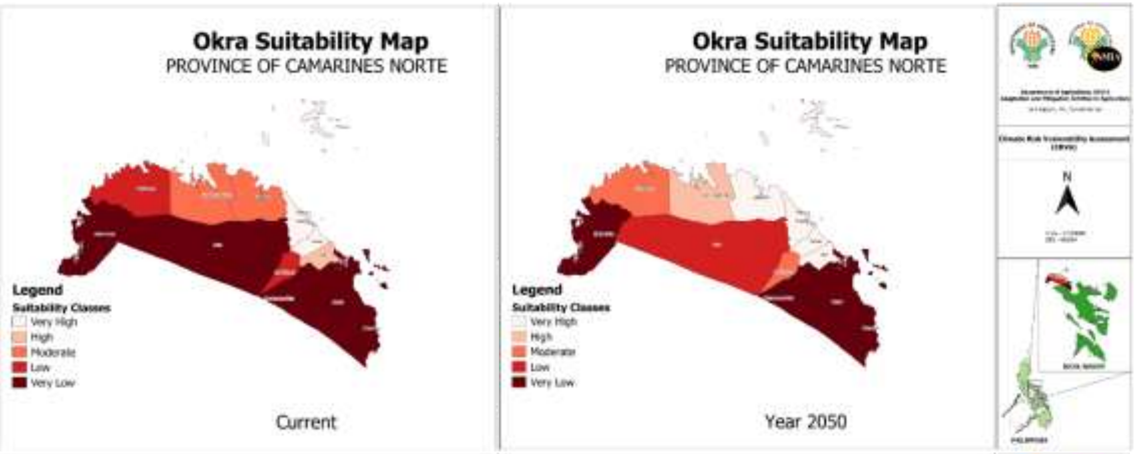

Tomato Occurrence Map
PROVINCE OF CAMARINES NORTE
Legend
Tomato
Municipal Boundary
N

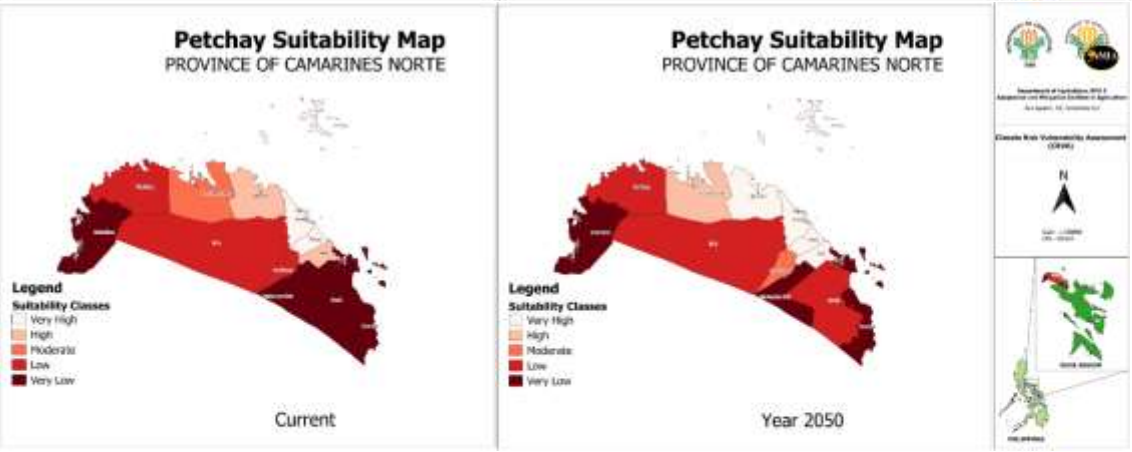
Appendix 14 Crop Climatic Sensitivity and Suitability of Other Crops in Camarines Norte Province

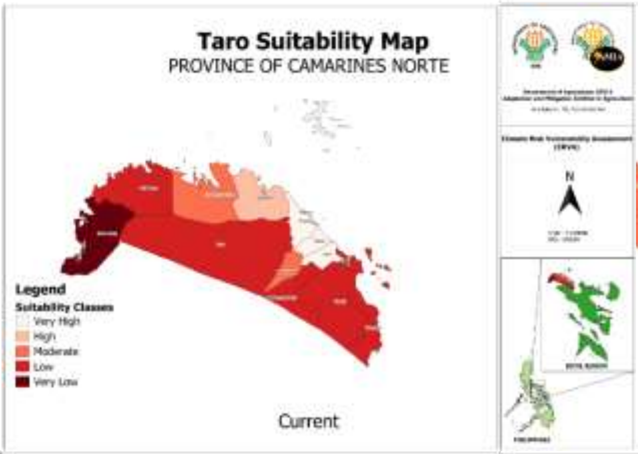



Eggplant Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Eggplant Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

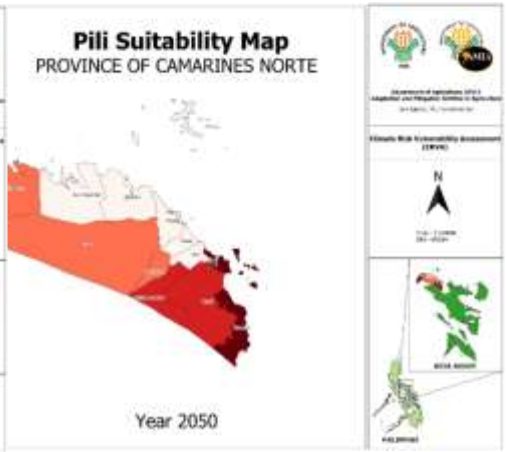

Napier Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Napier Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N


Okra Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Okra Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

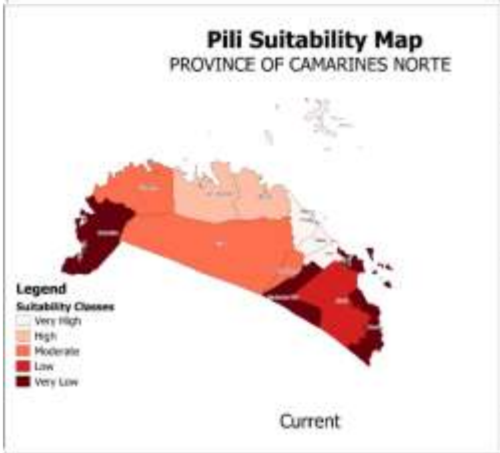

Petchay Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Petchay Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N



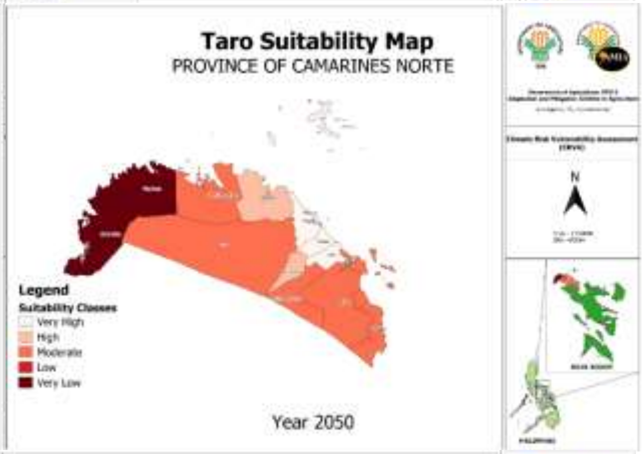
Taro Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
N



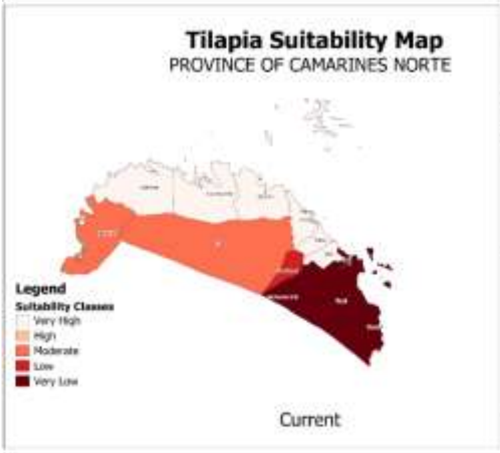
Pili Suitability Map
PROVINCE OF CAMARINES NORTE
Year 2050
N



Pili Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current

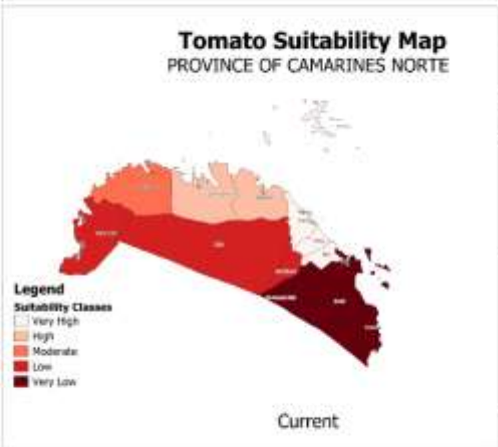


Taro Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

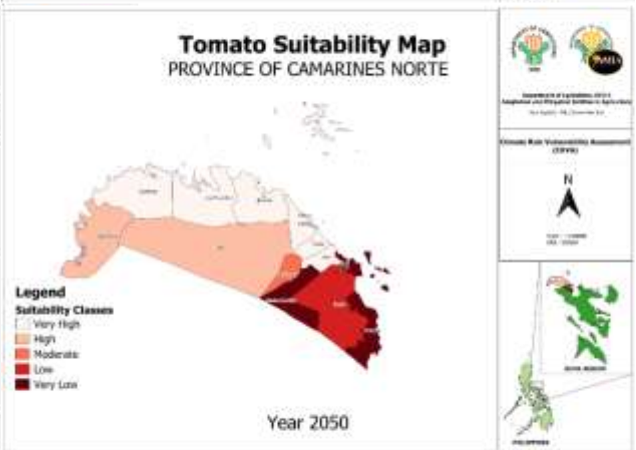


Tilapia Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current

Tilapia Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

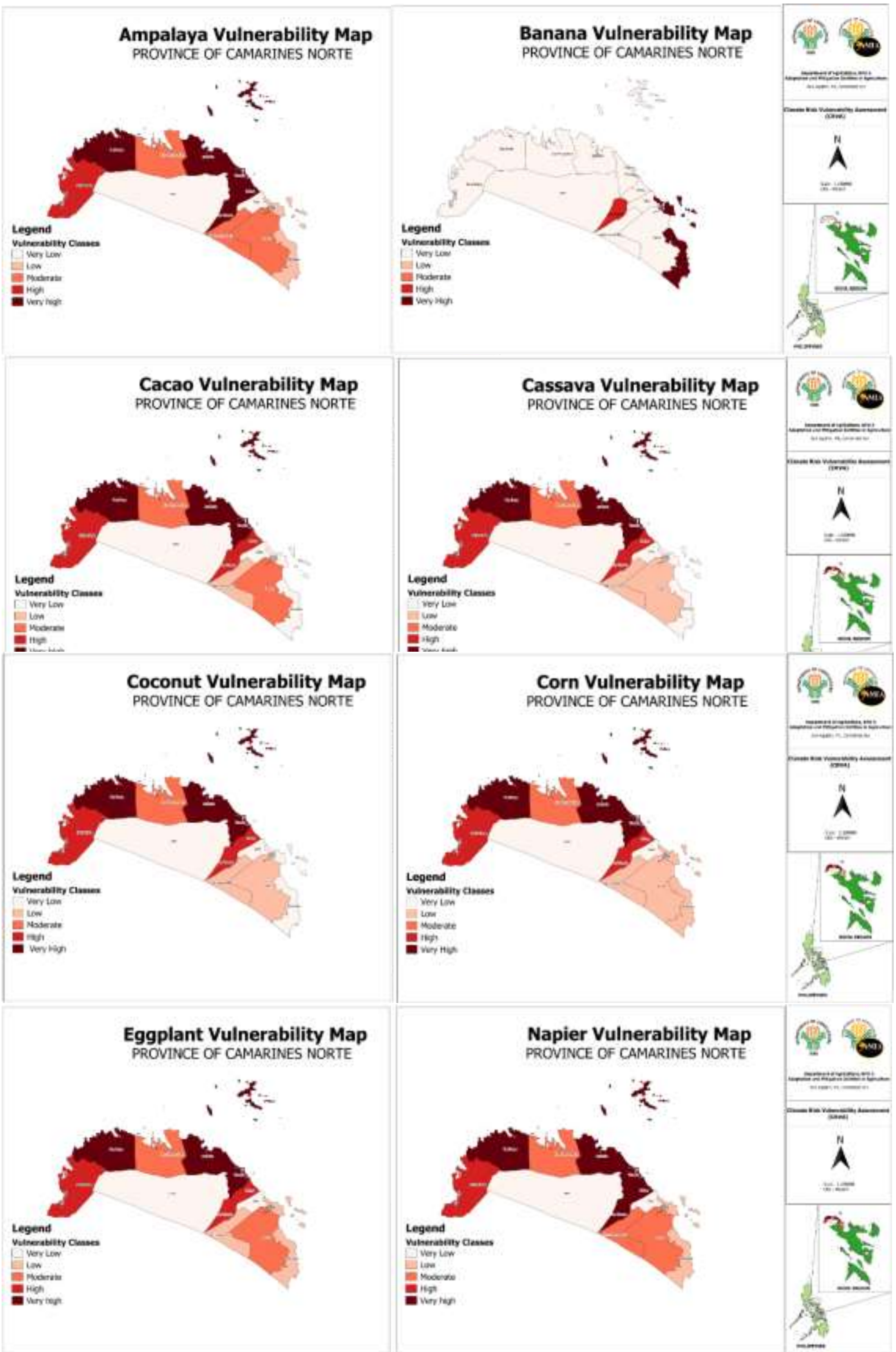


Tomato Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current



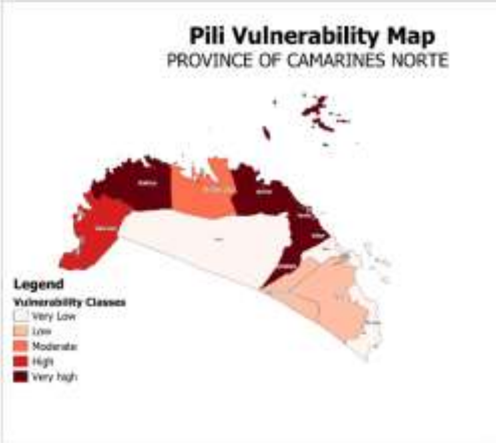
Tomato Suitability Map
PROVINCE OF CAMARINES NORTE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

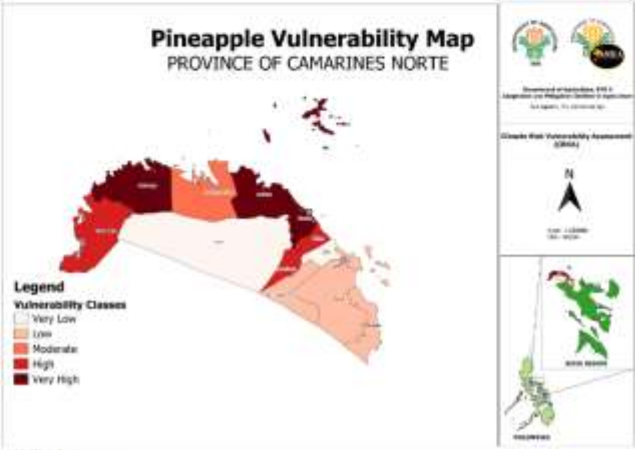
Appendix 15 Crop Vulnerability by 2050 in Camarines Norte Province

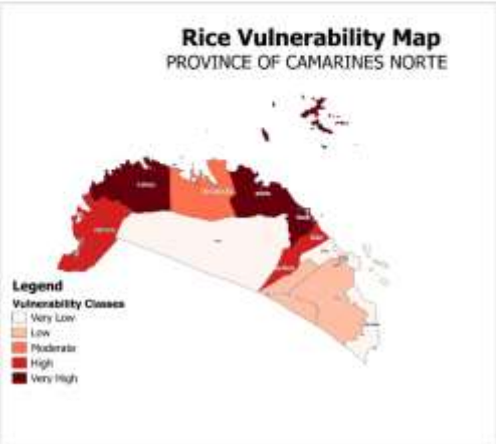


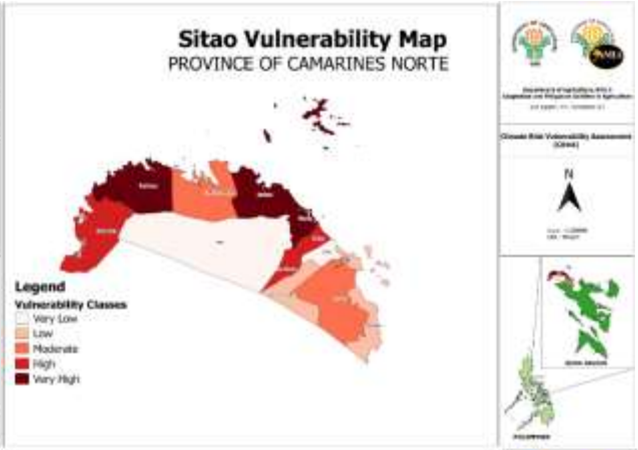
Okra Vulnerability Map
PROVINCE OF CAMARINES NORTE

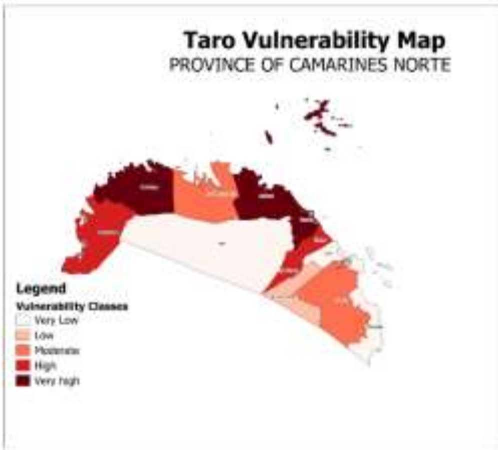
Petchay Vulnerability Map
PROVINCE OF CAMARINES NORTE

