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Climate Risk Vulnerability Assessment: Basis for Decision Making Support for the Agriculture Sector in the Province of Iloilo

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This study was conducted to assess climate risks in the agri-fisheries sector of Iloilo Province using Climate-Risks Vulnerability Assessment (CRVA) framework. Crop suitability, hazard exposure and adaptive capacity of each municipality were the three components obtained to obtain the climate risk vulnerability of the province. There were forty-two municipalities and two cities surveyed to collect data for adaptive capacity. Typhoons, floods and erosion are the prevalent hazards identified in Iloilo Province through reports and secondary data. Geospatial & climate modelling tools were used to obtain the sensitivity of five priority commodities: rice, corn, eggplant, cacao and milkfish. These five commodities are exposed to hazards that make these crops sensitive and affect the suitability of crops. A hazard map showed that the Fifth District of Iloilo has high exposure to typhoons and erosion, while the lower portion of the Fourth District is exposed to floods. Rice, corn, cacao and eggplant are sensitive crops in the Northern part of Iloilo and show low suitability when projected to 2050. Likewise, milkfish will be vulnerable in flood-prone areas of the Fourth District of Iloilo in 2050. Dumangas, Lambunao, Passi City, San Enrique and San Rafael have a very high adaptive capacity index and Iloilo City has a high adaptive capacity. The very high adaptive capacity is owed to strong institutional, natural, social, economic, physical and human capital. While the Municipality of Batad has the highest normalised result of 1.00 for CRVA, it implies that the municipality has a high sensitivity of crops to any changes in temperature and/or precipitation, which will lead to low suitability of crops in the area. It has moderate exposure to hazard; however, it's weak social, institutional and natural capital greatly influence its vulnerability. Thus, Batad is the municipality considered the most vulnerable to climate risk. It is recommended to have projects and programs for the agriculture sector in the most susceptible areas.

Keywords: *Climate Risk Vulnerability Assessment, Agriculture Sector, Crop Suitability, Adaptive Capacity, Province of Iloilo, Iloilo State College of Fisheries, Philippines.*

Introduction

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. This was spearheaded by the DA System-wide Climate Change Office (DA SCCO), AMIA Phase 1 in 2015-16, to implement activities to strengthen the DA's capacity to mainstream climate change adaptation and mitigation strategies in its core functions of R&D, extension, and regulation. It is also designed complementary activities for building appropriate climate responsive DA support services. AMIA2 aims to invest in the launching of CRA communities - as the first 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 a unified and multi-stakeholder effort to operationalise CRA at the community level.

Climate change studies in the Philippines are emerging fast, focusing on different fields of sciences. Several climate change and vulnerability (VA) studies (Jose and Cruz, 1999, Badjeck *et al*., 2010; Sajise et al., 2012; Mamauag et al., 2013; Perez et al. 2013) have been conducted in the Philippines. This study will not result in any duplicate of these earlier studies. It would use the results of recent studies, including those cited above, to validate the climate change risks and suitability of selected agri-aqua commodities as climate-resilient livelihood options for Iloilo. Climate-Smart Agriculture (CSA) is not a single specific agricultural technology or practice that can be universally applied (FAO, 2013). It is an approach that requires site-specific assessments to identify suitable agricultural production technologies and practices. Scherr et al. (2012) suggested that agricultural systems can achieve climate-smart objectives, including improved rural livelihoods as well as climate change adaptation and mitigation through adopting a landscape approach. To be sustainable and climate-resilient, the needs of different stakeholders in a given landscape, land use planning, as well as management of natural resources, need to be coordinated across sectors and through a participative and consensus-based decision-making process. Achieving socio-ecologically sound landscape approaches will require building a national and local capacity to develop responsible and inclusive governance arrangements, which include improvements in tenure security and the recognition of the rights of individuals and groups (FAO 2012). Thus, the study will ensure that the communities in Iloilo and local level actors can assess the suitability of various commodities as to given changes in rainfall patterns, temperature, risks due to climate change and to develop climate-responsive adaptation mechanisms. This necessitates working closely with farming/fishing organisations and Local Government Units. (LGUs).

The research focuses on bringing all stakeholders into the process of identifying and understanding risks associated with climate change and assessing adaptation mechanisms/strategies that will build or improve the resilience of the communities and the livelihood options that are available in the communities. The sustainability assessment and mapping were done to understand how the interactions among climate and other drivers of change (e.g. rising temperatures, sea-level rise and pollution among others) impact key agriculture, aquaculture, fisheries production systems, value chains and livelihoods in the study areas. This study was the basis of the AMIA 2++ project in the identification of communities for pilot testing of agriculture interventions. The result of the study was also the basis of future projects and plans of the regional agriculture sector. These findings can assist the policymakers in decision making, that are needed to move forward and to facilitate and inform community leaders on climate change impact. Prioritisation is on the development that is necessary for the community and to create strategies to cope with and adapt (e.g. appropriate CRA practices) based on the projected climate change impact within the community. The study covers the Iloilo Province that focuses on the five (5) stakeholder identified commodities: rice, corn, cacao, milkfish and eggplant. The climate risks in Iloilo Province were assessed using geo-spatial and climate modelling tools.

Objectives

To assess climate risks in the region's agri-fisheries sector through geospatial & climate modelling tools, specifically;

- To determine the sensitivity of crops to hazards and suitability of current crops and projected to 2050
- To determine the adaptive capacity of the agriculture sector for each municipality of the province
- To determine the climate risk vulnerability of crops

Methodology

The study was conducted in the Province of Iloilo (Figure 1). Series of training was organised and facilitated by the AMIA 2-CIAT for SUCs that focused on action planning, and ISCOF GIS specialist was trained to various tools to layout the CRVA map for each region. With all the results of training, the regional team adopted these learning processes through project implementation.

