CLIMATE RISK VULNERABILITY ASSESSMENT IN DAVAO ORIENTAL

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ABSTRACT

Climate risks pose a significant hazard to sustaining the productivity of the agriculture sector in the Philippines. One of the government strategies to manage climate risk is to established climate resilient agri-fishery (CRA) communities. A crucial step in targeting and planning for CRA communities is to assess climate-risk vulnerability at the Davao region's agri-fisheries sector through geospatial & climate modelling tools covering the province of Davao Oriental, Philippines.

According to IPCC 2014, Climate-risk vulnerability assessment (CRVA) has three components namely, Sensitivity Index, Hazard Exposure Index, and Adaptive Capacity Index. Sensitivity index is a measure of change in the climatic suitability of each crop in future condition. Climate suitability model was generated using MaxEnt software program for the current and future scenarios. Hazard Exposure Index is climate-exacerbated hazards. Lastly, the Adaptive Capacity Index is the rate of the ability of each municipality/city to adapt to climate change. The experts from different offices came up with a conclusion that the effect of this three components varies for sensitivity, hazards and adaptive capacity were 15%, 15%, and 70% respectively.

Results show that there will be fewer areas suitable for crop production in the study sites as a consequence of climate change. Lower class municipalities were found to be most vulnerable to climate risk due mainly to their low adaptive capacity.

The result of the CRVA study can be used to inform and guide decision-makers from government agencies, extension working groups, and private sectors on geographic areas that are vulnerable and in most need of development interventions, and the kind of interventions needed to minimize the level of cropping vulnerability and eventually establish resilience in cropping.

Keywords: AMIA, Climate Resilient Agriculture (CRA), GIS, Maximum Entropy Model (MaxEnt), Sensitivity, Hazards, Adaptive Capacity, Vulnerability

INTRODUCTION

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

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

Through the AMIA Component 1 project in 2015–2016, the DA has undertaken vulnerability assessment focusing on key hotspots for risks 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 Climate-Risk Vulnerability Assessment (CRVA).

A full CRVA is essential to enable AMIA 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.

Furthermore, AMIA Phase 2 project in 2016-2017 already undertaken Climate-risk Vulnerability Assessment in nine (9) areas across the country but only two provinces in each Davao region namely, Davao City and Davao del Sur. Thus, there is a need to replicate CRVA in the other adjacent province in the region. The provinces that will undertake CRVA will be the province of Davao Oriental.

Objectives

The overall objective is to assess the climate risk vulnerability in the province of Davao Oriental (Region XI).

Specifically, this project intends to meet the following objectives:

1. To model the current and future suitability distribution of different crops using niche modelling tools.
2. To assess the extent of climate related hazard in the two provinces.
3. To assess the adaptive capacity of the different cities/municipalities in the two provinces.

METHODOLOGY

Geospatial assessment of climate risks

Climate-Risk Vulnerability Assessment has three key components.

1. **Sensitivity:** The increase or decrease of climatic suitability of selected crops to changes in temperature and precipitation.
2. **Hazard:** The nature and degree to which a system is exposed to significant climate variations (IPCC 2014).
3. **Adaptive Capacity:** The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. (IPCC 2014).

The detailed composition of each component is visualized in Figure 1. The resulting vulnerability assessment permits evidence based spatial targeting of agricultural extension and financial investment in areas most at risk to a specific hazard, crop or lack of adaptive capacity.

The team selected the top commodity produced in the region that will be assessed to determine its vulnerability for climate change. This include crops such as banana, cacao, coconut, corn, eggplant, mango, rice, rubber, squash, tomato and tilapia. Each crops were assessed its vulnerability for the year 2050.

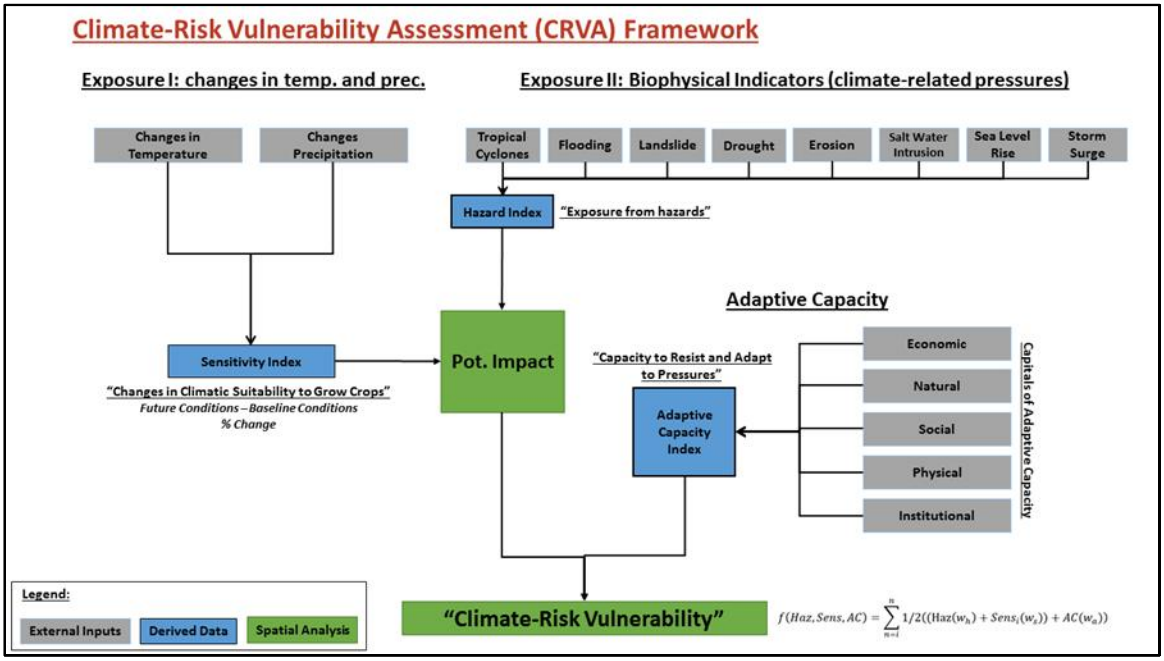


Figure 1. CRVA framework

SENSITIVITY INDEX

The sensitivity of the crop was assessed by determining the change in climatic suitability of the crops for the year 2050 in contrast with the baseline crop suitability. MaxEnt software was used to generate suitability of each crop. The first step is to assess the baseline (current climate condition) crop suitability which is based on the condition that a species is predicted to occur at a particular location if it approximately matches the environmental condition where it is observed. The second step is to predict the location of a species on a particular time slice if it matches the environmental condition where it is observed in the baseline condition.

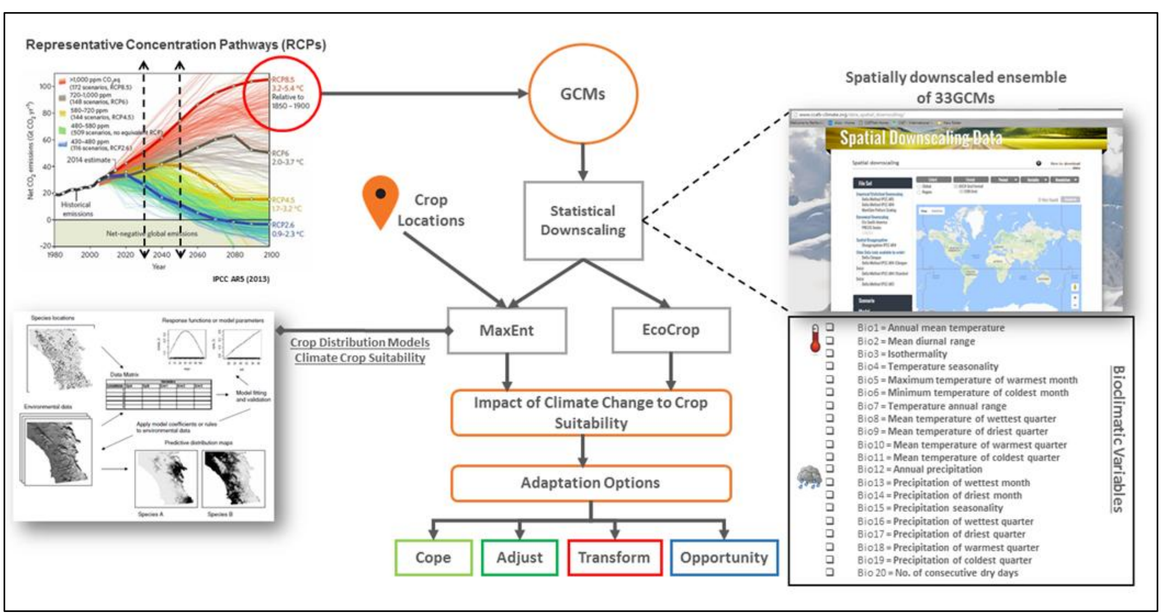


Figure 2. Sensitivity framework

Environmental Layers

Species are affected by both climatic and non-climatic factors. Climatic change can impose physiological constraints on species and therefore can affect species distributions to varying degrees. The relationship between climate and the distribution of a species throughout a landscape varies due to local adaptation and other factors, such as dispersion constraints related to habitat availability (O'Donnell, M and Ignizio, D., 2012).

