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TERMINAL REPORT

A. BASIC INFORMATION

1. Project Title:
Regional Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting & Prioritization in Negros Island Region for the Adaptation and Mitigation Initiative (AMIA) Phase 2

2. Proponent: **Visayas State University** (VSU)
Name of Proponents:

Team Position	**Name/Institution**
Project leader	Alan B. Loreto (VSU)
GIS specialists	Pastor P. Garcia (VSU) and Alan B. Loreto
Socio-economist	Fe M. Gabunada (VSU)
Agriculture/fisheries specialist	Ervin F. Ferraris (CPSU) – on call
DA-RFO collaborating staff	Joyce S. Wendam (DA-RFO XVIII)

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3. Implementing Agency
3.1. Lead Agency: Visayas State University (VSU)
Head of Agency: Dr. Edgardo E. Tulin, University President

3.2. Collaborating Agencies: **DA-RFO XVIII and Central Philippine State University**

4. Project Duration: **12 months (1 Aug 2016 – 31 July 2017)**

5. Project Location: **Negros Occidental** (All cities and municipalities in the province)

6. Project Funding
6.1. Total Approved Budget: **Php 1,000,000.00**
6.2. Total Amount Released: **Php 1,000,000.00**
6.3. Actual Expenses:

DEPARTMENT OF AGRICULTURE
BUREAU OF AGRICULTURAL RESEARCH

CIAT
International Center for Tropical Agriculture
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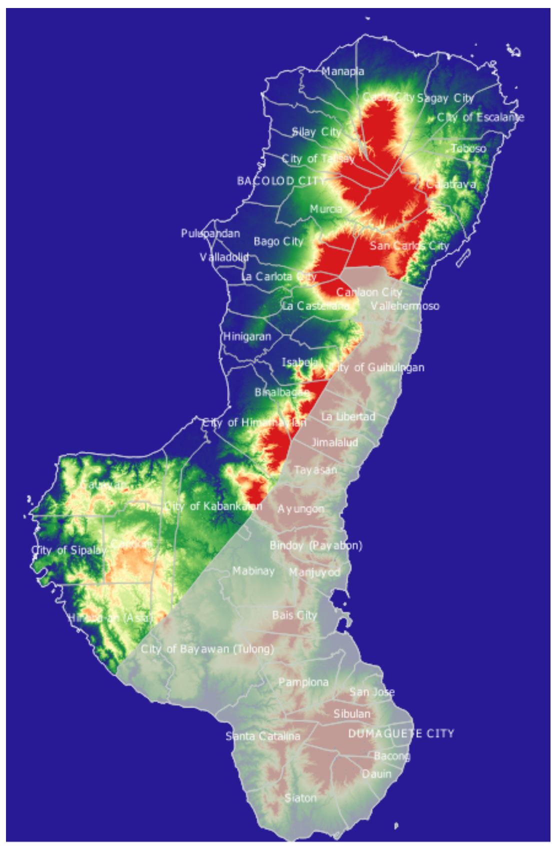
Regional Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting & Prioritization in Negros Island Region for the Adaptation and Mitigation Initiative (AMIA) Phase 2



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DOCUMENT NO.: **BAR/QSF-B.01.05**
REVISION NO.: **01**
REVISION DATE: **24 May 2016**
EFFECTIVITY DATE: **13 September 2005**

ACKNOWLEDGEMENT

The authors are grateful to the different agencies and institutions who in one way or the other contributed to the success of this research as follows;

- Department of Agriculture-Systems Wide Climate Change Office (DA SWCCO) for providing the funds for this research which was managed by the Department of Agriculture Bureau of Agricultural Research (DA BAR).
- The efforts and facilitative works of the Department of Agriculture Regional Field Office XVIII under the leadership of Dr. Joyce S. Wendam – Regional Executive Director.
- Centro Internacional de Agricultura Tropical (CIAT) for providing the trainings and the CRVA methodologies and the CBA tools
- Visayas State University (VSU) – Philippine Root Crop Research and Training Center (PhilRootcrops) for the use of its facilities and the administrative support during the research

Likewise, we acknowledge the great contribution of Mr. Dale P. Loreto for the technical support in the processing of vulnerability maps using GIS.

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ABSTRACT

The primary objectives of the project were a) to assess climate risks of Negros Occidental agriculture sector through geospatial and climate modelling tools, and b) to document and analyze local Climate-Resilient Agriculture (CRA) practices to support AMIA2 knowledge-sharing and investment-planning.

The changes in the climatic suitability to grow rice, corn, coffee, cacao, squash, and napier were modelled using MaxEnt software, while QGIS was used for mapping and analysis.

In general, for the projected year 2050 (using the RCP 8.5 scenario), there is an increase in the low and moderate suitability areas to grow crops and a decrease in the high and very high suitability. The reduction of highly suitable areas implies that cultivating the same crops using the same agri-management practices results in a decrease in yield compared to the current conditions.

The multi-hazard index showed that there are 4 municipalities/cities with very high hazard index while 5 with high index. Five (5) municipalities have very low adaptive capacity.

The vulnerability map of each crop was modelled using different weights assigned to sensitivity:exposure:adaptive capacity as follows; 1) 15:15:70, 2) 33:33:33, 3) 25:25:50, 4) 20:20:60, and 5) 30:30:40. Despite the differences in weight assignments, there are municipalities/cities, namely, Hinobaan, Sipalay City, Candoni and Cauayan, that are consistently vulnerable to climate change. These areas are not suitable to both coffee and cacao production.

A cost-benefit analysis (CBA) was computed using the tool developed by CIAT for each climate-resilient agriculture (CRA) practice. The CRA practices subjected to CBA were Organic Red Rice Production and the Use of Submergence-Tolerant Rice Varieties. Results showed that Organic Red Rice Production with a current adoption rate of 15% has an IRR of 31%, while the Submergence-Tolerant Rice Varieties with a current adoption rate of 10% has an IRR of 102%.

TECHNICAL DESCRIPTION

1. Rationale

The Adaptation and Mitigation Initiative in Agriculture (AMIA) seeks to enable the Department of Agriculture (DA) to plan and implement strategies to support local communities in managing climate risks – from extreme weather events to long-term climatic shifts. Spearheaded by the DA System-wide Climate Change Office (DA SCCO), AMIA Phase 1 in 2015-16 to implemented activities to strengthen DA's capacity to mainstream climate change adaptation and mitigation strategies in its core functions of R&D, extension, and regulation. It is also designing complementary activities for building appropriate climate responsive DA support services.

With AMIA Phase 2 in 2015-16, the next big challenge is making climate-resilient agri-fisheries (CRA) an operational strategy through field-level action that directly involves, and impacts on the livelihoods of, farming communities. AMIA2 aims to invest in the launching of CRA communities -- as the initial target sites for action learning, supported by an integrated package of climate services and institutions, within a broader food system/value chain setting. The program is launching an integrated and multi-stakeholder effort to operationalize CRA at the community level in 9 target regions.

The AMIA2 program framework consists of 9 key clusters of inter-related activities, whose cumulative and combined results are envisioned to help AMIA achieve its goal for 2016 and beyond. For each cluster, a set of projects and activities would be designed towards operationalizing the AMIA framework.

Cluster 1: Enabling environment
Cluster 2: Vulnerability assessment and risk targeting
Cluster 3: Developing knowledge pool of CRA options
Cluster 4: CRA community participatory action research initial phase
Cluster 5: Enhancing services and institutions
Cluster 6: Integrating CRA in food systems and value chains
Cluster 7: Implementing CRA on scale
Cluster 8: Knowledge Management for results

The AMIA2 framework provides overall guidance in the planning and design of research and development interventions in 10 target regions.

1. Region I-Ilocos,
2. Region II-Cagayan Valley,
3. Region III-Central Luzon,
4. Region IVA-CALABARZON,

5. Region V-Bicol,
6. Region VI-Western Visayas,
7. Region X-Northern Mindanao,
8. Region XI-Davao,
9. Region XII-SOCSKSARGEN, and
10. Region XVIII-Negros Island Region.

Successful implementation of AMIA2 at the regional level requires the strong collaboration and support of key research and development institutions within the region. This proposed project enables AMIA2 to establish and mobilize regional teams, each led by a local State University/College (SUC), and in partnership with the corresponding Department of Agriculture - Regional Field Office (DA-RFOs).

State of the Art

Several vulnerability assessment studies (Mallari, 2016, Mias-Mamomong and Flores, 2016, Briones NA, 2016, ADB, 2015, and Licuanan, 2015) have already been conducted in the Philippine agricultural sector. However, many of these studies vary greatly in terms of the following: 1) assessment of each components were highly variable, and impact of climate change were not explicitly analysed, 2) coverage is sparse, 3) coverage was broad but resolution was coarse, 4) climate change was assessed using a single weather event (typhoon), and 5) some are content specific (agriculture) while others are general. These studies can be useful for different objectives and institutions, but the context and component indicators are of limited use if impacts of climate change will be assessed for the agricultural sector (Palao, et.al., 2016).

Hence, this project considered the three key dimensions of vulnerability for the agriculture sector.

2. Objectives of the Project

The overall objective is to assess, target and prioritize climate-resilient agriculture (CRA) research and development in Region XVIII in support of AMIA2.

1. To strengthen capacities for CRA methodologies of key research and development organizations in the region.
2. To assess climate risks in the region's agri-fisheries sector through geospatial & climate modelling tools.
3. To determine local stakeholders' perceptions, knowledge & strategies for adapting to climate risks

4. To document and analyze local CRA practices to support AMIA2 knowledge-sharing and investment planning.
5. To establish AMIA baseline for outcome monitoring and evaluation (M&E) of CRA communities and livelihoods.

The main limitation or constraint in the project is availability and access of data sources for adaptive capacity.

3. Review of Related Literature

Negros Island Region is a newly created region through Executive Order 183 signed by President Aquino on May 29, 2015. It separated Negros Occidental from Region VI and Negros Oriental from Region VII, making the total number of regions of the Philippines to 18. Negros Island Region comprises 1 *highly urbanized* city, 18 *component* cities, 38 municipalities and 1,219 barangays with a total population of 4,414,131 as of 2015 and population growth rate of 5.2% from 2010 (PSA 2016 and https://en.wikipedia.org/wiki/Negros_Oriental).

In terms of agriculture, the Office of the Provincial Agriculturist (OPA) of Negros Occidental reported that it is the second highest producer of rice in Western Visayas, and ninth in the country. While the Philippine Statistics Authority reported that in 2014, the Negros Island region had a combined production of 14.6 million tons of sugar, 271,000 MT coconut, 161,000 MT banana, 92,000 MT saba banana, 30,000 MT sweet potato and 54,000 MT cassava. The new region also has a sizeable combined production of hogs at 86,743 MT in 2015 (Sarian, 2016). It is also in the forefront of organic agriculture with 16,000 ha. of land are already being utilized to produce organic produce, from the famous Mt. Kanlaon coffee to gourmet rice, muscovado sugar, mango, papaya, squash, lettuce, pork cuts and various herbs.

In its aquaculture industry, notable gains were seen in the value of their production of milkfish, tilapia, prawns, white shrimp, catfish, grouper, oyster, mussel and seaweeds. Its inland municipal fisheries have seen stable value and production of eel, mullet and spade fish as well as blue and mangrove crabs. Its commercial fisheries have also seen steady production, particularly the big-eyed scad, frigate and yellow fin tuna, Indian mackerel and sardines, threadfin bream, roundscad and squid (Sarian, 2016).

It was said that "agriculture employs around 30% of the whole workforce for each province, so a robust agricultural industry is essential. It is a means of enhancing competitiveness and innovations in research and development, and generating employment and income that underpin sustainable livelihood for the farmers and fisherfolks.

Despite all these data that show the agri-fisheries potential of Negros Island Region still its vulnerability against climate change needs to be addressed and incorporated in their agri-fisheries development agenda in order to minimize its impact. Being a newly created region several meetings were done to formulate initiatives related to the impact of climate change in the region. One of the initiatives in the region, is to improve their water reservoirs mainly the Bago River Watershed in Bago City and Ilog-Hilabangan Watershed and to lobby for the creation of more dams in the region. This was brought about by the report of the state weather bureau, which identified Negros Island Region as the most high-risk area, along with Central Visayas, as El Niño is projected to continue affecting the country until 2018.

On the other hand, the Bureau of Fisheries and Aquatic Resources (BFAR) included South Negros Island in the Ecofish project which seeks to help raise Philippine fisheries production by promoting sustainable management of coastal and marine resources and related ecosystems (http://www.edgedavao.net).

Aside, the Department of Agriculture-Negros Island Region in collaboration with the Office of the Provincial Agriculture (OPA) is developing the 2016-2022 Roadmap (Nicavera, 2016). However, a good risk and vulnerability assessment is necessary to incorporate Climate Change Adaptation and Disaster Risk Reduction (CCA-DRR) in their plans in order to provide a climate resilient agriculture system.

4. Methodology and Results per Objective

Objectives	Methodology/ Activities	Outputs	Target Date of Accomplishment	Results
1. To strengthen capacities for CRA methodologies of key research and development organizations in the region.	Trainings	Project Team members are more knowledgeable about CRVA, CRA prioritization, knowledge-hub and M&E	Jun, Aug, Sep and Nov. 2016	CIAT conducted the following: • Training on CRVA (Jun 6-8) • Training on CBA of Climate Resilient Agriculture Technologies and Practices (Aug 4-6)

2. To assess climate risks in the region's agri-fisheries sector through geospatial & climate modeling tools.	Primary and secondary data collection Data analysis Workshop	Data for exposure sensitivity Data for adaptive capacity GIS-climate data model	Jun 2016 – Jan 2017	Primary & secondary data collection was made per municipality of the region Summary data was collated GIS Workshop for CRVA Analysis (Sep 22-23) Preliminary results of the Crop Suitability Modelling was made using MaxEnt with WorldClim data as Environmental layers
3. To determine local stakeholders' perceptions, knowledge & strategies for adapting to climate risks	Stakeholders validation Workshops	FGD/Meeting data	Sep 2016 – Feb 2017	FGD of the MA/CA was conducted last Aug 23 at Bacolod Meeting with the MA/CA and
4. To document and analyze local CRA practices to support AMIA2 knowledge-sharing and investment planning.	Key informant survey Data analysis Workshop	Survey data Cost-benefit and trade-off analysis	Aug-Nov 2016	Farm visit and discussion with Pastor Jerry Dionson, Mr. Ramon Uy, Jr., President of ONOPRA and Mr. Edgar Libetario, Director, PhilRice-Negros
5. To establish AMIA baseline for outcome monitoring and evaluation (M&E) of CRA	Survey Workshop	Survey data	Dec 2016 - Feb 2017	Preliminary survey data was collected and collated for analysis

communities and livelihoods.				

5. Results and Discussion per Objective

Overview of Agricultural Production System

Negros Island Region is the first island to adopt organic farming practices. The agricultural production systems in the area is quite diverse such as monocropping, intercropping, multi-storey cropping, relay cropping and also crop-livestock integration. In terms of land area, Negros Occidental has 796,521 ha with a crop production area of 445, 234 ha or 56 % of the total (PSA 2015). The top crop planted in the Negros Island Region (Table 1) is sugarcane followed by rice and corn. Compared to Negros Oriental, the volume of production of rice and corn in Negros Occidental is relatively high at 491,239 and 137,029 metric tons, respectively (Table 2).

Table 1. Top 5 crops and area harvested in Negros Island Region.

Crops Planted	Area Harvested (ha)	Percent (%)
Sugarcane	229,250	35
Rice	148,009	23
Corn	127,557	20
Coconut	80,103	12
Banana	27,348	4
Other crops	38,227	6

Table 2. Area (ha) and Volume Harvested by Province.

Crop	Negros Occidental		Negros Oriental	
	Area (ha)	Volume (MT)	Area (ha)	Volume (MT)
Sugarcane	190,213	11,737,577	39,037	1,702,682
Rice	126,057	**491,239**	21,952	**66,393**
Corn	63,100	**137,029**	64,457	**48,718**
Coconut	34,578	116,341	45,525	157,974
Banana	13,829	133,155	13,519	123,971

In terms of livestock, swine has the highest number of heads followed by goat, carabao and finally cattle (Table 3). This also explains why forage grasses such as napier, which was used as the proxy crop for livestock raising is not extensively grown in the area. The data in Table 4 shows the municipalities/cities where forage grasses are cultivated which also corresponds to the areas where livestock other than swine is also raised.