Figure 1. Map of Panay Island with Iloilo Province highlighted as the sampling site

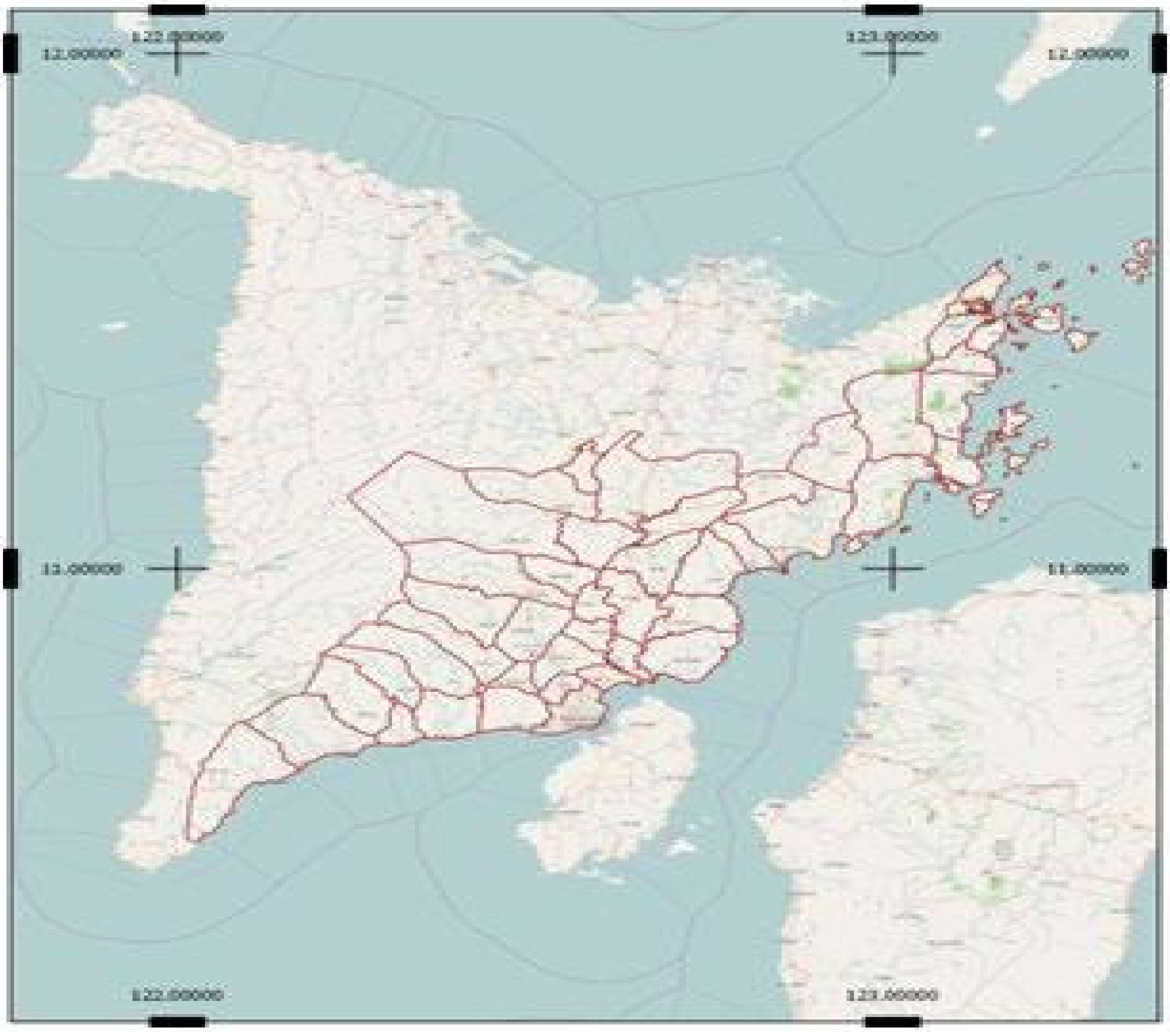
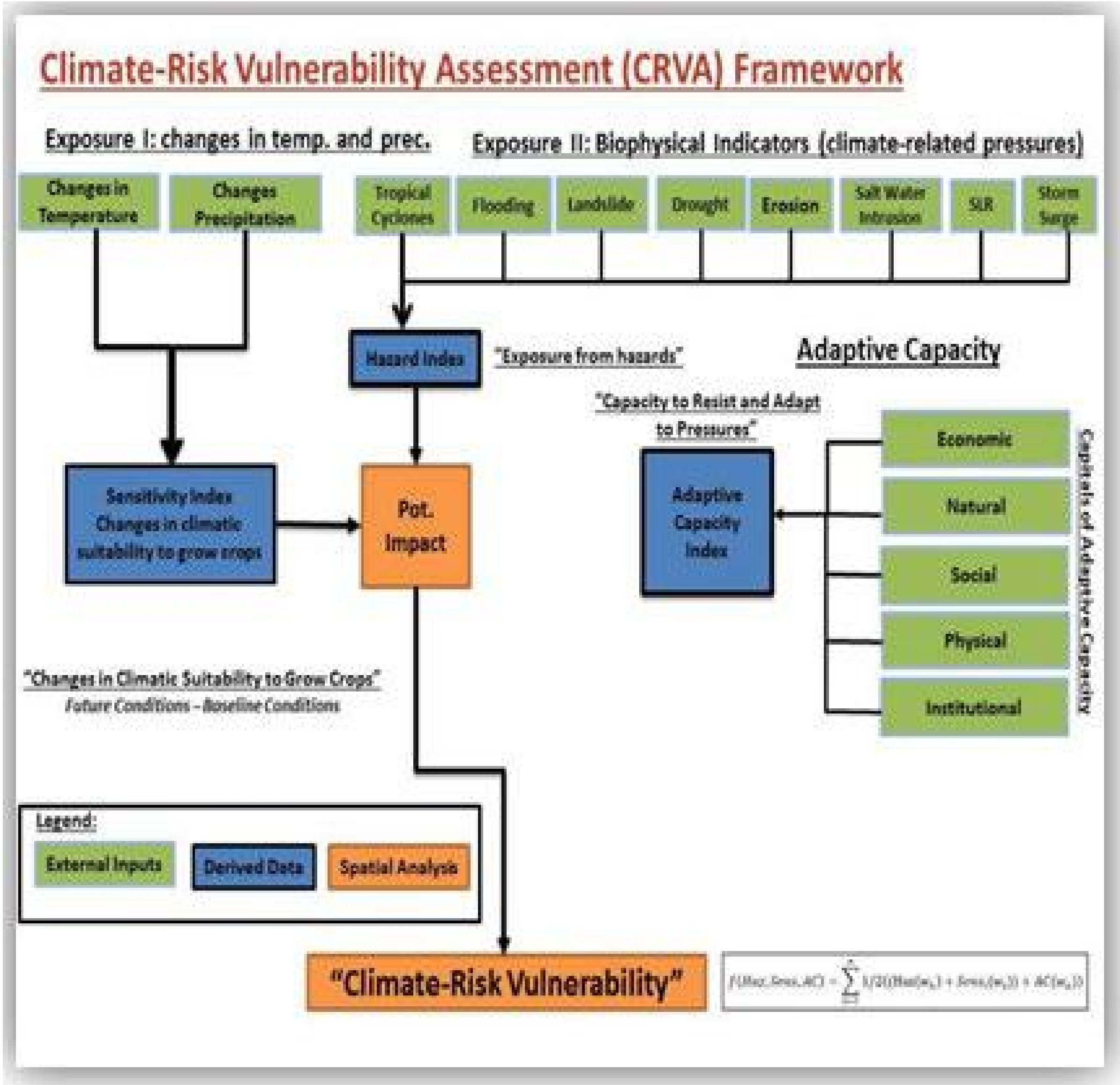
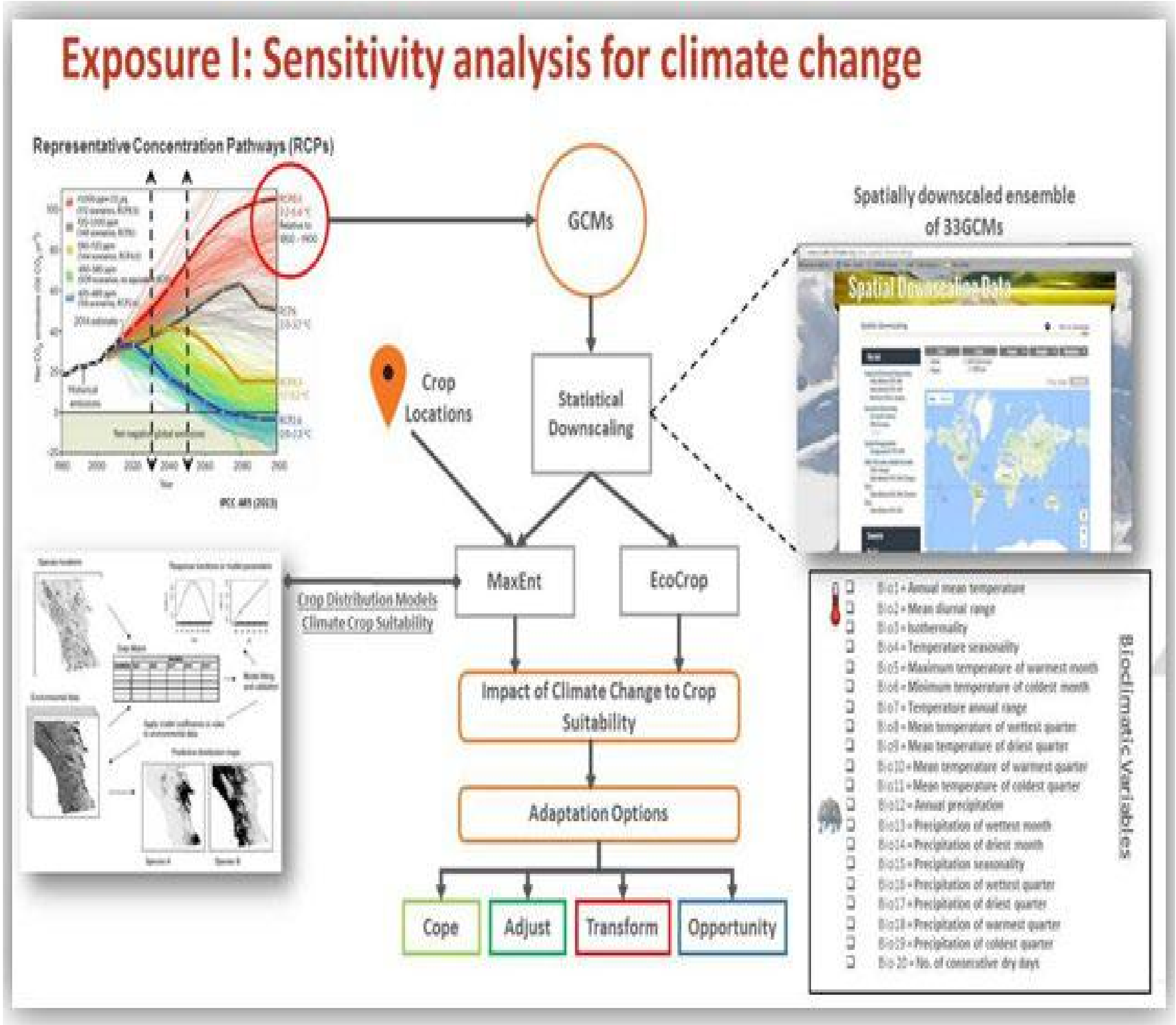