A set of selected 20 bioclimatic variables was chosen to assess climate suitability of crops and it is described in table 1. This bioclimatic variables was from Wordclim dataset (available at Worldclim.org) (Hijman, xxxx).

Table 1. List of bio-climatic variables and its description

Parameters	Description
Temperature Related	
Bio 1 - Annual mean temperature	Annual mean temperature derived from the average monthly temperature.
Bio 2 - Mean diurnal range	The mean of the monthly temperature ranges (monthly maximum minus monthly minimum).
Bio 3 – Isothermality	Oscillation in day-to-night temperatures.
Bio 4 - Temperature seasonality	The amount of temperature variation over a given year based on standard deviation of monthly temperature averages.
Bio 5 - Maximum temperature of warmest month	The maximum monthly temperature occurrence over a given year (time-series) or averaged span of years (normal).
Bio 6 - Minimum temperature of coldest month	The minimum monthly temperature occurrence over a given year (time-series) or averaged span of years (normal).
Bio 7 - Temperature annual range	A measure of temperature variation over a given period.
Bio 8 - Mean temperature of wettest quarter	This quarterly index approximates mean temperatures that prevail during the wettest season.
Bio 9 - Mean temperature of driest quarter	This quarterly index approximates mean temperatures that prevail during the driest quarter.
Bio 10 - Mean temperature of warmest quarter	This quarterly index approximates mean temperatures that prevail during the warmest quarter.
Bio 11 - Mean temperature of coldest quarter	This quarterly index approximates mean temperatures that prevail during the coldest quarter.
Precipitation Related	
Bio 12 - Annual precipitation	This is the sum of all total monthly precipitation values.
Bio 13 - Precipitation of wettest month	This index identifies the total precipitation that prevails during the wettest month.
Bio 14 - Precipitation of driest month	This index identifies the total precipitation that prevails during the driest month.
Bio 15 - Precipitation seasonality	This is a measure of the variation in monthly precipitation totals over the course of the year. This index is the ratio of the standard deviation of the monthly total precipitation to the mean monthly total precipitation and is expressed as percentage.
Bio 16 - Precipitation of wettest quarter	This quarterly index approximates total precipitation that prevails during the wettest quarter.
Bio 17 - Precipitation of driest quarter	This quarterly index approximates total precipitation that prevails during the driest quarter.
Bio 18 - Precipitation of warmest quarter	This quarterly index approximates total precipitation that prevails during the warmest quarter.
Bio 19 - Precipitation of coldest quarter	This quarterly index approximates total precipitation that prevails during the coldest quarter.

Bio 20 - Number of consecutive dry days	Consistent number considered as dry days.

This 20 bioclimatic variables were generated base on the thirty-three (33) Global Circulation Model (GCM) developed by Consultative Group for International Agricultural Research (CGIAR) on one of its project called Climate Change, Agriculture and Food Security (CCAFS). This GCM is a type of climate model that employs a mathematical model that represent physical processes in the atmosphere, ocean, cryosphere and land surface. Furthermore, this model is the most advanced tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations.

This GCM's were based on the RCPs used for climate modelling. This RCPs describe possible climate futures, all of which are considered possible depending on how much greenhouse gases are emitted in the years to come. This RCPs were governed by the estimated rate of carbon footprint emitted into the atmosphere. Every rate of carbon emission has a number of possible scenarios that represent a future trajectory as shown in figure 3. This scenarios were interpolated to define a concentrated path called Representative Concentration Pathways (RCPs).

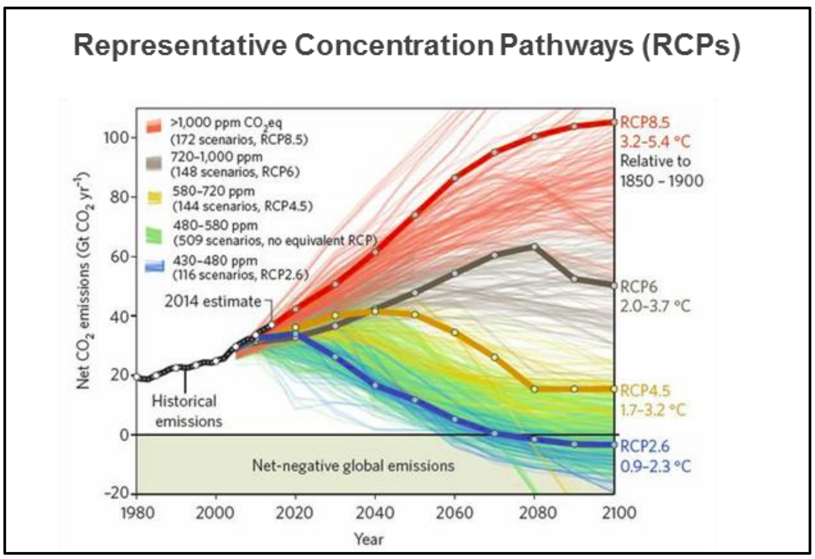


Figure 3. Graph of the different scenarios

Furthermore, there were four (4) RPC's adopt by Intergovernmental Panel on Climate Change (IPCC), namely, RCP2.6, RCP4.5, RCP6, and RCP8.5. This four RCPs are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0, and +8.5 W/m2, respectively). RCP8.5 was used by this study because it was the most recent and policy relevant in the global trend.

Moreover, this twenty (20) Bioclimatic variables was then spatially downscaled to 1kmx1km resolution. The method of downscaling this dataset was discussed on the webpage of ccafs-climate.org. The detailed process in generating this 20 bioclimatic variables was showed in figure 4.