Table 3. Livestock Inventory as of January 1, 2016 (PVO, 2016)

Livestock species	Number of Heads
Swine	726,278
Goat	381,954
Carabao	165,937
Cattle	116,393

Table 4. Pasture and Forage/Grasses Areas

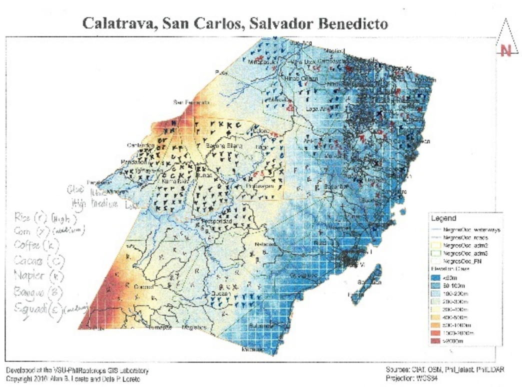
Municipality	Livestock	Total Area (ha)	Kind of Forage/Grasses
San Carlos City	Goat	4	Napier, Indigo fera, Tricantera
Sagay	Sheep/Cattle	65	Napier
Murcia	Sheep/Cattle	40	Napier
Pontevedra	Goat	1.2	Napier
La Carlota City	Goat/Cattle	13	Napier
Isabela	Goat	30	Citaria, Napier, Paragrass
Kabankalan	Dairy Cattle	7	Napier
Sipalay	Sheep	4	Napier, rensoni, etc.
Hinigaran	Sheep/Dairy cattle	32	Napier, rensoni, etc.
San Enrique	Beef cattle	10	Napier, rensoni, etc.

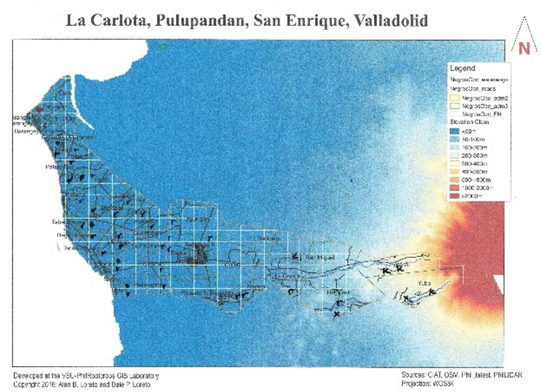
Source: Provincial Veterinary Office, 2016.

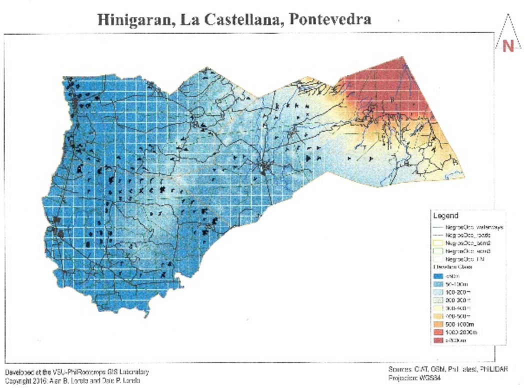
Crop Occurrence Data

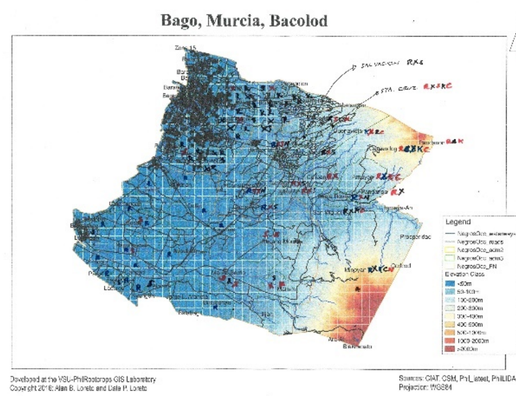
The crop occurrence was determined by the Municipal / City Agriculturists (MA/CA) through a Focus Group Discussion (FGD) that was conducted in August 2016. Maps were prepared with municipal/city boundaries, road network, rivers/streams and other water bodies, elevation and the 1 km x 1 km grid.

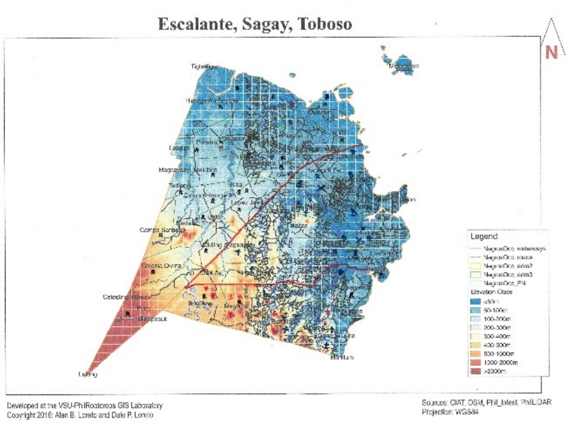
The crops that were considered for the crop occurrence markings were the choice of the DA-RFO and OPA in concurrence with the CIAT as program coordinator. Further, the entire province was divided into clusters with three to four municipalities per cluster. The clusters were adjacent municipalities/cities. This was so designed such that during the FGD at least three MA/CA can discuss and cross validate the crop occurrence in their respective municipalities. The clustered maps are shown in Figs. 1-9.

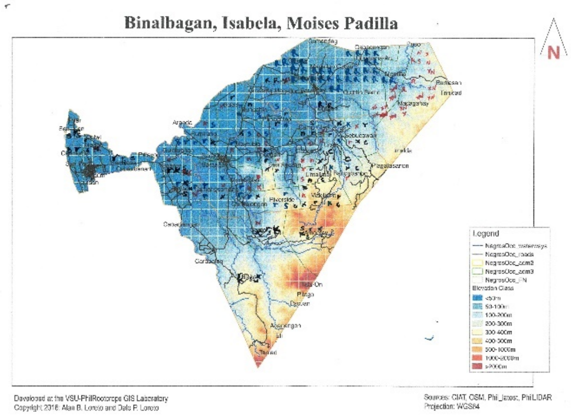












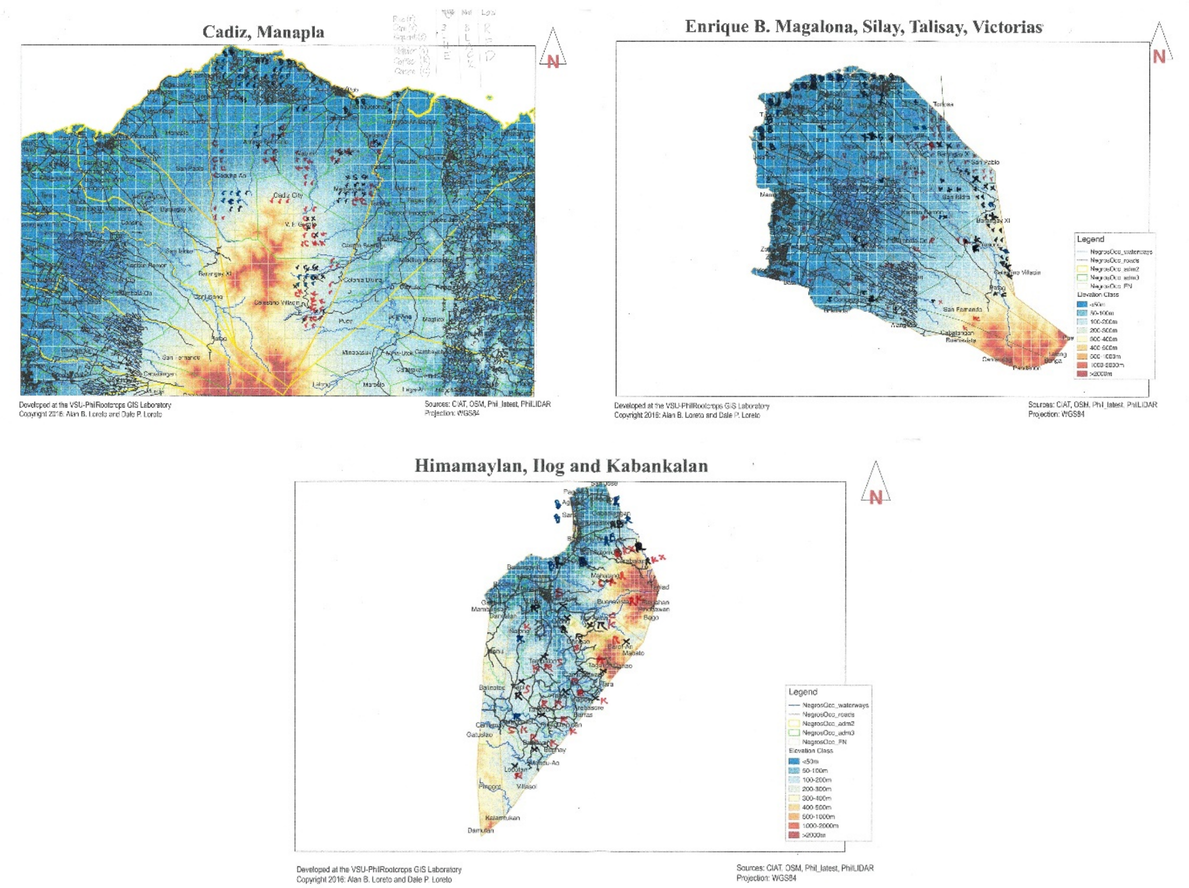


Fig. 1-9. Cluster of Municipalities in Negros Occidental used in the study.

Validation of Occurrence Points

It was observed during the FGD that some MA/CA though knowledgeable about agriculture in their respective municipalities and cities have a difficulty in specifically locating the production areas relative to the 1km x 1km grid. Hence, the points in the maps that were marked by the MA/CA were validated in the post processing of the points, using Google Earth images. A Google Earth overlay is shown in Fig 10, which clearly emphasize the need to do a validation of the points that was made by the MA/CA or the technician representatives. The blue points are the validated occurrence points for bangus, while the star points are the estimated spatial location done during the FGD. Although there are some points that were correctly located by the MA/CA. The validation process for all crops and for bangus took some time mainly because there is a need to zoom-in to the specific areas for the GIS encoder to decide whether it was a fishpond or otherwise. Validated occurrence points for rice, corn, cacao, coffee, squash, napier and bangus are shown in Figs. 11-17. These validated points were used in the crop suitability modeling using MaxEnt.

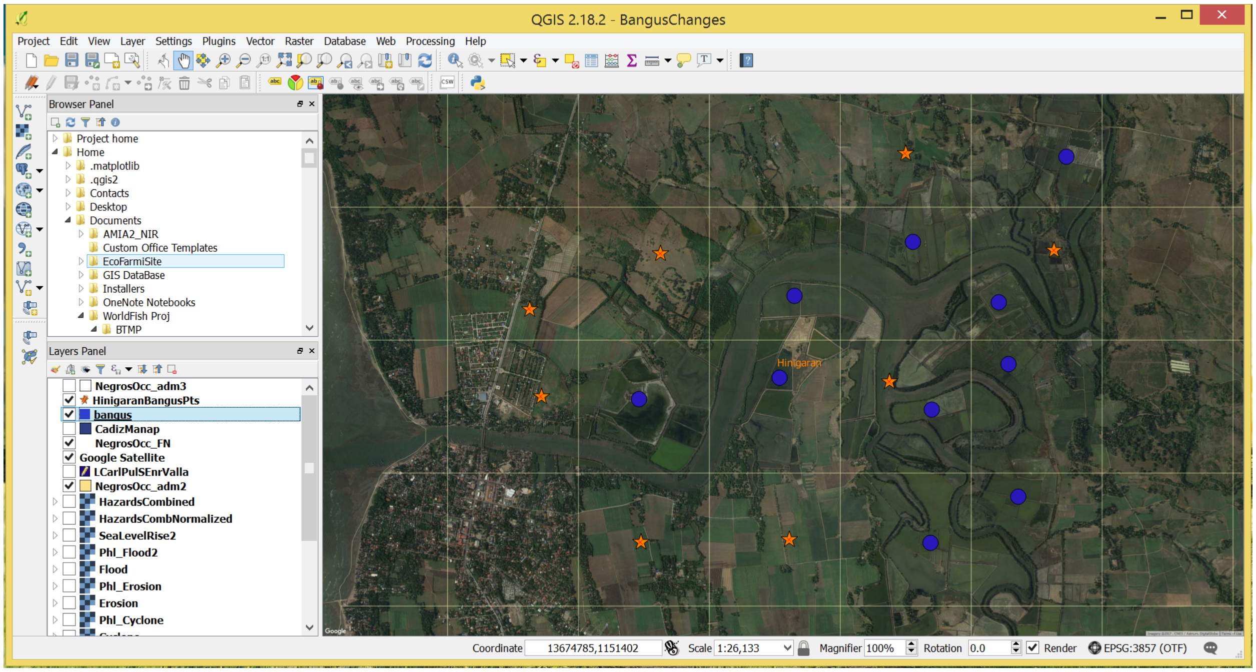
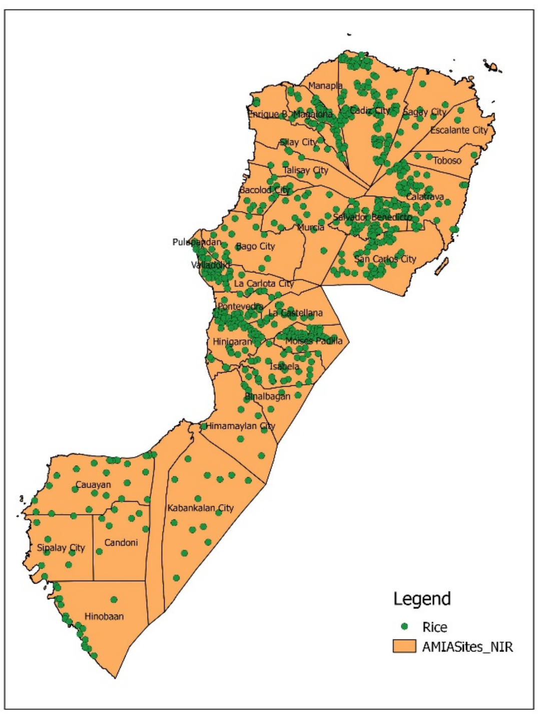
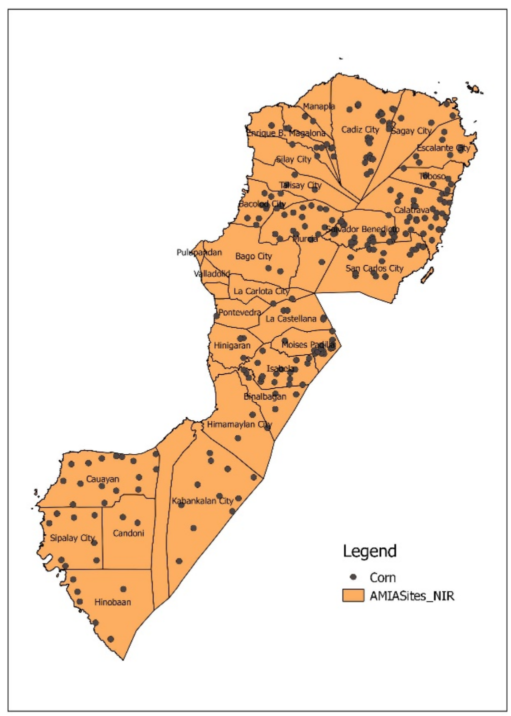
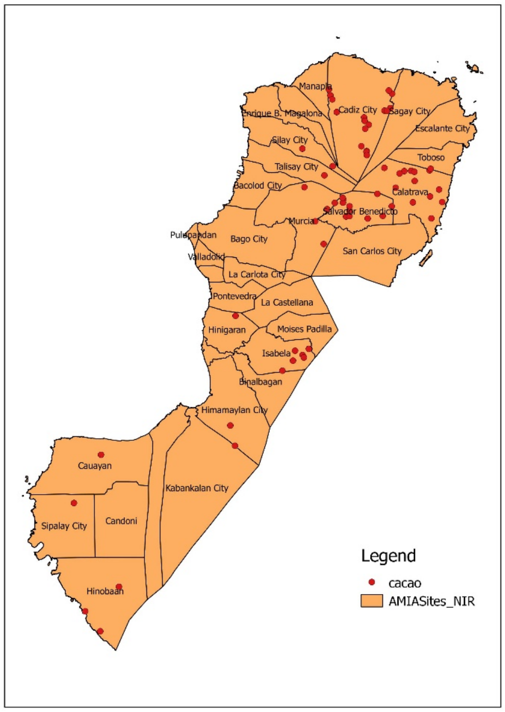