Figure 2. Climate-risks Vulnerability Assessment (CRVA) Framework



The assessment (CRVA) framework (Figure 2.) methodological framework formulated by AMIA-CIAT team has three (3) components: (1) sensitivity that determines the changes in climatic suitability to grow crops; (2) exposure of crop to hazards; and (3) its adaptive capacity to cope and adapt to climate change impacts. The vulnerability results can serve as assistance to the decision-makers to plan and make strategies to manage and resist the adverse effects of climate change.

Figure 3. Sensitivity Analysis Framework



Sensitivity analysis is one of the components of the CRVA framework. This method used Representative Concentration Pathways (RCPs) 8.5 combined with 33 GCMs (Global Climate Models) ensemble to provide input on climate models because it is most recent and policy-relevant. RCP 8.5 represents a future with higher emissions and is distinguished by the highest amount of greenhouse gas concentrations (Fahad et al., 2017). This can be done by statistically downscaling to 1km to predict scenarios with 20 bioclimatic variables using the Maxent Model. The output would be used to determine the impact of climate change on crop suitability (Present Condition and Year 2050).

The Province of Iloilo has five (5) priority commodities, namely; rice, corn, eggplant, cacao and milkfish. Changes in climatic conditions (e.g., change in temperature and precipitation) were used to measure the sensitivity of a particular crop. They determined the crop suitability based on climate-risk.