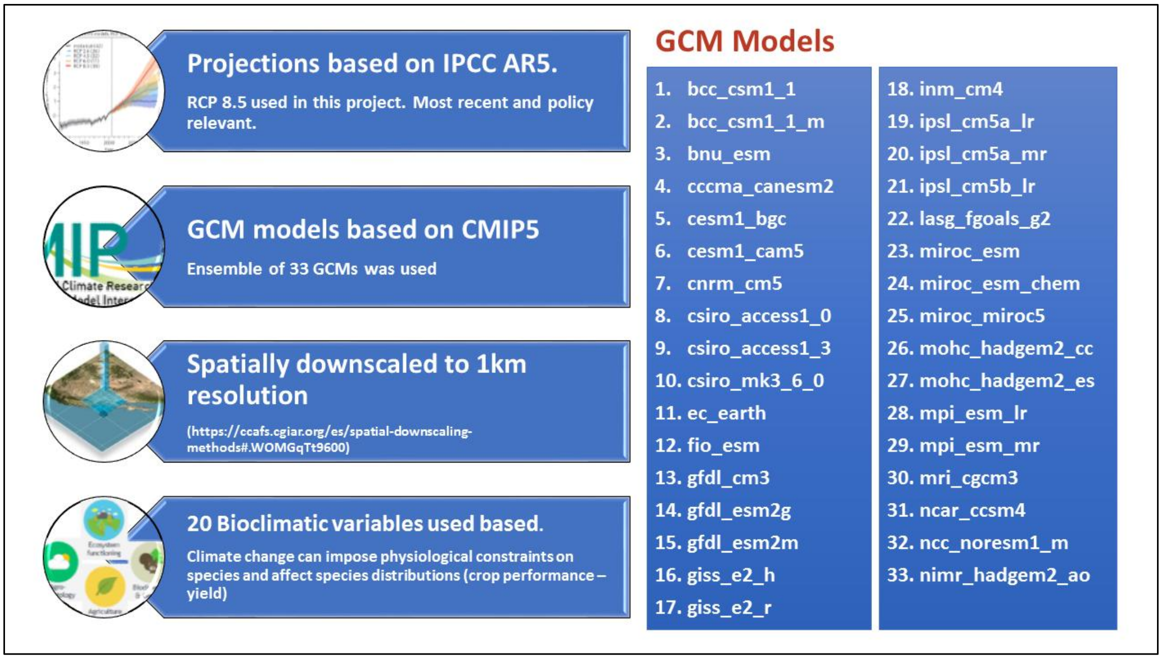


Figure 4. Process on how bioclimatic variables generated

Crop Selection and Presence Data Collection

The main criteria for selecting the crops are based on two factors: 1) crops are important for food security, and 2) crops are important sources of cash. The crops were classified into grains (rice and maize), vegetables (squash, tomato, and eggplant), livestock forage (napier), and integrated farming (cacao, coffee, rubber, mango, and banana). It is also important to emphasize that we chose forages as proxy for livestock, but we did not run the sensitivity analysis because of insufficient points across the regions.

In determining the point data for crop occurrence, the project team conducted data gathering from local agricultural offices, which include crop production and distribution. With the support of DA-RFO 11, a workshop entitled "Participatory Workshop on Data Collection for Crop Occurrence" was conducted. This was participated by the personnel from the city and municipal agricultural offices of Davao Oriental. The output of this workshop was a crop occurrence map.

During the workshop, the team provides satellite imaged maps of each city/municipalities that show barangay boundary, road networks, and river networks to easily identify the locations as shown in Figure 5. This maps also have a 1kmx1km grid line that corresponds to the MaxEnt requirement that only one crop occurrence point will put in every raster cell. This was to ensure that the generated suitability map had a high accuracy. The agricultural technicians and extension workers were tasked to locate the crops in their respective areas.

Figure 6. Sample of satellite imaged map used in the workshop.

Some of the Municipal Agriculture Office who was not able to join the workshop were individually visited and the team conducted a brief orientation of the project. Also, a short-lived workshop was conducted and maps were given to locate the crops.

Engr. Tabañera (Project Leader) presented the rationale of the project and CRVA framework to the personnel of MAGRO Lupon. Afterwards, the AEW's of MAGRO-Lupon map the crops in the Municipalities of Lupon.

The output of this workshop was manually encoded in GIS Software to give each point data a spatial reference. The longitude and latitude of each point data were determined and transferred to a .csv excel file. This data then inputted to MaxEnt software to generate climatic suitability for each crop for the year 2050.

Crop Prediction Models

In generating models for crops climatic suitability, The Maximum entropy (Maxent) model was used because of its robustness (able to show most important variable that affects crop distribution). Maxent is a niche modeling method that has been developed involving species distribution information based only on known presences and is a general-purpose method for making predictions or inferences from incomplete information.

Climate suitability of crops was assessed using a two-step process: First, the model was run and assessed for baseline conditions. We employ two ways to assess the performance of the model: 1) value of the "Area under curve" or AUC if greater than 85%, and 2) visual inspection where a crop is reported to be present. For instance, for Rubber, we should not expect a higher suitability prediction in low laying areas, because the majority of those crops is present in the upland areas. Then we should also expect a higher suitability in upland areas. Second, if those criteria for step 1 was satisfied, then we run it for future conditions.

The difference (expressed as percentage) in future and baseline suitability determines the climate change crop suitability, and reflects the degree of crop sensitivity to changing environmental conditions. Higher change in a negative direction reflects higher impact of climate change that will loss the crops climatic suitability. Sensitivity index for each municipality was calculated by determining the average sensitivity on each municipal boundaries and categorized as of what sensitivity index it falls. An index was developed from -1.0 to 1.0 for CRVA (Table 2). An index range from 0.25 to 1.0 indicates a loss in suitability, while -0.25 to -1.0 indicates a gain in suitability.

Table 2. Percent change of suitability between future and baseline condition and its corresponding sensitivity index.

Percent Change (%)	Sensitivity Index	Description
-50 – -100	1	Negative (Loss)
-25 – -49	0.5	
-5 – -24	0.25	
-5 – 5	0	No Change
5 – 24	-0.25	Positive (Gain)
25 – 49	-0.5	
50 – 100	-1	

The average sensitivity index for each municipalities was integrated into a shapefile of municipal boundaries. The resulted dataset was a shapefile of the cities/municipalities boundaries with an attribute containing its city/municipal name and its corresponding sensitivity index.

HAZARD INDEX

The development of a hazard index relies on spatial analysis of the weighted combination of different historical climate-related natural hazards in the Philippines using data (Table 3) that are open-sourced or developed by partner institutions, such as the Department of Agriculture (DA). Eight (8) hazards were identified for the Philippines, and these are typhoon, storm surge, flood, drought, erosion, landslide, saltwater intrusion and sea level rise. Seven out of eight hazard dataset used in this study was from the output of the Adaptation and Mitigation Initiative in Agriculture (AMIA) phase 1 project of the Department of Agriculture and are described below:

Table 3. List of hazards datasets and its sources

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. Estimate of tropical cyclone frequency based on Saffir-Simposon category 5 and higher from 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 Philippines from the past 10 years
Drought	AMIA multi-hazard map / baseline data from National Water Resources Board	Groundwater potential for the Philippines
Erosion	AMIA multi-hazard map / baseline data from Bureau of Soils and Water Management	1:10,000 scale. Soil erosion classified from low to high susceptibility
Landslide	AMIA multi-hazard maps / baseline data from MGB, DENR	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

With the use of GIS Software, this hazard datasets were normalized to generate new datasets with a boolean values of 1 (with hazard) and 0 (no hazard). In addition, the resulting datasets were averaged in associated with its municipal boundary to determine the extent of the effect of this hazards. The resulted dataset was a shapefile with an attribute containing the name of the city/municipality and its corresponding hazard effect.

Furthermore, each datasets containing the averaged hazard effect for each municipality was multiplied by its weighted percentage to generate its hazard index. The resulted datasets was a shapefile with an attribute containing the municipal name and its hazard index.

ADAPTIVE CAPACITY INDEX

Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2014). Adaptive capacity one of the component of vulnerability assessment. It was also one of the three components when measuring resilience, in addition to absorptive coping capacity and transformative capacity.

The adaptive capacity for this vulnerability assessment was a group of several indicators. A single indicator cannot give a consistent status of the correct level of the adaptive capacity. This indicators are group into different capitals which will best describe how well and with which tangible and intangible assets a population can cope with climate change and variability. This capitals are economic, natural, human, physical, and institutional capital. There are many indicators that could form a strong adaptive capacity index, but data availability was a driving factor in establishing the final adaptive capacity index. This vulnerability assessment is aiming to provide a high resolution analysis on municipality level as this is where most socio-economic data can be derived.

To generate the adaptive capacity, CIAT gave the list of indicators that was needed to determine the adaptive capacity index. The data for each indicator was collected from various government agencies like LGU's of each municipality, Provincial Agricultures Office, Provincial Planning, National Competitiveness Council (NCC), Philippine Statistics Authority XI, DepED XI and DA-RFO XI. The list of indicators with its corresponding capitals was showed in table 5. Some of this indicators was not included in the analysis of the adaptive capacity because some municipality has no data available or the data was the same for all the municipalities across the province.