Fig. 10. Spatial occurrence points of bangus (star – done by technicians, blue – validated points using Google earth)



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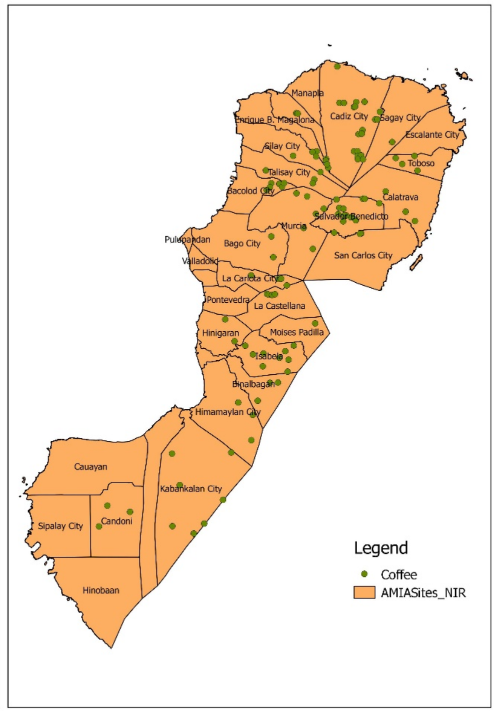
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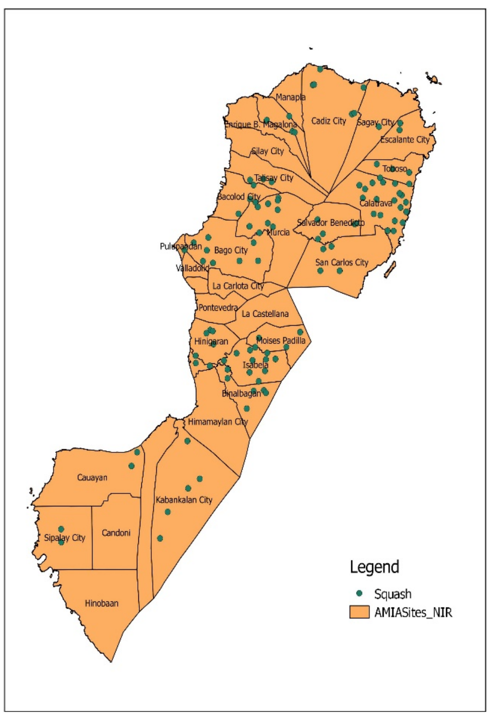
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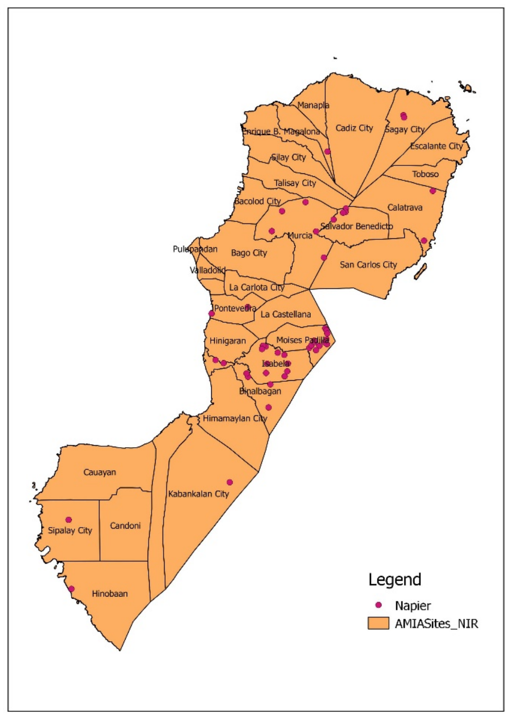
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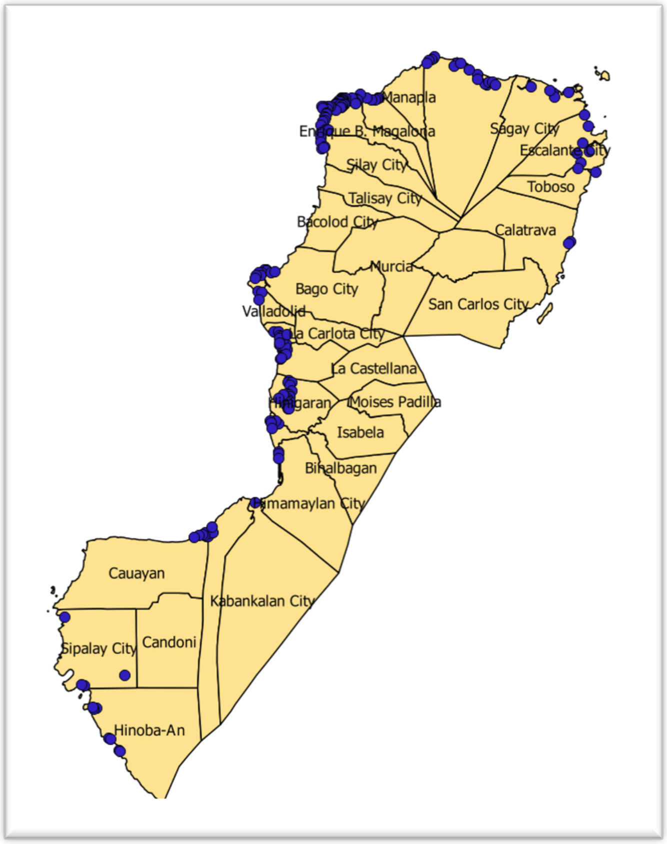


Figs. 11-17. Validated Crop and Fishery (Bangus) occurrence in Negros occidental.

Climate-Risk Vulnerability Assessment

The climate-risk vulnerability assessment follows the conceptual framework outlined by the CIAT below.

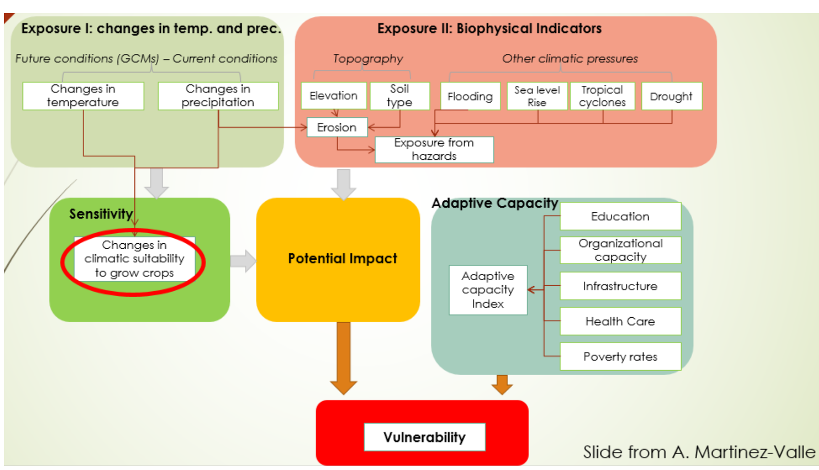


Fig. 18. Climate-risk vulnerability assessment (CRVA) framework.

The bioclimatic factors include 11 temperature related variables (Bio 1-11) and 9 precipitation variables (Bio 12-20). The variables were downscaled spatial data from the CIAT-CCAFS website with regional extent, 30-second resolution and year 2050 projection. The sensitivity used the Representative Concentration Pathway(RCP) 8.5 and the year 2050 time slice (Fig. 19). The RCP 8.5 is otherwise known as the High Emissions Scenario. This RCP is consistent with a future with no policy changes to reduce emissions. It was developed by the International Institute for Applied System Analysis in Austria and is characterized by increasing greenhouse gas emissions that lead to high greenhouse gas concentrations over time. Comparable SRES scenario A1 F1. This future is consistent with:

- Three times today's CO_2 emissions by 2100
- Rapid increase in methane emissions
- Increased use of croplands and grassland which is driven by an increase in population
- A world population of 12 billion by 2100
- Lower rate of technology development
- Heavy reliance on fossil fuels
- High energy intensity
- No implementation of climate policies

(https://www.iiasa.ac.at/web/home/research)
According to the 2014 estimate of the Net CO_2 emissions as shown in the figure below, RCP 8.5 is the closest pathway.

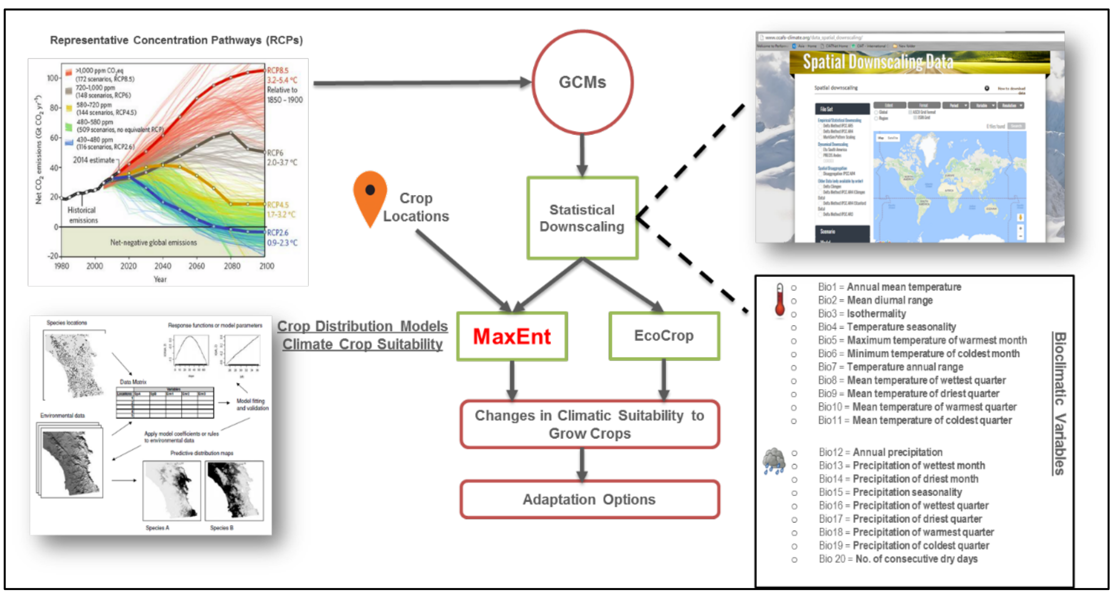


Fig. 19. Process flow for changes in climatic suitability to grow crops (RCPs, Biovariables).

Field Survey and Secondary Data Collection

In order to gather the data for Adaptive Capacity, a survey was conducted in the 32 municipalities of Negros Occidental using a questionnaire. Secondary data from various sources were also gathered and those municipalities where data is available were already filled-out in the questionnaire. Results of the survey revealed that some of the municipalities do not have a repository of data hence they were not able to fill-out the survey questionnaire. Further, among the indicators that were used, the economic indicators have complete attribution but the Anticipatory and Institutional capitals basically had incomplete data despite several attempts to gather them. Sample results of the survey for adaptive capacity are found in Annex A. Inasmuch as the data is incomplete, CIAT as program coordinator decided and advised the project team to utilize the data from the Cities and Municipalities Competitive Index (CMCI) for adaptive capacity and narrowed down the indicators to Infrastructure, Poverty, Education, and Health Care. Aside from the survey for Adaptive Capacity, a key informant interview (KII) of the farmers were also made to assess the climate- resilient agriculture (CRA) practices in selected areas where the crops are planted.

Climatic Suitability Modelling using MaxEnt

The determination of climatic suitability to grow crops used MaxEnt software (a free and open source software-FOSS) which was run twice - one for baseline, and the second run was for the future conditions projected at year 2050. In the year 2050 projection, only the bioclimatic variables for 2050 was changed as input environmental layers. Table 5 show the Mean Area Under Curve (AUC) in MaxEnt which is an important indicator prior to accepting the results of modelling. Values of AUC below or equal to 0.5 indicates that the performance of the model is no better than random, while values closer to 1.0 indicate better model performance. Similarly, analysis of variable contributions (AVC) identifies the bioclimatic factor that gave the highest predictive contribution. The higher the contribution the more impact that particular variable has in predicting the occurrence of that species.

Table 5. Mean Area under Curve and Analysis of Variable Contributions

Crop	Mean AUC	Std. Dev.	AVC	Jackknife
Rice	0.732	0.019	Bio_18: 15.2	Bio_13
Corn	0.670	0.032	Bio_12: 14.9	Bio_12
Cacao	0.758	0.065	Bio_15: 45.5	Bio_16
Coffee	0.769	0.041	Bio_9: 18.7	Bio_16
Squash	0.676	0.038	Bio_2: 32	Bio_7

Bioclimatic Factor	Variable
Bio_2	Mean diurnal range
Bio_7	Temperature Annual range
Bio_9	Mean Temperature of driest quarter
Bio_12	Annual Precipitation
Bio_13	Precipitation of wettest month
Bio_15	Precipitation seasonality
Bio_16	Precipitation of wettest quarter
Bio_18	Precipitation of warmest quarter

As indicated in Table 5, the precipitation of the warmest month gave the highest predictive contribution. This clearly show that rice is greatly affected by the amount of moisture that is available during its growing period. On the other hand, for corn production, the annual precipitation (Bio 12) had the highest predictive contribution since corn is known to be more productive during the summer months. Cacao is affected by precipitation seasonality (Bio 15), as its fruiting is almost year round but the occurrence of pest and diseases is more pronounced during the rainy season.

Results showed for rice, that there is a decline in the very highly suitable areas and an increase in the high and moderate and considerable increase in low suitable areas by 2050 (Figs. 20 and 21). Fig. 20 show that the increase in low suitable areas is about double compared to the increase in moderate and high suitability.