Table 1: Parameters and Data Sources of Climate Hazard for Region 6

Parameter	Source	Unit of measurement, spatial and temporal resolution
Typhoon	UNEP / UNISDR, 2013 (http://preview.grid.unep.ch/index.php?preview=data&events=cyclones&evcat=2&lang=eng	1-kilometer pixel resolution. An estimate of tropical cyclone frequency based on Saffir-Simposon category five (5) and higher from the year 1970 to 2009.
Flooding	AMIA multi-hazard map/baseline data from Mines and Geosciences Bureau, Department of Environment and Natural Resources (MGB, DENR	1:10,000 scale. Susceptibility of flood risk for the Philippines from the past 10 years
Drought	AMIA multi-hazard map/baseline data from the National Water Resources Board	Groundwater potential for the Philippines
Erosion	AMIA multi-hazard map/baseline data from the Bureau of Soils and Water Management (BSWM)	1:10,000 scale. Soil erosion classified from low to high susceptibility
Landslide	AMIA multi-hazard maps/baseline data from MGB, DENR	1:10,000 scale. Landslide classified from low to high susceptibility
Storm Surge	AMIA multi-hazard maps/baseline data from Disaster Risk and Exposure Assessment for Mitigation, Department of Science and Technology (DREAM, DOST)	
Sea level rise	AMIA multi-hazard map	
Saltwater Intrusion	AMIA multi-hazard map/baseline data from the NWRB	Groundwater potential for the Philippines

The ISCOF team considered exposure to hazards from secondary data, as shown in Table 1. This information from historical records of climate-related risks is considered to be a good representation of future climate.

Figure 4. Adaptive Capacity Weighting and Selection Process

Step 1: The dataset that was used to come up with the adaptive capacity index came from: National Competitive Council of the Philippines (NCCP), Philippine Statistics Authority (PSA), International Water Management Institute (IWMI), and National Mapping and Resource Information Authority (NAMRIA)

Step 2: Relevant variables were pre-selected from the database of NCCP, 2015

Step 3: Principal Component Analysis (PCA) and Random Forest was used to explore the geographic variances, correlation and feature importance of data across provinces and indicators. The shortlisted indicators were cross checked and some more variables were included to complete the representation of the other AC capitals.

Steps 4 and 5: Experts from DA (from different agencies), NEDA, FAO, NGOs and Academies were invited to the workshop. They were grouped into 2 clusters and ask to rank each of the indicators according to importance. Each group discussed and decided a common value/rate for each indicator. They were provided with 1-5 score/rates, where 5 was the highest/most important. Some of the variables were lumped into a single variable and were given a high score as suggested by experts. Overall weights for "Sensitivity (15%)", "Hazards (15%)", and "Adaptive Capacity (70%)" were also identified by the experts during the workshop.

Step 6: The values of the 32 indicators were integrated in the shape file municipal boundaries. Each of the indicators was normalised and were treated with equal weights. The sum of the 32 indicators provided the adaptive capacity index.

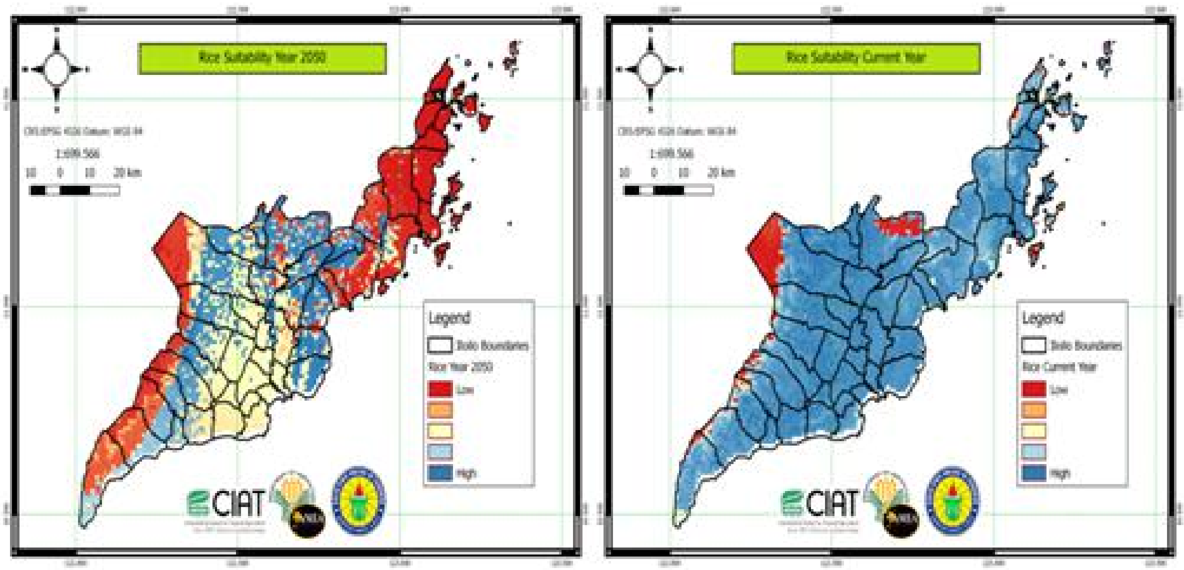
Step 7: Five equal breaks were arbitrarily used with 0-0.20 (Very Low), 0.20-0.40 (Low), 0.40-0.60 (Moderate), 0.60-0.80 (High), and 0.80-1.00 (Very High)

16 out of the 32 indicators came from different agencies, both from national & provincial levels, and were added to the data from the municipal level which included the rest of the indicators. 42 municipalities and 2 cities were surveyed to collect data for adaptive capacity. These included economic, natural, social, human, physical and institutional capital. Data was collected from the Municipal Planning and Development Office (MPDO), the Municipal Environment and Natural Resources Office (MENRO) and the Municipal Agriculture Office (MAO) some of the data needed are accessible at the office of Municipal Disaster Risk Reduction Management (MDRRMO). The interview was conducted using a validated checklist questionnaire.