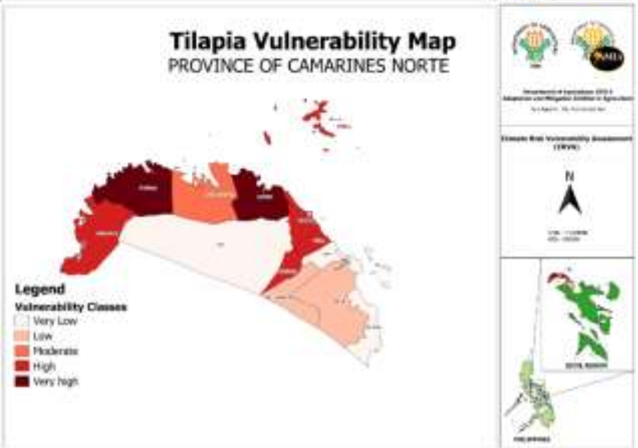


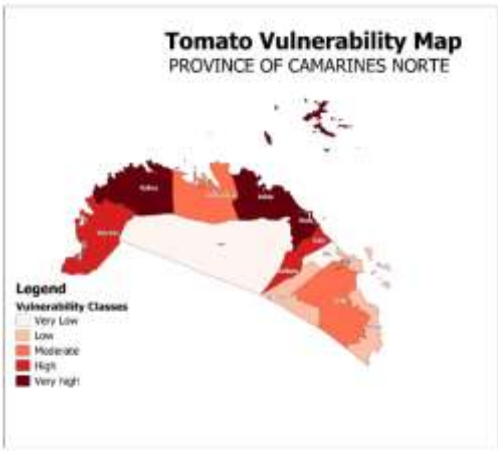


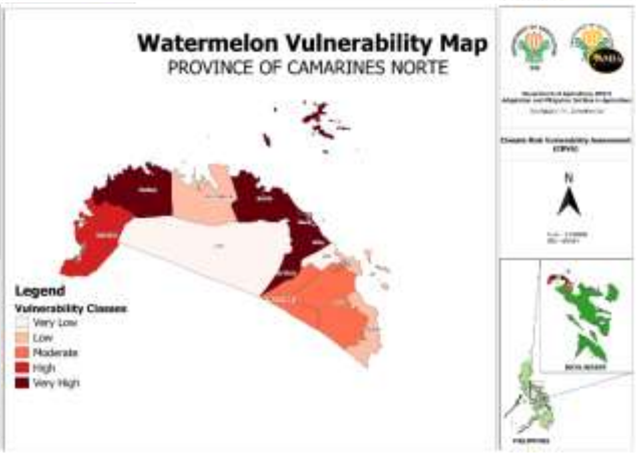




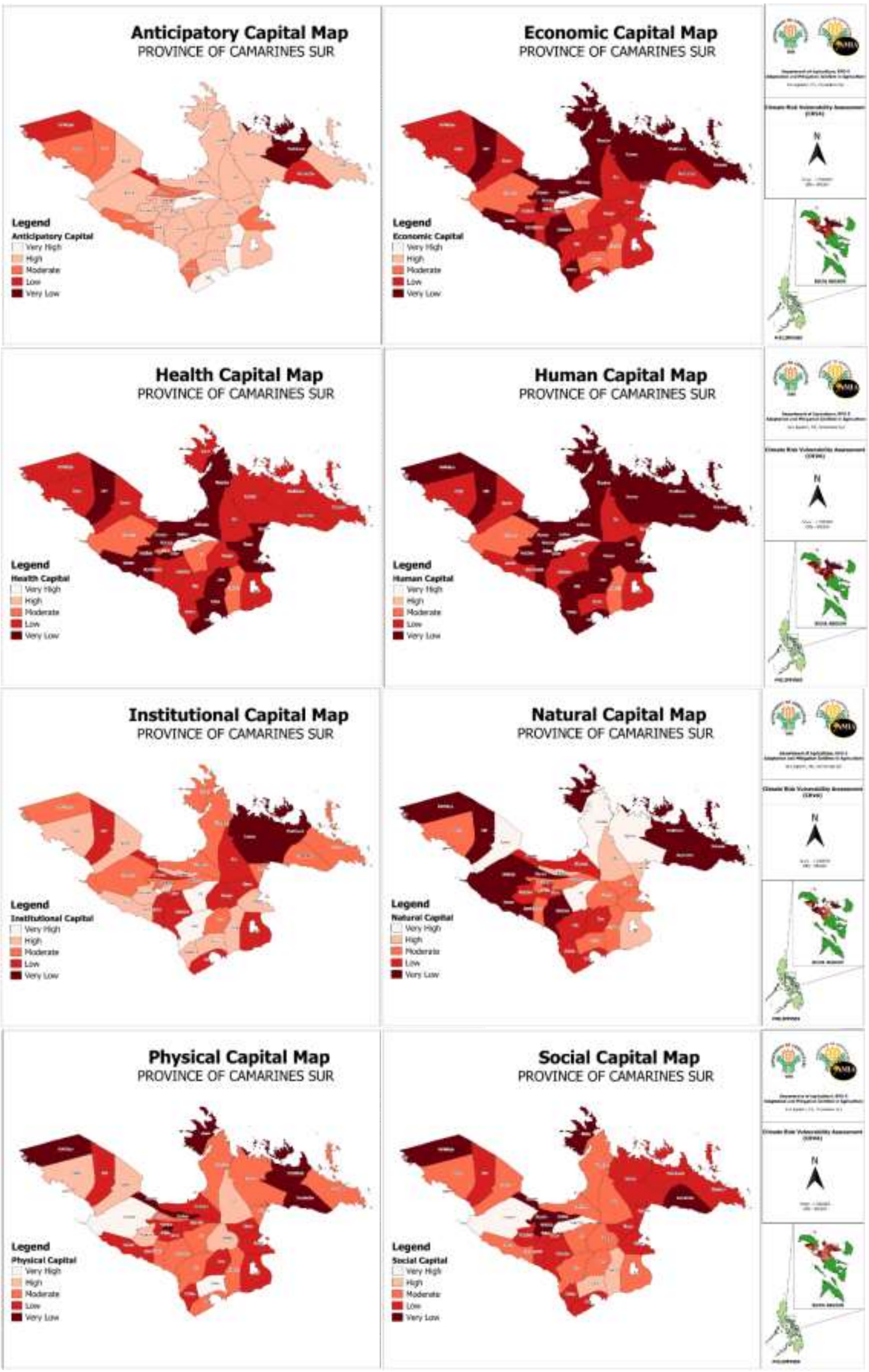




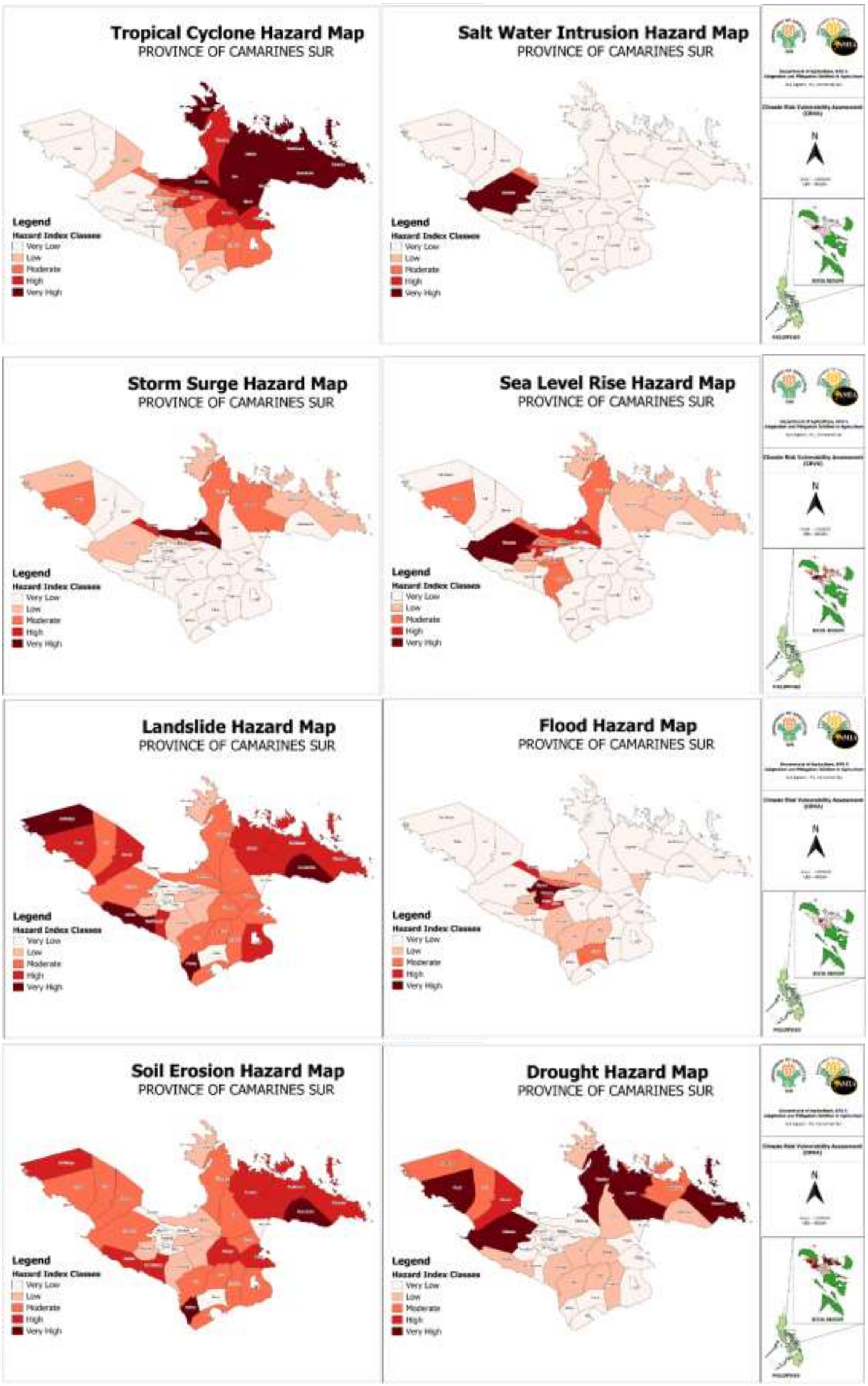




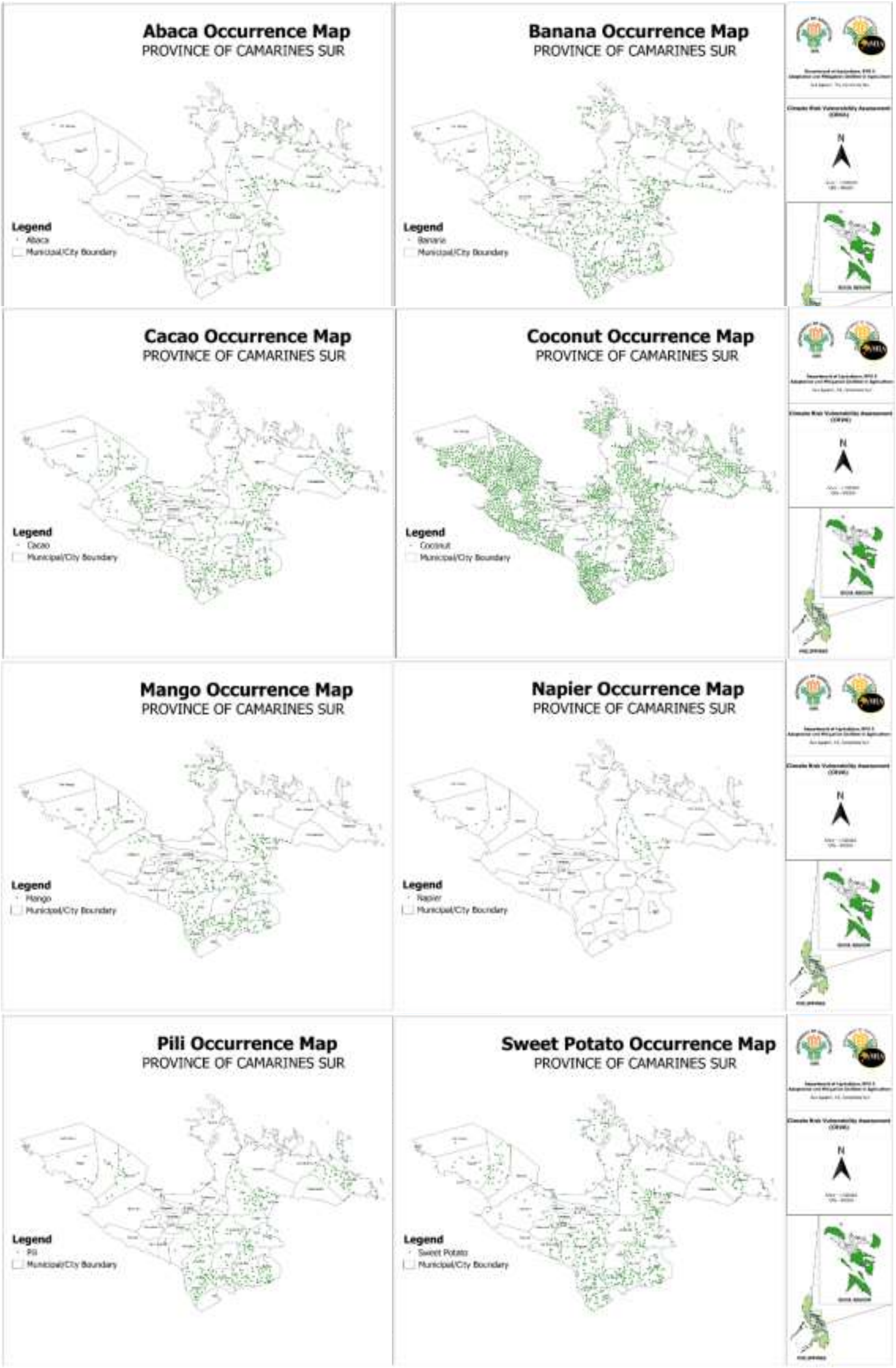
Appendix 16 Adaptive Capacity Maps of the Province of Camarines Sur (Per Capital)



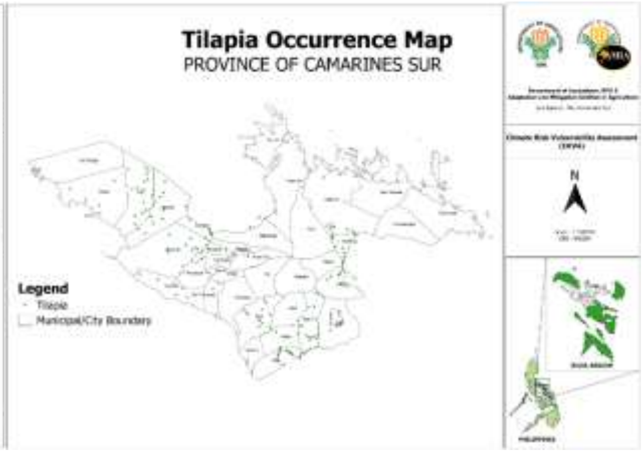
Appendix 17 Hazard Map of Camarines Sur Province

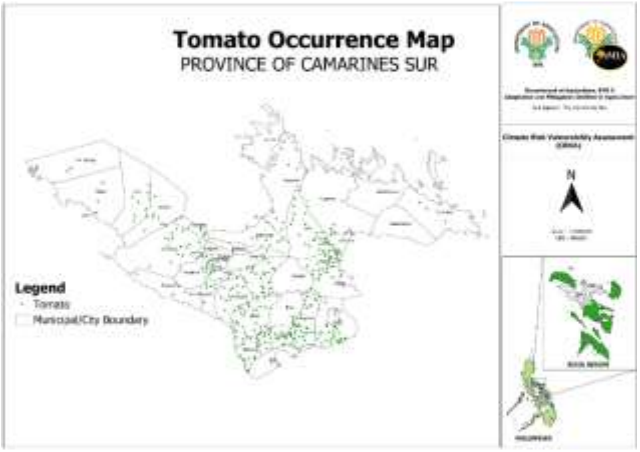


Appendix 18 Crop Occurrence of other crops in Camarines Sur Province

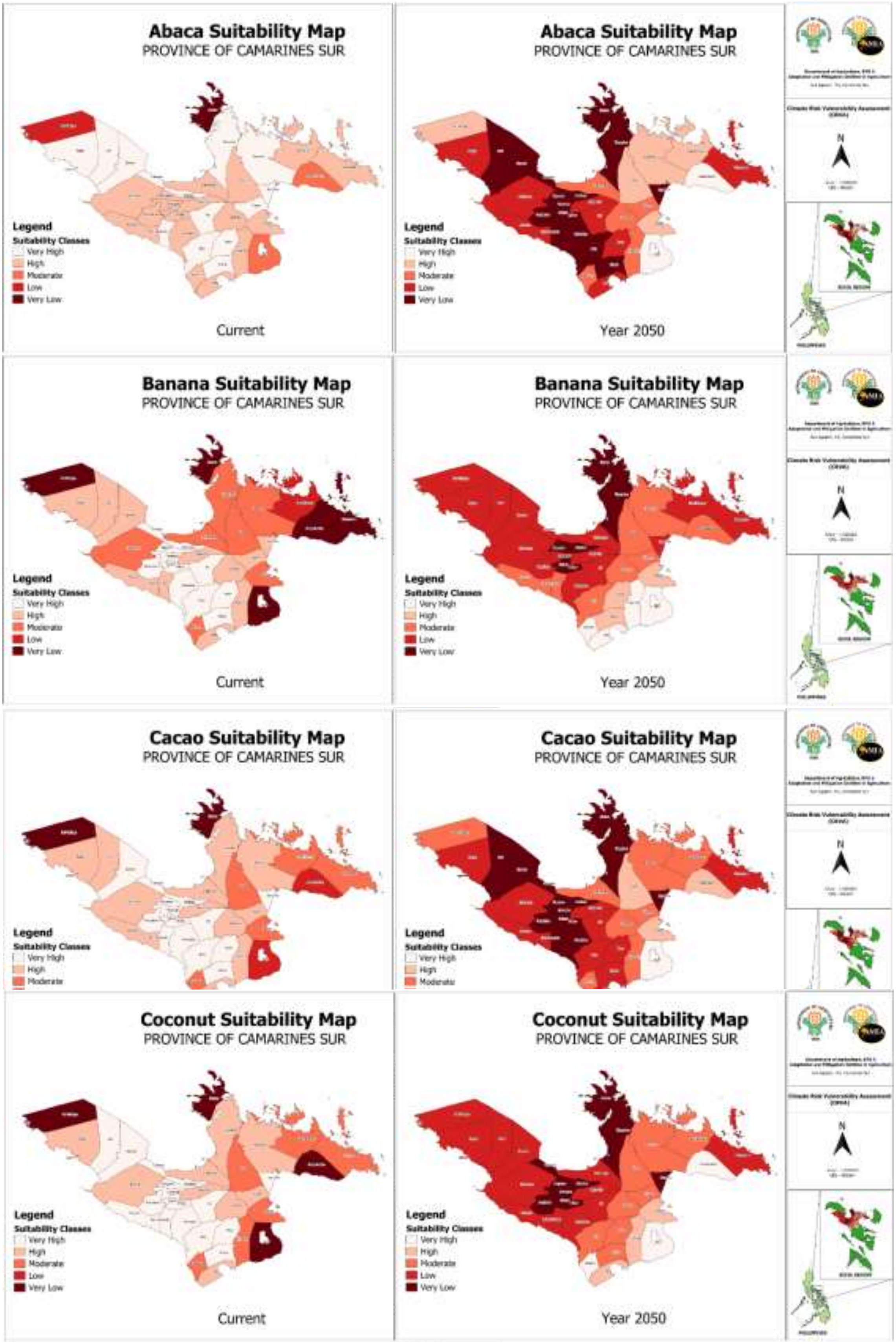


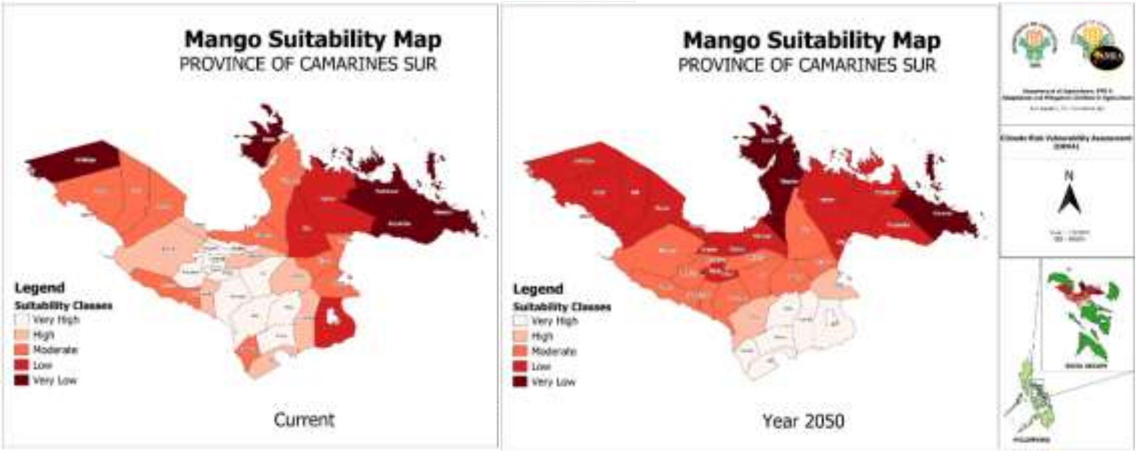

Taro Occurrence Map
PROVINCE OF CAMARINES SUR
Legend
Taro
Municipal/City Boundary

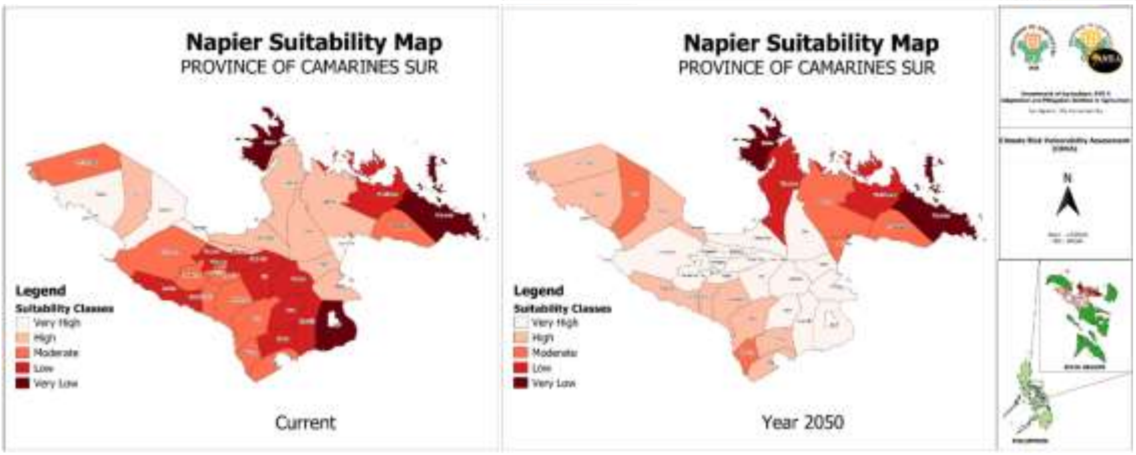

Tilapia Occurrence Map
PROVINCE OF CAMARINES SUR
Legend
Tilapia
Municipal/City Boundary
N

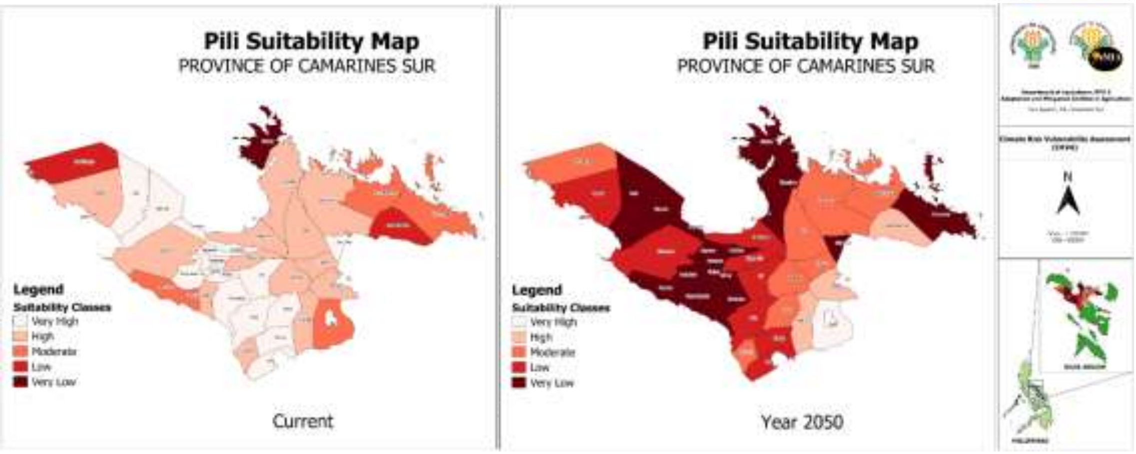

Tomato Occurrence Map
PROVINCE OF CAMARINES SUR
Legend
Tomato
Municipal/City Boundary
N

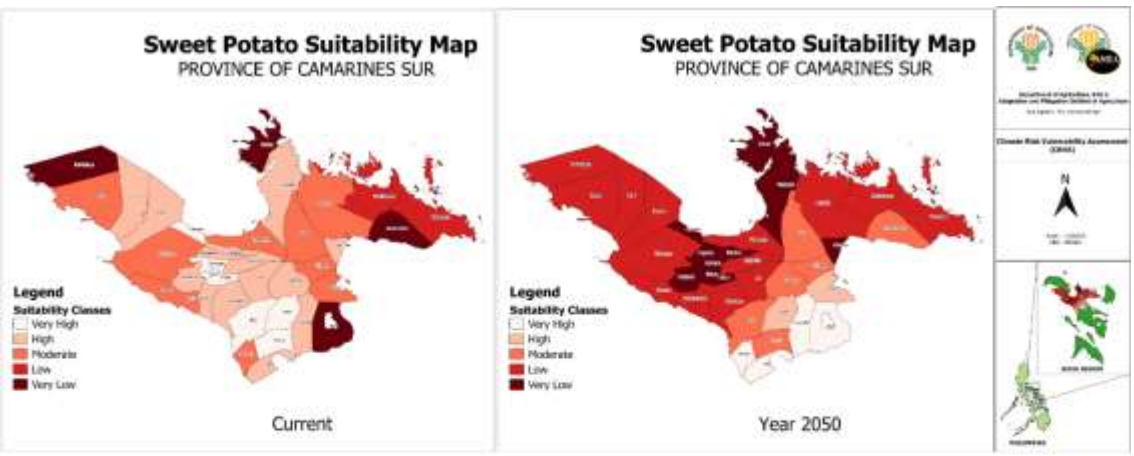
Appendix 19 Crop Climatic Sensitivity and Suitability of Other Crops in Camarines Sur Province

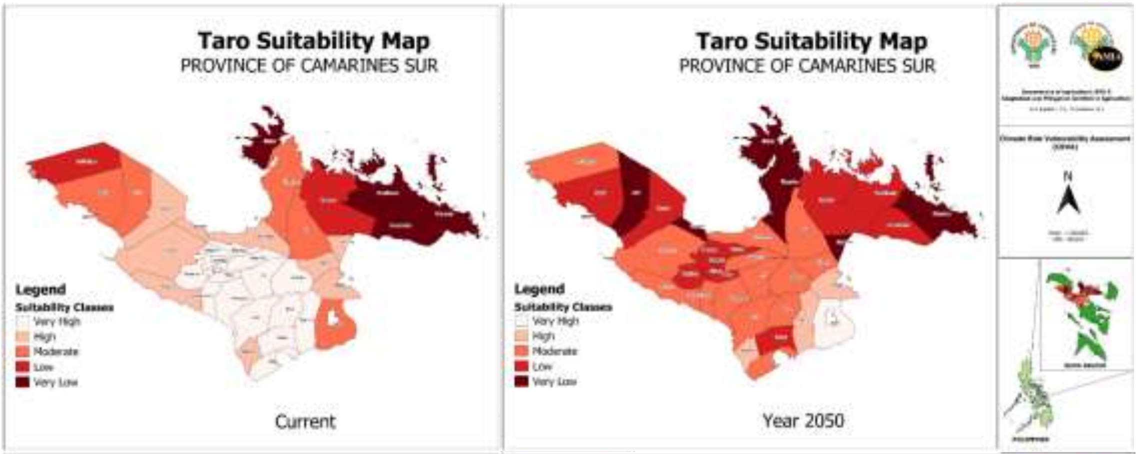


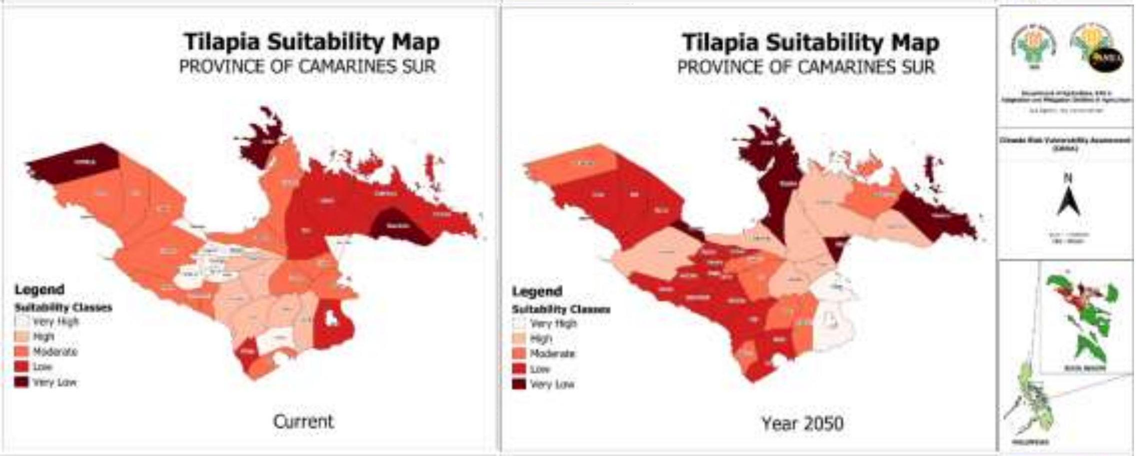

Mango Suitability Map
PROVINCE OF CAMARINES SUR
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Mango Suitability Map
PROVINCE OF CAMARINES SUR
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

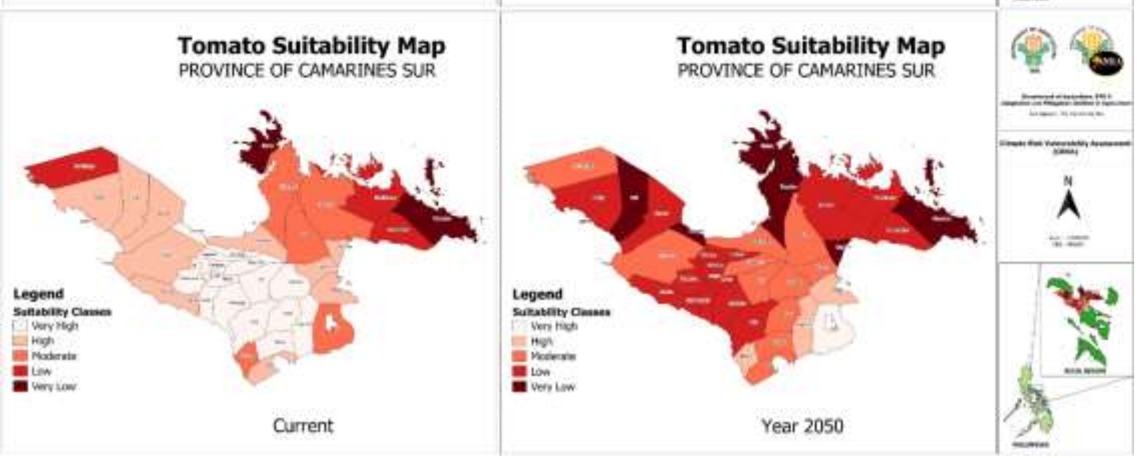

Napier Suitability Map
PROVINCE OF CAMARINES SUR
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Napier Suitability Map
PROVINCE OF CAMARINES SUR
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N