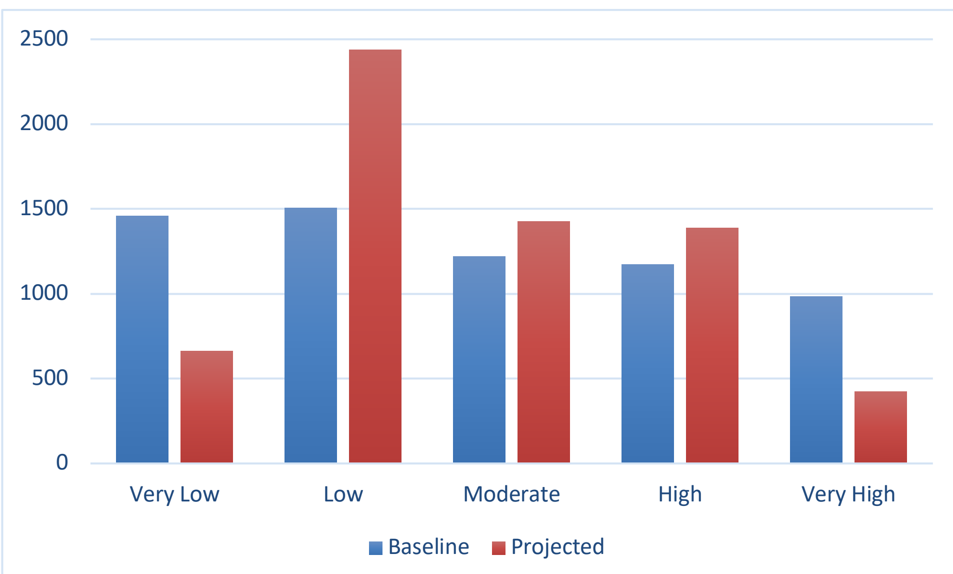


Fig. 20. Change in Baseline and Projected (2050) Area (ha.) for Rice

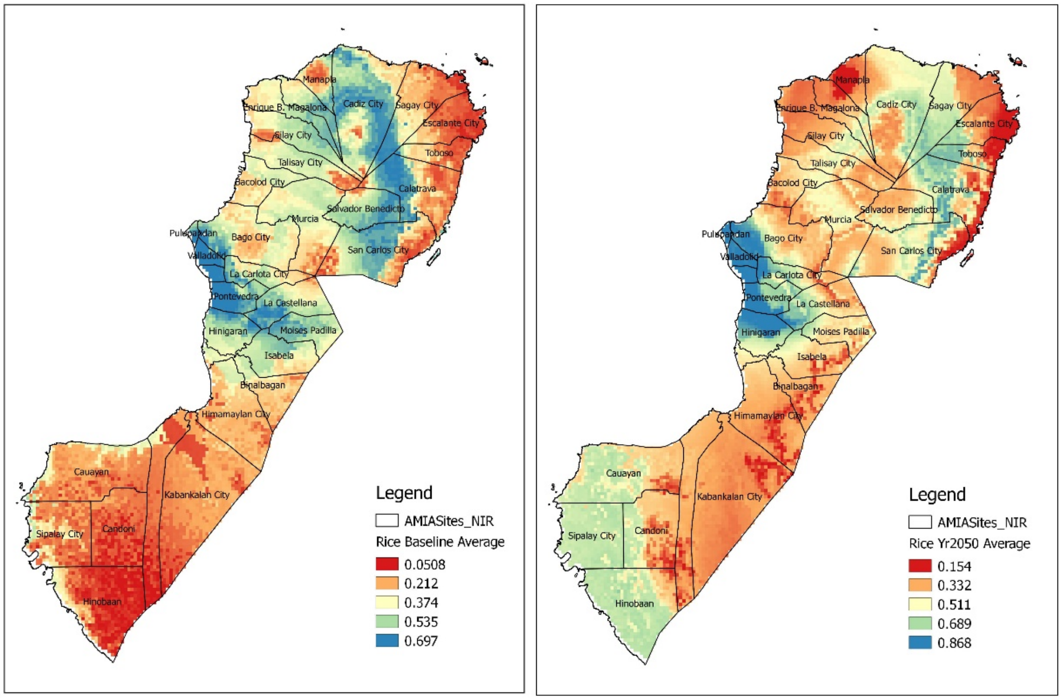


Fig. 21. Map of change in Baseline and Projected (2050) for Rice

For corn, the moderate suitability index increased considerably as well as the high suitability index in the projected 2050 scenario while the low and very low have drastically decreased compared to the baseline. The annual precipitation is the highest predictive contribution to the model which according to farmers practice is consistent with the variable when to plant corn. The results can also be interpreted that those areas that is not suitable for corn can now be planted towards year 2050.

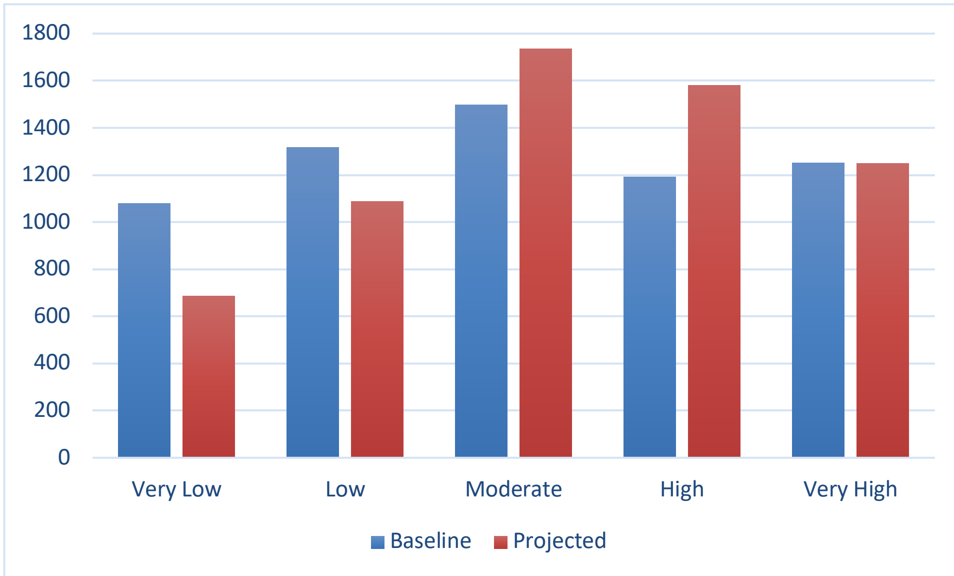


Fig. 22. Change in Baseline and Projected (2050) Area (ha.) for Corn

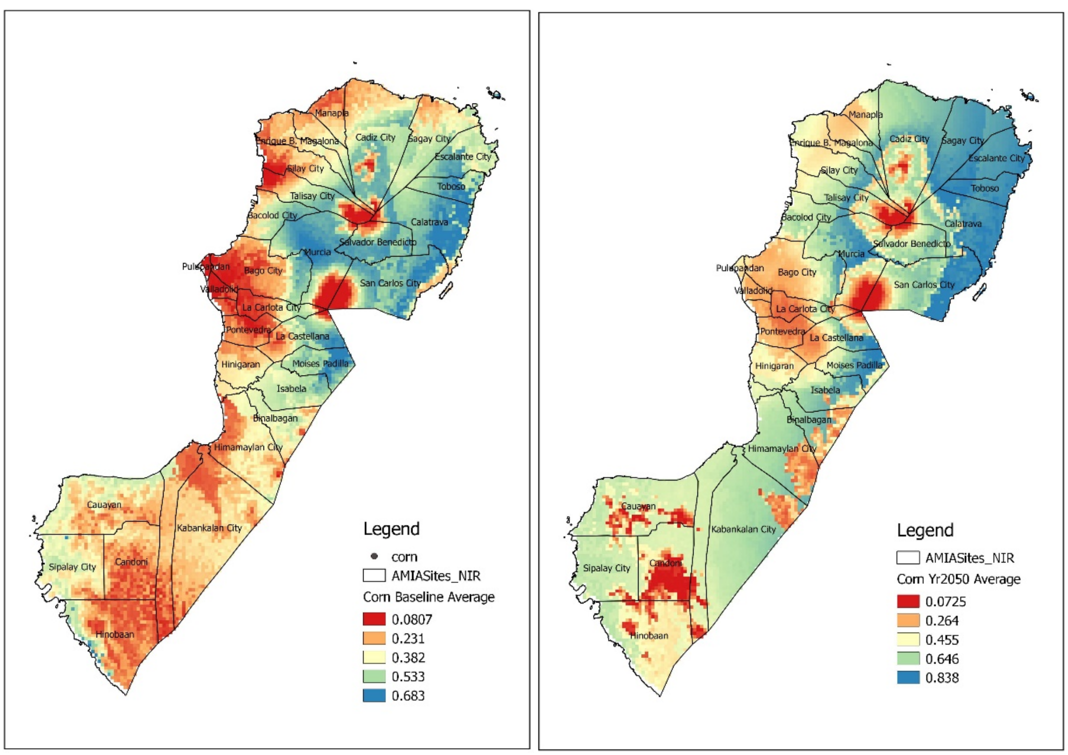


Fig. 23. Map of change in Baseline and Projected (2050) Area (ha.) for Corn.

The cacao, suitability index follows the same trend as that of corn. The moderate suitability index increased as well as the high but the low and very low suitability decreased.

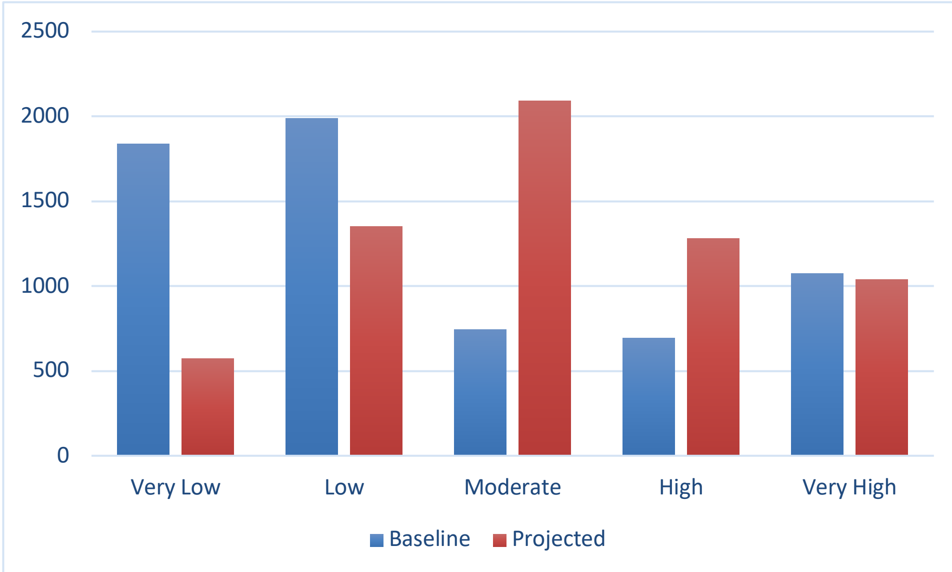


Fig. 24. Change in Baseline and Projected (2050) Area (ha.) for Cacao

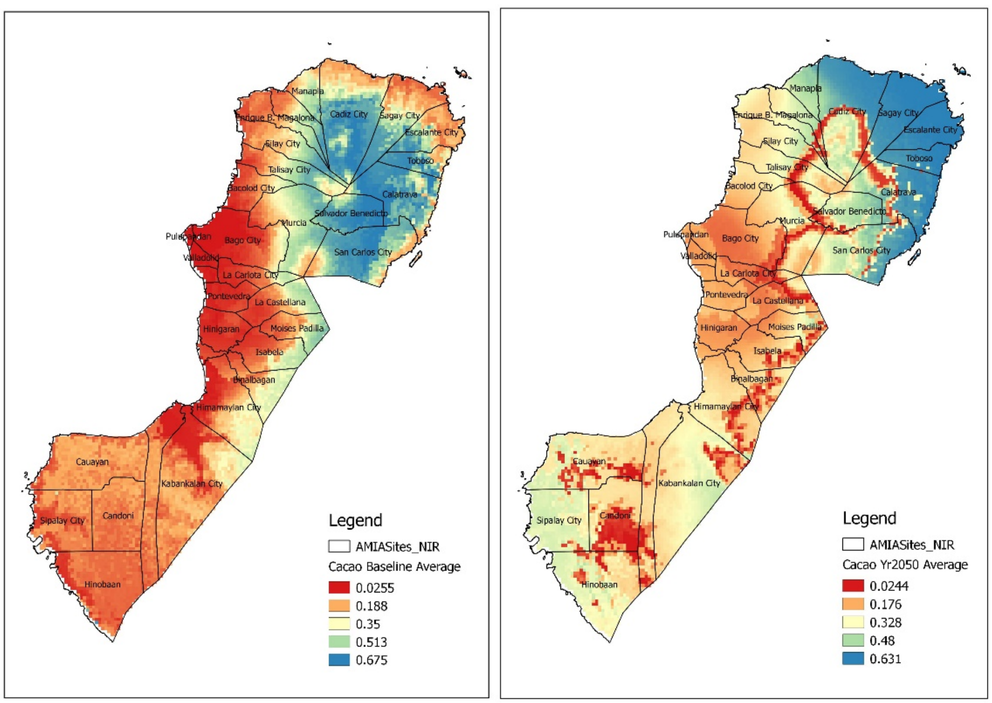


Fig. 25. Map of change in Baseline and Projected (2050) Area (ha.) for Cacao.

For coffee, in the year 2050, most of the areas have very low suitability index. This implies that planting coffee using the same technology will not produce better harvest compared to the current.

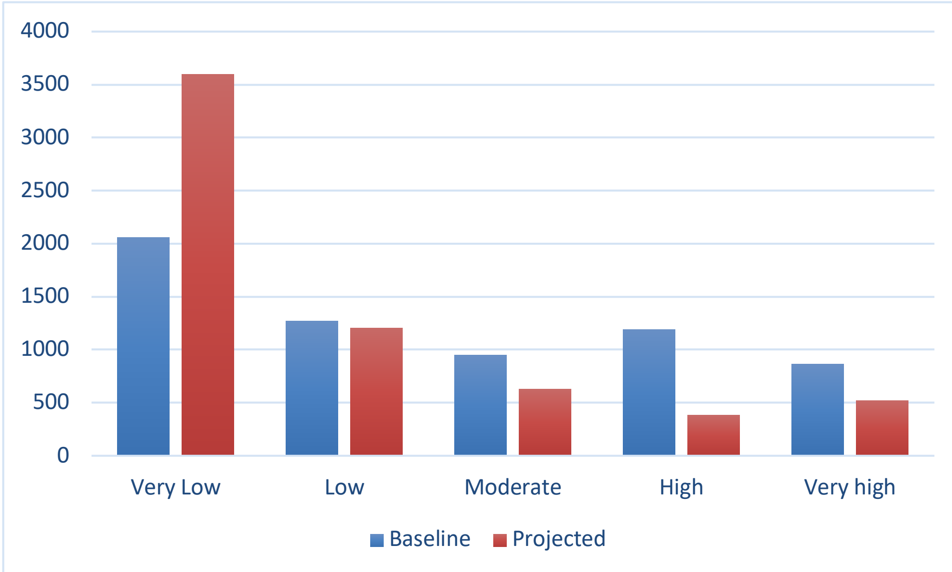


Fig. 26. Change in Baseline and Projected (2050) Area (ha.) for Coffee.

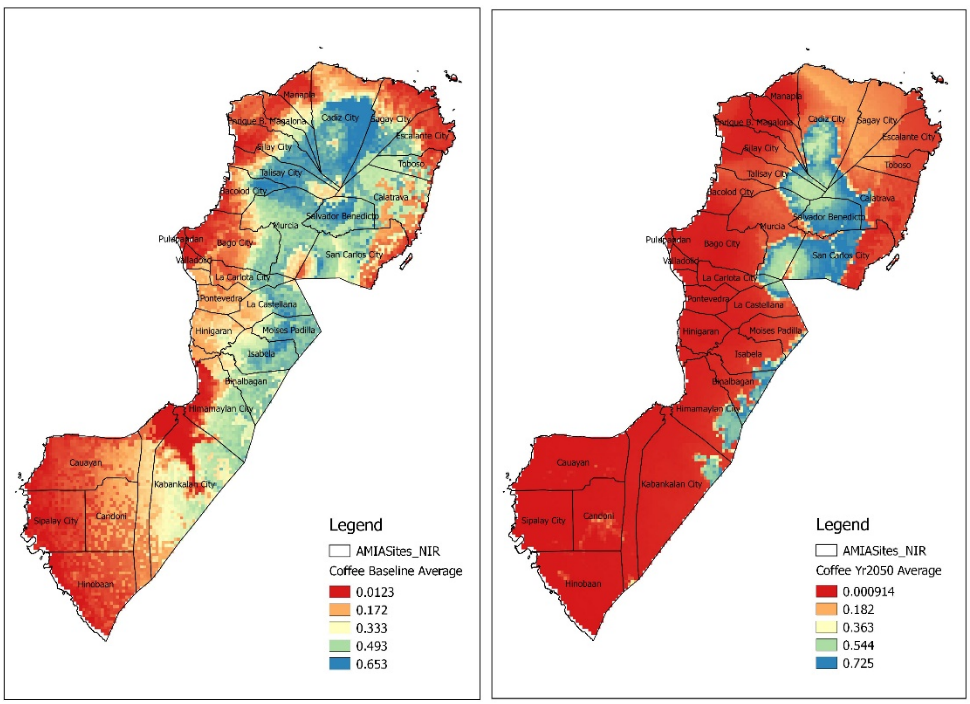


Fig. 27. Map of change in Baseline and Projected (2050) Area (ha.) for Coffee.

Squash suitability index showed that the moderate suitability increased in 2050 but the very high suitability decreased. It is only in the high suitability that increased in the 2050 projection.