Table 5. Adaptive Capacity Indicators

CAPITAL	INDICATORS
Economic Capital	Average Yield
	Average Yield
	Municipality Class
	Ownership of assets – household appliances, equipment, etc.
	Households have electricity
	Households with access to safe water
	Households have a good sanitation
	Access to credit
	Commodity price fluctuation
	Poverty Incidence

	Daily Minimum Wage Rate (Agricultural)
	Receipt of remittances
	Agricultural insurance
	Employment in agriculture
Natural Capital	Supporting ecosystems and their health (e.g. mangroves, forests, lakes, coral reefs)
	Groundwater availability
Human Capital	Education level ((i) literacy rate (ii) % of school enrollment)
	Quality of education in local schools (Teacher-to-Student ratio, Number of schools buildings, Classroom to student ratio)
	Adults in household
	Health (Number of health center, Number of health workers)
	Nutrition sufficiency
	Police-to-Population Ratio
Physical Capital	Land tenure
	Average farm size
	Value of machinery and equipment owned
	Access to post-harvest infrastructure
	Access to irrigation infrastructure
	Reliable infrastructure
	Market access
Anticipatory Capital	Disaster preparedness committee
	Existing early warning systems
	Access to early warning
	information via Radio, TV, or meetings
	Access to communication technology: cell phone, internet

In formulating the adaptive capacity index. Data in each indicators was normalized and was treated with equal weights. The sum of the normalized value of all the indicators was further normalized to provide the adaptive capacity index. This adaptive capacity index for each municipalities was integrated into a shapefile of municipal boundaries. The resulted dataset was a shapefile of the cities/municipalities boundaries with an attribute containing its city/municipal name and its corresponding sensitivity index.

Overall Vulnerability

The values of the sensitivity index (all crops), hazard index, and adaptive capacity were merged into one shapefile of the municipal boundaries. The weights that were used to determine vulnerability were "Sensitivity (15%)", "Hazards (15%)", and "Adaptive Capacity (70%)". This weights were formulated during a workshop participated by experts from different government sectors and NGO's. In addition, five equal breaks were arbitrarily used to rate the vulnerability. Specifically, 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).

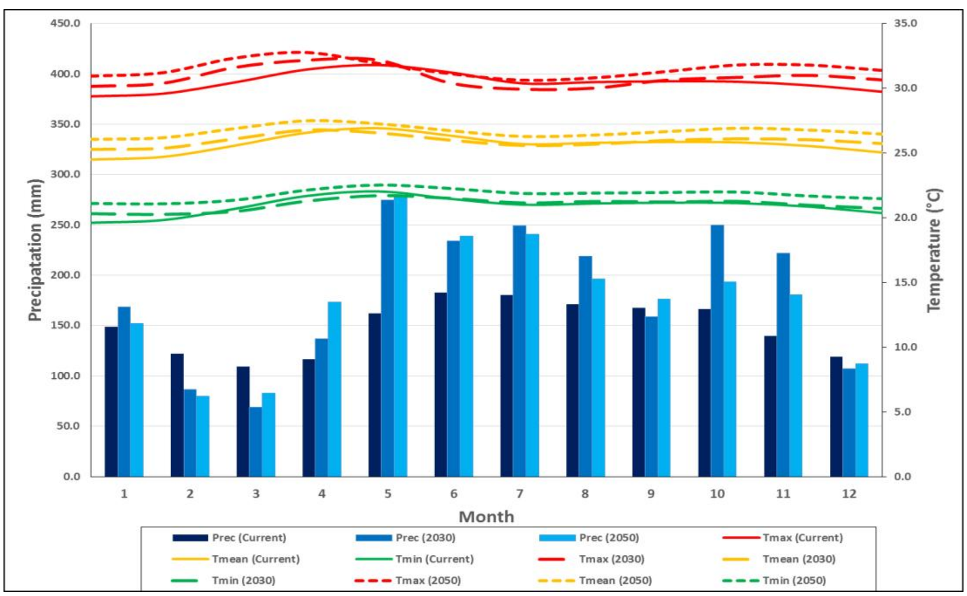
DISCUSSION

PREDICTED CLIMATE CHANGE FOR DAVAO ORIENTAL

After downscaling monthly averaged data of GCMs to the local level we extracted 20 bioclimatic variables from current and future (2030 and 2050) climate data and generated a general climate change description for Davao Oriental. The province fall under Type IV which means rainfall is more or less evenly distributed throughout the year.

According to the future projection from Worldclim, the temperature in Davao Oriental will increase and the average increase is 1.0°C for 2050 passing through 0.2°C in 2030. The mean daily temperature range decreases from 9.6°C to 9.8°C in 2050. While Rainfall Increase slightly from an average of 2136 millimeters to 2234 millimeters by 2050 passing through 2186 in 2030. The maximum number of cumulative dry months decreases from 4 months to 2 months in 2050.

Overall climates becomes more seasonal in terms of variation throughout the year with temperature in specific districts increasing by about 1.2°C by 2030 and 2.1°C by 2050 and more seasonal in precipitation with the number of dry months decreasing from 4 to 3 months.



General climatic characteristics for Davao Oriental

- The rainfall increases from 2136 millimeters to 2234 millimeters in 2050 passing through 2186 millimeters in 2030.
- Temperatures increase and the average increase is 2.1 ºC passing through an increment of 1.4 ºC in 2030.
- The mean daily temperature range increases from 9.6 ºC to 9.7 ºC in 2050 passing through 9.8 ºC in 2030.
- The maximum number of cumulative dry months decreases from 4 months to 2 months.

Extreme conditions

- The maximum temperature of the year increases from 30.5 ºC to 32.7 ºC while the warmest quarter gets hotter by 2.2 ºC in 2050.
- The minimum temperature of the year increases from 18.9 ºC to 21.0 ºC while the coldest

quarter gets hotter by 2.1 ºC in 2050.

- The wettest month gets wetter with 288 millimeters instead of 265 millimeters, while the wettest quarter gets wetter by 12 mm in 2050.
- The driest month gets drier with 97 millimeters instead of 99 millimeters while the driest quarter gets wetter by 13 mm in 2050.

Climate Seasonality

- Overall this climate becomes more seasonal in terms of variability through the year in temperature and more seasonal in precipitation.

Figure 8. Climate change predictions for Davao Oriental.

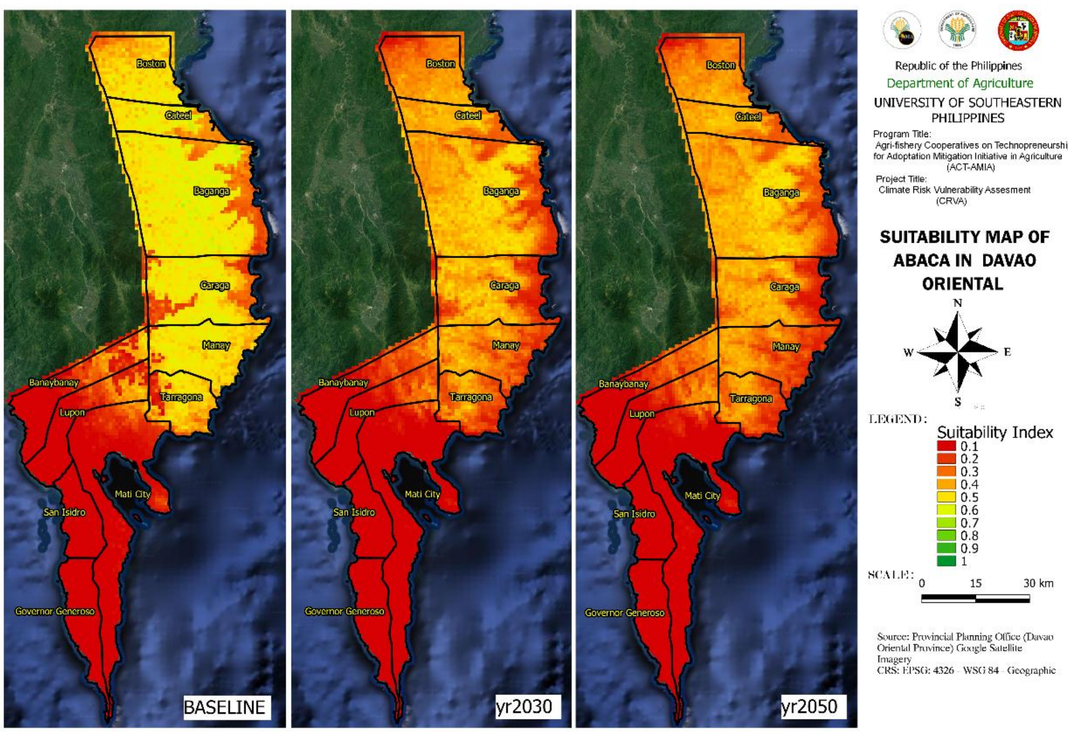
1.1.1. SUITABILITY AND SENSITIVITY INDEX

Impact of climate change on crops

In general, Davao Oriental may experience an intense rainfall pattern as the wettest months get wetter but a minimal decrease in rainfall during those driest months. Also, the maximum number of cumulative dry months decreases. This may entails that the region will most likely experience La Nina phenomenon in the future. Furthermore, temperature will generally increase by more or less 2.1 °C while the maximum temperature may reach up to 32.7 °C.