Pili Suitability Map
PROVINCE OF CAMARINES SUR
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Pili Suitability Map
PROVINCE OF CAMARINES SUR
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

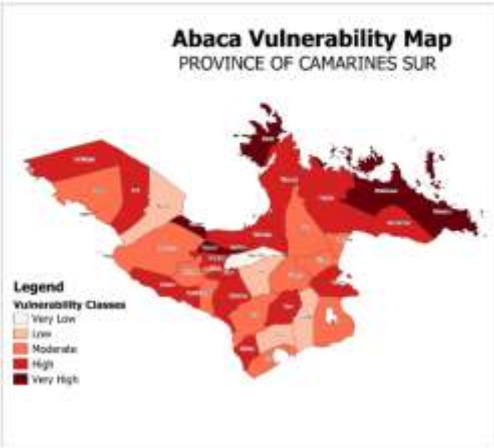

Sweet Potato Suitability Map
PROVINCE OF CAMARINES SUR
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Sweet Potato Suitability Map
PROVINCE OF CAMARINES SUR
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

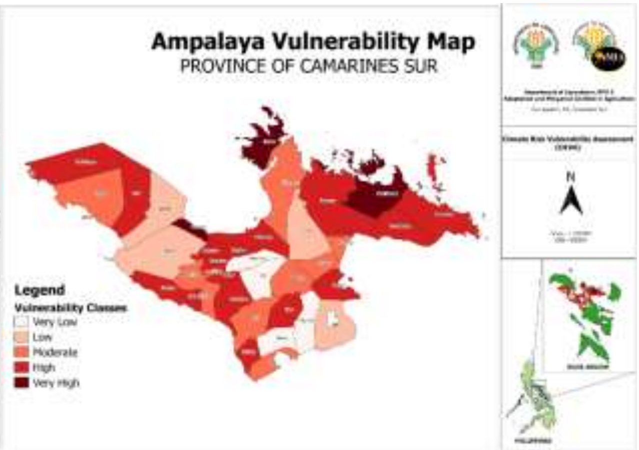

Taro Suitability Map
PROVINCE OF CAMARINES SUR
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Taro Suitability Map
PROVINCE OF CAMARINES SUR
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

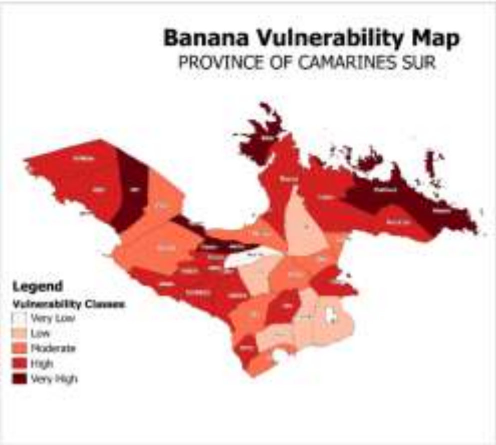

Tilapia Suitability Map
PROVINCE OF CAMARINES SUR
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Tilapia Suitability Map
PROVINCE OF CAMARINES SUR
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

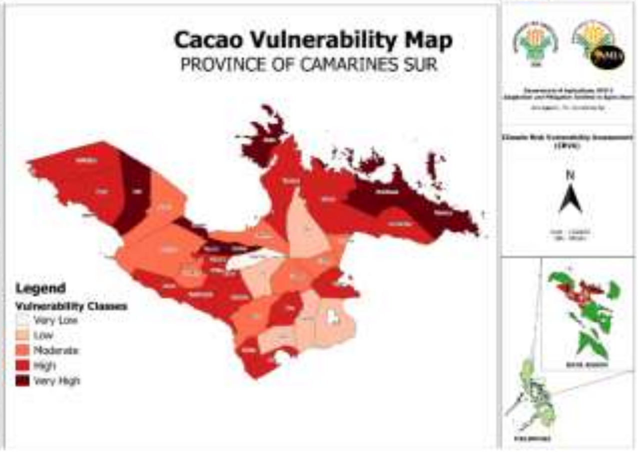

Tomato Suitability Map
PROVINCE OF CAMARINES SUR
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Tomato Suitability Map
PROVINCE OF CAMARINES SUR
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

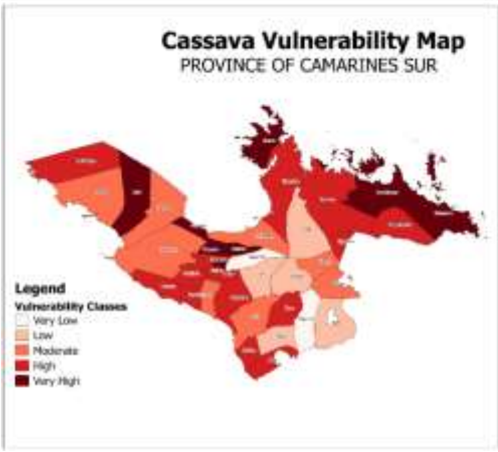
Appendix 20 Crop Vulnerability by 2050 in Camarines Sur Province

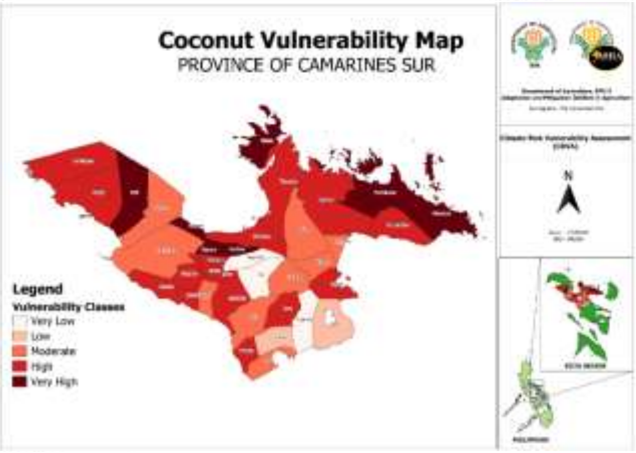


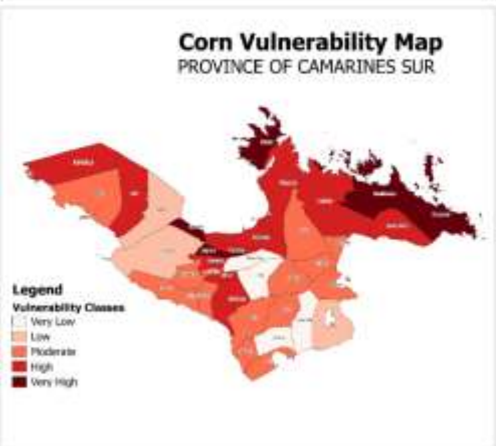


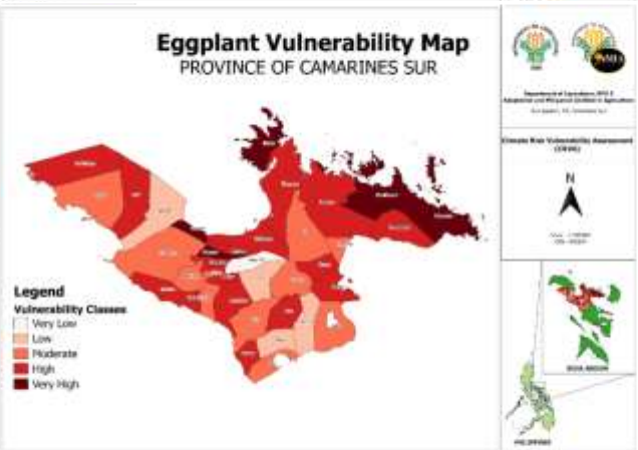


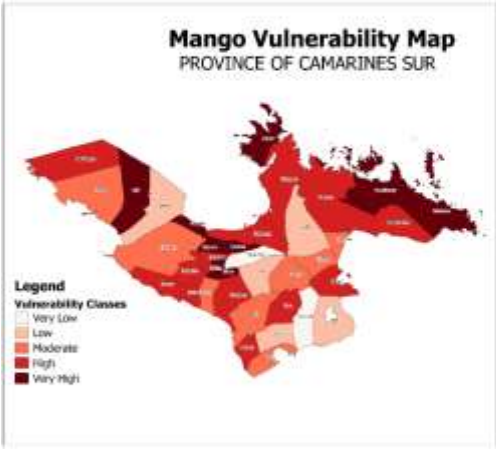


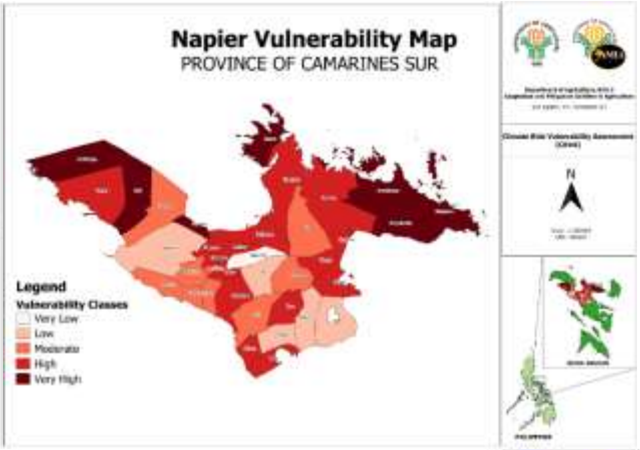


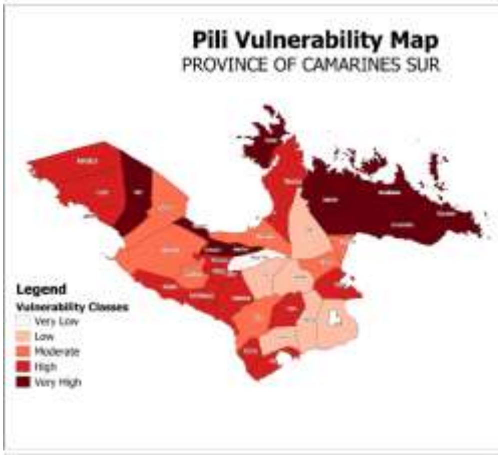


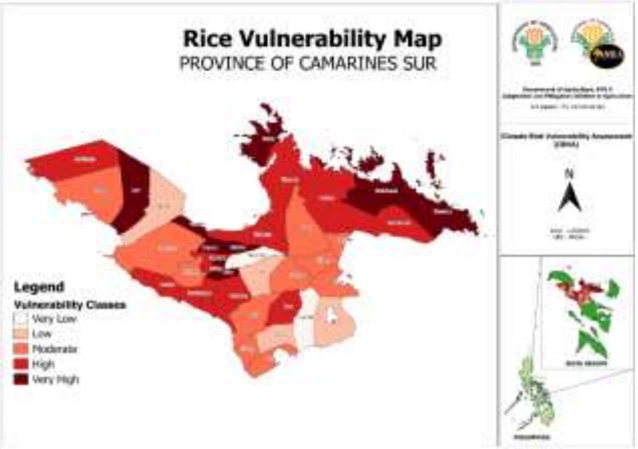


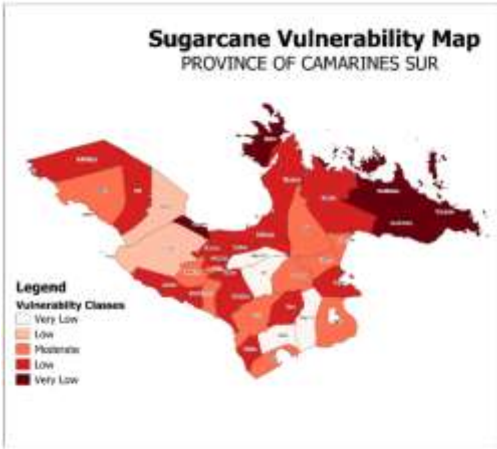


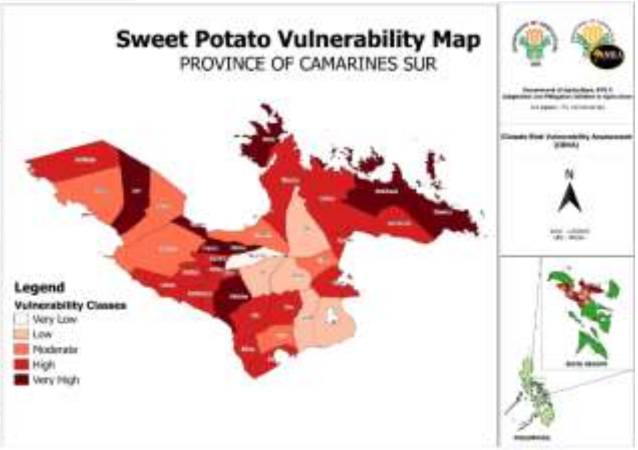

Mango Vulnerability Map
PROVINCE OF CAMARINES SUR
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High

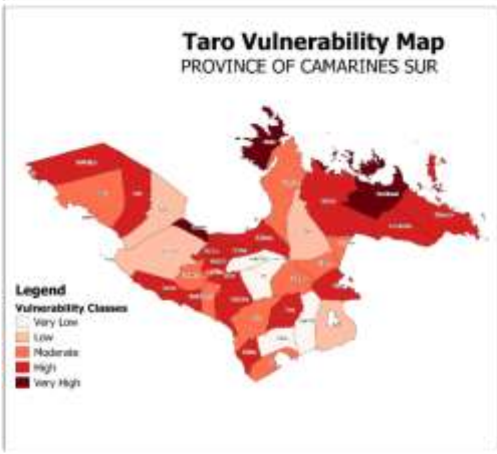

Napier Vulnerability Map
PROVINCE OF CAMARINES SUR
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N

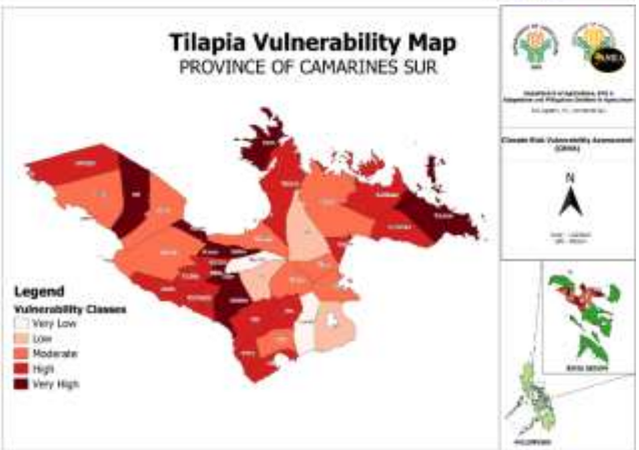

Pili Vulnerability Map
PROVINCE OF CAMARINES SUR
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High

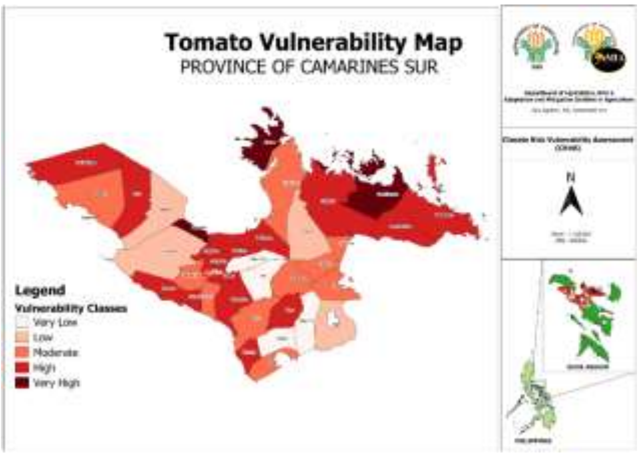

Rice Vulnerability Map
PROVINCE OF CAMARINES SUR
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N


Sugarcane Vulnerability Map
PROVINCE OF CAMARINES SUR
Legend
Vulnerability Classes
Very Low
Low
Moderate
Low
Very Low

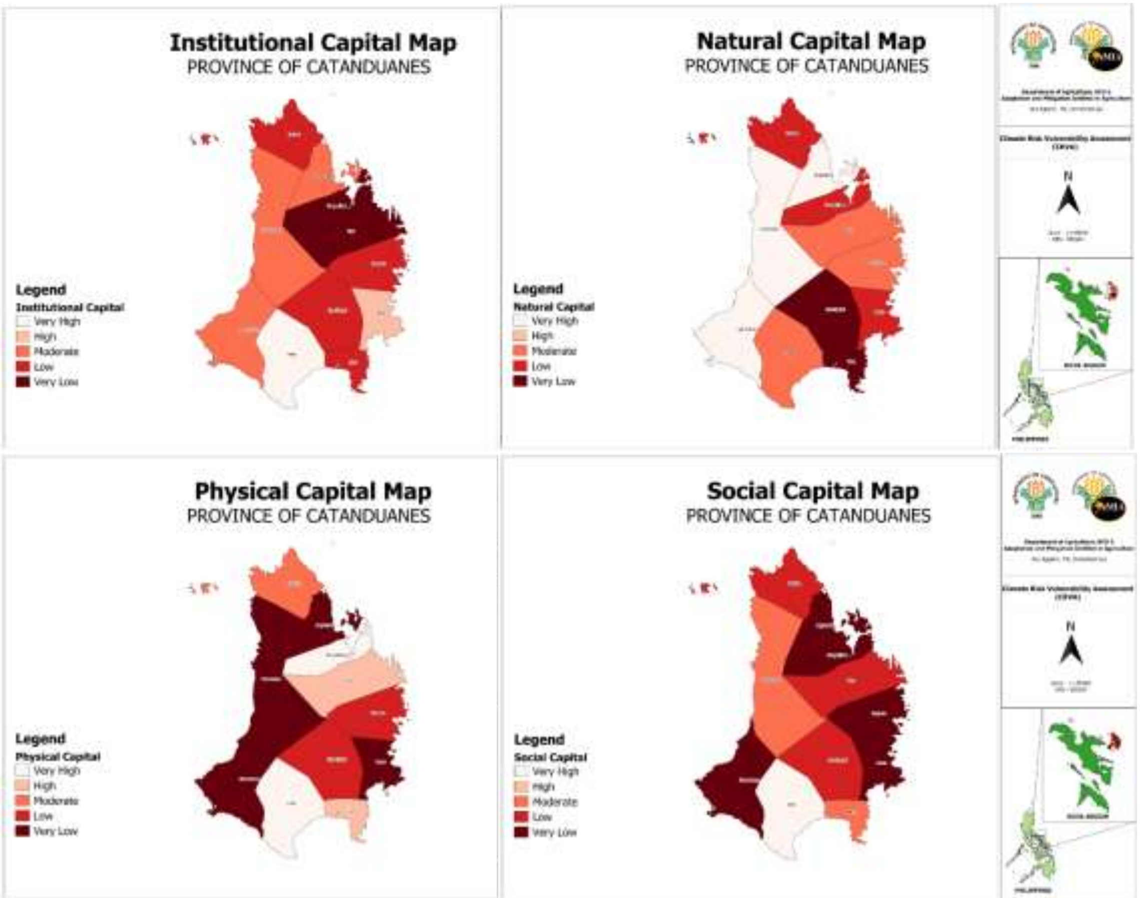

Sweet Potato Vulnerability Map
PROVINCE OF CAMARINES SUR
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N

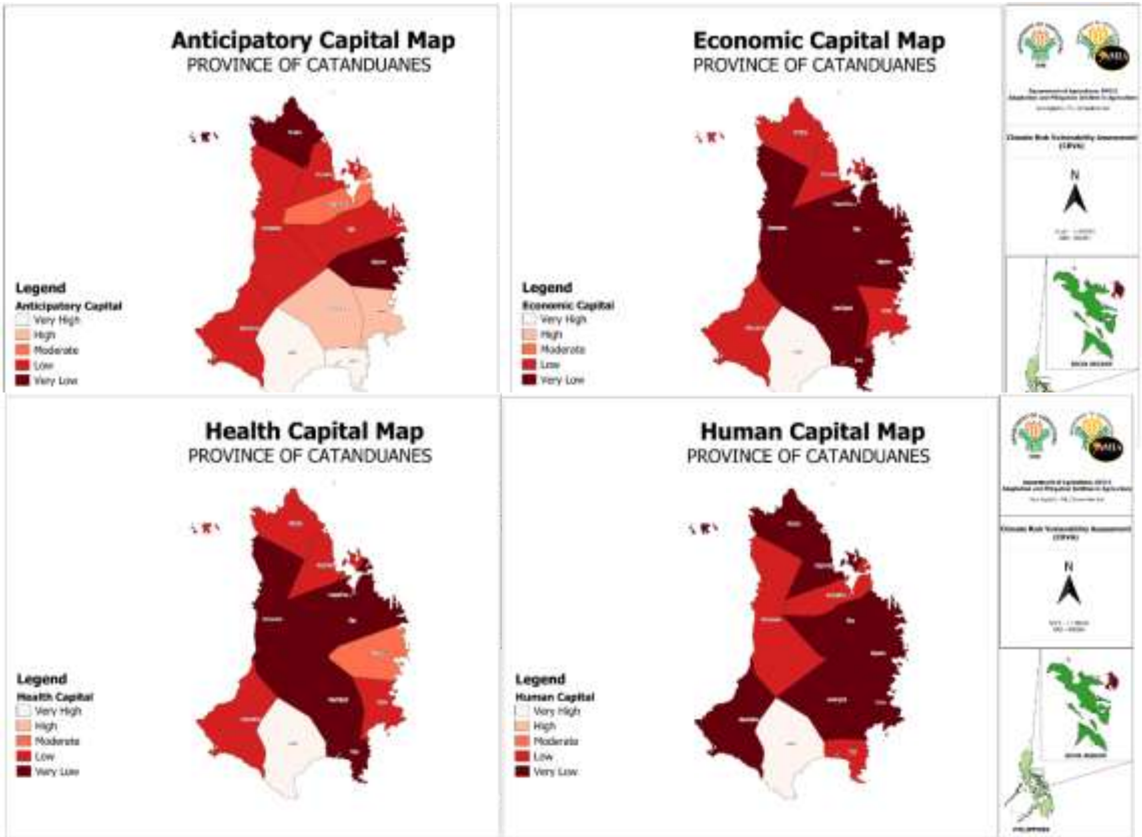

Taro Vulnerability Map
PROVINCE OF CAMARINES SUR
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High


Tilapia Vulnerability Map
PROVINCE OF CAMARINES SUR
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N