Results and Discussions

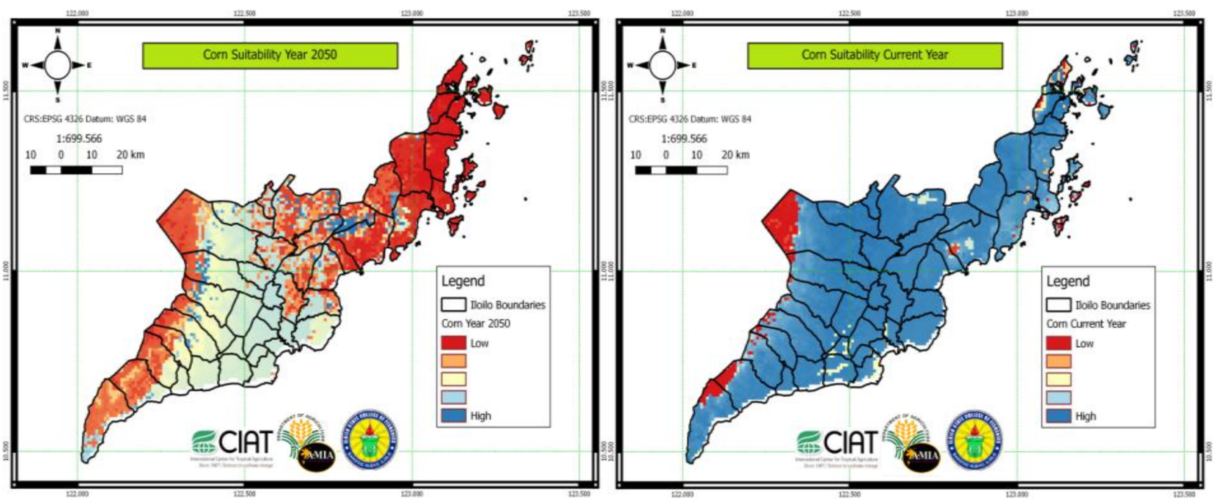
A. Crop Suitability Index

Figure 5. Current (2017) and 2050 projected Rice Suitability Index in the Province



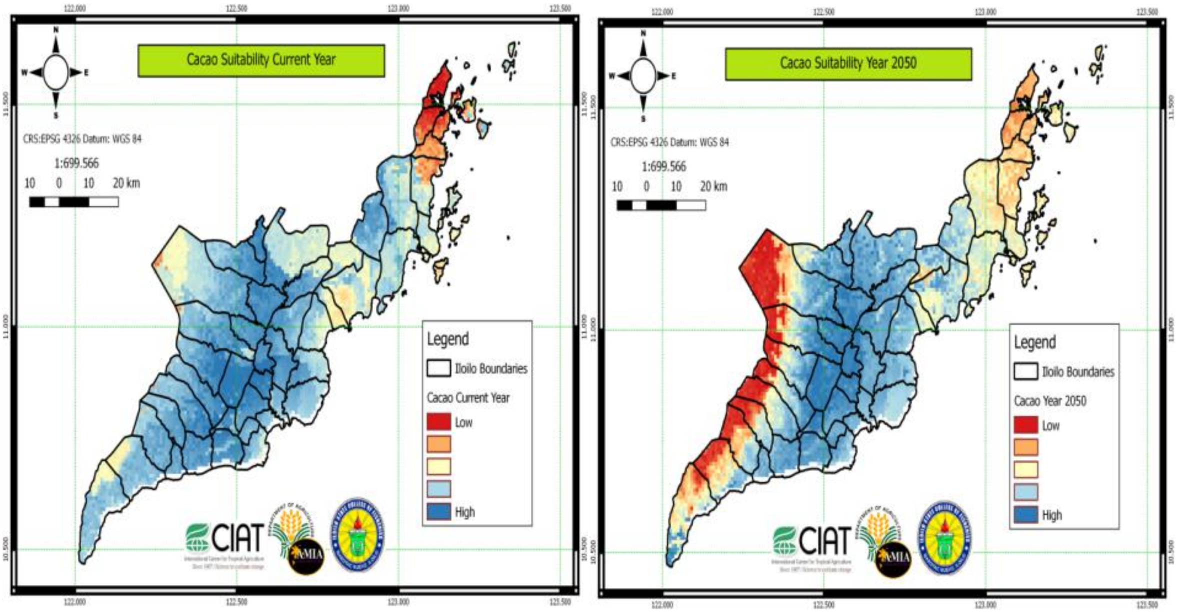
Rice currently has a high suitability for the entire province. However, it is projected to be less suitable in 2050 in the Northern part of Iloilo, as shown in Figure 5. The municipalities of Lambunao, San Enrique, San Rafael and the component city of Passi are expected to be moderately suitable for rice due to scarcity of water sources. The same with the municipality of Dumangas, which is due to saltwater intrusion in some of their rice land.

Figure 6. Current (2017) and 2050 projected Corn Suitability Index in the Province



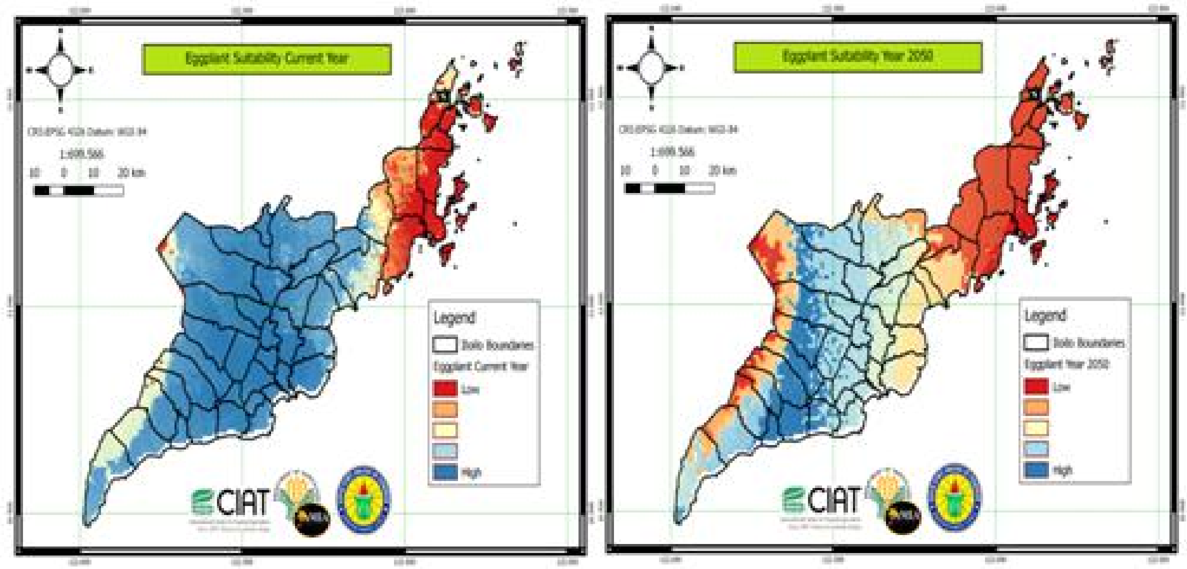
Corn is currently very highly suitable in the majority of the municipalities in the Province but projected to have very low suitability or to be crop sensitive in 2050 in the municipalities located in the Northern part of Iloilo such as Batad, Estancia San Rafael, Carles, San Dionisi, Barotac Viejo and Ajuy due to the area being highly exposed to hazards in the next decades, such as landslides, floods, typhoons and erosion.