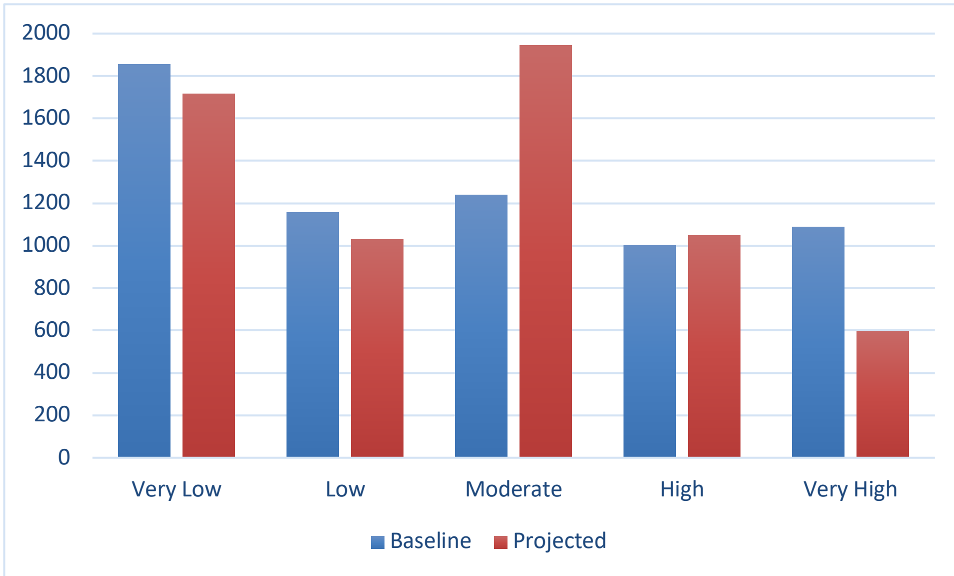


Fig. 28. Change in Baseline and Projected (2050) Area (ha.) for Napier.

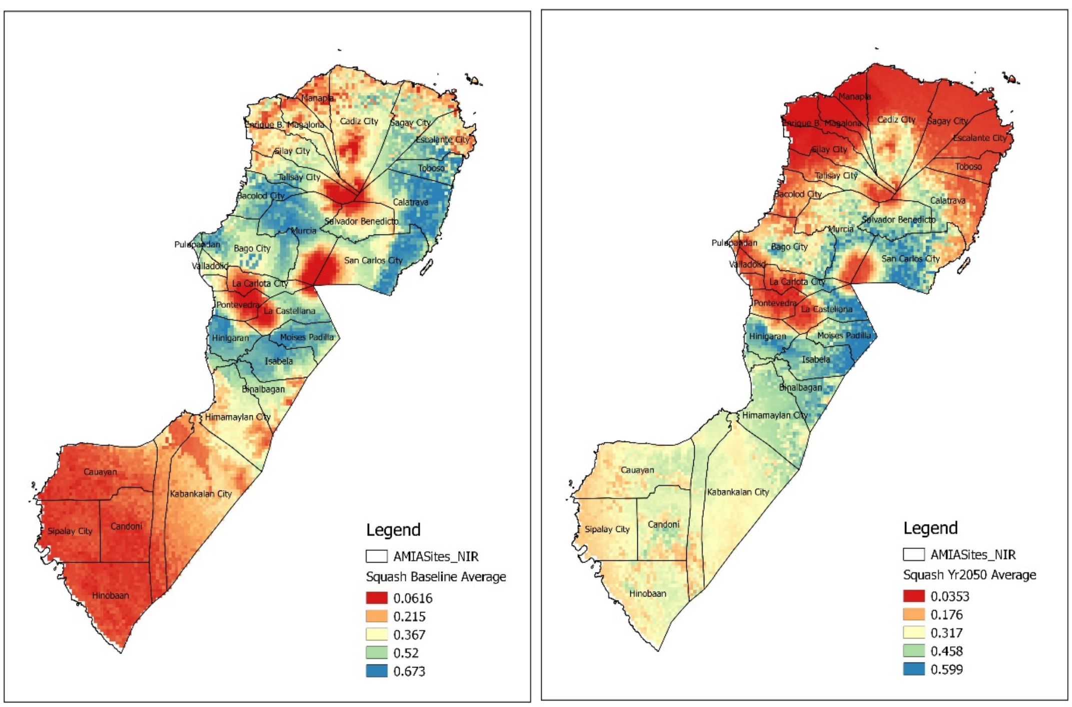


Fig. 29. Map of change in Baseline and Projected (2050) Area (ha.) for Squash.

The multi-hazard and the adaptive capacity maps of Negros Occidental are shown below. The multi-hazard includes erosion, typhoon frequency, flood frequency, sea level rise 1m, and drought (Global Aridity Index). While the adaptive capacity includes infrastructure, poverty, education, and health care which data were taken from the Cities and Municipalities Competitiveness Index (CMCI) to complement with the survey data.

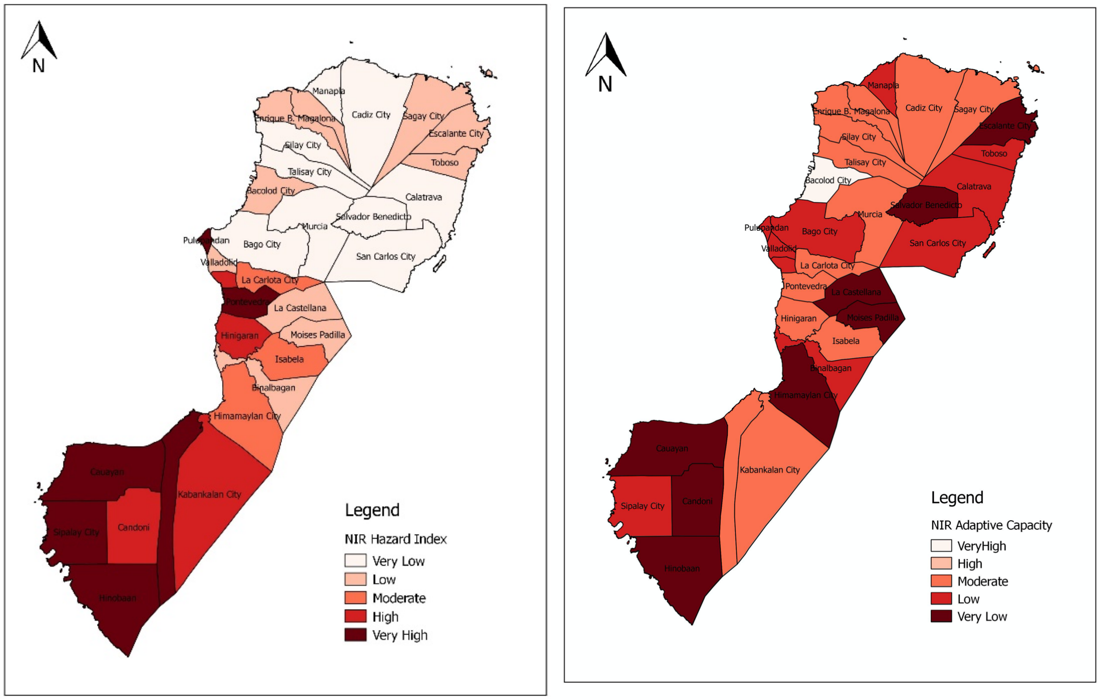


Fig. 30. Natural hazard index and Adaptive Capacity index of Negros Occidental.

The top municipalities in Negros Occidental with index ranging from moderate to very high is shown in Table 7. The very high hazard index occurs at Pulupandan, Ilog, Hinobaan, Cauayan and Pontevedra

Table 7. Top municipalities affected by natural hazards and adaptive capacity

Municipality/City	Hazard Index	Description	Municipality/City	Adaptive Capacity	Description
Pulupandan	0.90	VERY HIGH	Candoni	0.9469	VERY LOW
Ilog	0.88	VERY HIGH	Hinobaan	0.8722	VERY LOW
Hinobaan	0.86	VERY HIGH	Moises Padilla	0.8698	VERY LOW
Cauayan	0.83	VERY HIGH	Salvador Benedicto	0.8204	VERY LOW
Pontevedra	0.77	VERY HIGH	Cauayan	0.8093	VERY LOW
Sipalay City	0.76	VERY HIGH	Himamaylan City	0.7964	VERY LOW
Hinigaran	0.71	HIGH	La Castellana	0.7720	VERY LOW
Kabankalan City	0.68	HIGH	Escalante City	0.7646	LOW
San Enrique	0.67	HIGH	Sipalay City	0.7481	LOW
Candoni	0.59	HIGH	Bago City	0.7426	LOW
Himamaylan City	0.49	MODERATE	Toboso	0.7334	LOW
Isabela	0.44	MODERATE	Calatrava	0.6900	LOW
La Carlota City	0.39	MODERATE	Pulupandan	0.6825	LOW

The adaptive capacity index must be interpreted in inverse manner since in the vulnerability formula it is computed as (1-AC) such that those municipalities with very high adaptive capacity index are those that have difficulties to bounce back whenever calamities occur. Therefore, the municipalities of Candoni, Hinobaan, Moises Padilla, Salvador Benedicto, Cauayan and Himamaylan City have actually low adaptive capacity. Among the places in Negros Occidental, Bacolod City has the highest adaptive capacity. A close examination of the capitals indicate that the Bacolod have the highest index in all the capitals, economic, human, health and infrastructure.

The vulnerability maps of each crop are shown in Figs. 27-33. Different versions represent 5 different weight assignments of the sensitivity, exposure and adaptive capacity as follows; v1)15, 15, 70; v2)33, 33, 33; v3)25,25, 50; v4)20, 20, 60; and v5)30, 30, 40. Nevertheless, the Millenium Development Goals of NEDA recommended the 30, 30, 40 weights for sensitivity, exposure and adaptive capacity. In this particular report the 15, 15, 70 since this is the result of the Focus Group Discussion done by CIAT.

In all the weights scenario the municipalities of Hinobaan and Sipalay City is consistently having very high vulnerability index. While the municipalities of Candoni and Cauayan changes its index from moderate to high. This is probably so, because both municipalities have high exposure to natural hazards (Table 7) and low adaptive capacity.

Rice

The vulnerability of rice in Bago City in all scenarios ranges from high to very high. This simply suggests that the traditional cultivation practices of producing rice may no longer yield at the same level when used by the year 2050.

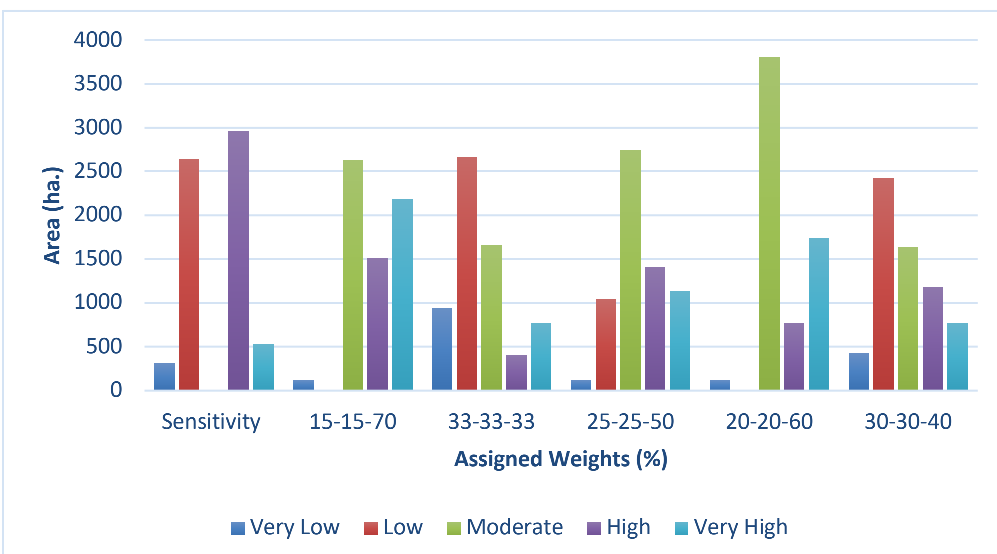
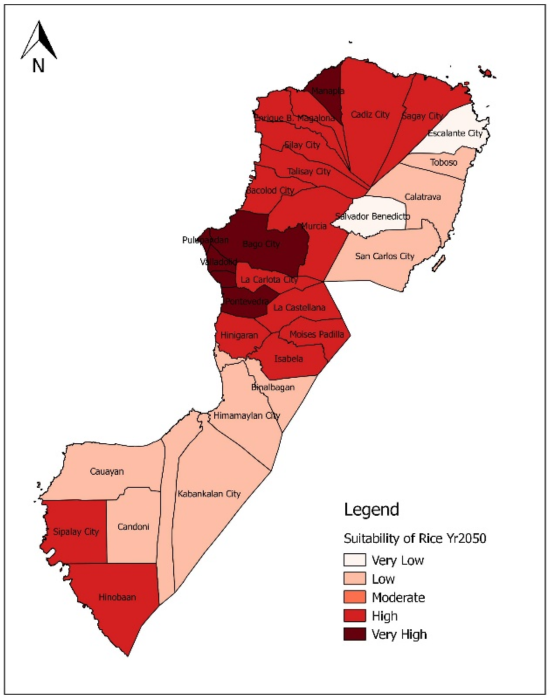
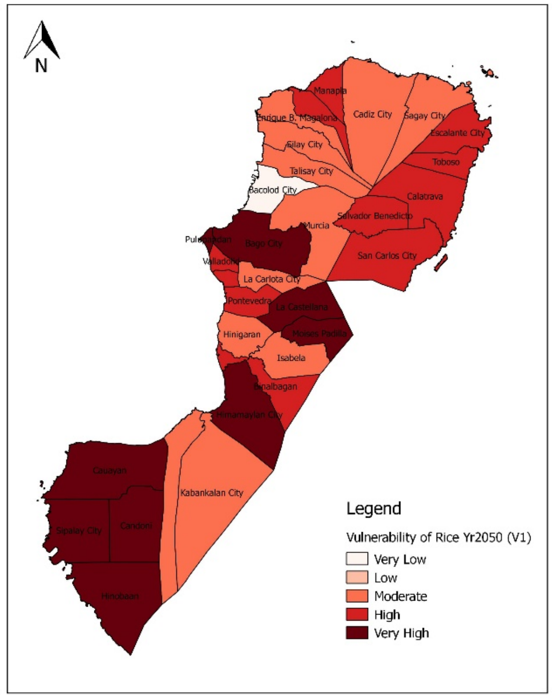
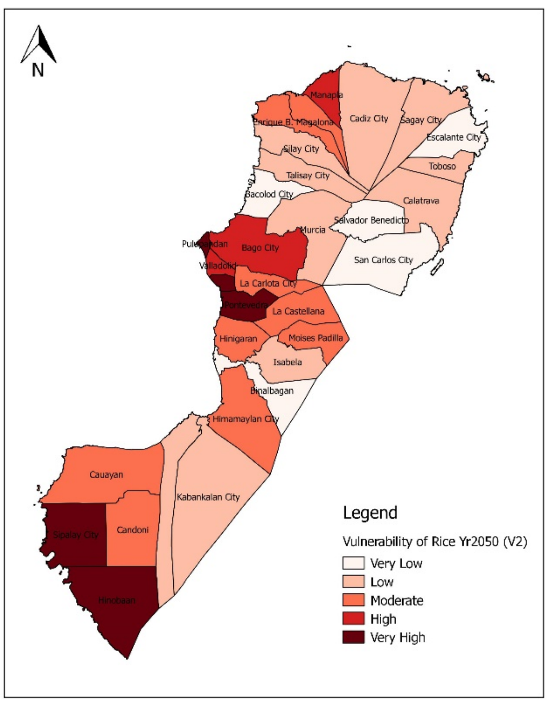


Fig. 31. Plot of the area (ha.) of rice at different weights of sensitivity, exposure and adaptive capacity.