Due to these extreme climatic condition, the distribution of suitability of crops will affect quite seriously by 2050. This will cause a general decrease of areas suitable for all the crops and reduce areas which currently possess high climatic suitability for crop production. Climatic suitability is predicted to climb up altitudinal gradients to currently cooler climates.

Figure 9 shows the climatic suitability of crop for the baseline condition as well as for the future condition.



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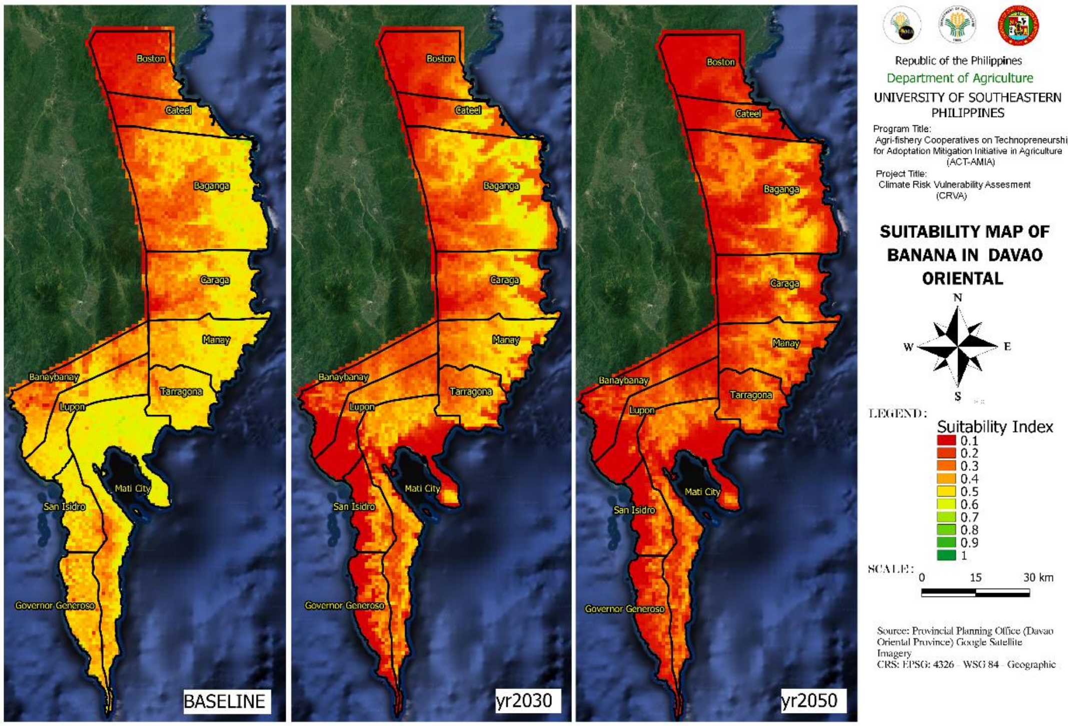
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Department of Agriculture
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Agri-fishery Cooperatives on Technopreneurship for Adoptation Mitigation Initiative in Agriculture (ACT-AMIA)
Project Title:
Climate Risk Vulnerability Assesment (CRVA)
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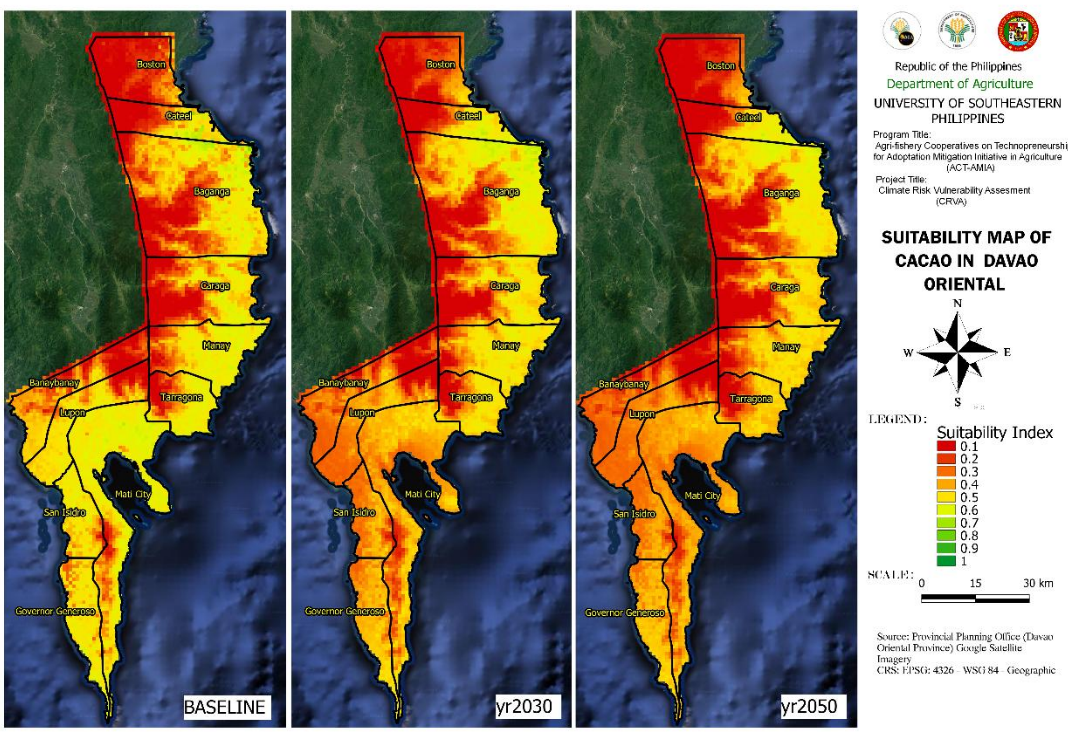