Figure 7. Current (2017) and 2050 projected Cacao Suitability Index in the Province



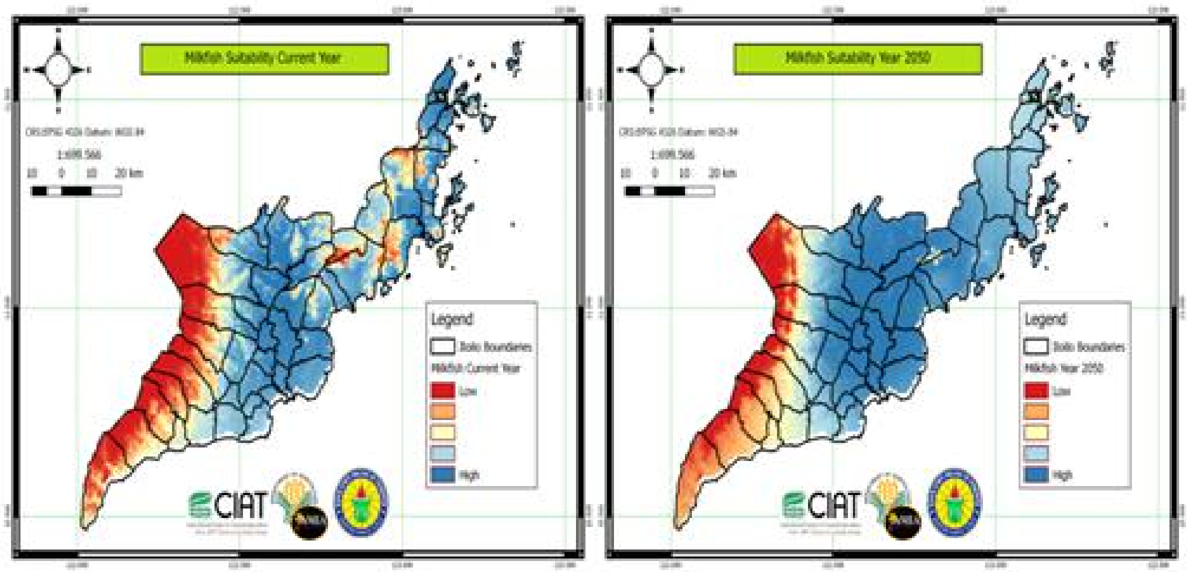
Cacao is highly suitable in the First, Second and , Third Districts of Iloilo, and in a portion of the Fourth District. There is “low suitability” in the municipalities of Carles, Estancia and Batad. It is projected that a part of the First, Second, Third and Fourth Districts will be highly suitable for cacao in 2050. The Northern portion of the Fifth District has a low suitability index and is projected to have low suitability in 2050. Furthermore, a portion of the municipalities of Lambuano, Janiuay, Alimodian, Leon, Tubungan, Igbaras, Miag-ao and San Joaquin have low suitability. Cacao in 2050 showed as a highly sensitive crop in the mountainous areas of Lambunao and other parts of the first district of Iloilo.

Figure 8. Current (2017) and 2050 Projected Eggplant Suitability Index in the Province



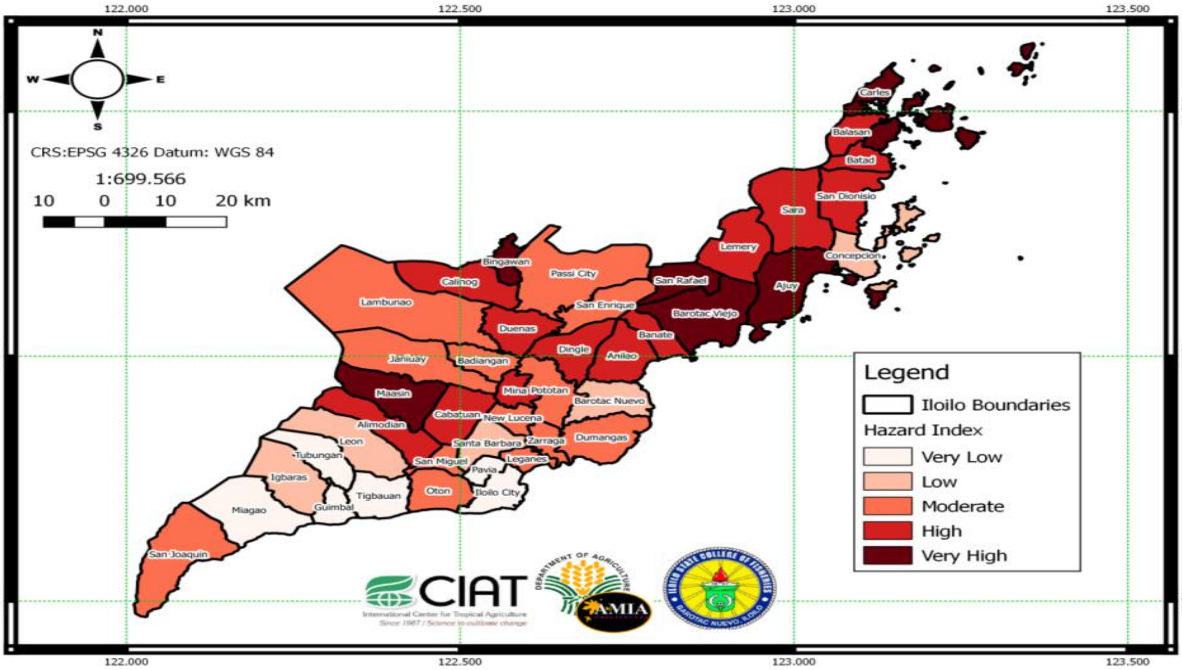
Eggplant currently has high suitability in the municipalities of the First, Second, Third, and Fourth Districts of Iloilo except for the municipality of San Joaquin. At the same time, there are portions of the Fifth District that had low suitability for eggplant. Furthermore, eggplant at 2050 projections showed a high sensitivity in the municipalities of the Fifth District, such as Carles, Balasan, Batad and Estancia. It also has high sensitivity in some mountainous parts of the First District towards Lambunao.