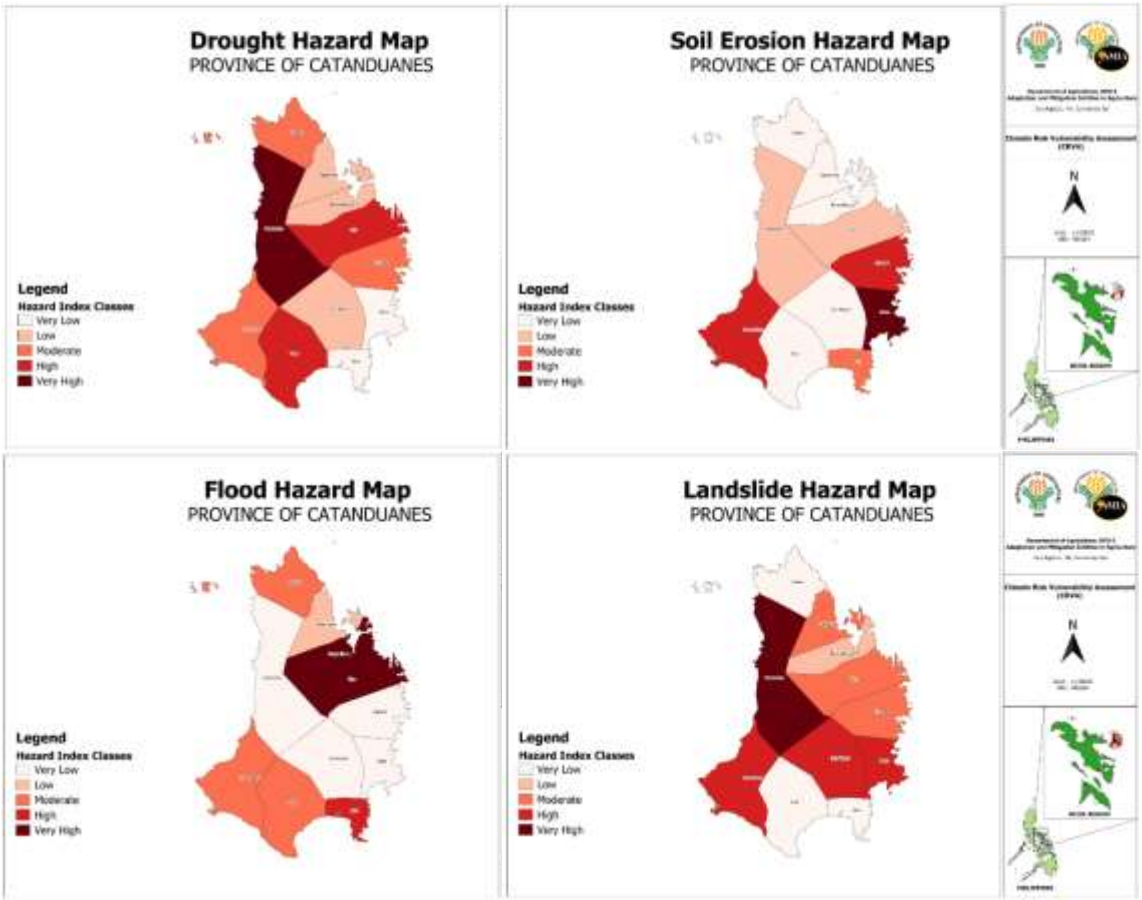


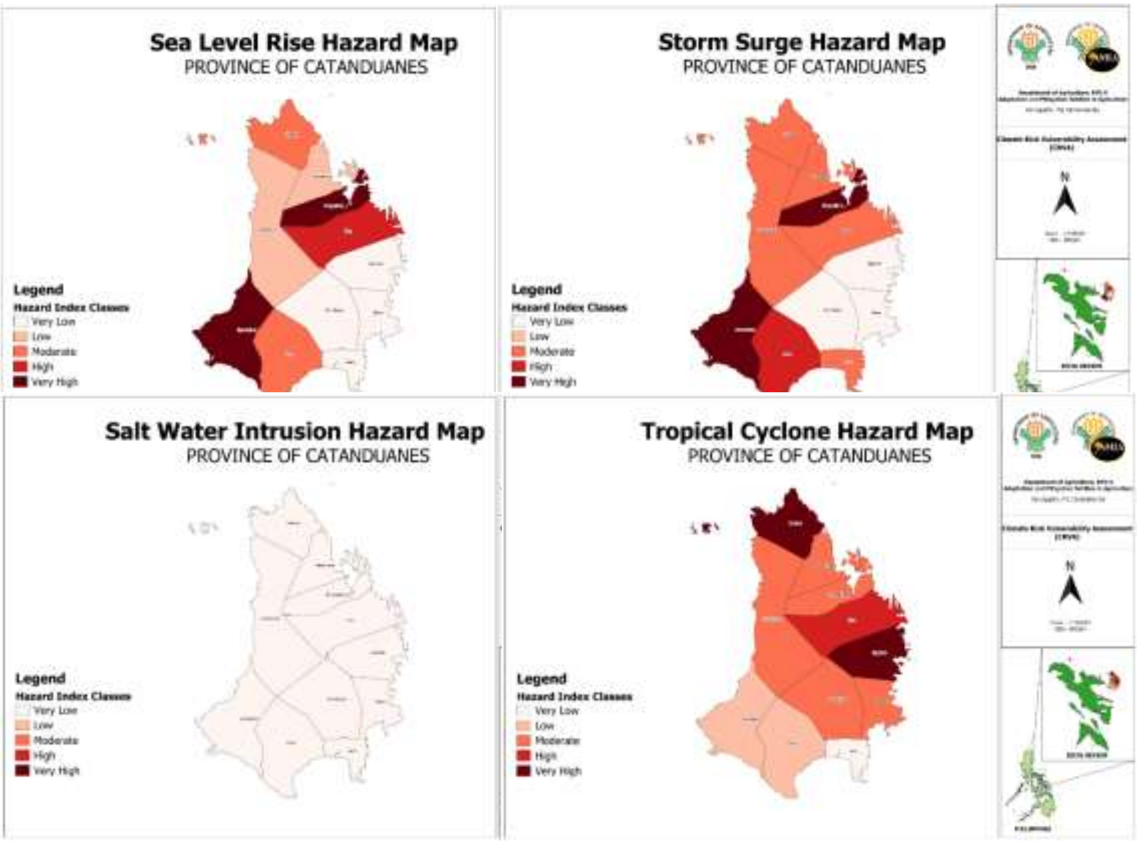
Appendix 21 Adaptive Capacity Maps of the Province of Catanduanes (Per Capital)



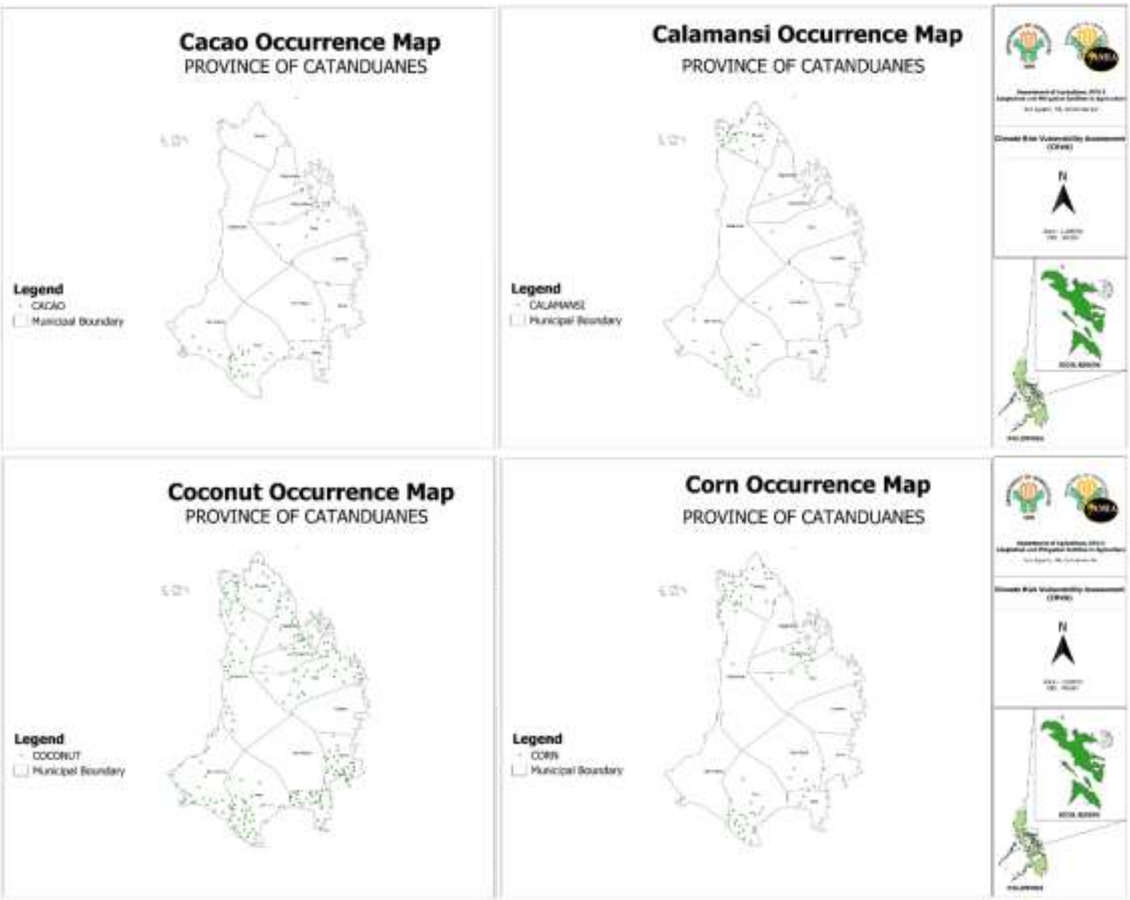


Appendix 22 Hazard Map of Catanduanes Province



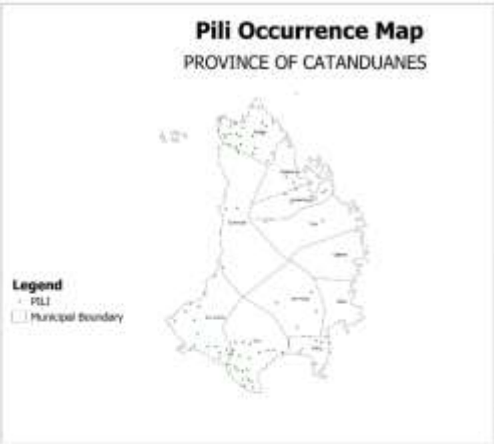


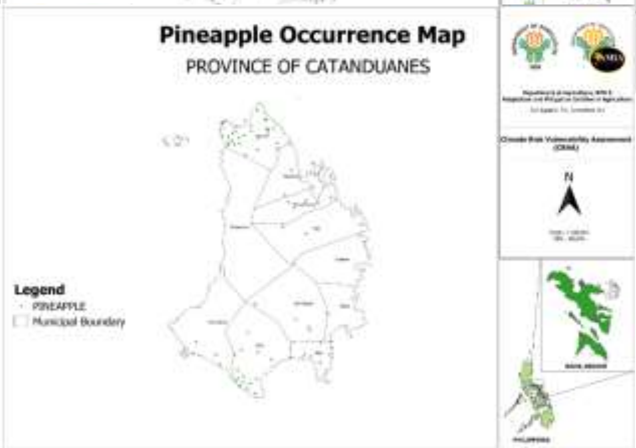
Appendix 23 Crop Occurrence of other crops in Catanduanes Province

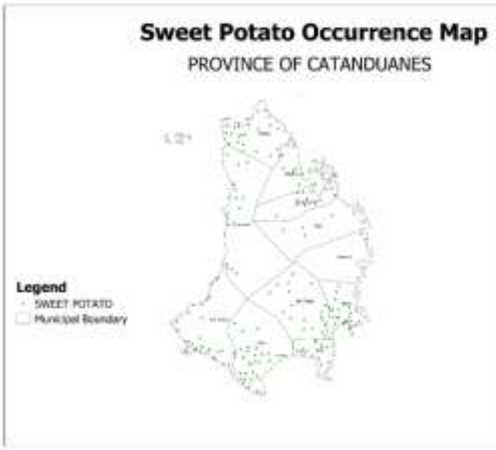


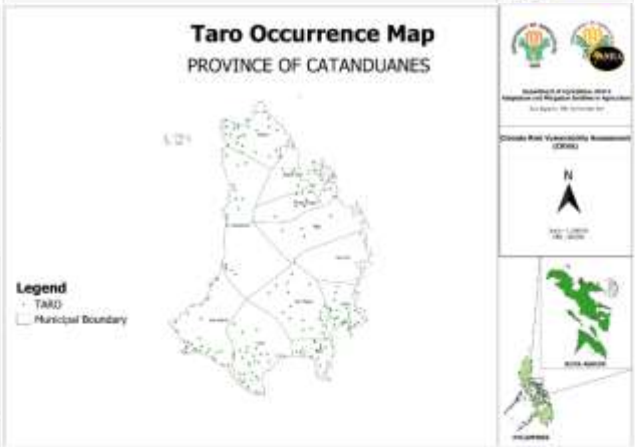

Millet Occurrence Map
PROVINCE OF CATANDUANES
Legend
MILLET
Municipal Boundary


Mud Crab Occurrence Map
PROVINCE OF CATANDUANES
Legend
MUD CRAB
Municipal Boundary
N

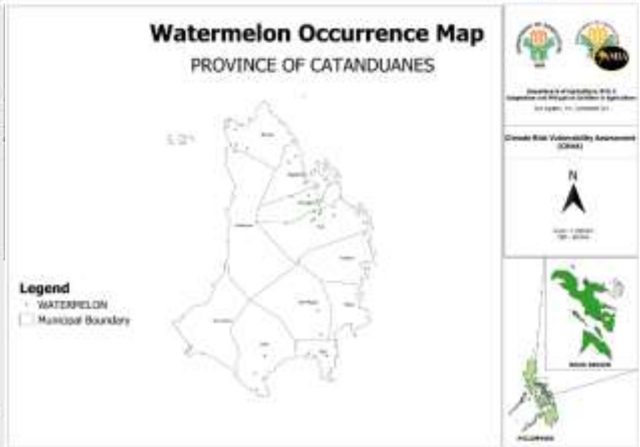

Pili Occurrence Map
PROVINCE OF CATANDUANES
Legend
PILI
Municipal Boundary

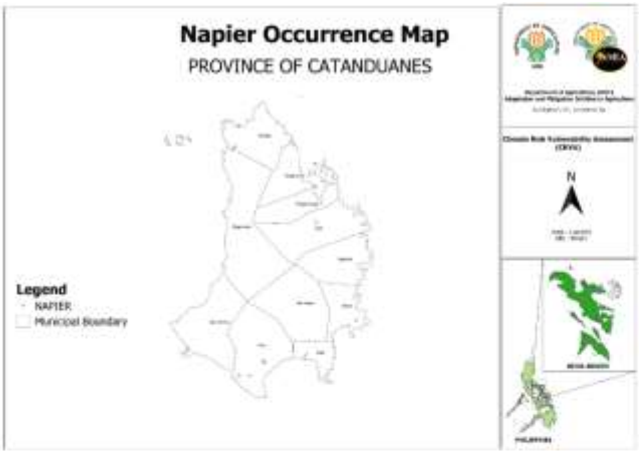

Pineapple Occurrence Map
PROVINCE OF CATANDUANES
Legend
PINEAPPLE
Municipal Boundary
N


Sweet Potato Occurrence Map
PROVINCE OF CATANDUANES
Legend
SWEET POTATO
Municipal Boundary

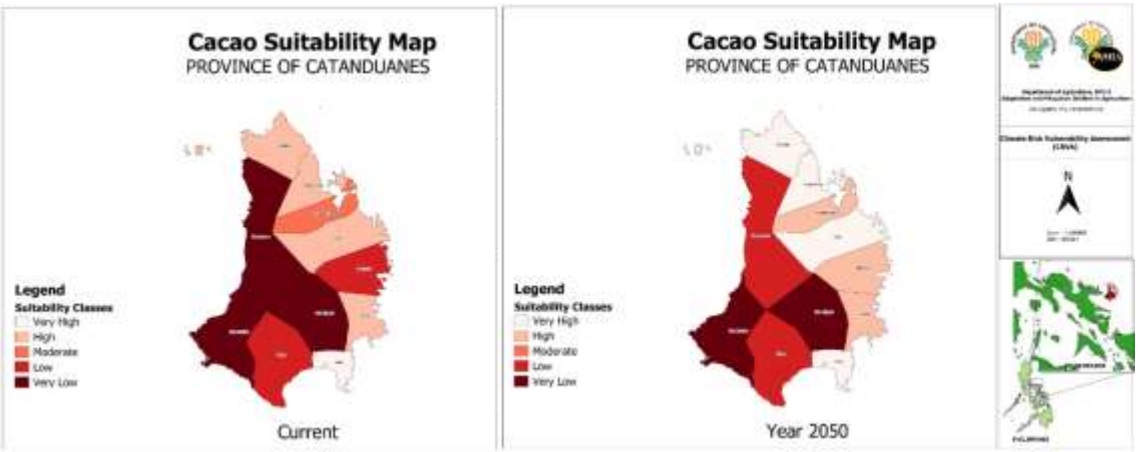

Taro Occurrence Map
PROVINCE OF CATANDUANES
Legend
TARO
Municipal Boundary
N

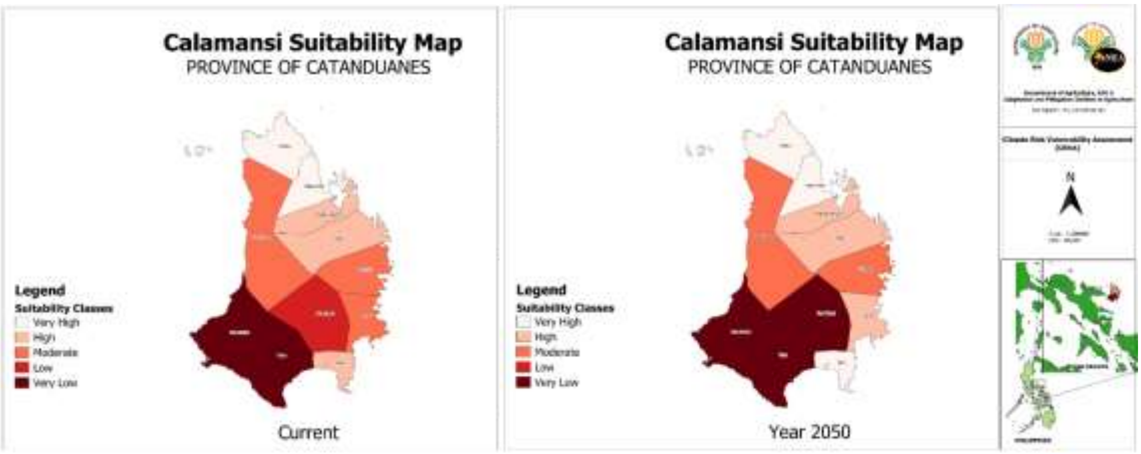

Tilapia Occurrence Map
PROVINCE OF CATANDUANES
Legend
TILAPIA
Municipal Boundary

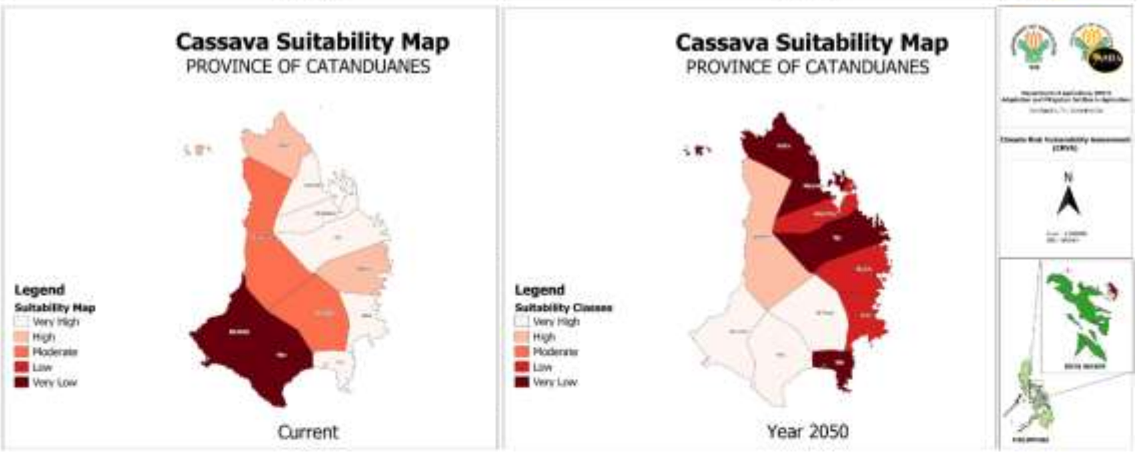

Watermelon Occurrence Map
PROVINCE OF CATANDUANES
Legend
WATERMELON
Municipal Boundary
N

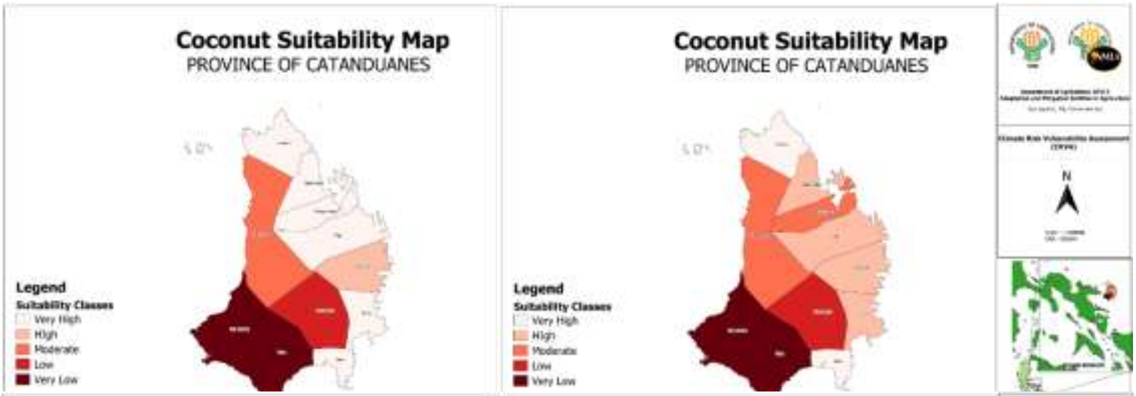


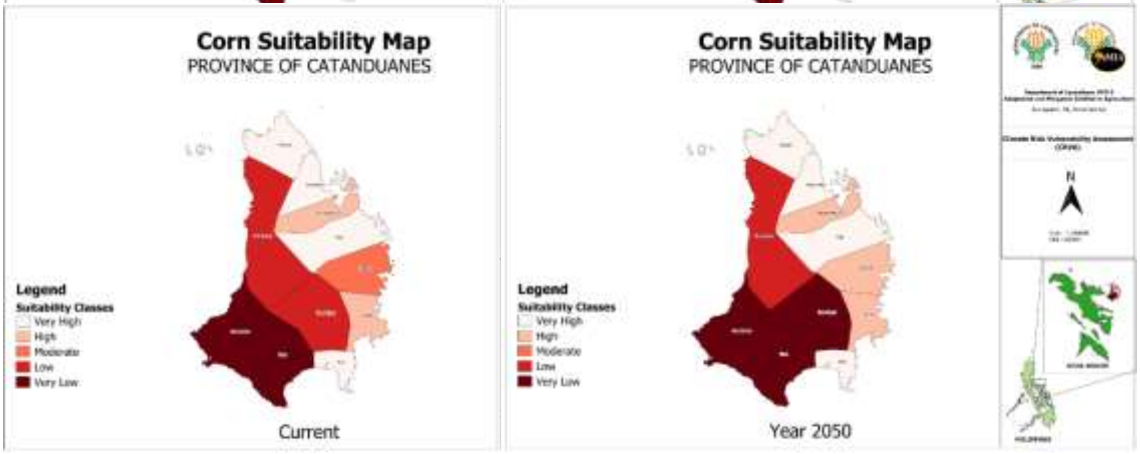
Appendix 24 Crop Climatic Sensitivity and Suitability of Other Crops in Catanduanes Province

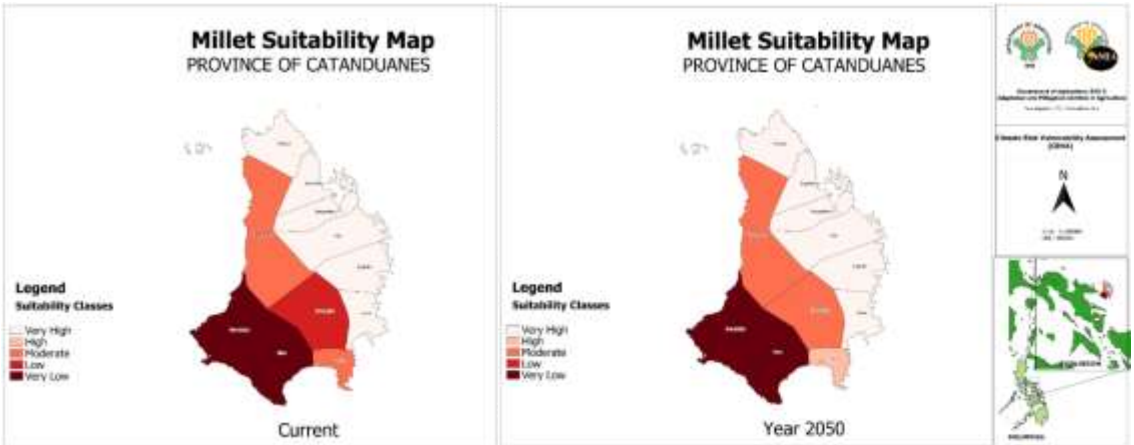


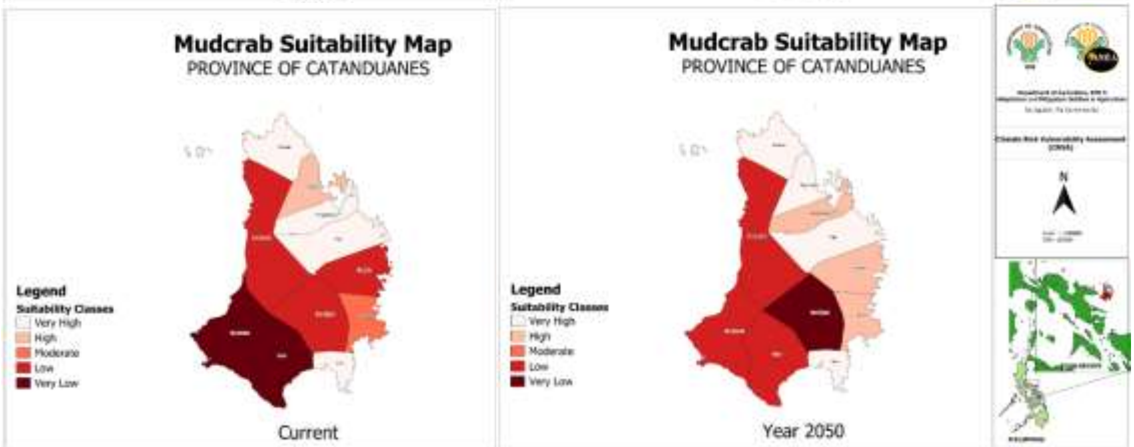


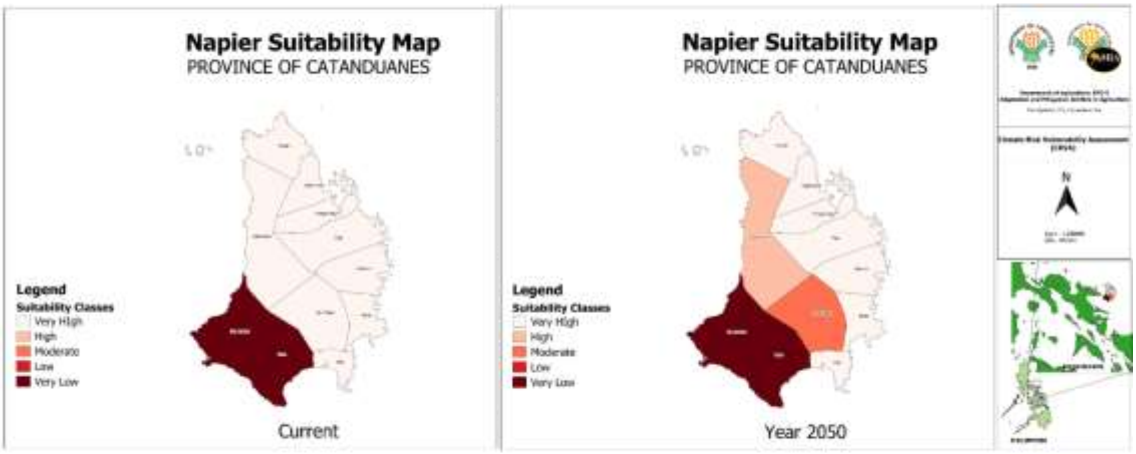


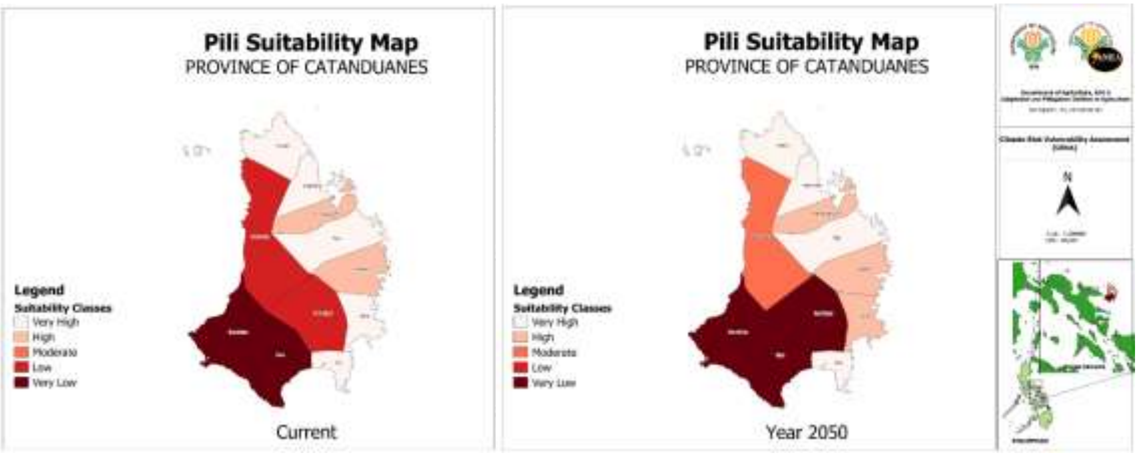

Coconut Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Coconut Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low