N
Manapla
Cadiz City
Sagay City
Escalante City
Silay City
Toboso
Talisay City
Calatrava
Bacolod City
Salvador Benedicto
Murcia
Bago City
San Carlos City
Valladolid
La Carlota City
Pontevedra
La Castellana
Hinigaran
Moises Padilla
Isabela
Binalbagan
Himamaylan City
Cauayan
Kabankalan City
Sipalay City
Candoni
Hinobaan
Legend
Suitability of Rice Yr2050
Very Low
Low
Moderate
High
Very High


N
Manapla
Cadiz City
Sagay City
Escalante City
Silay City
Toboso
Talisay City
Calatrava
Bacolod City
Salvador Benedicto
Murcia
Bago City
San Carlos City
La Carlota City
Pontevedra
La Castellana
Hinigaran
Isabela
Binalbagan
Kabankalan City
Legend
Vulnerability of Rice Yr2050 (V1)
Very Low
Low
Moderate
High
Very High


N
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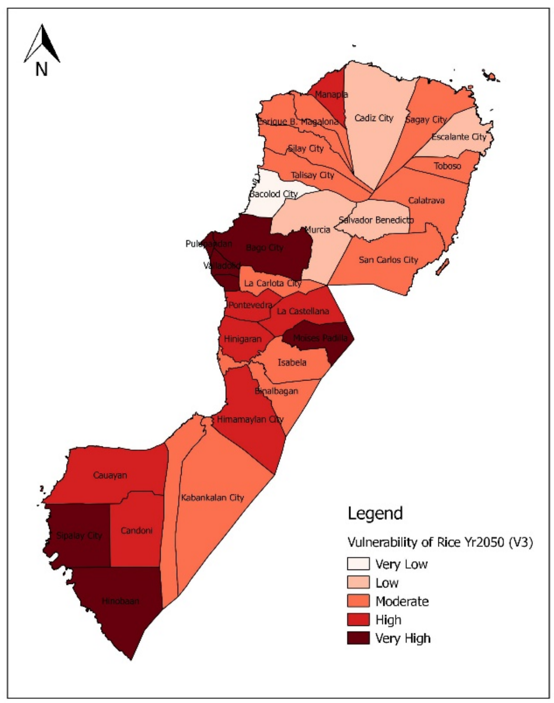
Sagay City
Escalante City
Silay City
Toboso
Talisay City
Calatrava
Bacolod City
Salvador Benedicto
Murcia
Bago City
San Carlos City
La Carlota City
La Castellana
Hinigaran
Moises Padilla
Isabela
Binalbagan
Himamaylan City
Cauayan
Kabankalan City
Candoni
Legend
Vulnerability of Rice Yr2050 (V2)
Very Low
Low
Moderate
High
Very High


N
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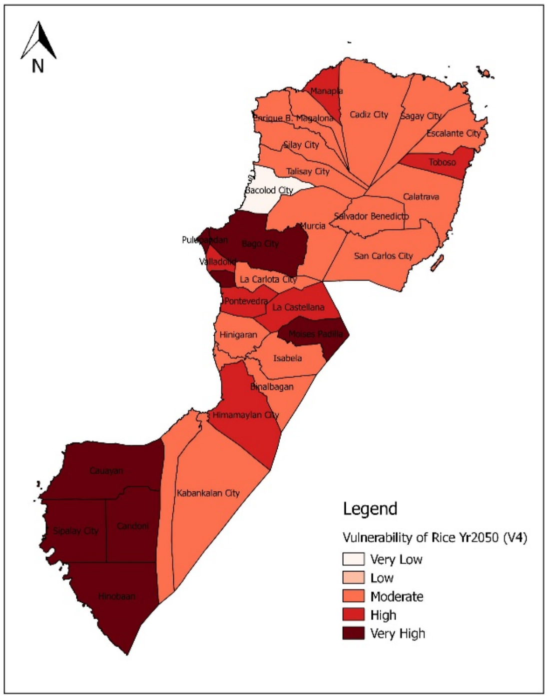
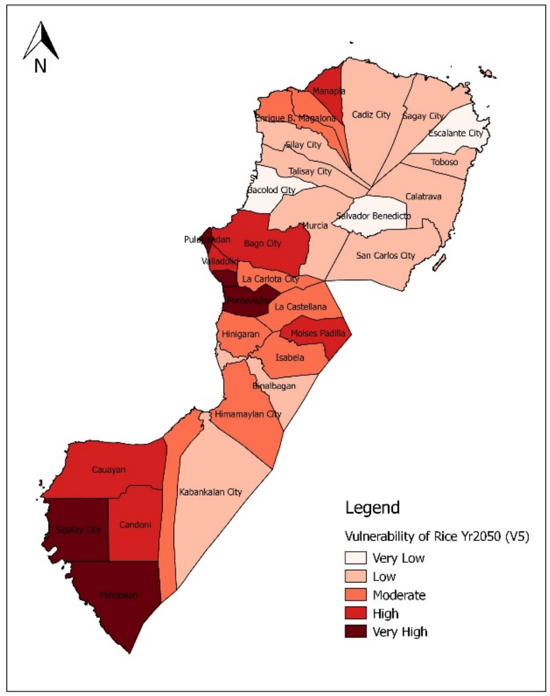
Cadiz City
Sagay City
Escalante City
Silay City
Toboso
Talisay City
Calatrava
Bacolod City
Salvador Benedicto
Murcia
Bago City
San Carlos City
La Carlota City
Pontevedra
La Castellana
Hinigaran
Isabela
Binalbagan
Himamaylan City
Cauayan
Kabankalan City
Candoni
Legend
Vulnerability of Rice Yr2050 (V3)
Very Low
Low
Moderate
High
Very High





Figs. 32-37. Maps of rice vulnerability using different weights assigned to exposure, sensitivity and adaptive capacity.

Corn

For corn, there is not much change in the area at different scenarios. It is quite clear that as the adaptive capacity weight is increased the moderate and the high indices are affected.

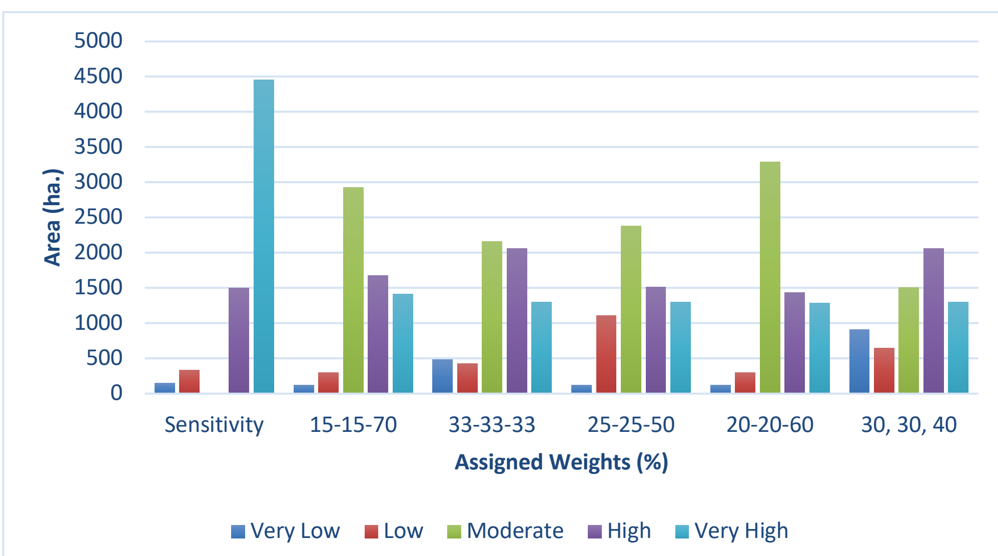
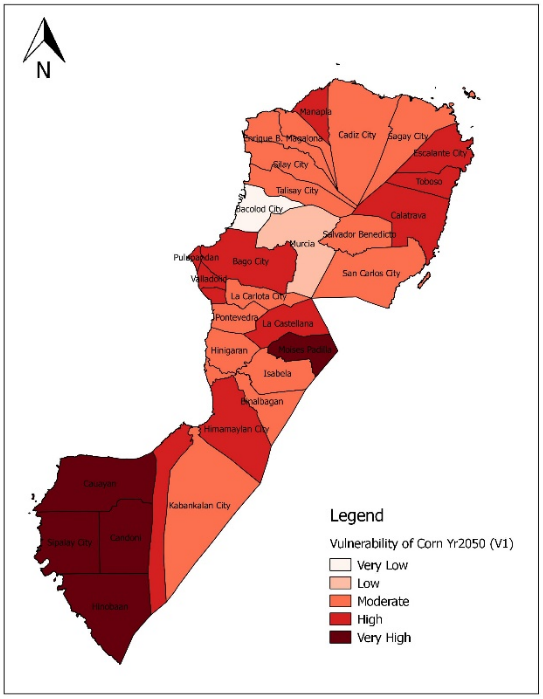
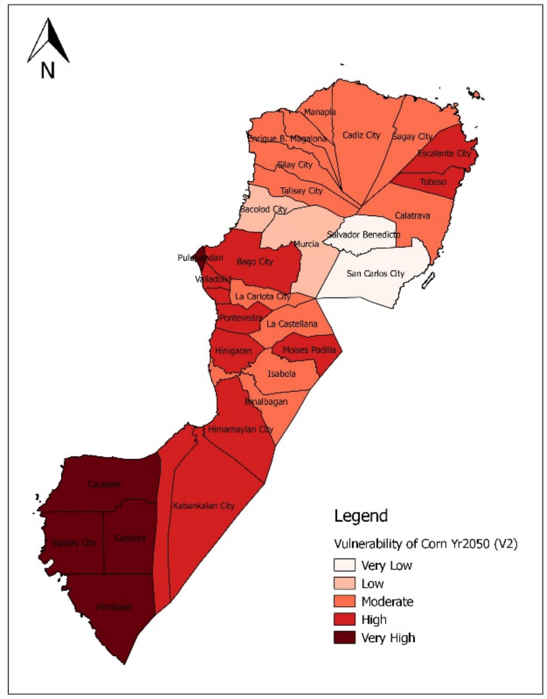
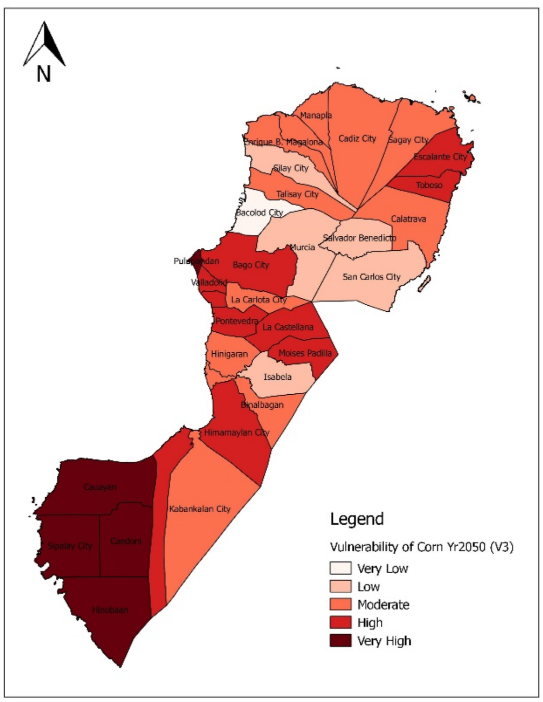
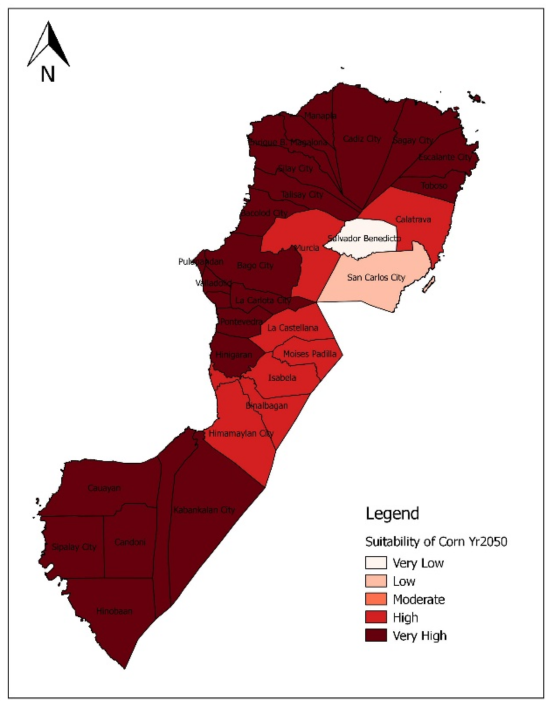


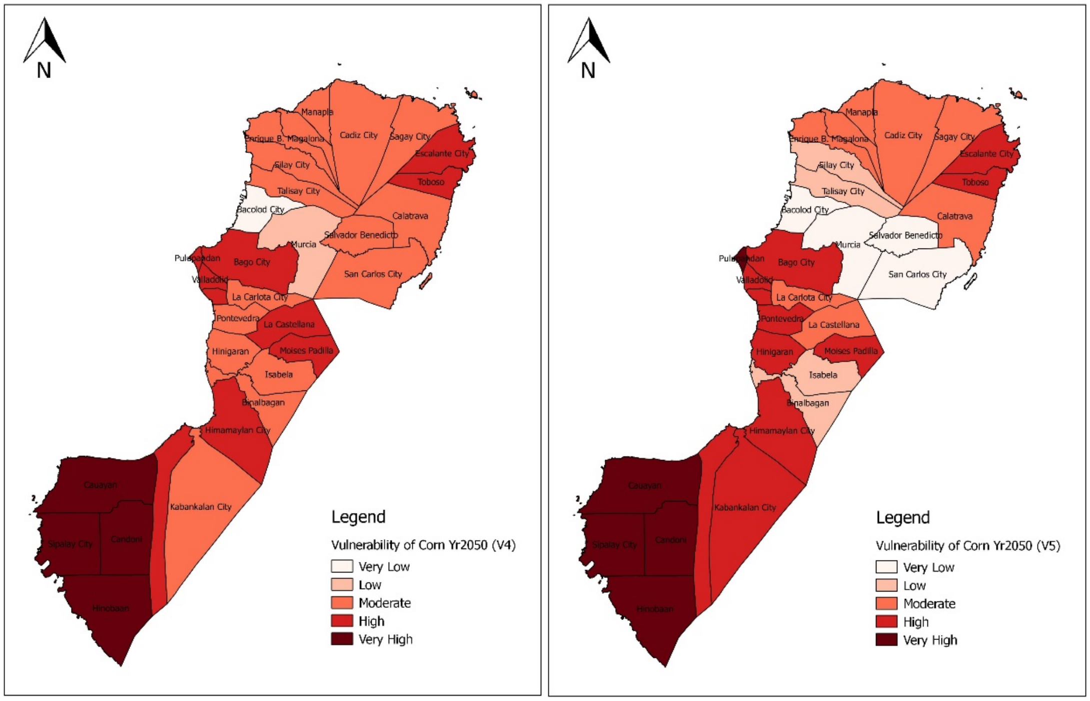
Fig. 38. Plot of the area (ha.) of corn at different weights of sensitivity, exposure and adaptive capacity.


N
Legend
Vulnerability of Corn Yr2050 (V1)
Very Low
Low
Moderate
High
Very High


N
Legend
Vulnerability of Corn Yr2050 (V2)
Very Low
Low
Moderate
High
Very High


N
Legend
Vulnerability of Corn Yr2050 (V3)
Very Low
Low
Moderate
High
Very High


N
Legend
Suitability of Corn Yr2050
Very Low
Low
Moderate
High
Very High



Figs. 39-44. Maps of rice vulnerability using different weights assigned to exposure, sensitivity and adaptive capacity.

Cacao

Cacao has a slightly different trend. When the adaptive capacity is increased to 70 the very high and the high areas are almost similar which is indicative that adaptive capacity has a considerable effect in determining vulnerability.