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SUITABILITY MAP OF CACAO IN DAVAO ORIENTAL
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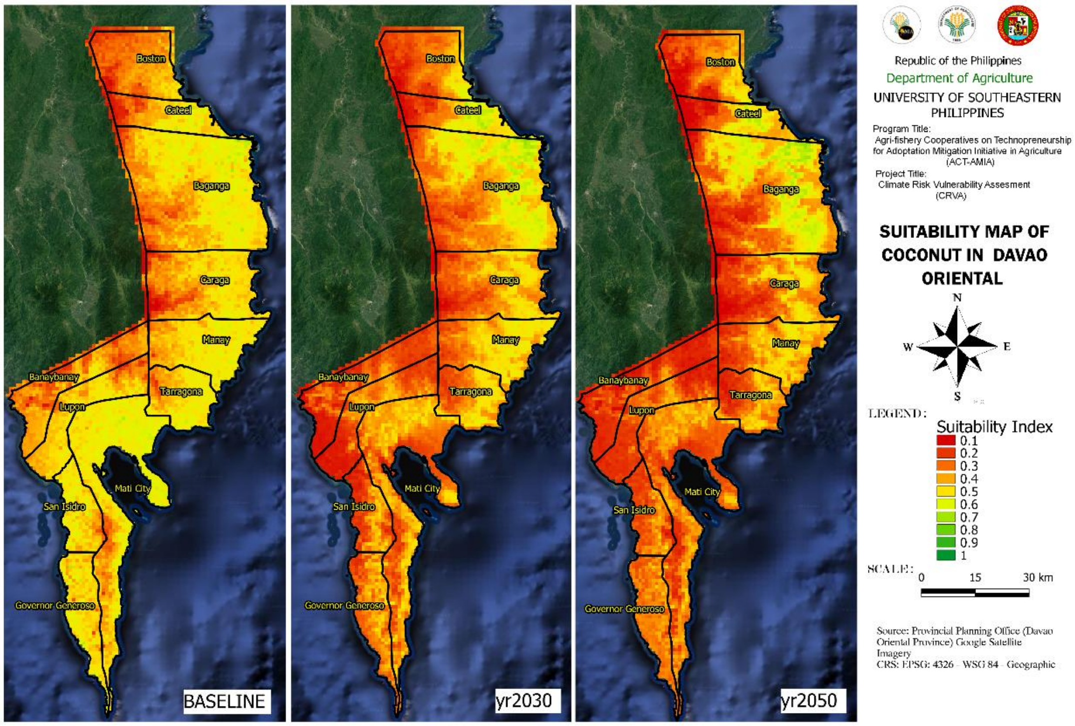
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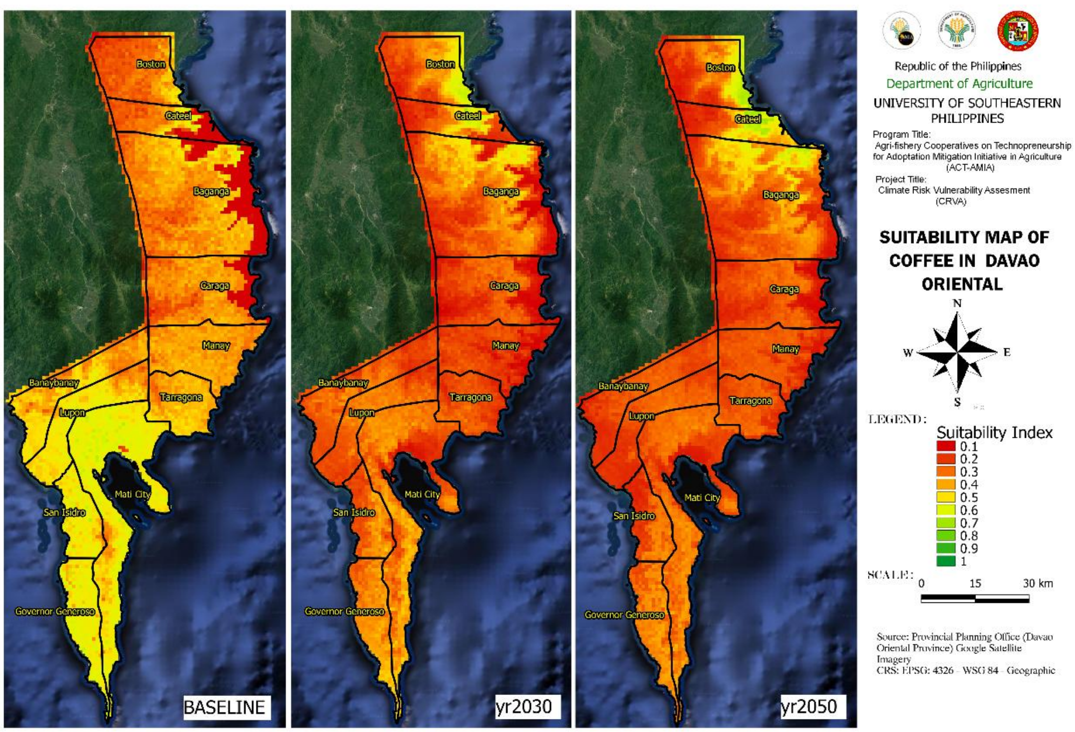
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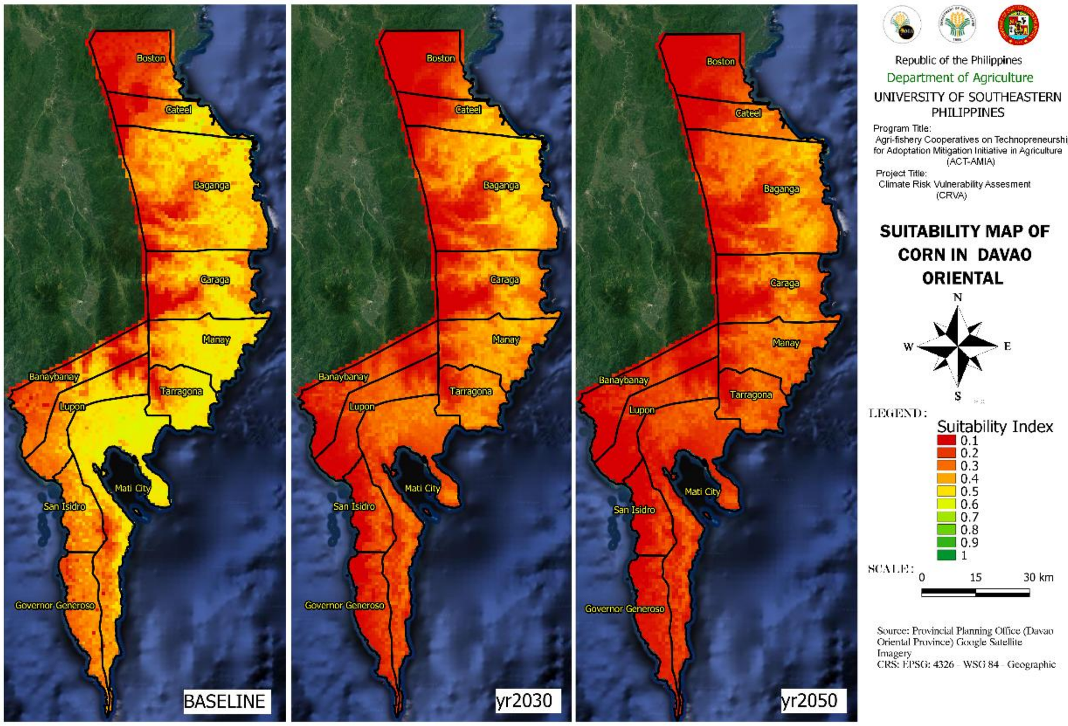
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Department of Agriculture
UNIVERSITY OF SOUTHEASTERN PHILIPPINES
Program Title:
Agri-fishery Cooperatives on Technopreneurship for Adoptation Mitigation Initiative in Agriculture (ACT-AMIA)
Project Title:
Climate Risk Vulnerability Assesment (CRVA)
SUITABILITY MAP OF CORN IN DAVAO ORIENTAL
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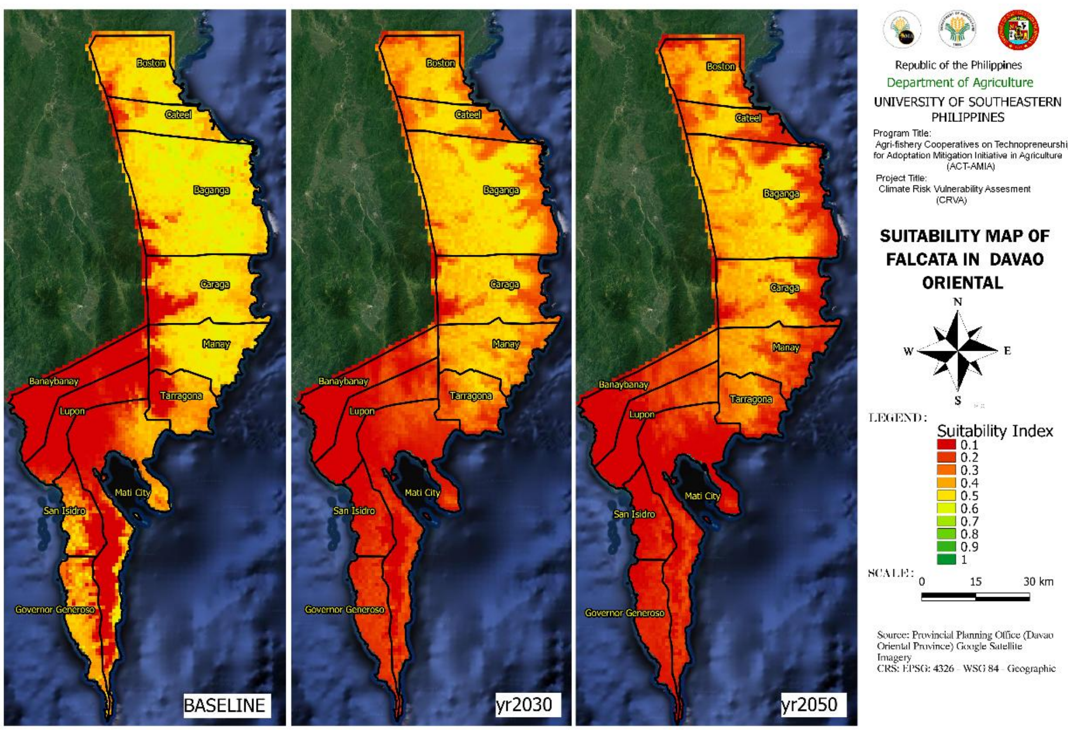
Source: Provincial Planning Office (Davao Oriental Province) Google Satellite Imagery
CRS: EPSG: 4326 - WSG 84 - Geographic