Figure 9. Current (2017) and 2050 projected Milkfish Suitability Index in the Province



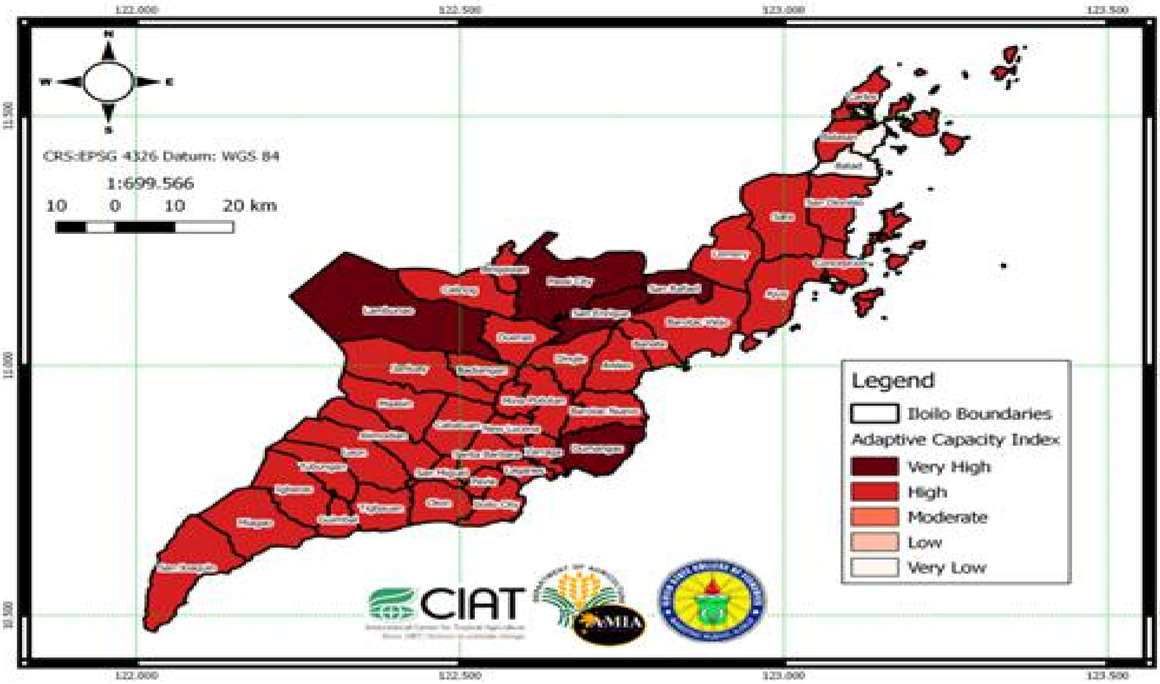
Milkfish is currently suitable in the locations identified as being a source of milkfish, such as Dumangas, Barotac Nuevo and a portion of the Fifth District, such as Ajuy. Whilst it is still projected in 2050 to be suitable in those areas, these municipalities are facing flooding as the primary hazard in the area.

Figure 10. Hazard Index in Iloilo Province



Hazards identified for Iloilo Province were typhoons, flooding and erosion. These three hazards were considered as the top three hazards for the Province of Iloilo. The hazard index of Iloilo Province is presented in Figure 10. Typhoon showed a high effect on the Fifth District of Iloilo, mostly these areas are considered as typhoon prone municipalities. Floods had a high impact in the municipalities of the Fourth District of Iloilo province; the prone municipalities are Dingle, Barotac Nuevo and Dumangas. Erosion would result in landslides showed that municipalities with higher slopes are caused by moderate hazard exposure. The hazard index showed (overlay of different hazards) that the Fifth District had a very high hazard exposure for the municipalities of Carles, Balasan and San Dionisio; high exposure for the municipalities of Sara, Concepcion, San Rafael and Lemery; moderate exposure for Ajuy and Barotac Viejo and likewise with the Fourth District municipalities of San Enrique, Dingle, Dumangas and Barotac Nuevo. Also, the Municipality of Badiangan had moderate hazard exposure while the rest of the municipalities in the Third District had a low and very low hazard index. This map (Figure 10) was used in the identification of areas that are highly exposed to climate hazards, at risk and this contributes to assessing the vulnerability index.

Figure 11. Adaptive Capacity Index in the Province of Iloilo



Iloilo City has high economic capital, as do the municipalities of Pavia and Concepcion. Sixteen municipalities of the province and the City of Passi have moderate economic capital while the rest of municipalities in the province are low in terms of economic capital. Also, Iloilo City has a very high human capital in terms of health and education. The municipality of Santa Barbara has high human capital. In contrast, the municipalities of Guimbal, Cabatuan, Janiuay, Calinog, Dumangas, Concepcion and Balasan have moderate human capital, and the rest are low.