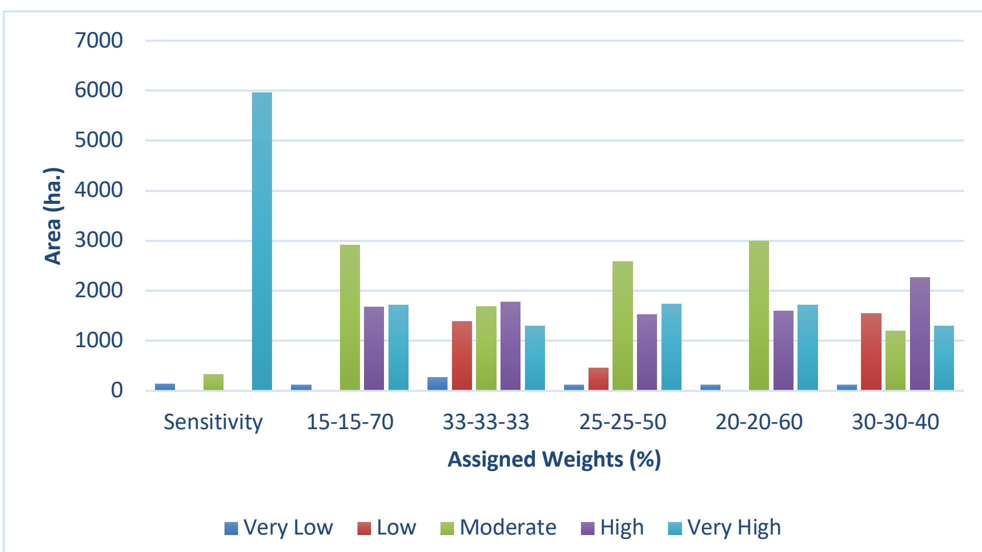
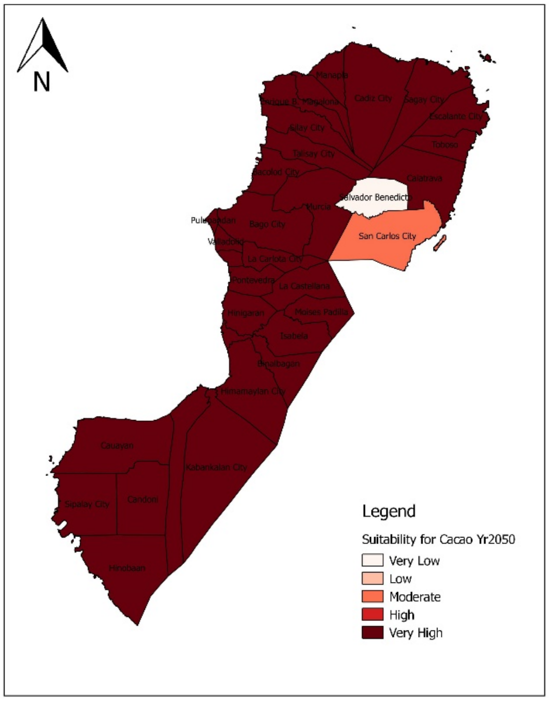
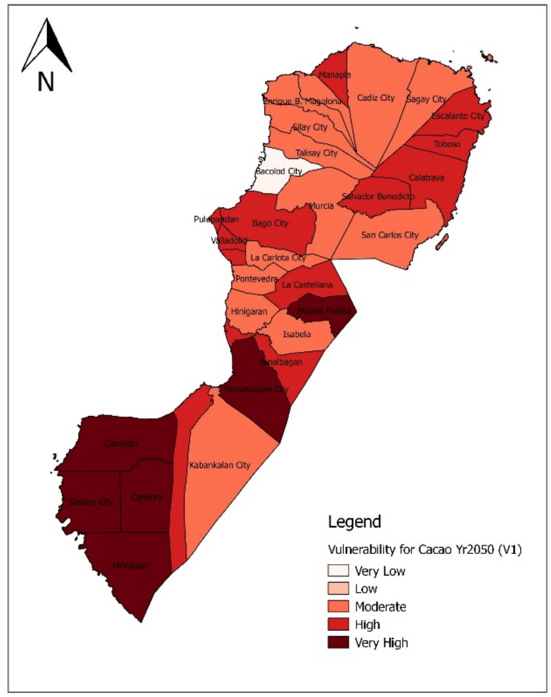
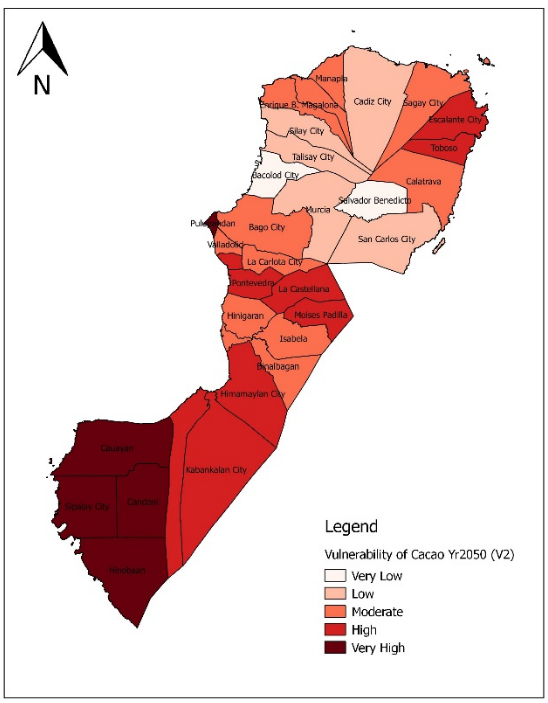
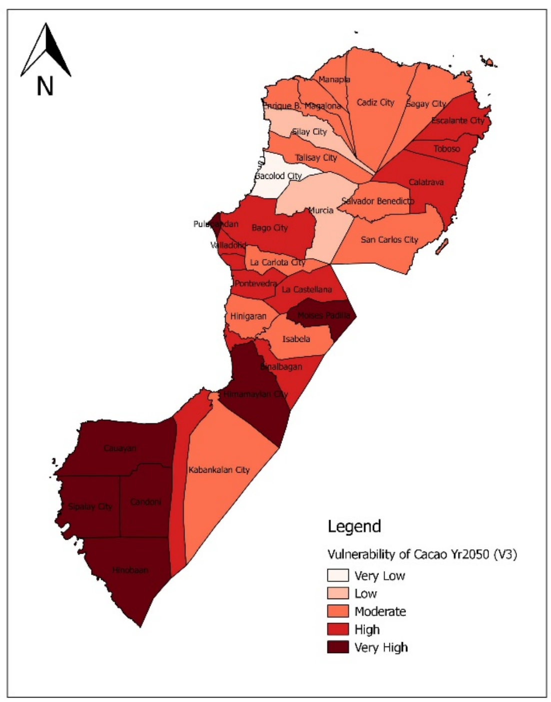


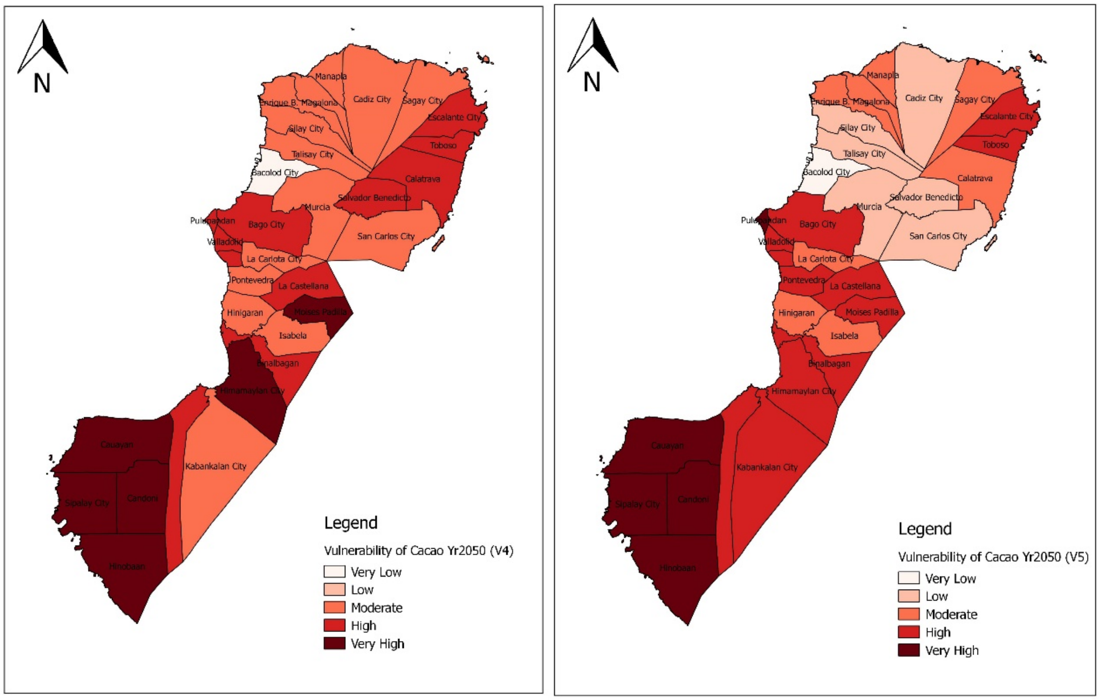
Fig. 45. Plot of the area (ha.) of cacao at different weights of sensitivity, exposure and adaptive capacity.


N
Legend
Suitability for Cacao Yr2050
Very Low
Low
Moderate
High
Very High


N
Legend
Vulnerability for Cacao Yr2050 (V1)
Very Low
Low
Moderate
High
Very High


N
Legend
Vulnerability of Cacao Yr2050 (V2)
Very Low
Low
Moderate
High
Very High


N
Legend
Vulnerability of Cacao Yr2050 (V3)
Very Low
Low
Moderate
High
Very High



Figs. 46-51. Maps of cacao vulnerability using different weights assigned to exposure, sensitivity and adaptive capacity.

The municipalities of Hinobaan, Sipalay City, Candoni and Cauayan are also very highly vulnerable to growing cacao.

Coffee

Similarly, Hinobaan, Sipalay City, Candoni and Cauayan are not suitable to planting coffee since it has very high vulnerability index in all scenarios. A plot of the behavior of the areas suitable for growing coffee is shown in Fig. 48. Again, the distribution of area for that is vulnerable is seen in the 30, 30, 40 weight distribution.

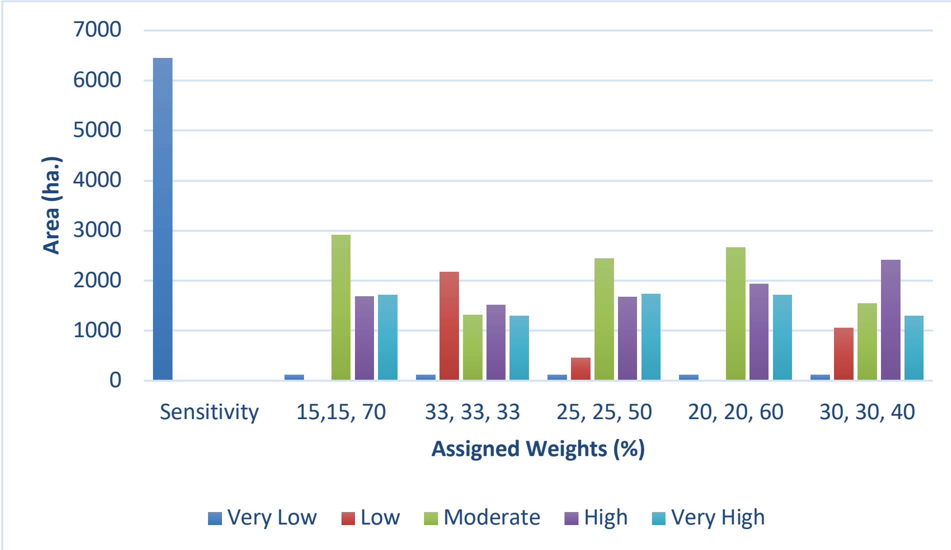
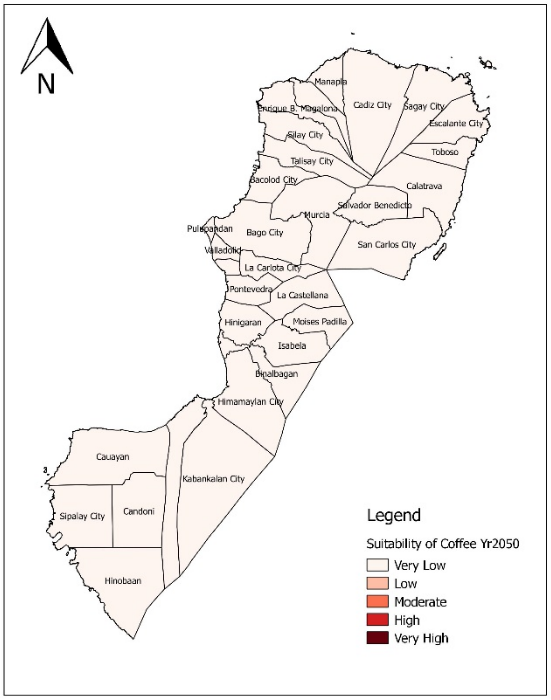
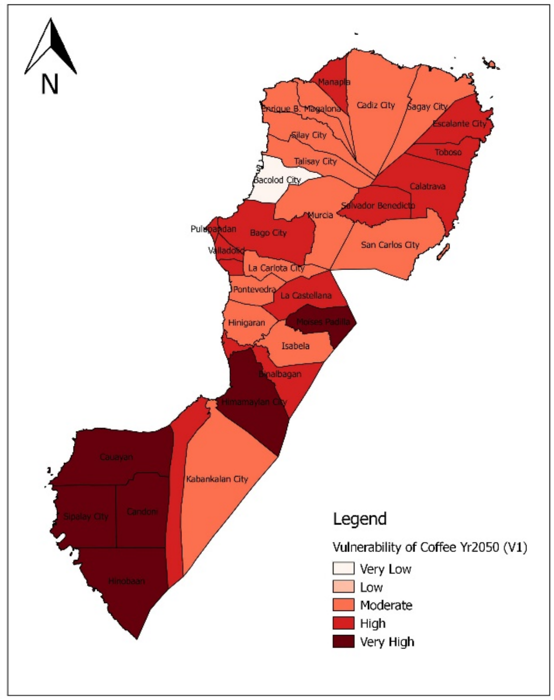
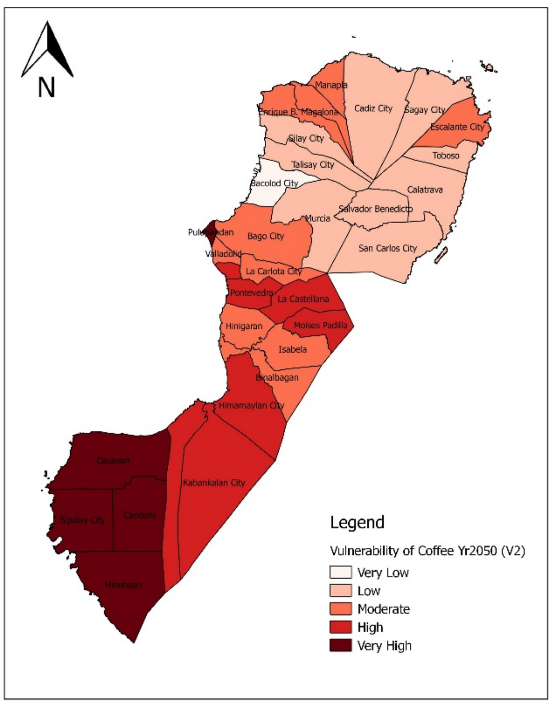
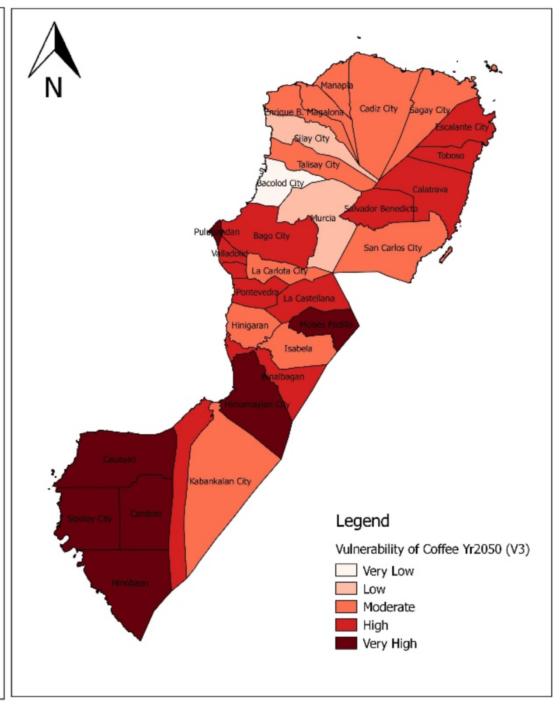


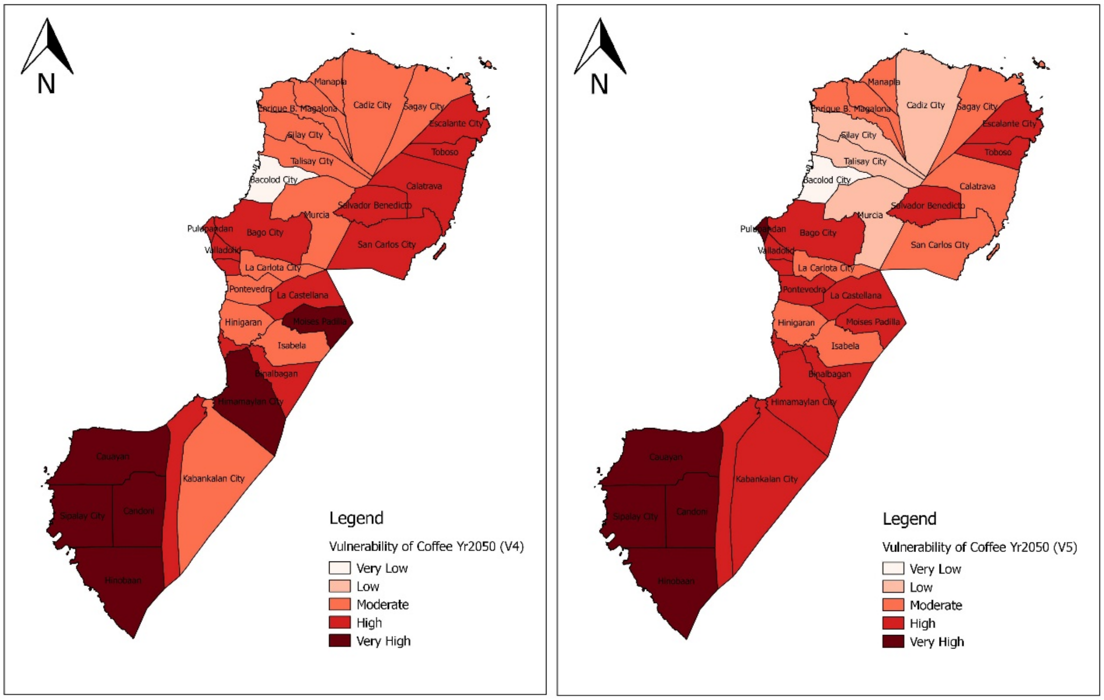
Fig. 52. Plot of the area (ha.) of coffee at different weights of sensitivity, exposure and adaptive capacity.