(f.)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Program Title:
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Climate Risk Vulnerability Assesment (CRVA)
SUITABILITY MAP OF FALCATA IN DAVAO ORIENTAL
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Source: Provincial Planning Office (Davao Oriental Province) Google Satellite Imagery
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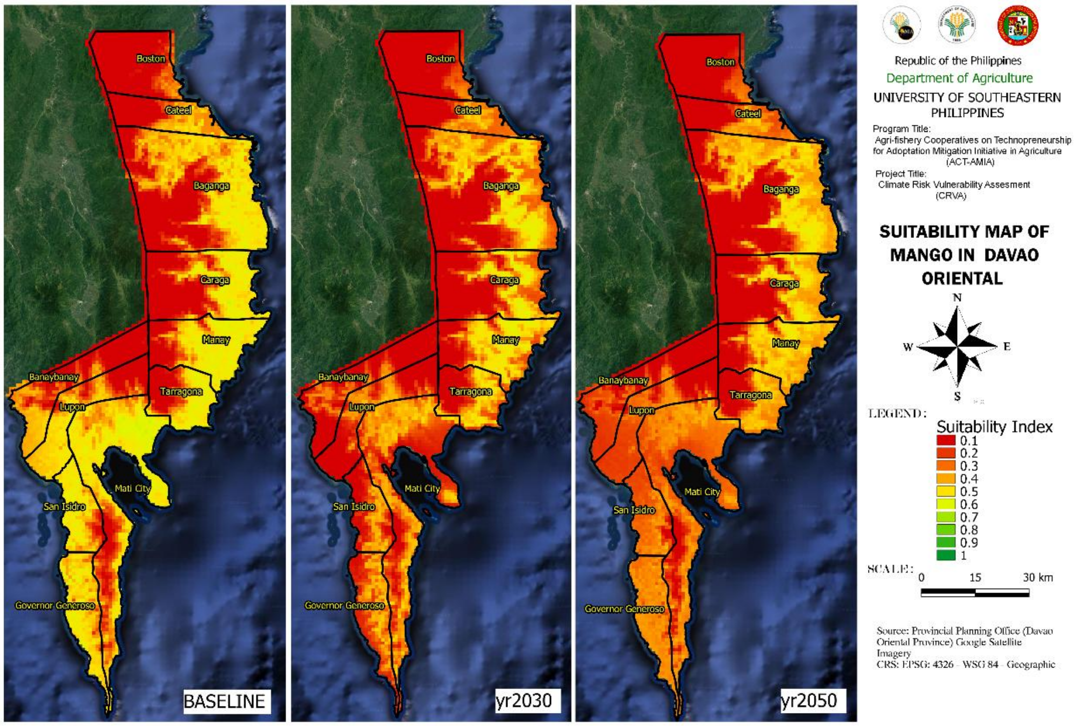
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Project Title:
Climate Risk Vulnerability Assesment (CRVA)
SUITABILITY MAP OF MANGO IN DAVAO ORIENTAL
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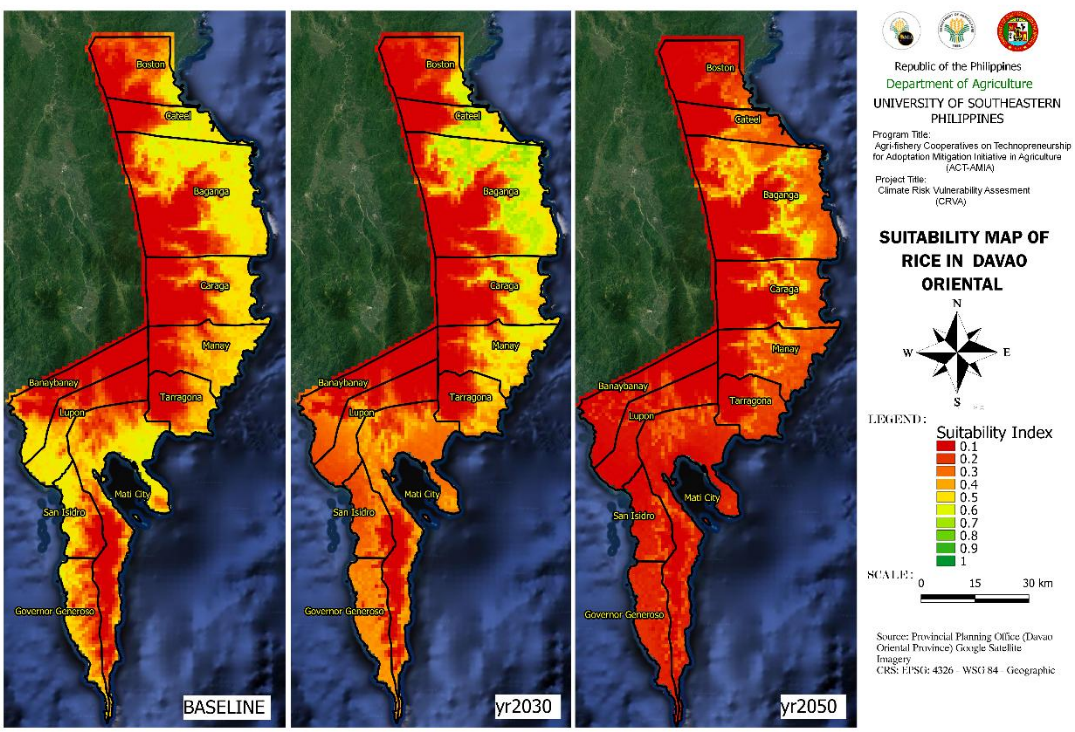
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Program Title:
Agri-fishery Cooperatives on Technopreneurship for Adoptation Mitigation Initiative in Agriculture (ACT-AMIA)
Project Title:
Climate Risk Vulnerability Assesment (CRVA)
SUITABILITY MAP OF RICE IN DAVAO ORIENTAL
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SCALE:
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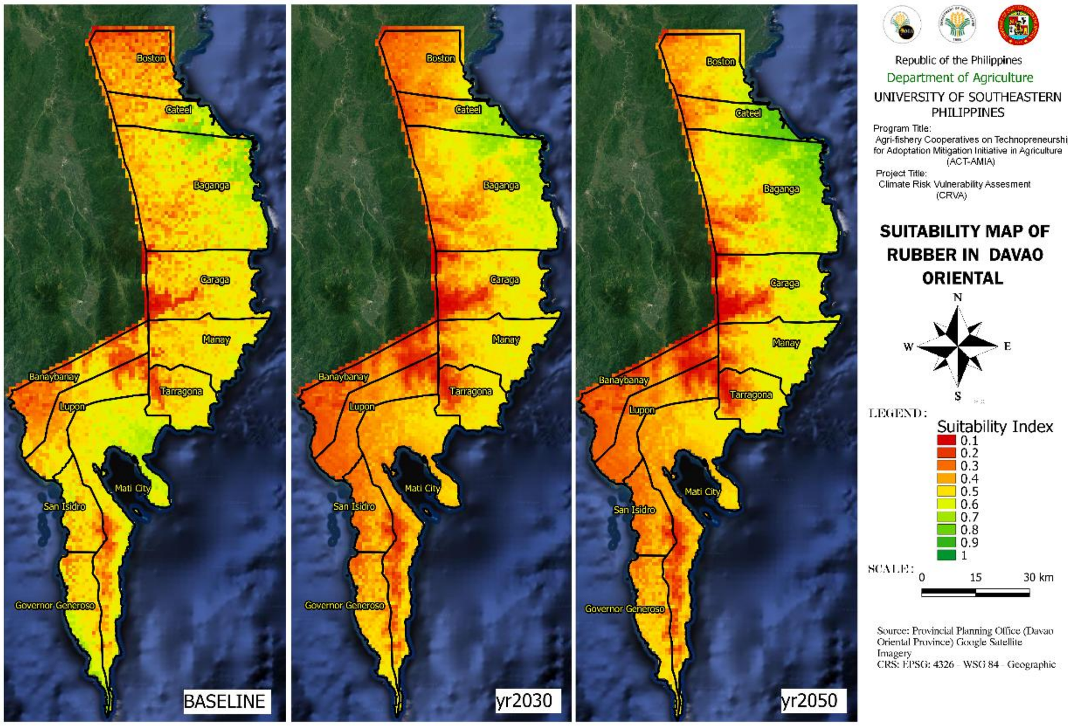
Source: Provincial Planning Office (Davao Oriental Province) Google Satellite Imagery
CRS: EPSG: 4326 - WSG 84 - Geographic

(i.)