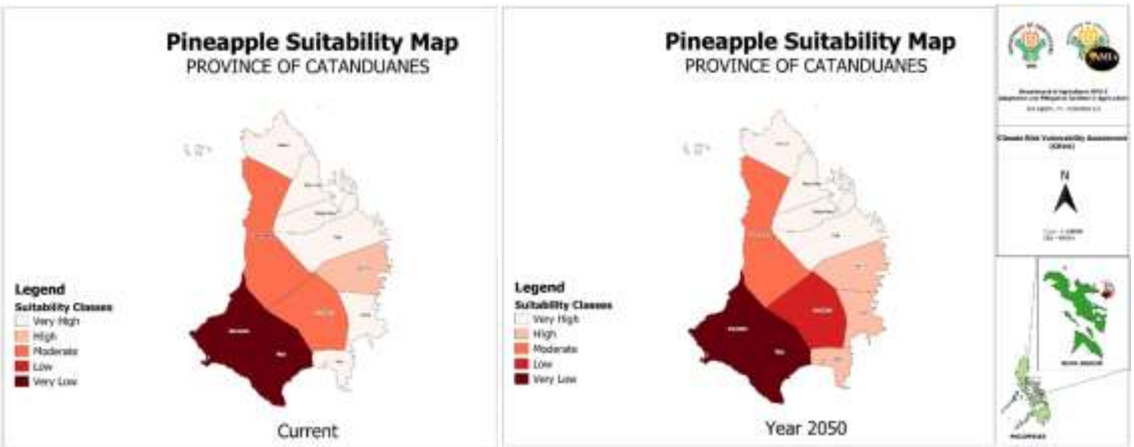

Corn Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Corn Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050

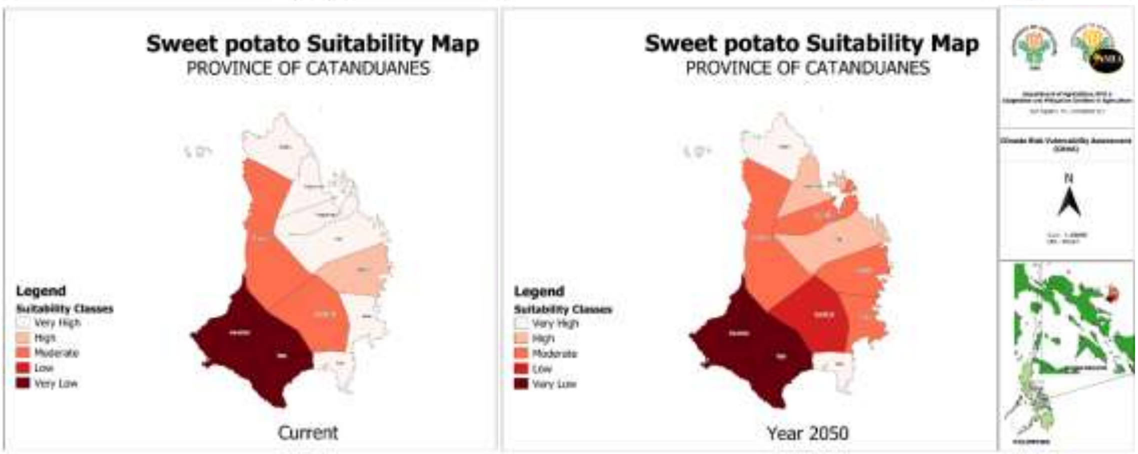

Millet Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Millet Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050


Mudcrab Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Mudcrab Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050

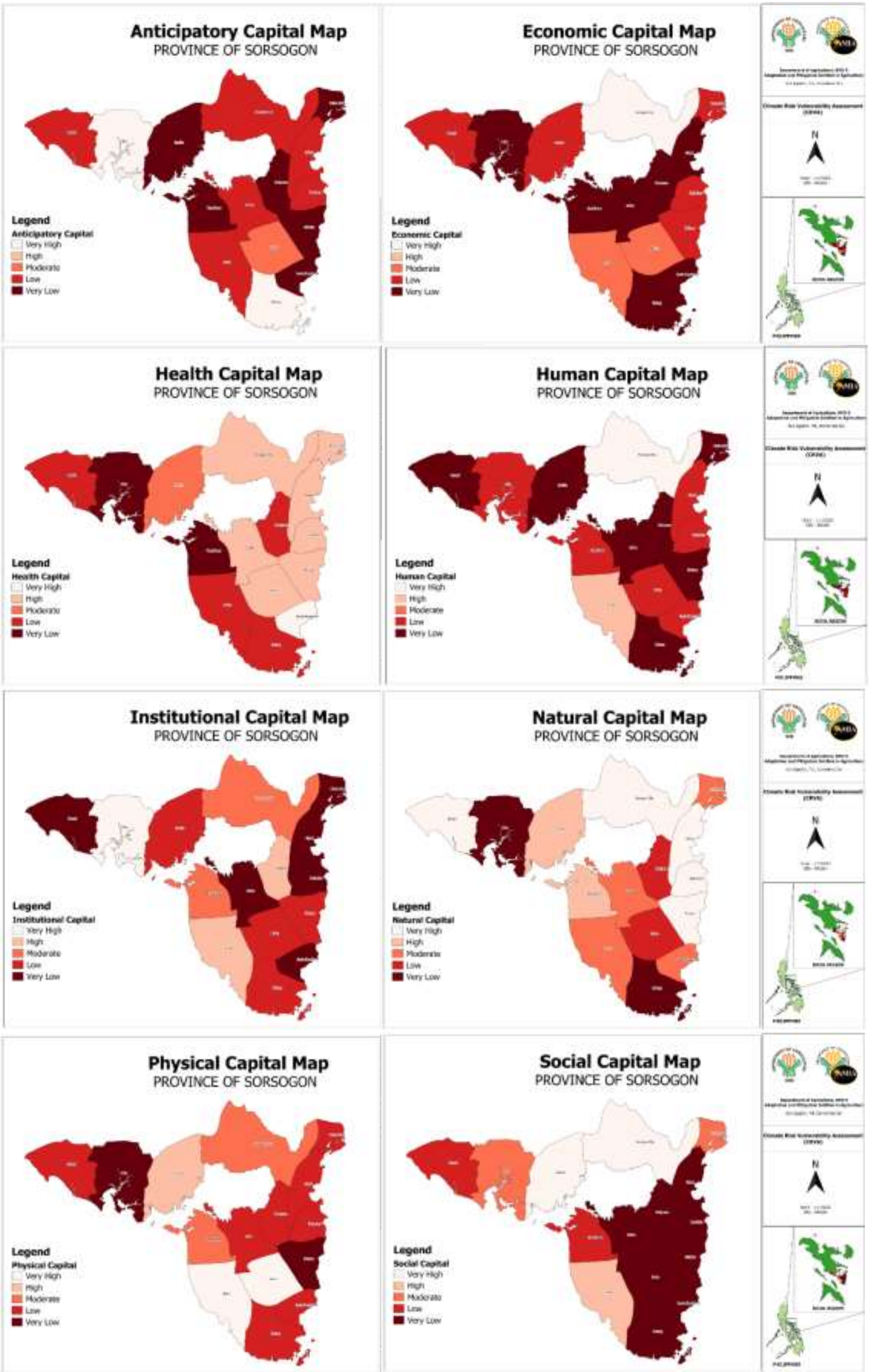

Napier Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Napier Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N


Pili Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Pili Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

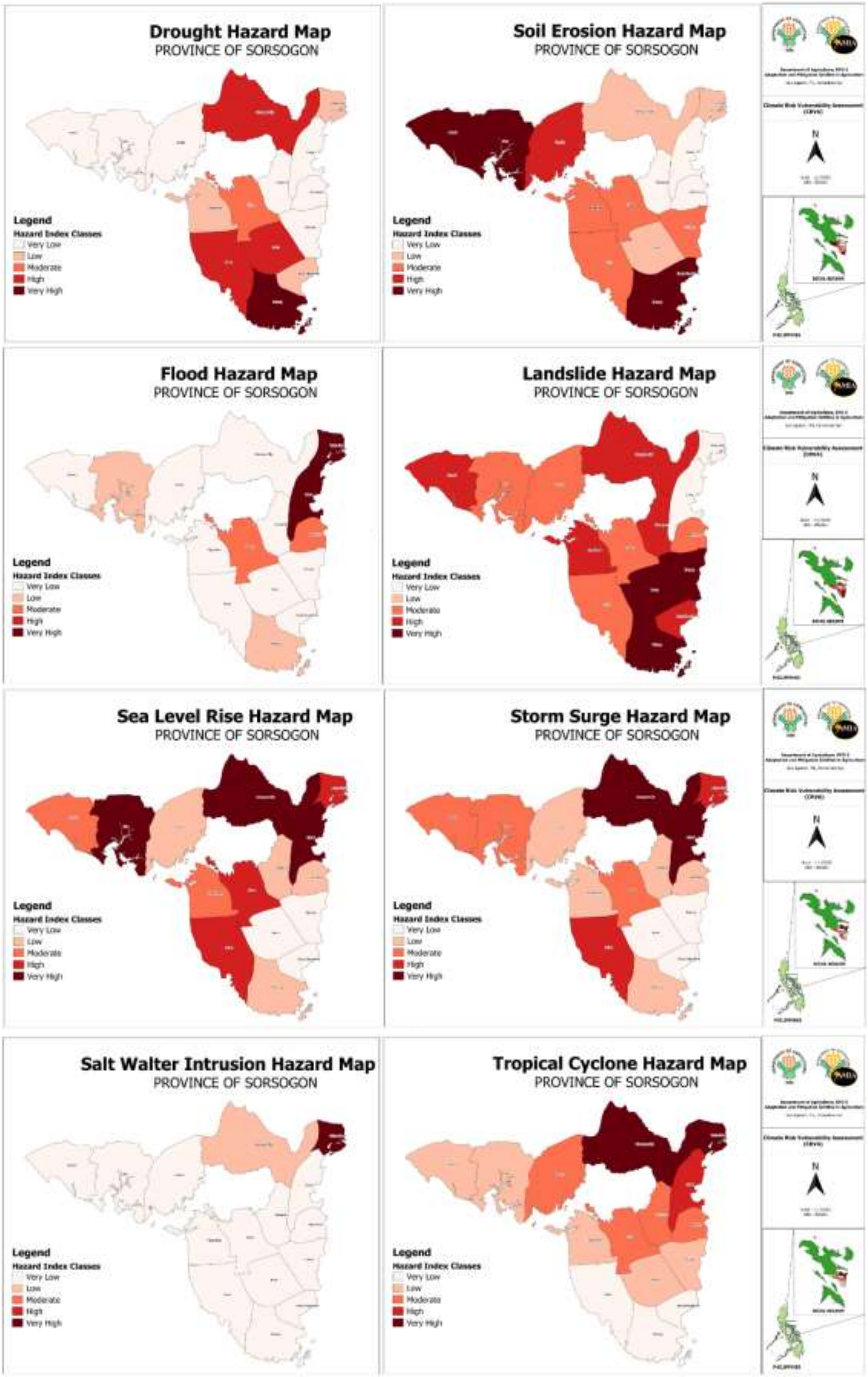

Pineapple Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Pineapple Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N


Sweet potato Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Sweet potato Suitability Map
PROVINCE OF CATANDUANES
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

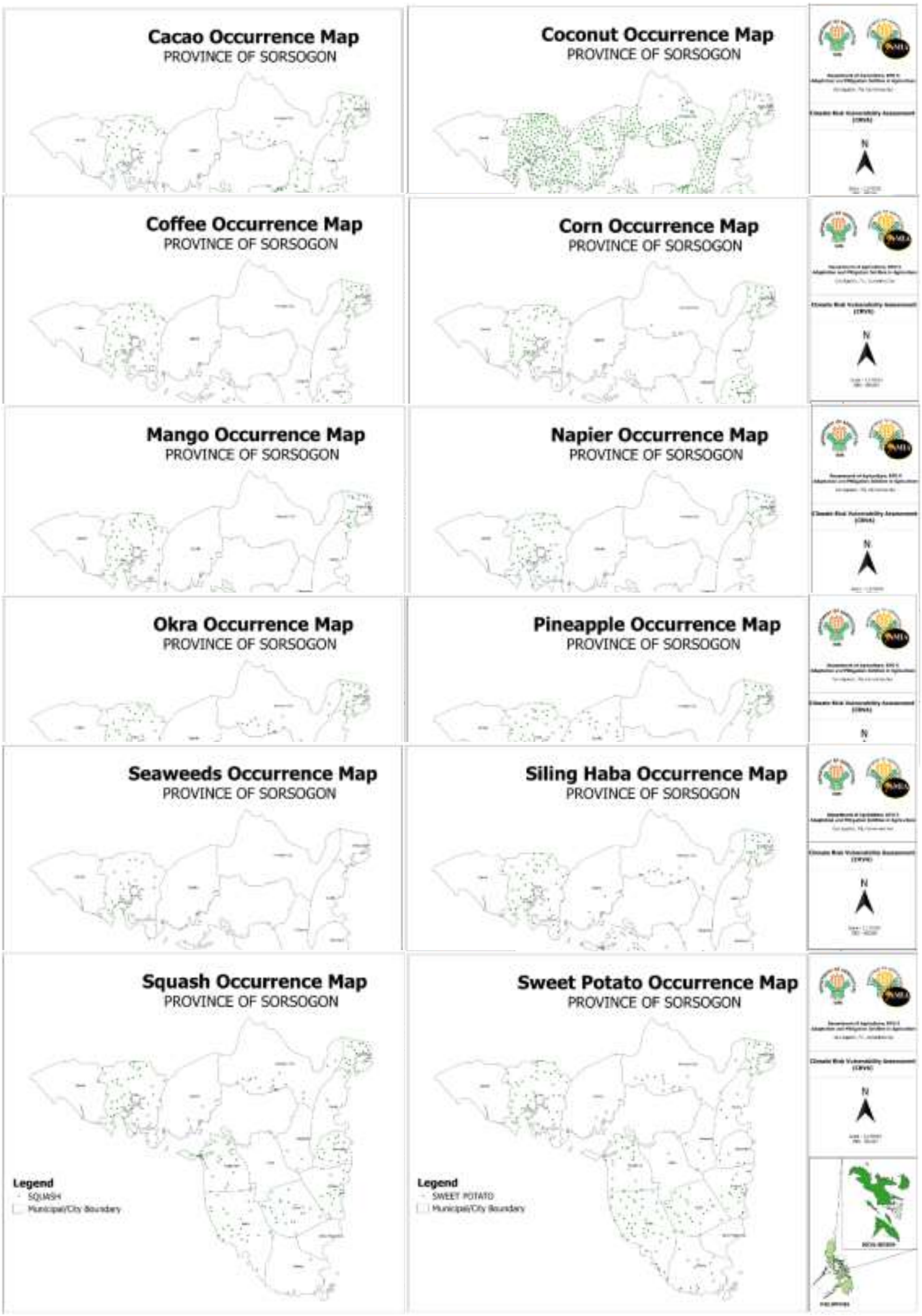
Appendix 25 Adaptive Capacity Maps of the Province of Sorsogon (Per Capital)

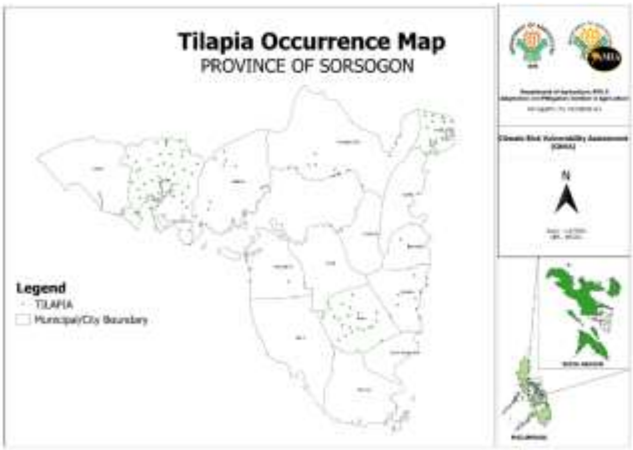


Appendix 26 Hazard Map of Sorsogon Province

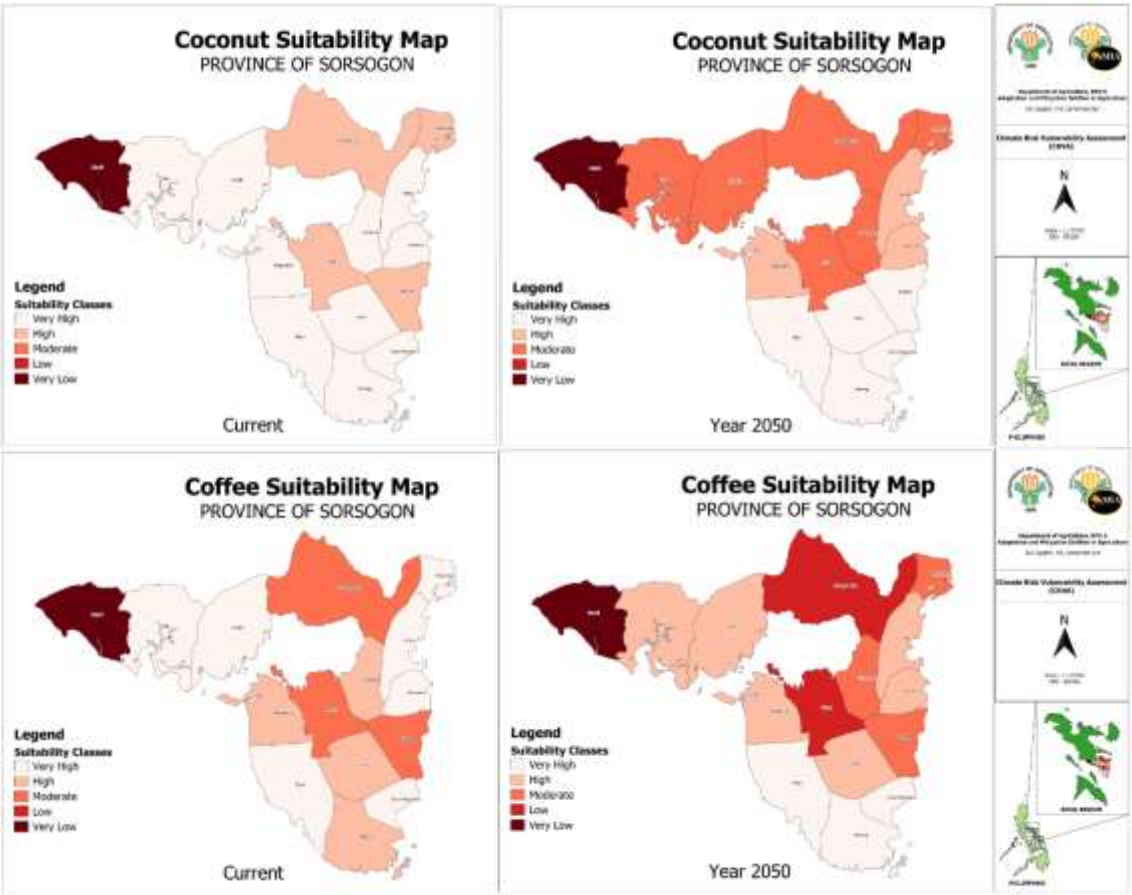


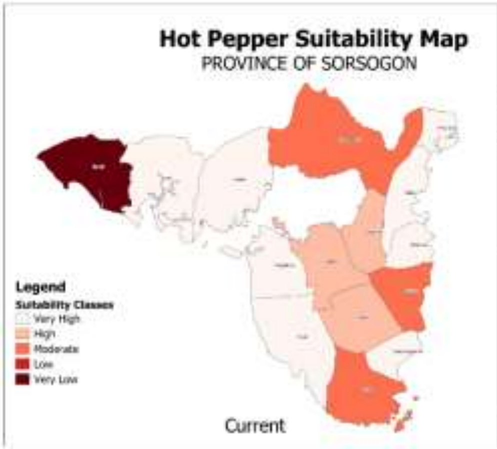
Appendix 27 Crop Occurrence of other crops in Sorsogon Province

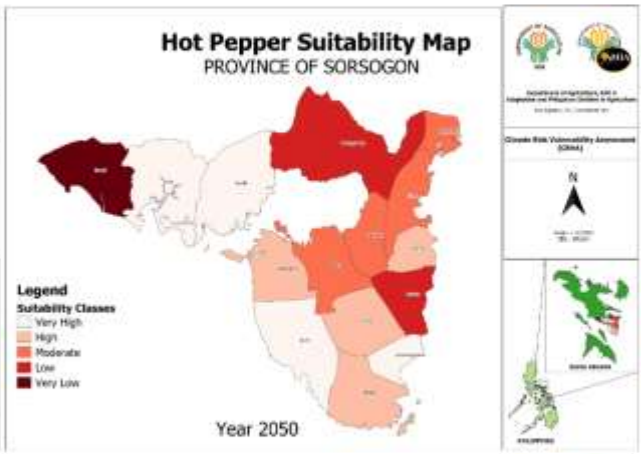


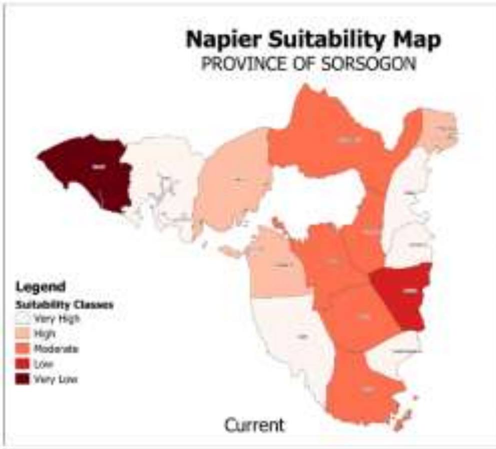


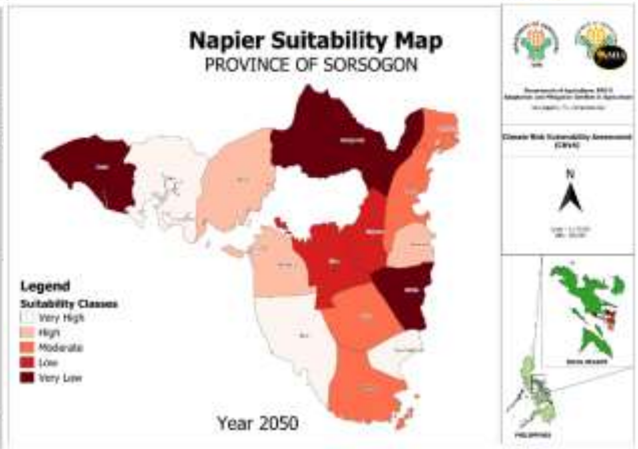
Appendix 28 Crop Climatic Sensitivity and Suitability of Other Crops in Sorsogon Province