N
Manapla
Enrique B. Magalona
Cadiz City
Sagay City
Escalante City
Silay City
Toboso
Talisay City
Bacolod City
Calatrava
Salvador Benedicto
Murcia
Pulupandan
Bago City
Valladolid
San Carlos City
La Carlota City
Pontevedra
La Castellana
Hinigaran
Moises Padilla
Isabela
Binalbagan
Himamaylan City
Cauayan
Kabankalan City
Sipalay City
Candoni
Hinobaan
Legend
Suitability of Coffee Yr2050
Very Low
Low
Moderate
High
Very High


N
Legend
Vulnerability of Coffee Yr2050 (V1)
Very Low
Low
Moderate
High
Very High


N
Legend
Vulnerability of Coffee Yr2050 (V2)
Very Low
Low
Moderate
High
Very High


N
Legend
Vulnerability of Coffee Yr2050 (V3)
Very Low
Low
Moderate
High
Very High



Figs. 53-58. Maps of coffee vulnerability using different weights assigned to exposure, sensitivity and adaptive capacity.

Squash

Fig. 55 show that the low vulnerability index is highest when the weights are 30, 30, 40. Figs. 56-61 show that Bacolod City has very low vulnerability due to its high adaptive capacity.

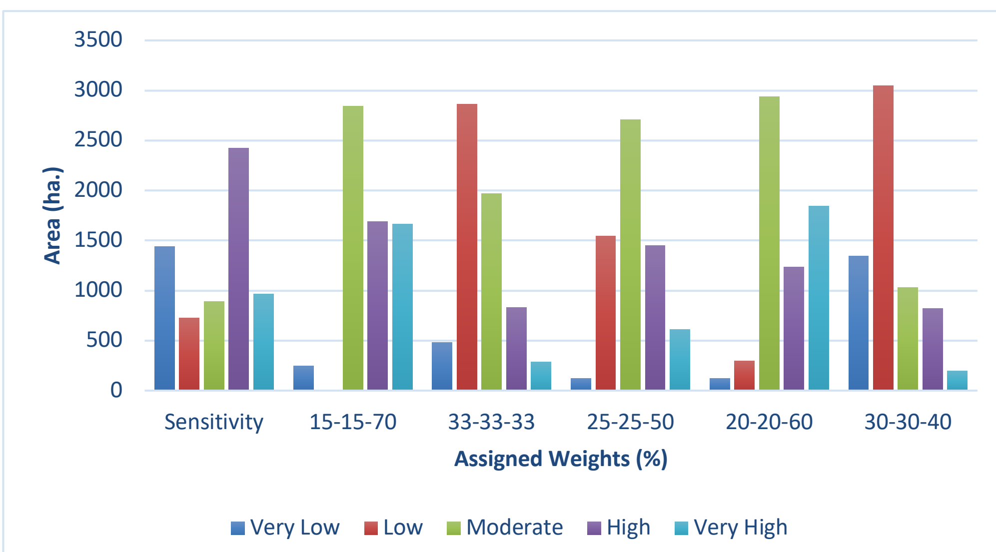
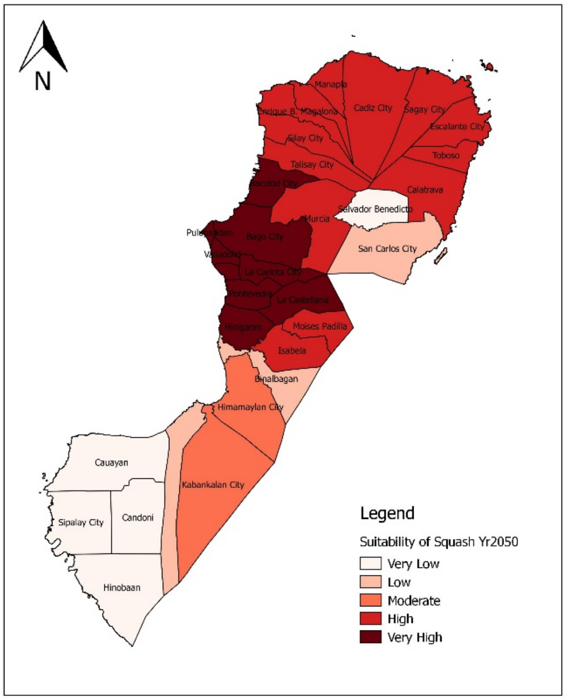


Fig. 59. Plot of the area (ha.) of coffee at different weights of sensitivity, exposure and adaptive capacity.


N
Manapla
Cadiz City
Sagay City
Escalante City
Silay City
Talisay City
Toboso
Bacolod City
Calatrava
Salvador Benedicto
Murcia
Bago City
San Carlos City
La Carlota City
Pontevedra
La Castellana
Hinigaran
Moises Padilla
Isabela
Binalbagan
Himamaylan City
Cauayan
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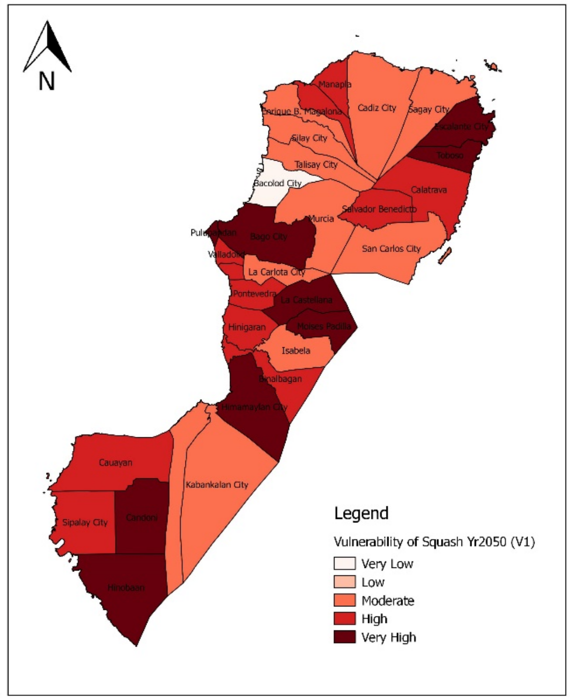
Sipalay City
Candoni
Hinobaan
Legend
Suitability of Squash Yr2050
Very Low
Low
Moderate
High
Very High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San Carlos City
La Carlota City
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Hinigaran
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Isabela
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Cauayan
Kabankalan City
Sipalay City
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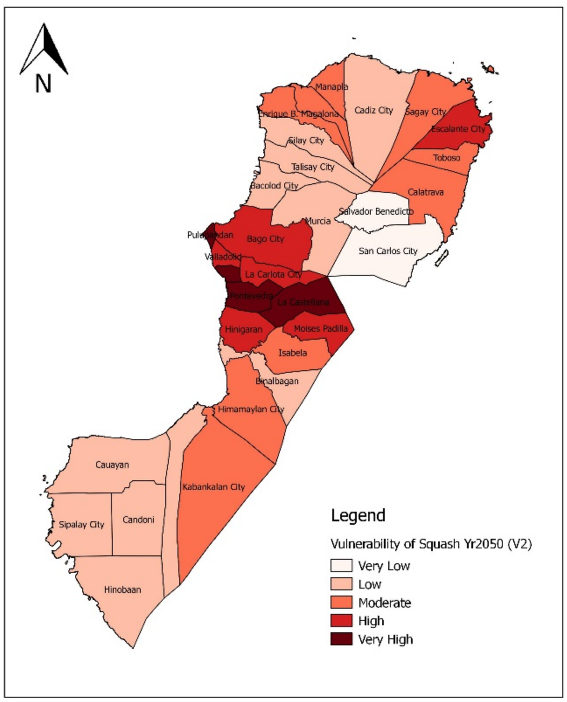
Legend
Vulnerability of Squash Yr2050 (V1)
Very Low
Low
Moderate
High
Very High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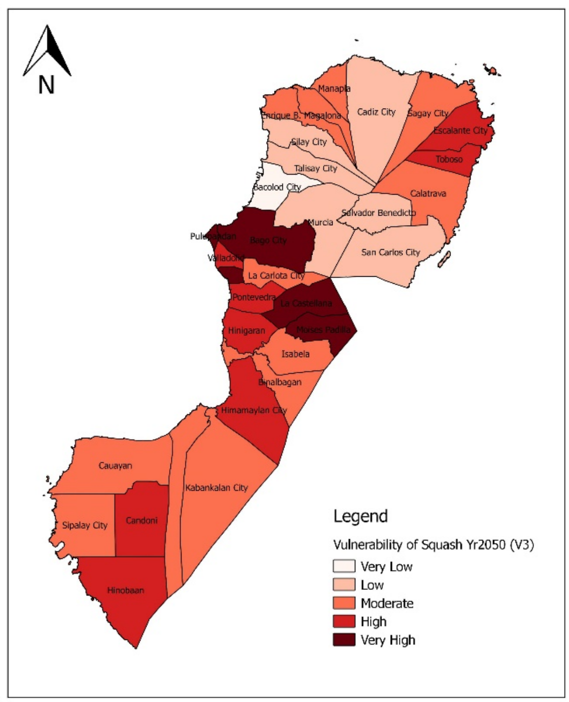
San Carlos City
La Carlota City
Pontevedra
La Castellana
Hinigaran
Moises Padilla
Isabela
Binalbagan
Himamaylan City
Cauayan
Kabankalan City
Sipalay City
Candoni
Hinobaan
Legend
Vulnerability of Squash Yr2050 (V2)
Very Low
Low
Moderate
High
Very High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San Carlos City
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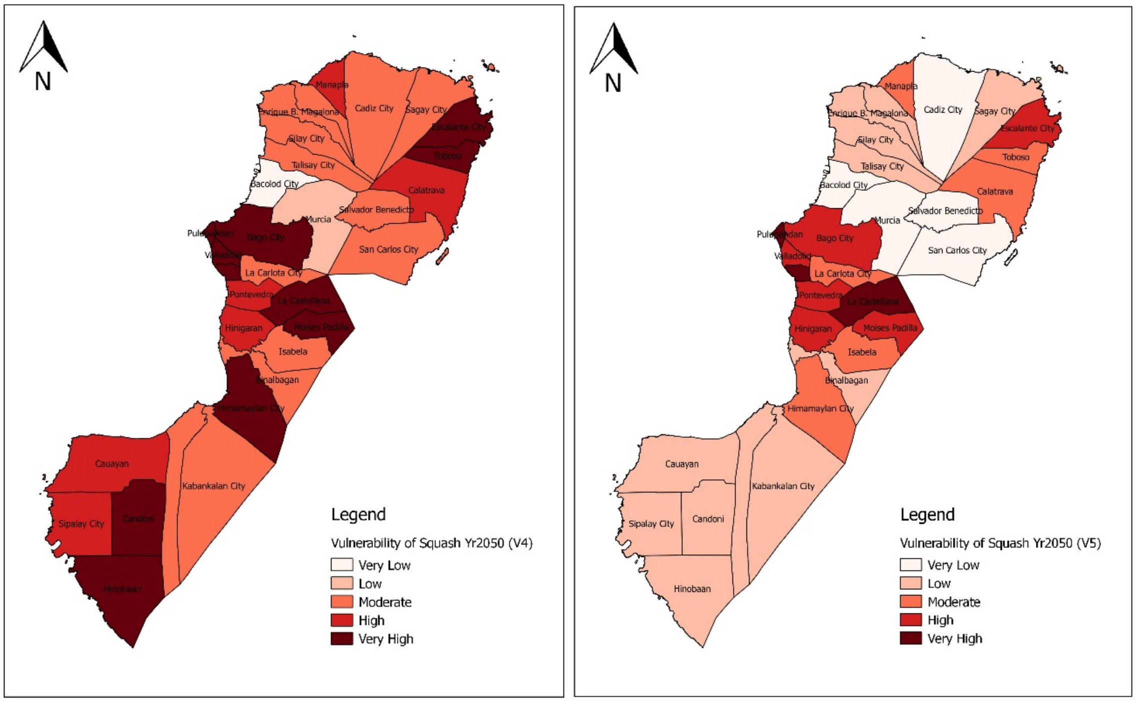
Pontevedra
La Castellana
Hinigaran
Moises Padilla
Isabela
Binalbagan
Himamaylan City
Cauayan
Kabankalan City
Sipalay City
Candoni
Hinobaan
Legend
Vulnerability of Squash Yr2050 (V3)
Very Low
Low
Moderate
High
Very High



Figs. 60-65. Maps of coffee vulnerability using different weights assigned to exposure, sensitivity and adaptive capacity.

Cost-Benefit Analysis

The CRA practice that is prevalent in Negros Occidental is organic agriculture, specifically organic red rice production. The CRA practice is actually shifting from direct seeded red rice production using traditional variety and chemical inputs as well as conventional production practices to transplanted red rice production using the same variety, pure organic in inputs and following the recommended production practices. The CRA Practices Investment Prioritization flyer is hereby attached. Although there are still adjustments that has to be made in the CBA tools which was developed by CIAT in order to come up with a more robust computation.

C. PROJECT MANAGEMENT

Summary and Conclusions

The results of the study clearly demonstrated the vulnerability of rice, corn, coffee, cacao, squash and napier to climatic changes as exhibited by the reduction in the very highly suitable areas to grow these crops to an increase in the low suitability. However, these results can be refined further if and when new bio-climatic data will have a better resolution other than the 1x1 km grid.

The CRVA methodology is a good tool in determining the changes in climatic suitability to grow crops at the municipal level. Also, the Investment Prioritization Guide is a good output that can be done to other priority crops in the region or province.

Implications and Recommendations

The great implication of this research is that it will serve as a guide for the Department of Agriculture and local government planners, most especially in the agriculture sector to plan and brace for the increase in population and improve productivity even with less land and water resources in the years ahead. It will also pose a big challenge to researchers to improve the productivity of crops by making it adaptive to climatic changes without adding to the GHGs in the atmosphere in the course of its production.

It is therefore recommended that the CRVA and CRA methodology be institutionalized in the regional and local offices of the Department of Agriculture, Office of the Provincial Agriculture, Bureau of Fisheries and Aquatic Resources and other agencies related to agriculture.

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