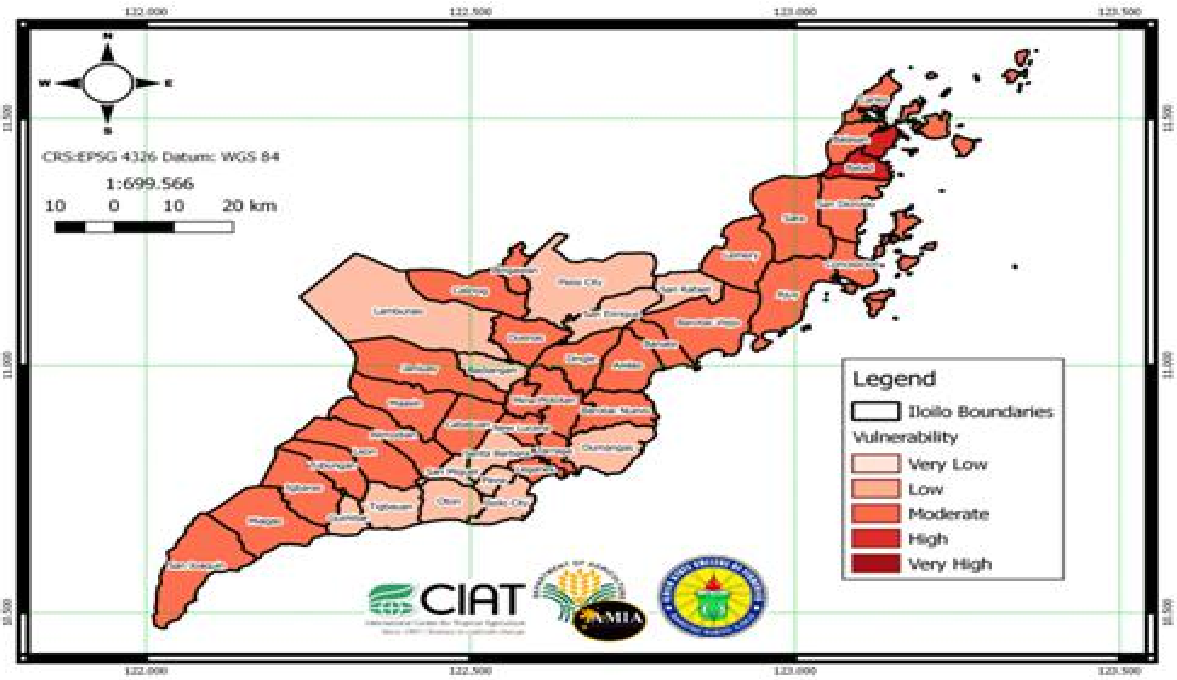
Natural capital, such as crop irrigation, natural resources and mangrove forests, are very high in the areas of San Joaquin, Miag-ao, Igbaras, Tubungan, Tigbauan, Carles, Dumangas and Concepcion. While, Cabatuan, Guimbal, Leon, Carles, Alimodian and Barotac Nuevo were identified as having high natural capital. Furthermore, natural capital is low in the municipalities of Oton, Duenas, San Enrique and Balasan, while very low in some areas that are not mentioned.

Physical capital includes: infrastructure investment, access to services, infrastructure network, amount of public transportation, telephone companies and mobile services. It was observed that it is very high in the municipalities of Miagao, Guimbal, Santa Barbara, Zarraga, Dumangas and Badiangan. There are twelve (12) municipalities identified as high in terms of physical capital, and there are also sixteen (16) municipalities identified as moderate. The rest of the municipalities are low in physical capital. Institutional capital, such as the presence of a functional Disaster Risk Reduction Management Plan (DRRMP), buffer stock and number of

Department of Agriculture (DA) officers and personnel are high in twenty-three (23) municipalities, eleven (11) are identified as high, and others are moderate.

Among the 44 municipalities and cities, Dumangas, Lambunao, Passi City, San Enrique and San Rafael have a “very high” adaptive capacity index, and Dumangas, Lambunao and Passi City were considered as First Class municipality. It is followed by Iloilo City and the rest of the municipalities in the province with high and moderate adaptive capacity indexes. At the same time, the Municipality of Batad has a “low” adaptive capacity index. The municipalities with a “very high” rating for adaptive capacity, as compared to other municipalities, is due to their strong capital in terms of economic, social institutional, human and physical. Thus, they have an edge and are more equipped for climate change (CC) impacts because of their rich natural capital (goods and services) that can support and satisfy the needs of the constituents. They have strong institutional capital such as functional DRRMP, and there is the presence of a climate field school along with equipped human capital that can greatly help to become an asset, and can build more in economic. From natural capital, human produces goods that reflect low poverty incidence rate on the said municipalities. There are various training and programs conducted in response to climate change and there is an active Disaster Risk Reduction Management Council (DRRMC) that facilitates communication to provide information through telephone, cell phones, radio and television. Also, the presence of the Early Warning System (EWS) can give the advantage to prevent and reduce the impact of disasters and hazards.

Figure 12. Climate-Risk Vulnerability Assessment in Iloilo Province



The results of the three (3) components of the climate risk vulnerability assessment, which include the sensitivity of crops, hazard exposure and adaptive capacity were considered in the most vulnerable municipality in changing climate. This was observed in the municipality of Batad with the highest normalised result of 1.00 located in the Northern portion of Iloilo Province. It implies that it has a high sensitivity of crops, which will lead to low suitability in the area that can significantly influence the level of vulnerability. Though its hazard exposure is moderate, it indicates that less exposure can also be determined the less vulnerable. On the other hand, the main factor that influences the vulnerability of the area is the adaptive capacity. As a result, Batad was considered to have a very low adaptive capacity due to the influence of low economic and human capital, and relatively low social capital. High social capital can build a high adaptive capacity to be more resilient and sustainable that then influences other social factors to be collaborative in a common challenge.

These findings can assist the policymakers in decision making that is needed to move forward and to facilitate and inform community leaders on climate change impact. Prioritisation of development is necessary for the community and creates strategies to cope with and adapt (e.g., appropriate CRA practices) based on the projected climate change impact within the community.

Conclusion and Recommendations

The five commodities identified in the province of Iloilo, rice, corn, cacao, eggplant and milkfish, are exposed and sensitive to hazards such as typhoons, floods and erosion. This exposure to hazards makes these crops sensitive and affects the suitability of crops in the area. Furthermore, rice, corn, cacao and eggplant are sensitive in the Northern Iloilo areas and showed low suitability for these crops as projected. Likewise, milkfish will be sensitive to areas prone to flood, such as in the lower portion of the Fourth District of Iloilo.

Dumangas, Lambunao, Passi City, San Enrique and San Rafael are the areas with “very high” adaptive capacity index, and are followed by Iloilo City with a “high” adaptive capacity. This high adaptive capacity is due to strong capital such as institutional, natural, social, economic, physical and human. Of the 42 municipalities and two (2) cities, Batad is considered the municipality that is the most climate risk vulnerable due to its moderate exposure to hazards and “low” adaptive capacity in terms of social, institutional and natural capital. These findings confirmed that climate change has a huge impact on these crops. It implies that there is a need to reshape the adaptation strategies to cope with climate change, that could be fit on the necessity of each municipality. It is also suggests strengthening LGU’s social capital, such as farming and fishing organisations, along with access to credit facilities, conservation of existing natural resources, additional infrastructure for agriculture facilities, provision of early warning devices and a series of training for a functional DRRMP.

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