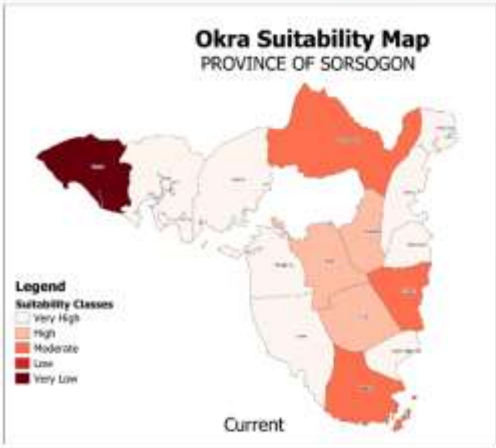


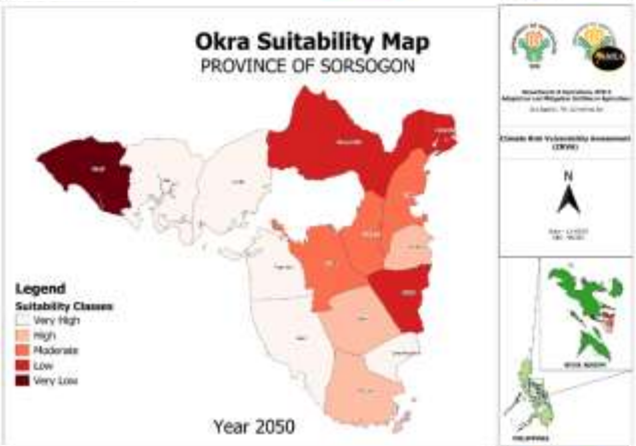

Hot Pepper Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current

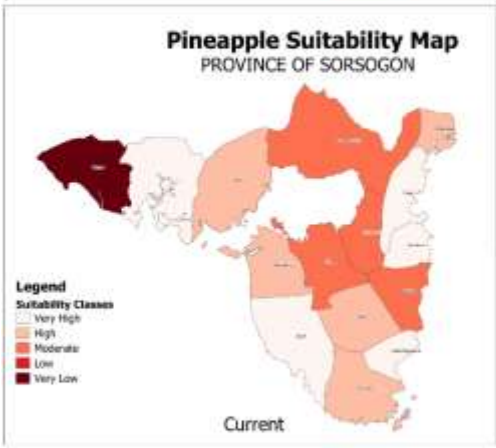

Hot Pepper Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

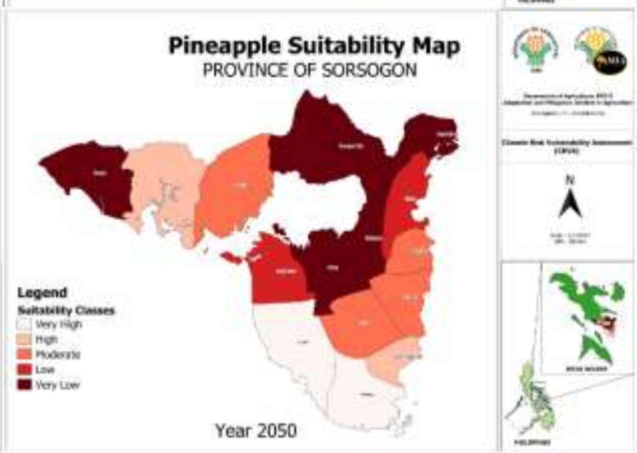

Napier Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current

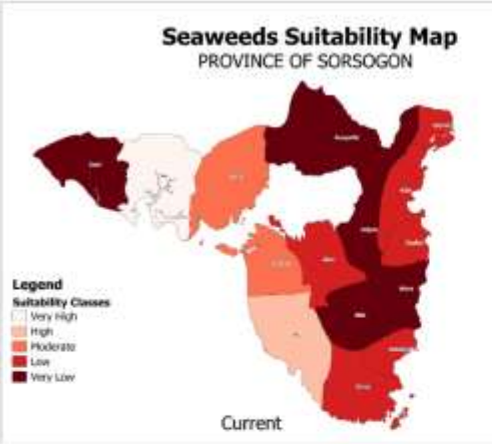

Napier Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

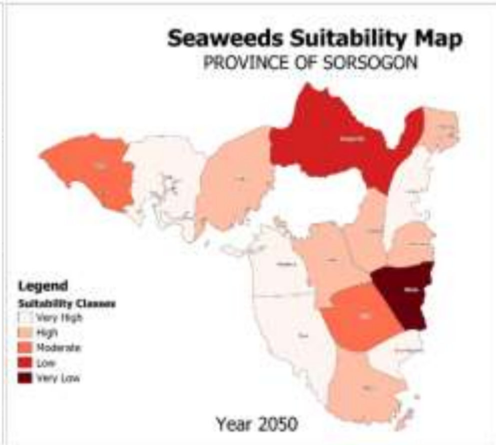

Okra Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current

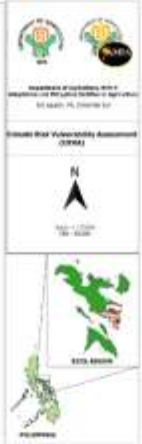

Okra Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N


Pineapple Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current


Pineapple Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N


Seaweeds Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current


Seaweeds Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050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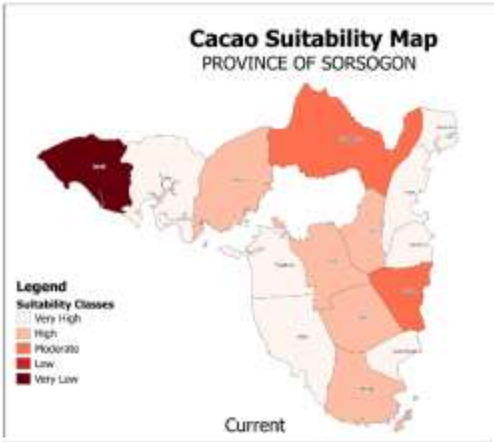
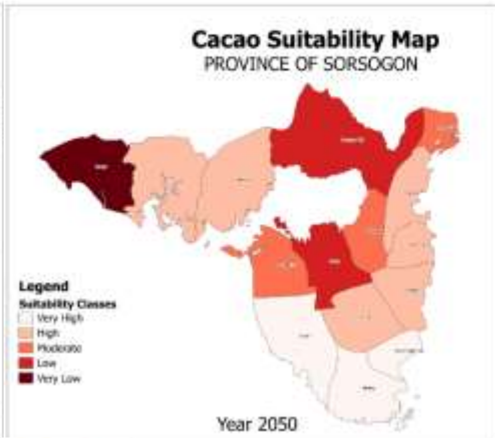
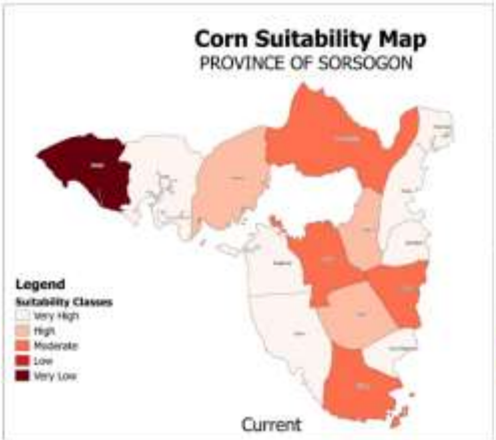
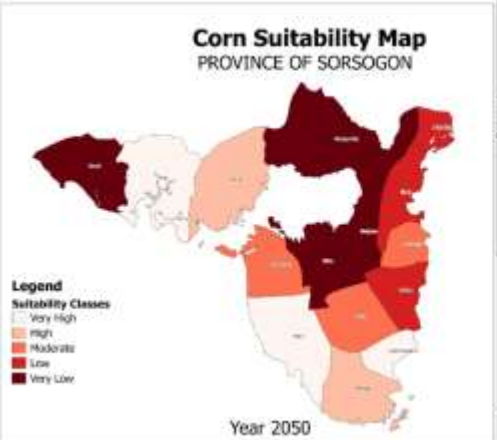

Cacao Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current

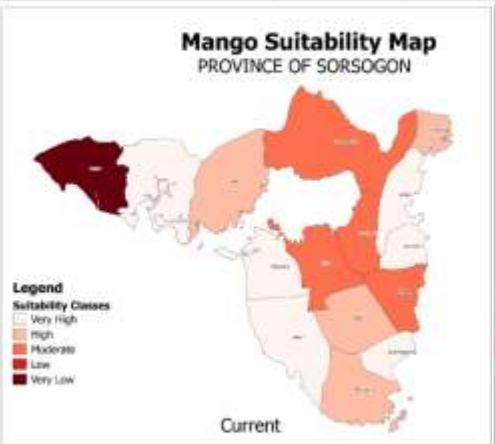

Cacao Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050

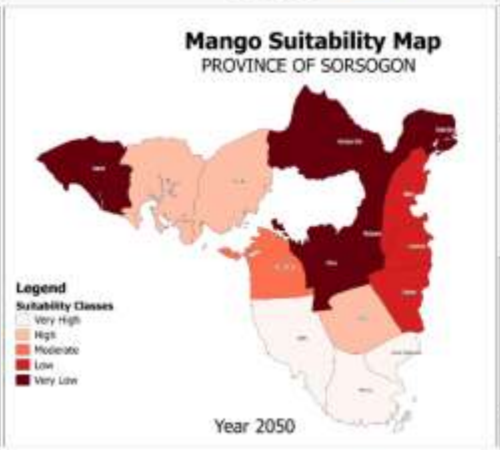

N

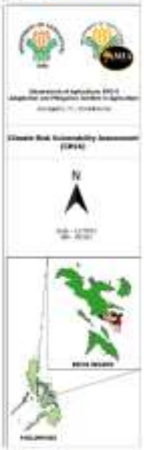

Corn Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current


Corn Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050


N


Mango Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current


Mango Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050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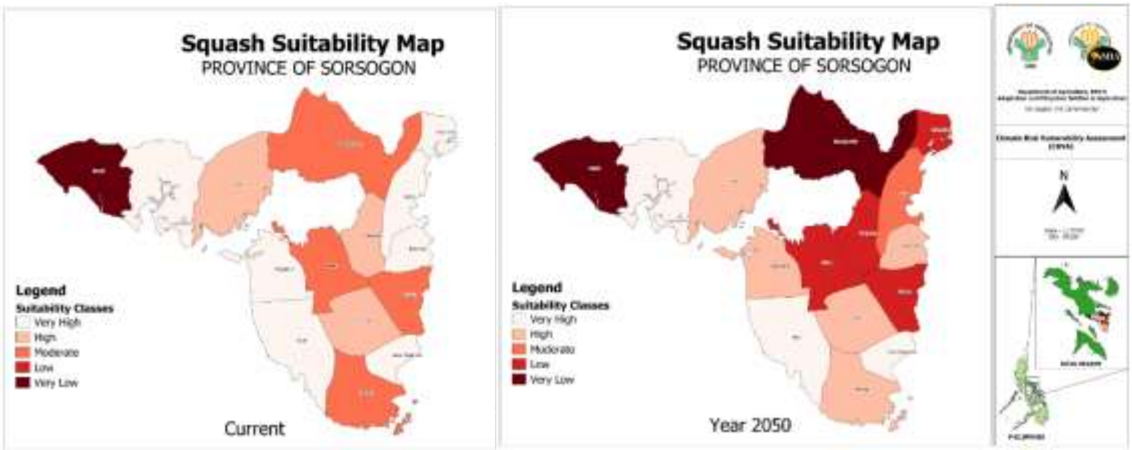
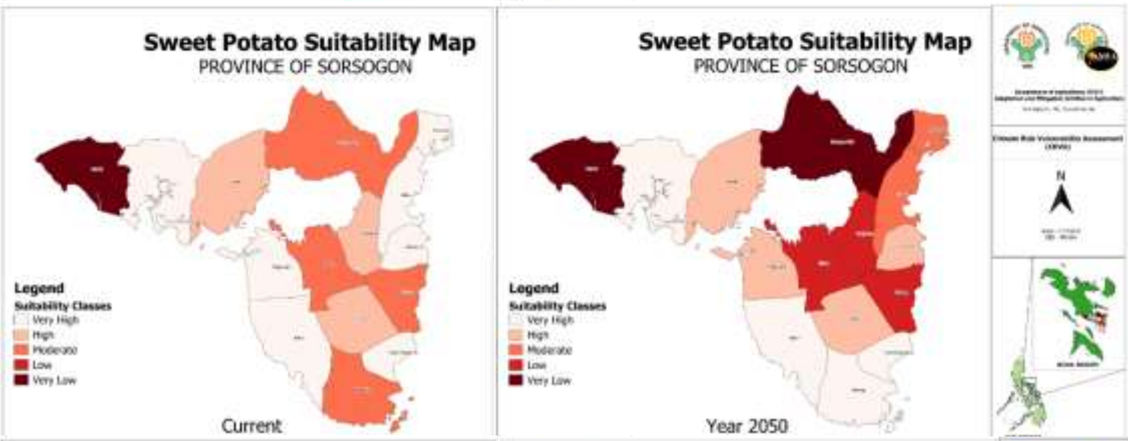
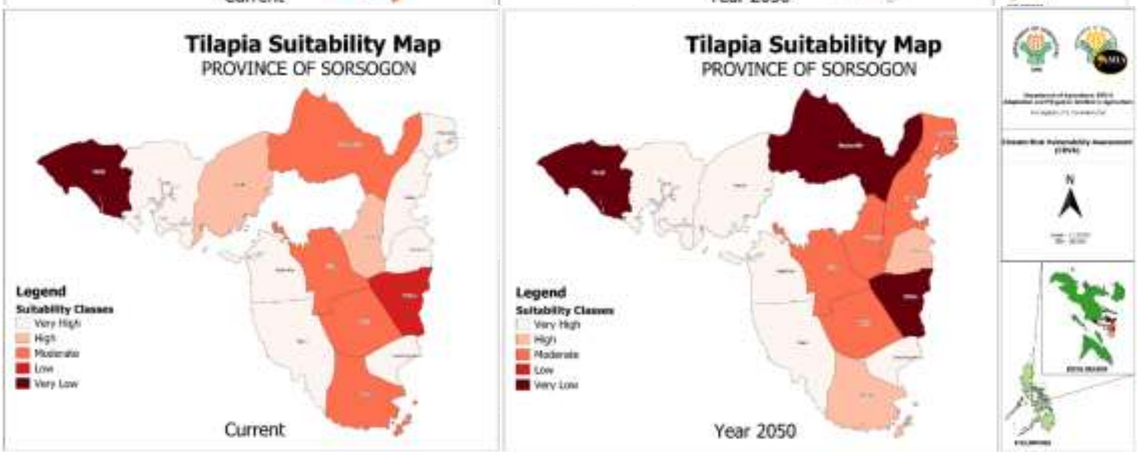
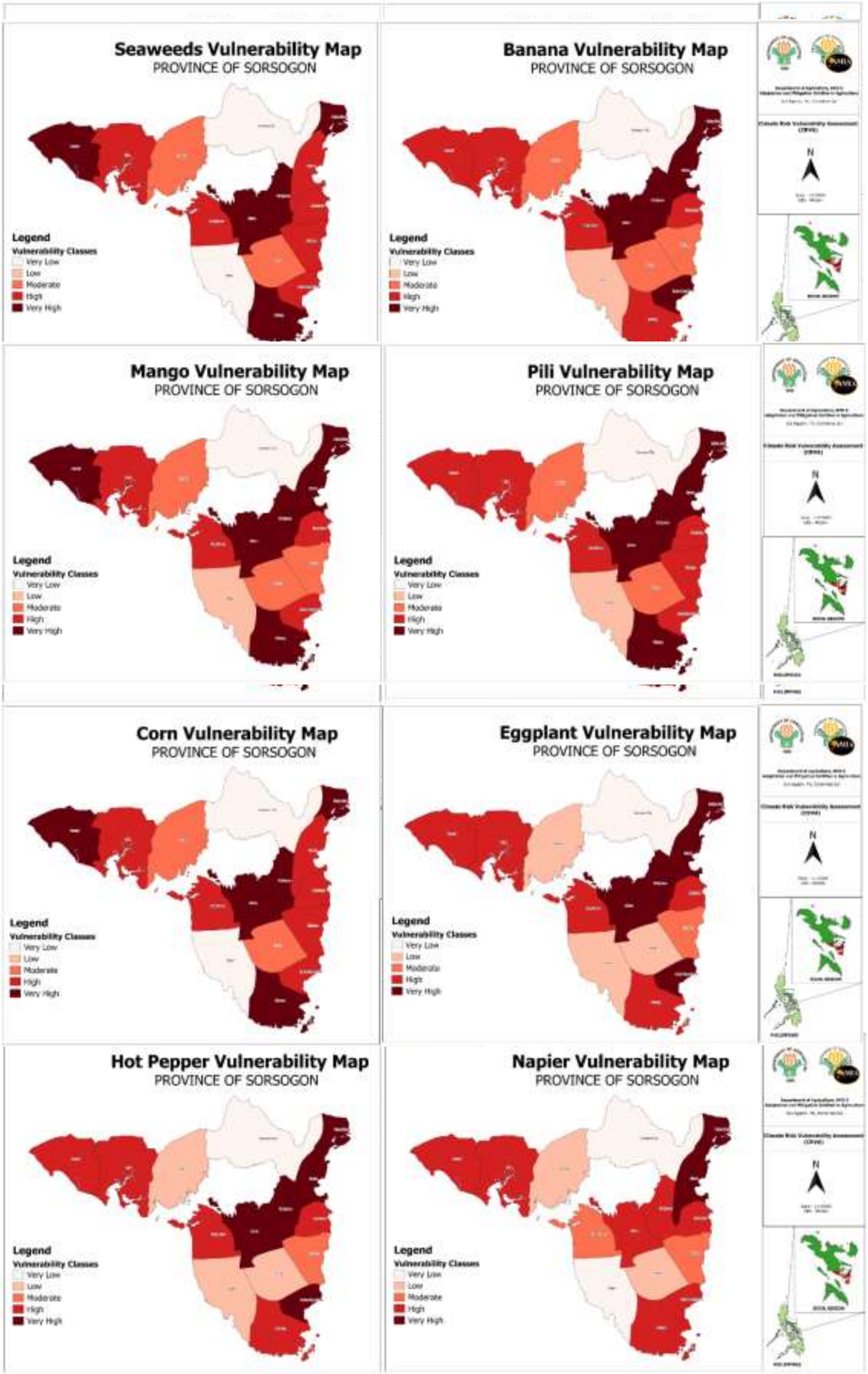
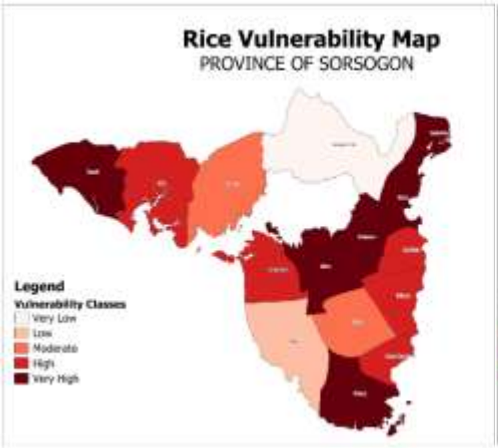

Squash Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Squash Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

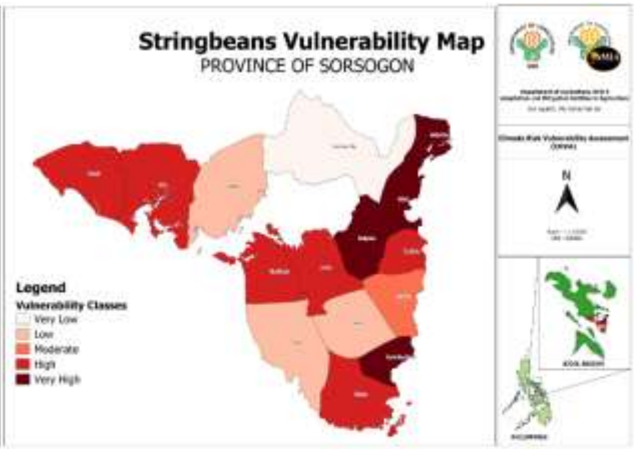

Sweet Potato Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Sweet Potato Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

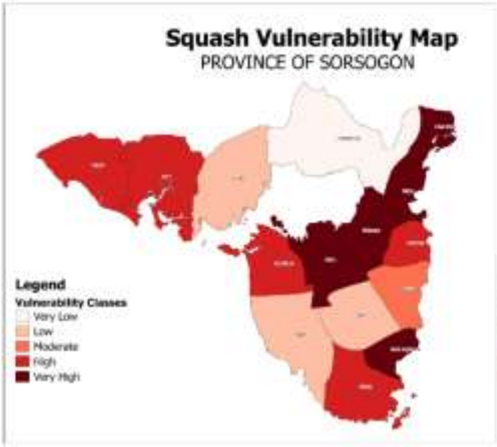

Tilapia Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Tilapia Suitability Map
PROVINCE OF SORSOGON
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

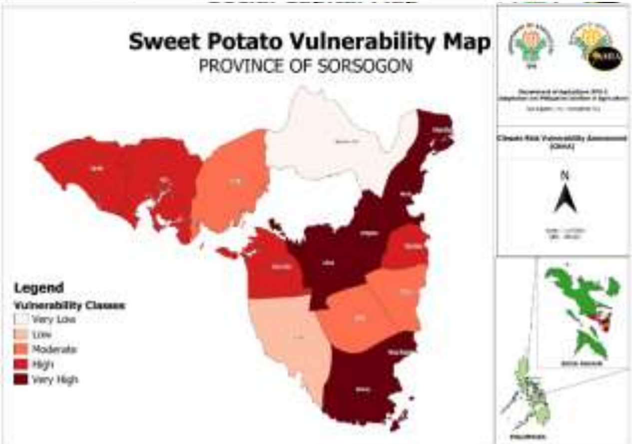
Appendix 29 Crop Vulnerability by 2050 in Sorsogon Province

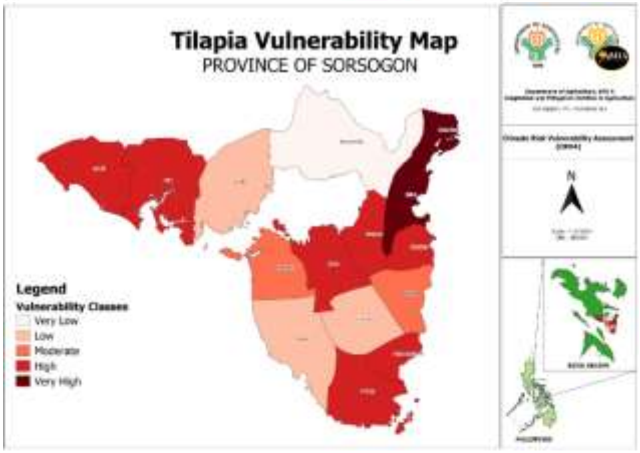



Rice Vulnerability Map
PROVINCE OF SORSOGON
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High

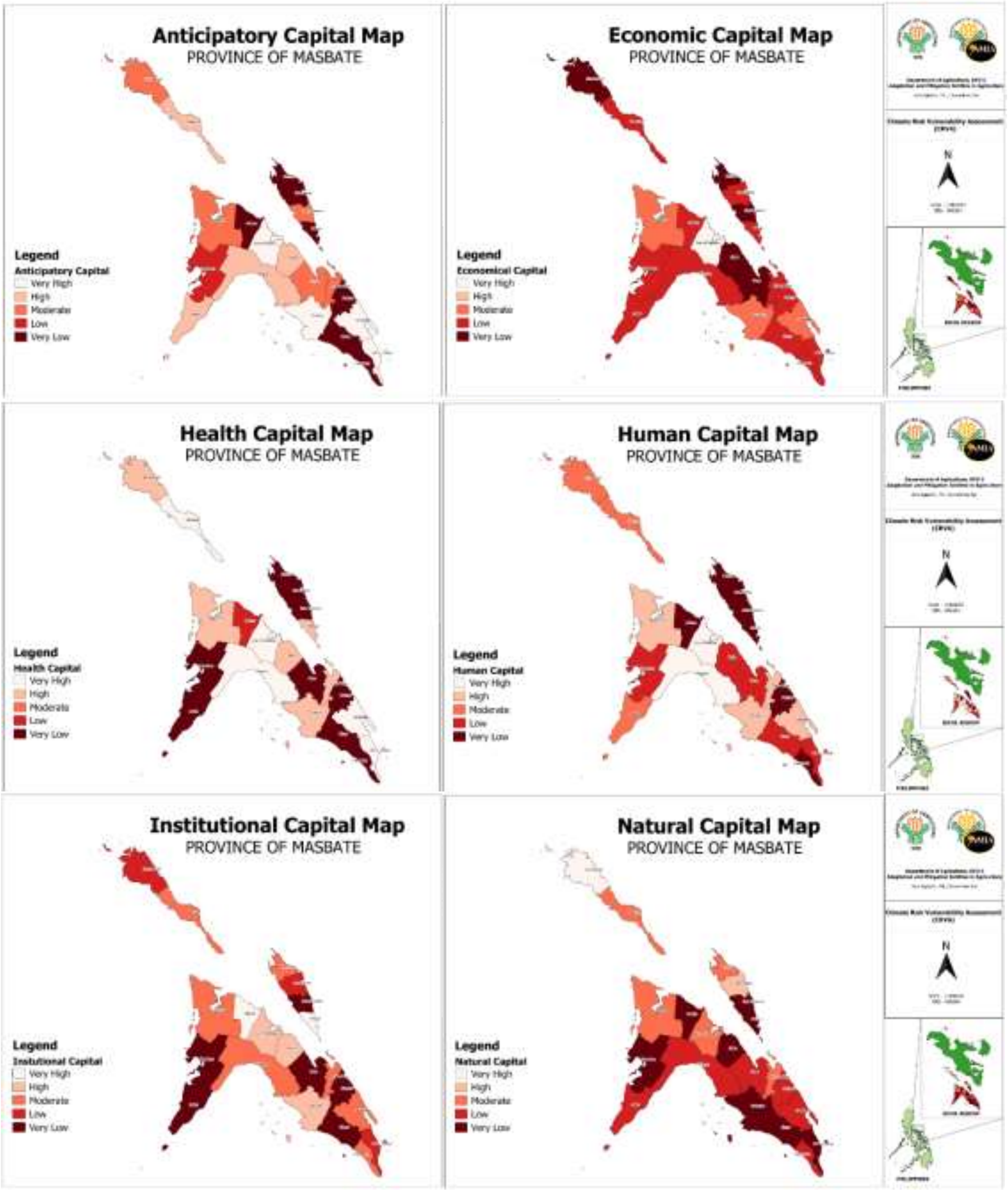

Stringbeans Vulnerability Map
PROVINCE OF SORSOGON
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N


Squash Vulnerability Map
PROVINCE OF SORSOGON
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High

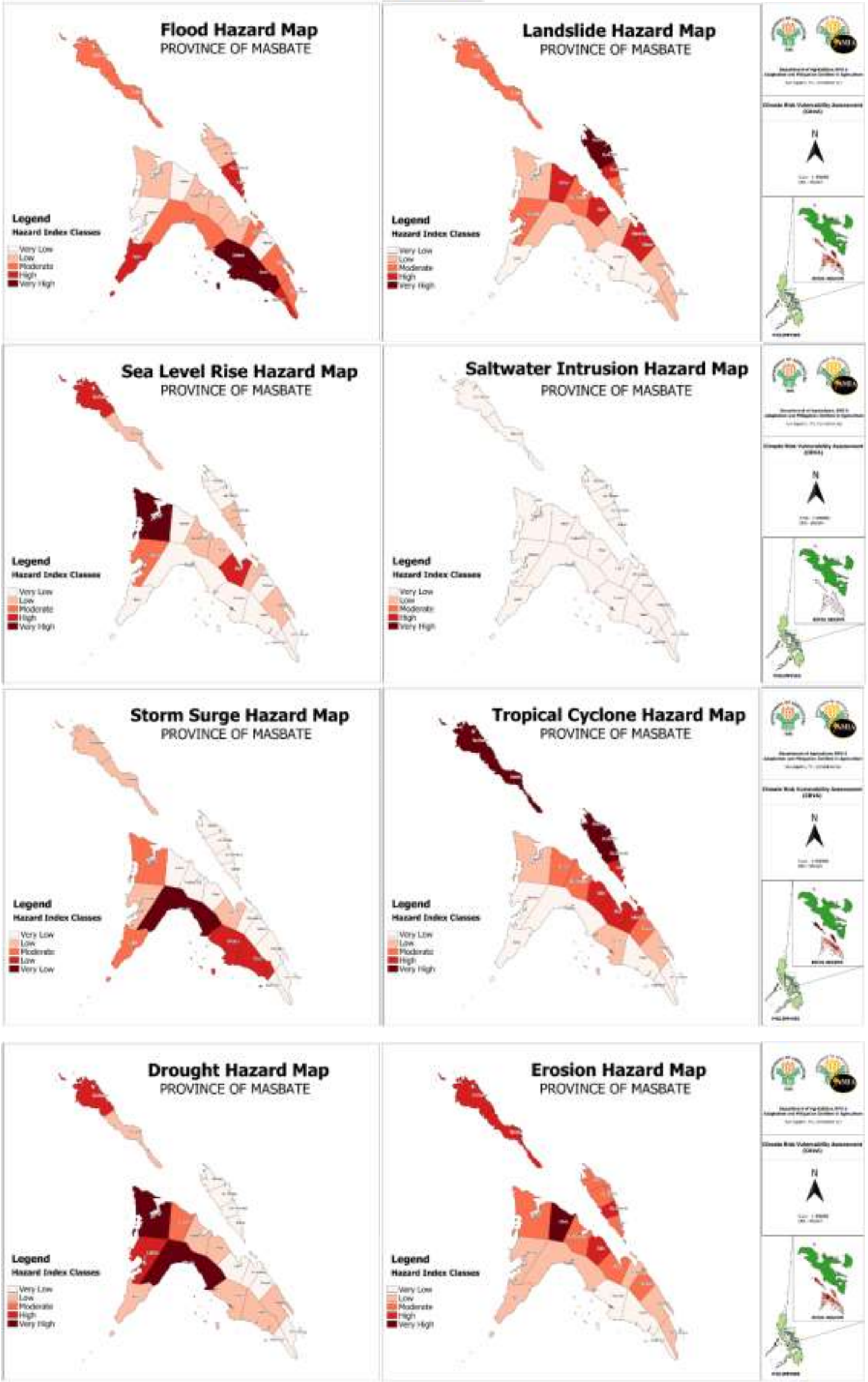

Sweet Potato Vulnerability Map
PROVINCE OF SORSOGON
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N


Tilapia Vulnerability Map
PROVINCE OF SORSOGON
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N

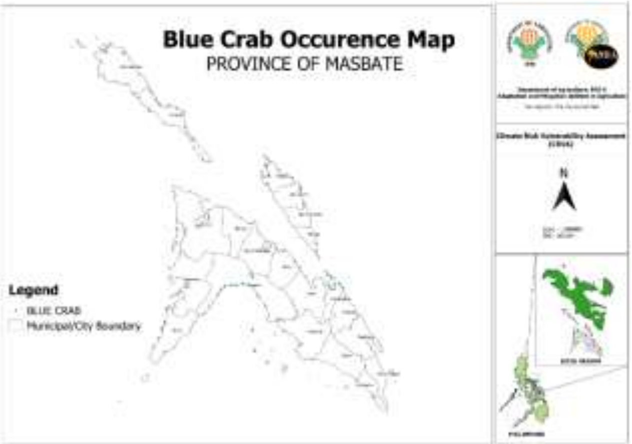
Appendix 30 Adaptive Capacity Maps of the Province of Masbate (Per Capital)

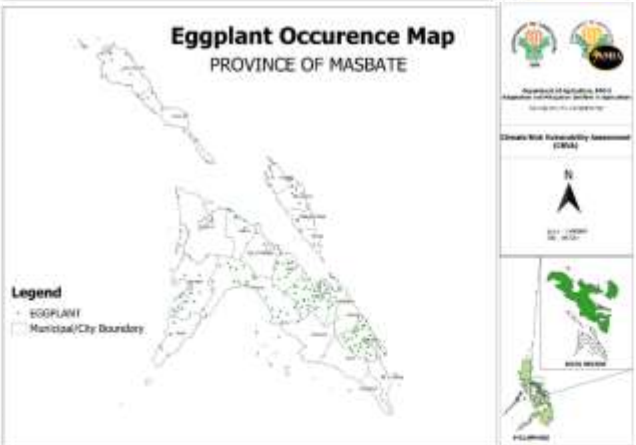


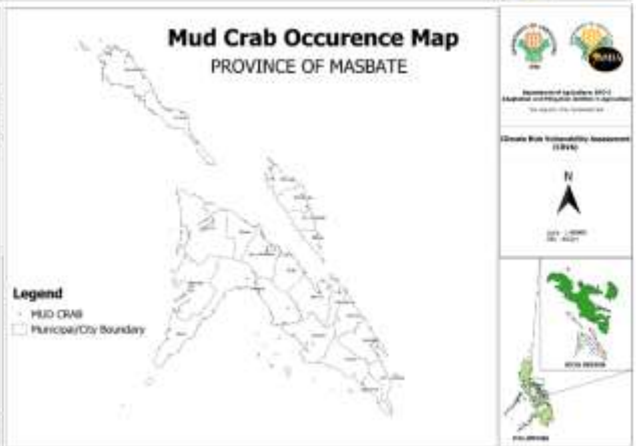
Appendix 31 Hazard Map of Masbate Province

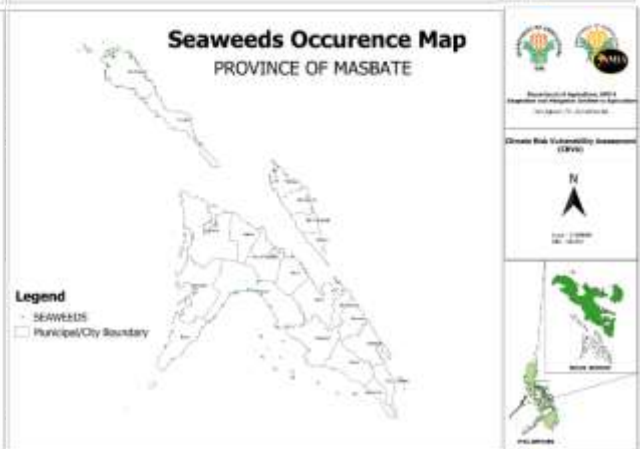


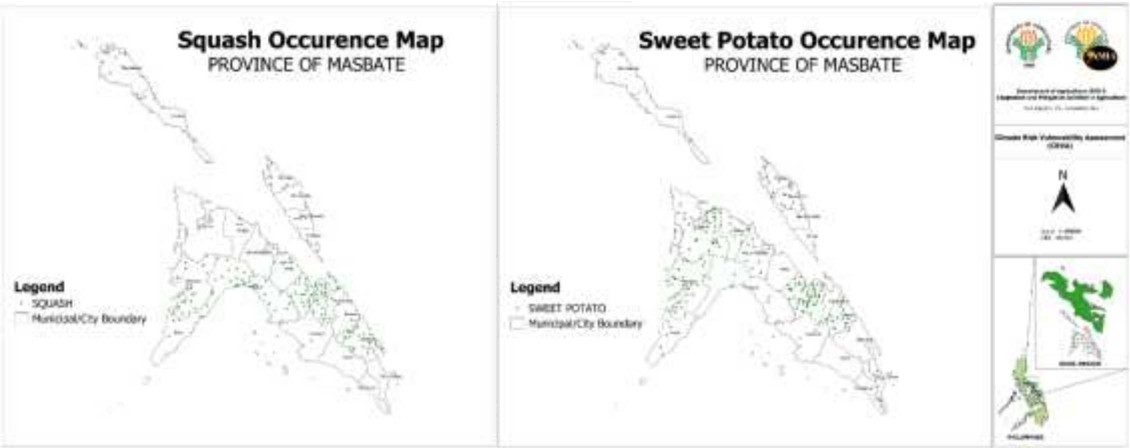
Appendix 32 Crop Occurrence of other crops in Masbate Province

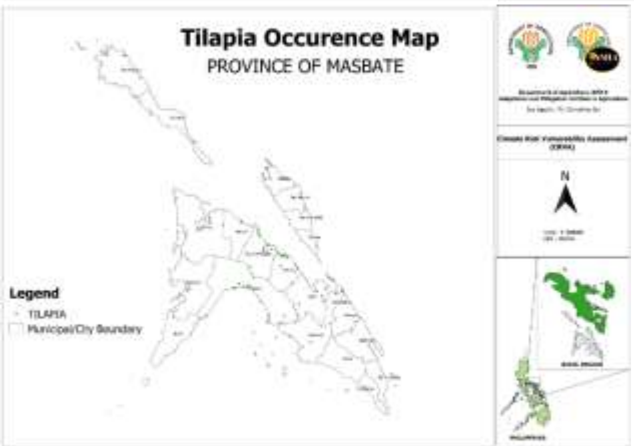




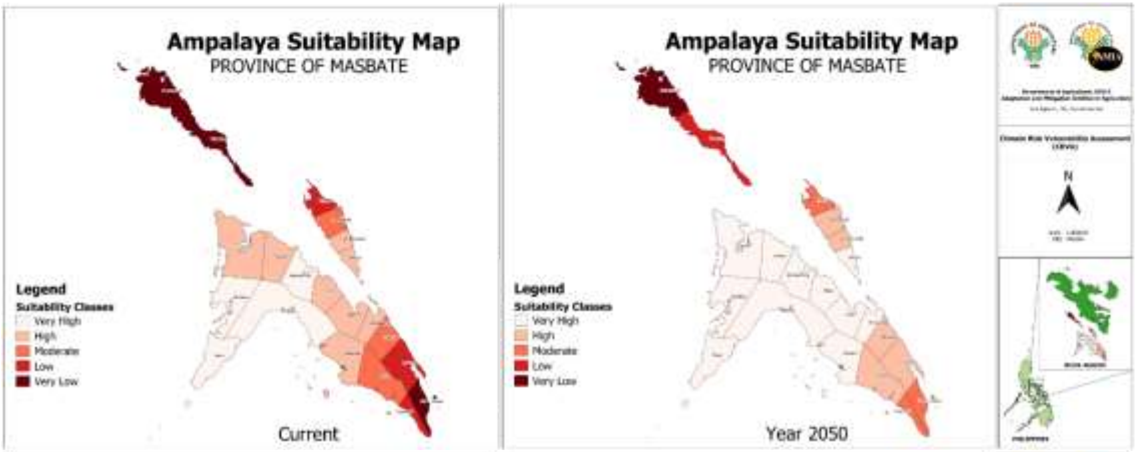


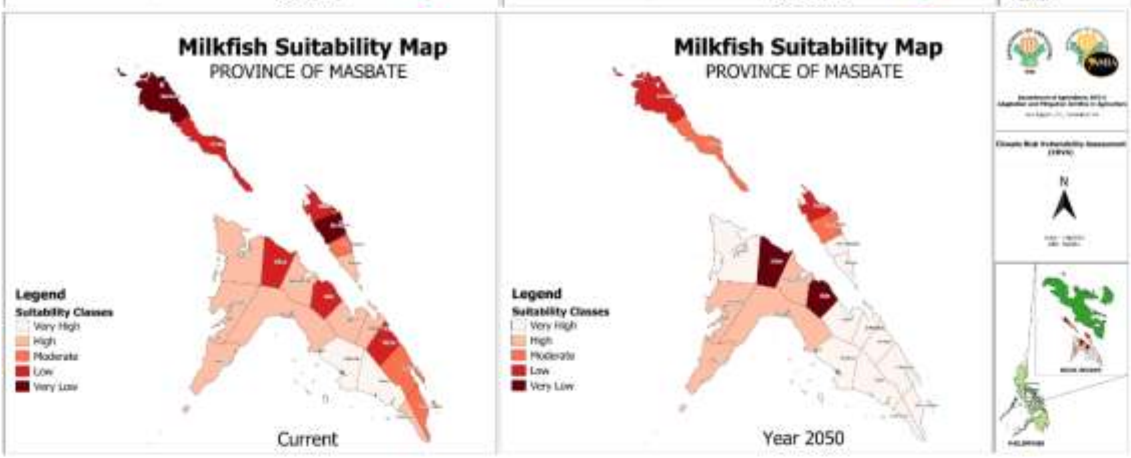


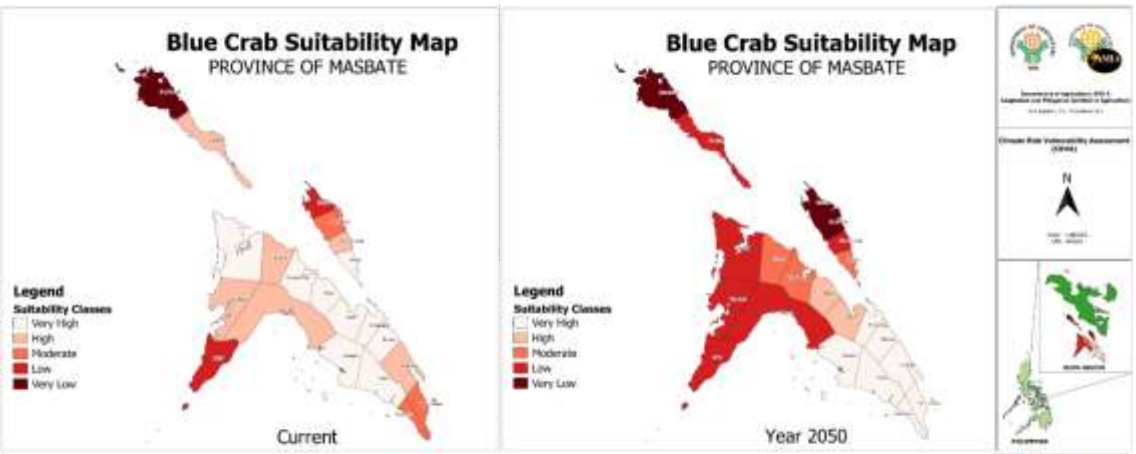


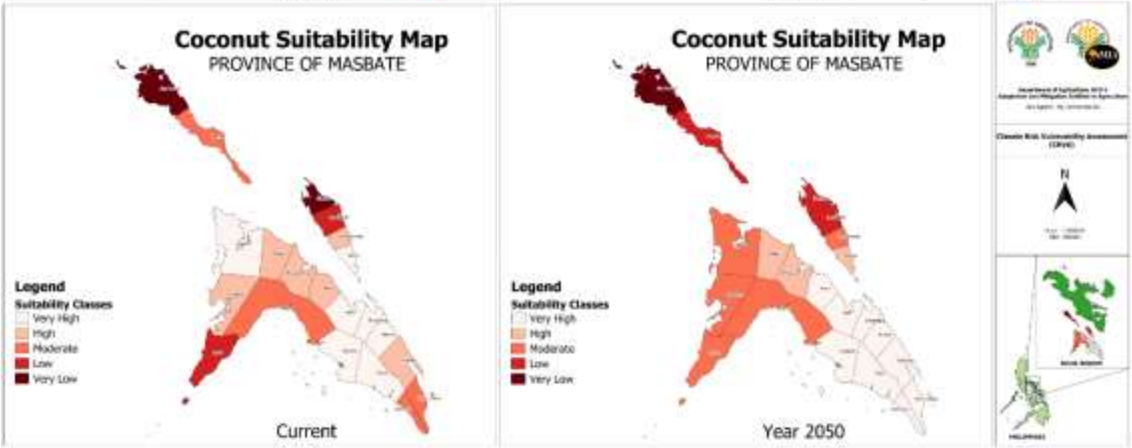


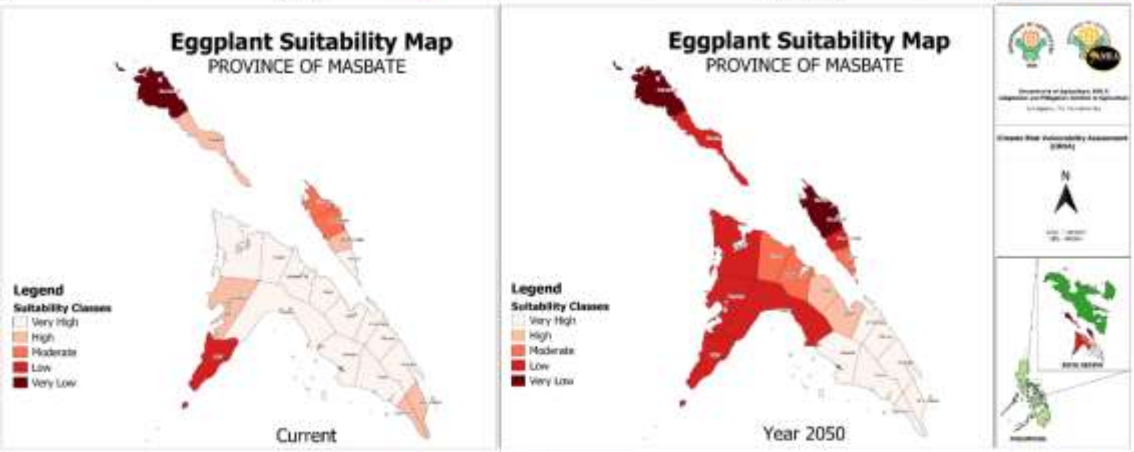
Appendix 33 Crop Climatic Sensitivity and Suitability of Other Crops in Masbate Province

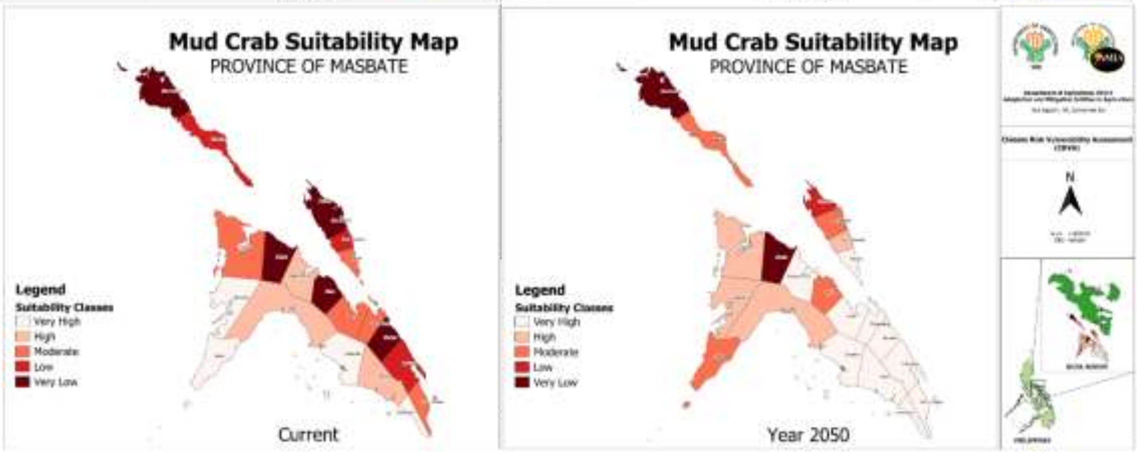




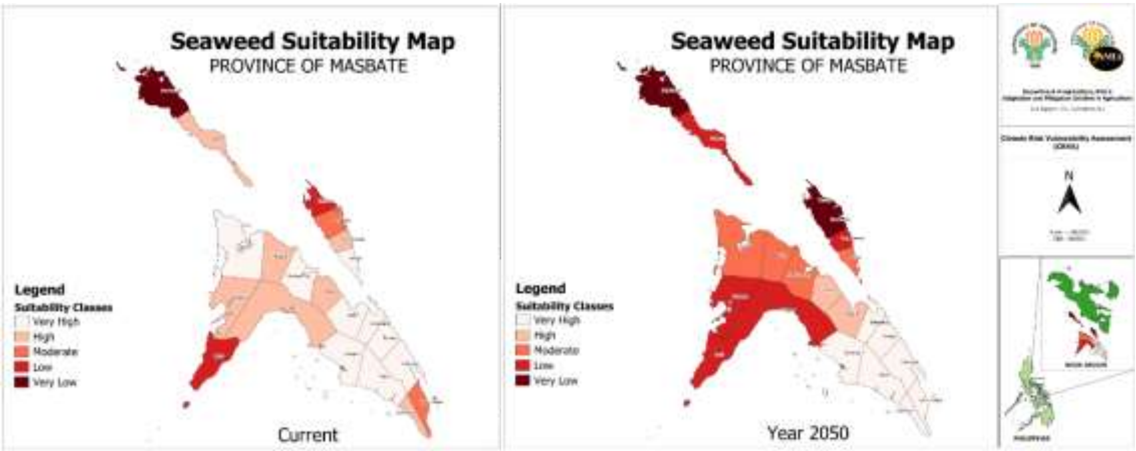

Blue Crab Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Blue Crab Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

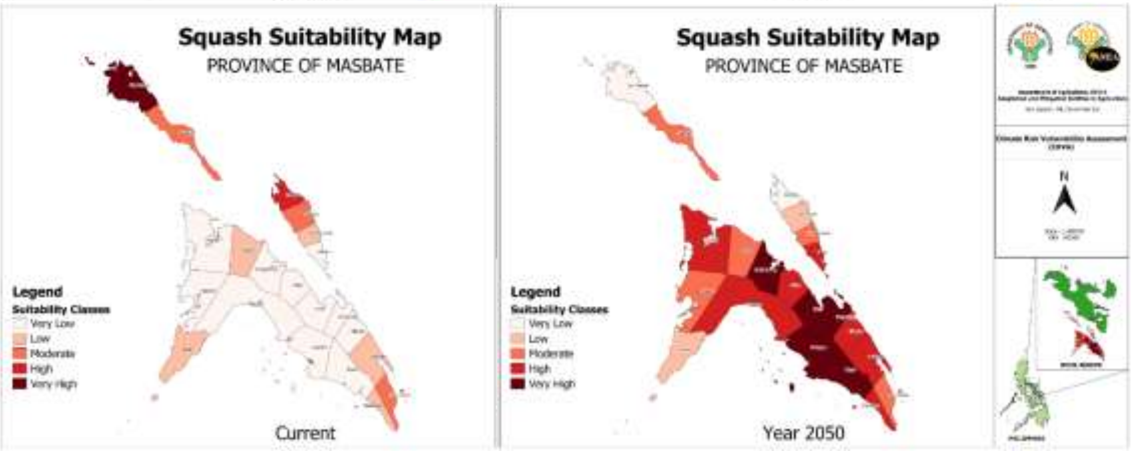

Coconut Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Coconut Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

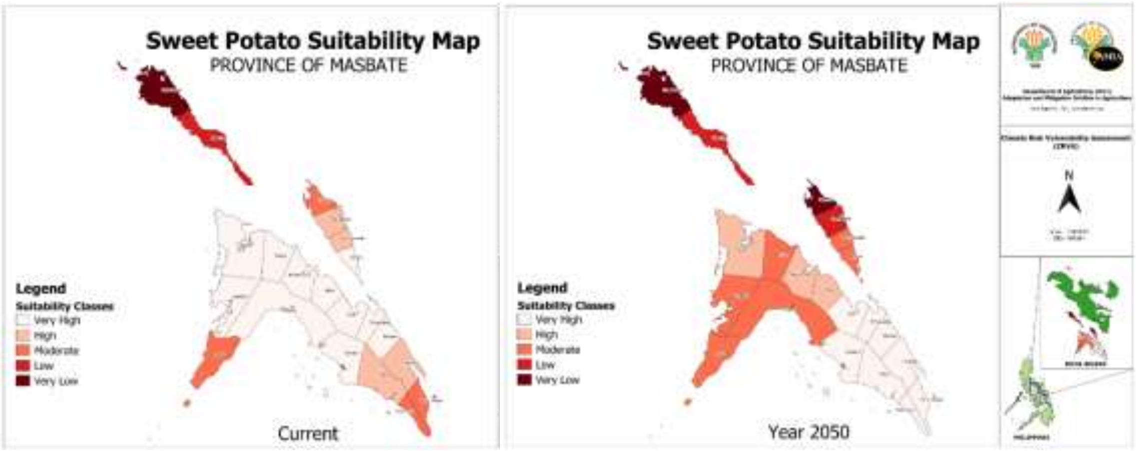

Eggplant Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Eggplant Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

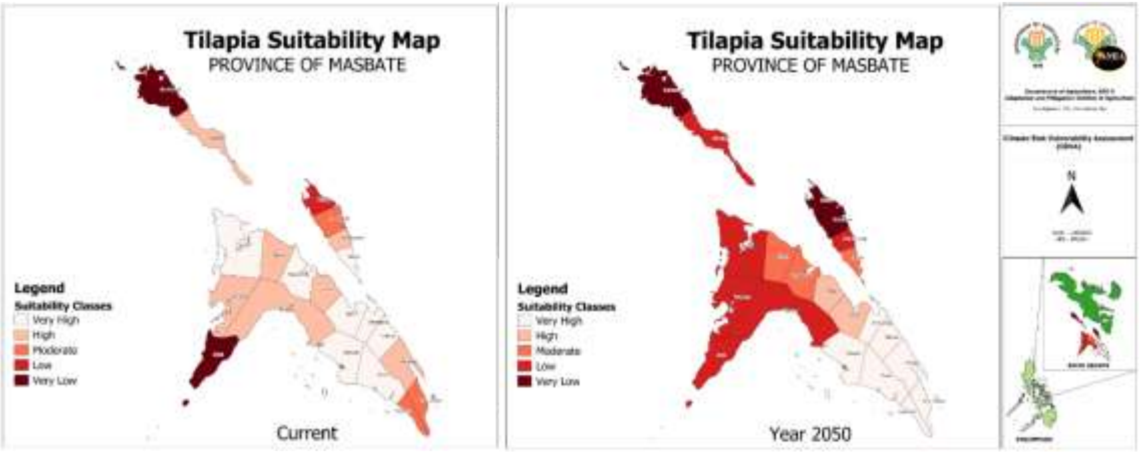

Mud Crab Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Mud Crab Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N


Peanut Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Peanut Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

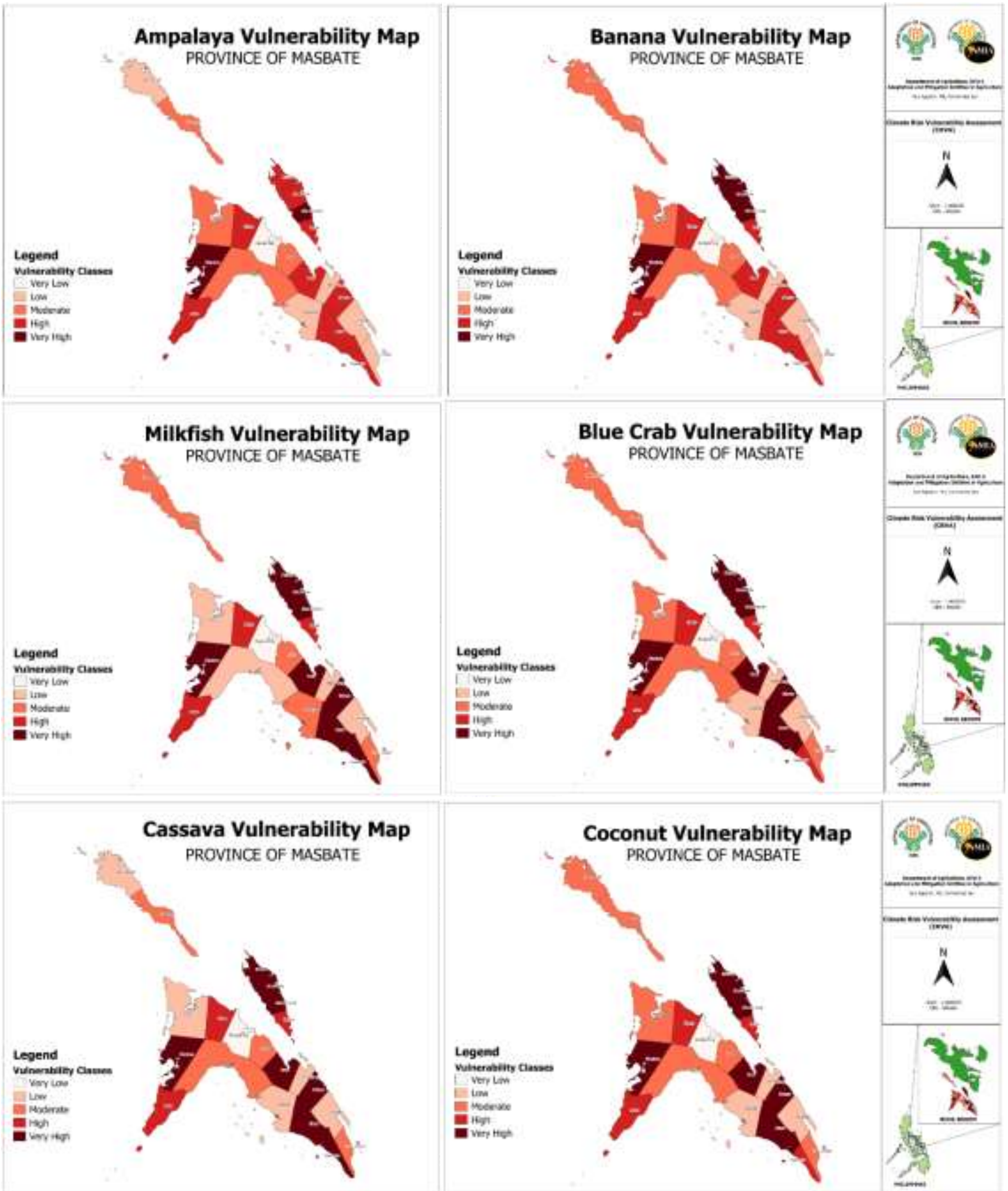

Seaweed Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Seaweed Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

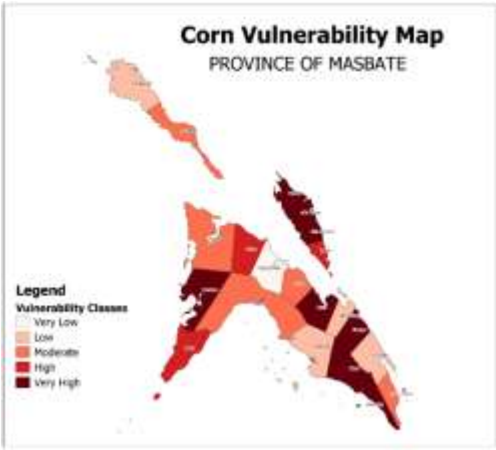

Squash Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very Low
Low
Moderate
High
Very High
Current
Squash Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very Low
Low
Moderate
High
Very High
Year 2050
N

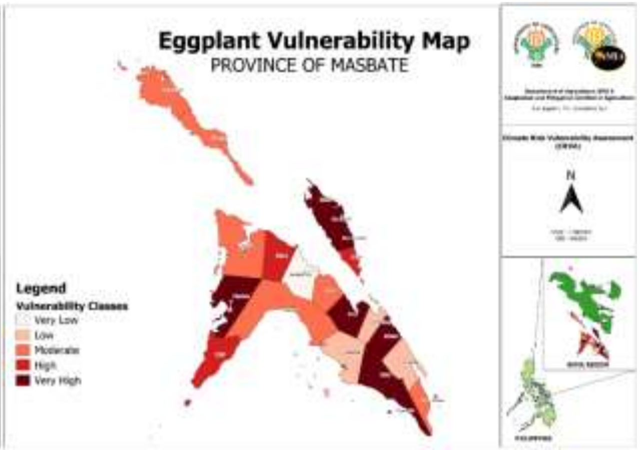

Sweet Potato Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Current
Sweet Potato Suitability Map
PROVINCE OF MASBATE
Legend
Suitability Classes
Very High
High
Moderate
Low
Very Low
Year 2050
N

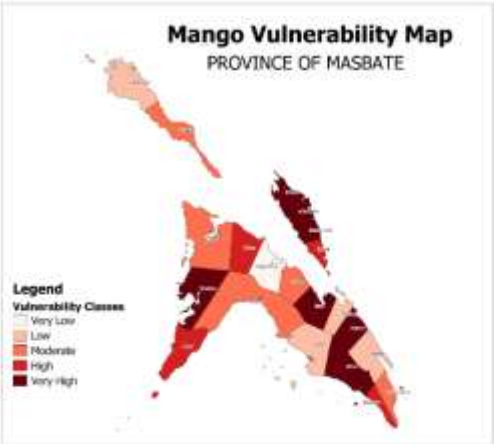


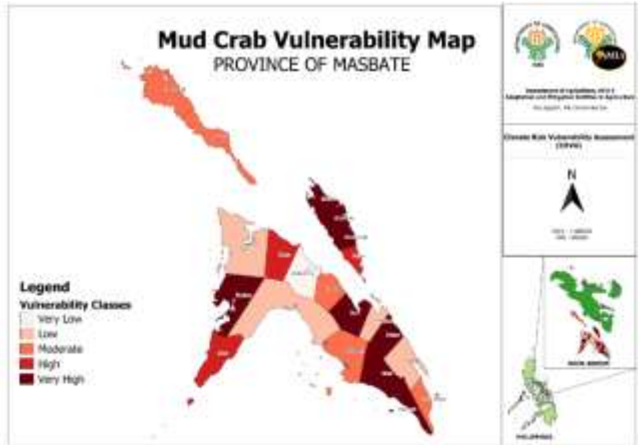
Appendix 34 Crop Vulnerability by 2050 in Masbate Province

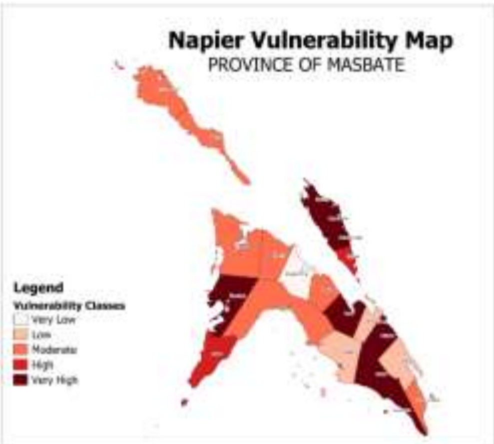


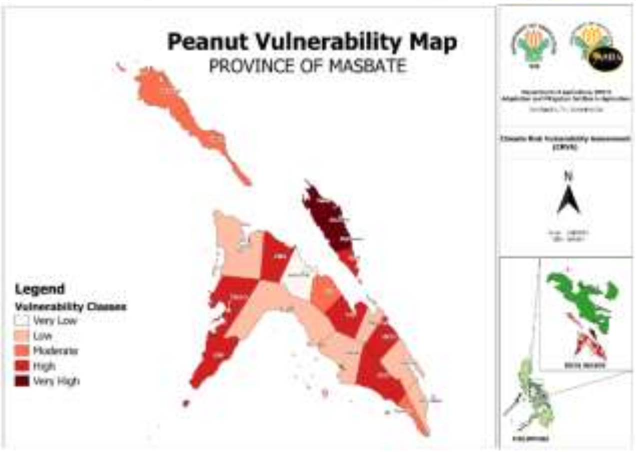

Corn Vulnerability Map
PROVINCE OF MASBATE
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High

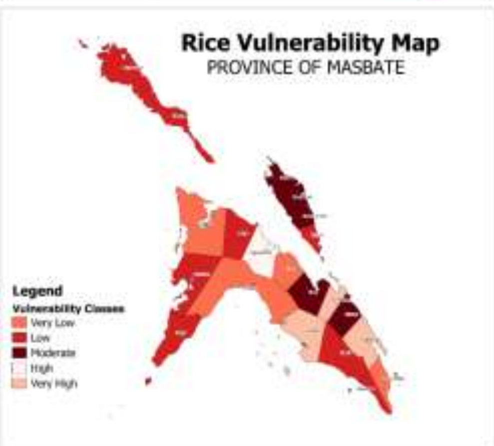

Eggplant Vulnerability Map
PROVINCE OF MASBATE
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N

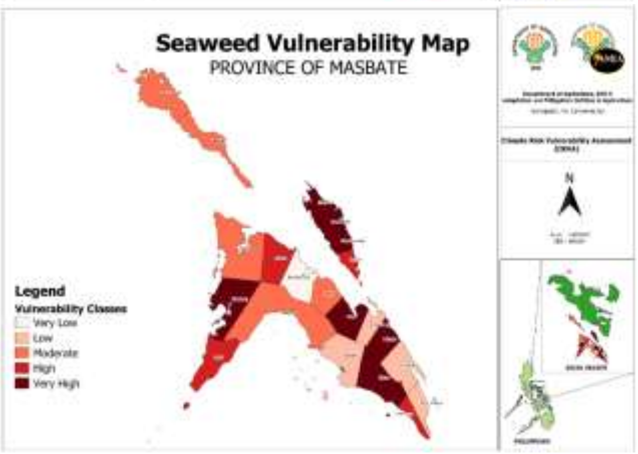

Mango Vulnerability Map
PROVINCE OF MASBATE
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High

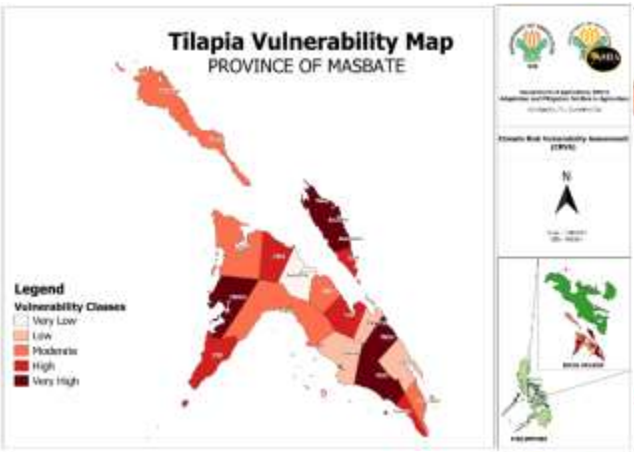

Mud Crab Vulnerability Map
PROVINCE OF MASBATE
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N

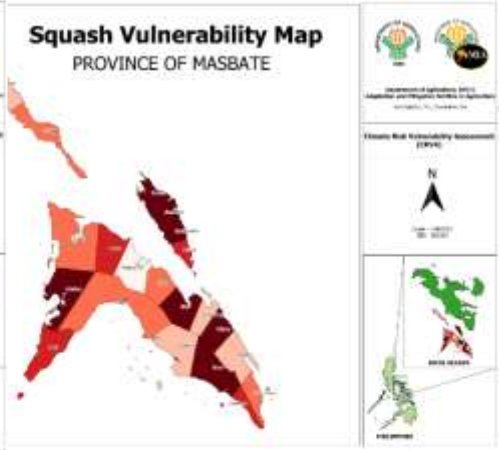

Napier Vulnerability Map
PROVINCE OF MASBATE
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High

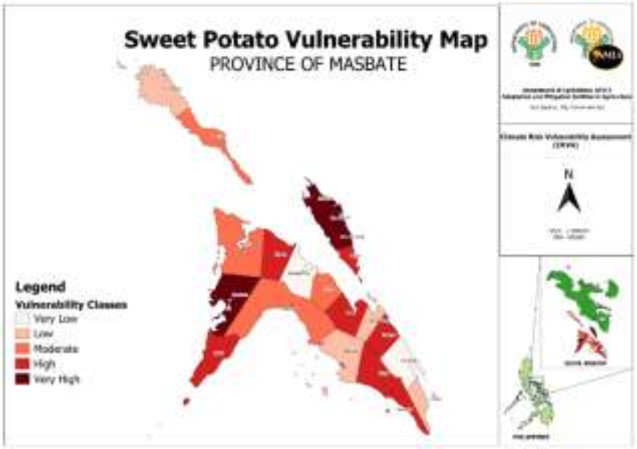

Peanut Vulnerability Map
PROVINCE OF MASBATE
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N


Rice Vulnerability Map
PROVINCE OF MASBATE
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High

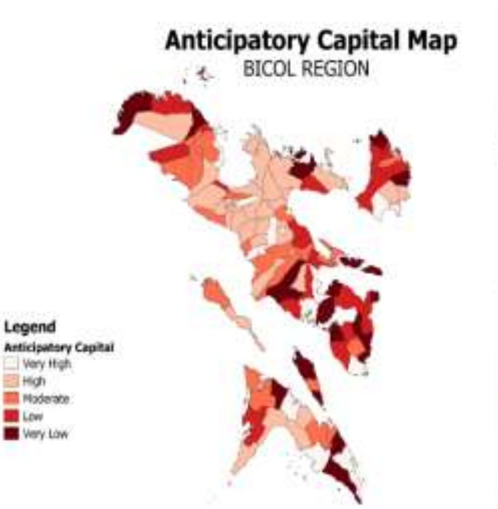

Seaweed Vulnerability Map
PROVINCE OF MASBATE
Legend
Vulnerability Classes
Very Low
Low
Moderate
High
Very High
N

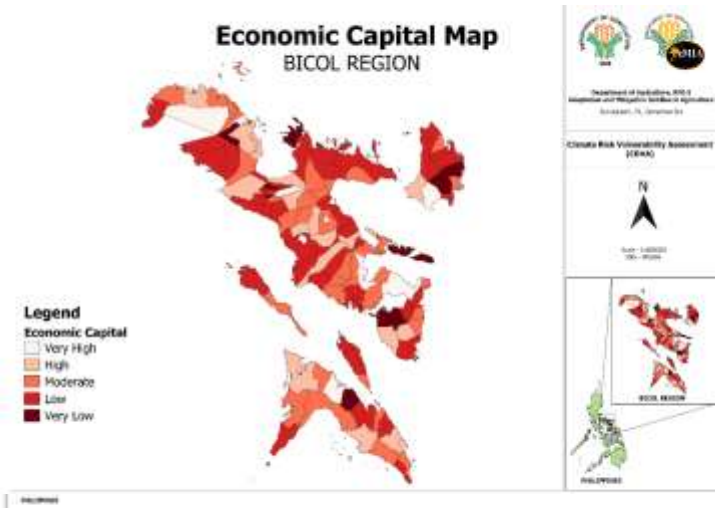


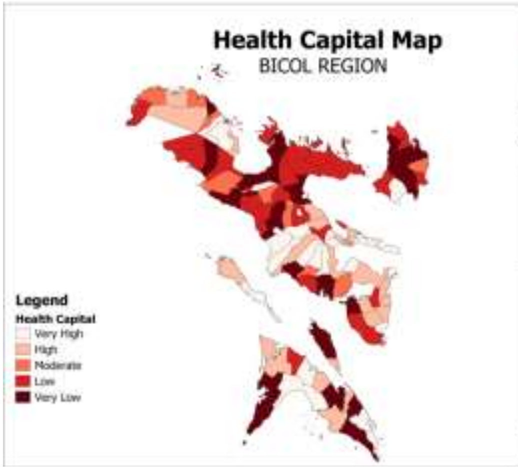


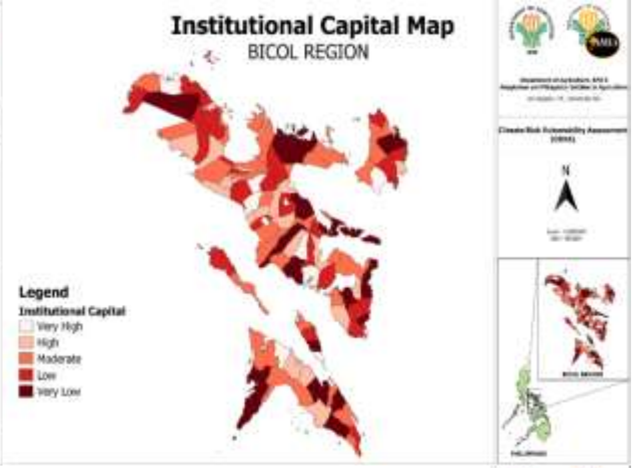


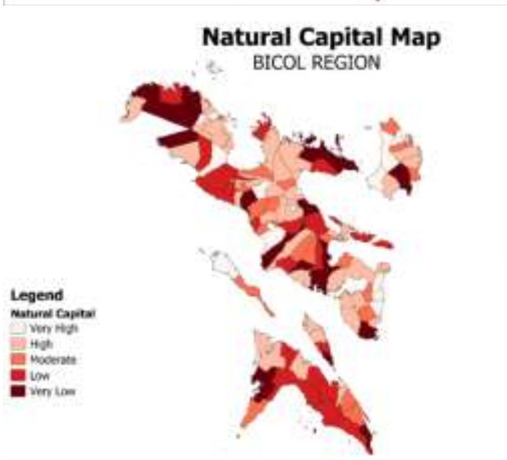
Appendix35 Adaptive Capacity Map Regional

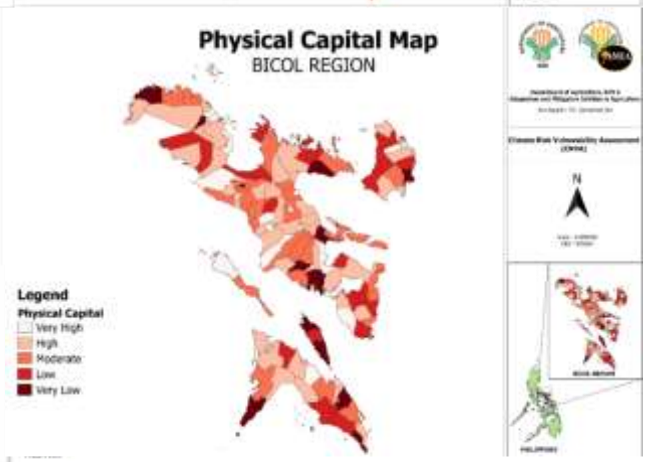





Health Capital Map
BICOL REGION
Legend
Health Capital
Very High
High
Moderate
Low
Very Low


Institutional Capital Map
BICOL REGION
Legend
Institutional Capital
Very High
High
Moderate
Low
Very Low
N


Natural Capital Map
BICOL REGION
Legend
Natural Capital
Very High
High
Moderate
Low
Very Low


Physical Capital Map
BICOL REGION
Legend
Physical Capital
Very High
High
Moderate
Low
Very Low
N


Social Capital Map
BICOL REGION
Legend
Social Capital
Very High
High
Moderate
Low
Very Low
N

Appendix36 Regional Hazard Map