(j.)

Figure 9. Suitability of climatic suitability of crop for the baseline condition as well as for the future condition: (a.) Abaca, (b.) Banana, (c.) Cacao, (d.) Coconut, (e.) Coffee, (f.) Corn, (g.) Falcata, (h.) Mango, (i.) Rice, and (j.) Rubber

1.1.2. HAZARD INDEX

Typhoon

The province is located at the southern part the country facing the Pacific Ocean. The province experienced damage brought by typhoons that will frequently happens during Amihan season (Norheast Monsoon). Depending on the size and scale of the typhoon, Davao Oriental also experienced thunderstorm brought by the typhoon's outer ring bands. The most devastating typhoon incident in the province was during the Super Typhoon Pablo last December 4, 2012 which landfall in Cateel, Davao Oriental and traverse in the province of ComVal and Davao Del Norte.

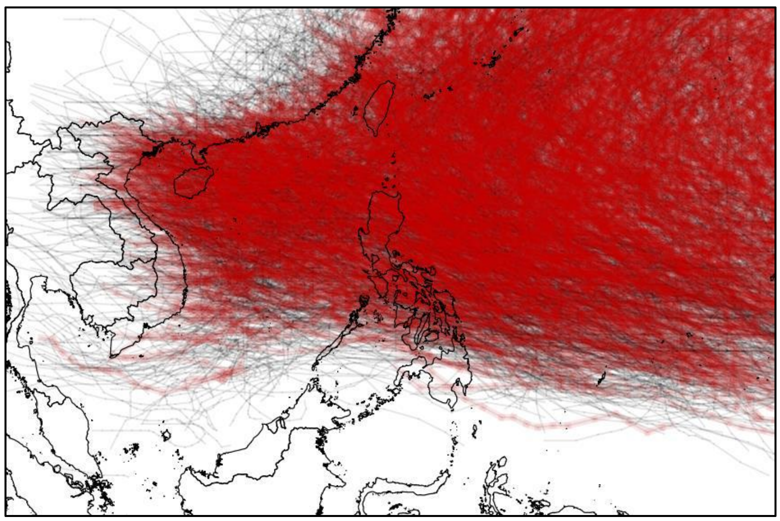


Figure 10. Typhoon incidence in the Philippines. Red lines are typhoon tracks with more than 160 kph wind speed.

Flood

Flooding is one of the major problems in the province, particularly when there were weather systems like low pressure area (LPA), Inter-Tropical Convergence Zone (I.T.C.Z.) and localized thunderstorms that brought severe rains in the region. Some rainfall events were torrential while some were moderate but will last for almost two to three weeks. The amount of rainfall during this weather system can flood areas in the low land part of the province especially in the flood plain areas of major rivers. Based on the flood analysis conducted by DOST- LIDAR, the towns that mostly experienced flooding were Caraga, Mati, Lupon, and San Isidro.

Drought

Drought has always an impact on agricultural, ecological and socio-economic spheres and causes serious environmental, social, and economic consequences worldwide.

The province had a minimal damage in terms of drought due to its climatic condition. The province falls under type 4 climate which has more or less evenly distributed rainfall throughout the year. The recent drought phenomenon reported in the region was on the last quarter of 2014 until the last quarter of 2015.

Erosion

Erosion is a natural occurring process attributed into different factors such as soil properties, ground slope, vegetation/land cover, and the amount and intensity of rainfall (Montgomery, 2007). It is usually a slow and gradual process which involves movement of rocks and loosened soil on the Earth's surface from one place to another. In the coming years, the soil erosion rate is expected to increase due to more total rainfall and more frequent extreme events brought by climate change. In turn, an increase in erosion rate may lead to poor soil productivity and accelerated siltation of waterways and reservoirs (R.Lal, 2010). Erosion had a scattered effect in the province, but mostly, it occurred in the areas with sloping terrain.

Storm Surge

A storm surge is an abnormal rise in the sea water level due to the presence of the storm and tropical cyclones also known as typhoons. Typically, storm surge happens in the coastal regions where water is pushed towards the shore by strong winds which can lead to flooding.

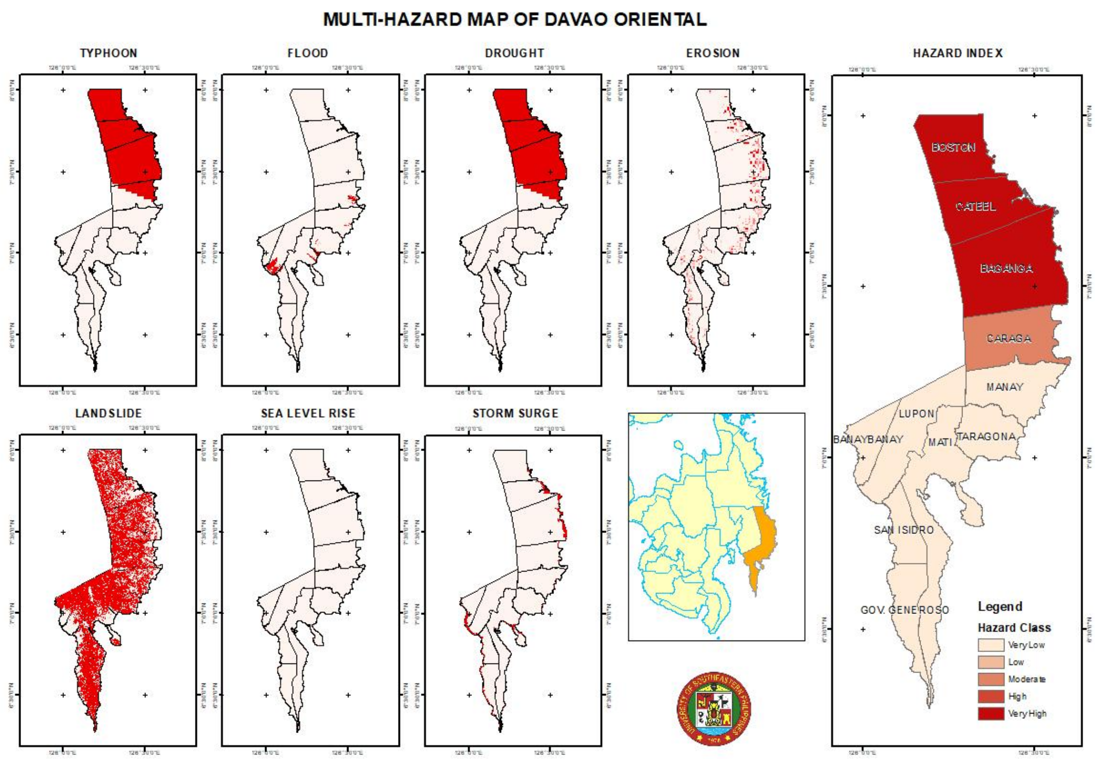


Figure 11. Multi-hazard maps for Davao Oriental.

1.1.3. ADAPTIVE CAPACITY

Results are available for each indicator and sub-indicator, so a strength of this vulnerability assessment is not just being able to identify areas with a low adaptive capacity as a priority but that specific capitals and separate indicators can be explored and targeted. The following presents spatial analysis of all 6 capitals (economic, social, physical, natural, human and anticipatory capital) as well as the aggregated overall adaptive capacity index. It can be seen that most municipalities across the study sites have moderate adaptive capacity. This is particularly true since the economic activities in municipalities of Davao Oriental tend to increase. Although, access to health and education is quite difficult for those municipalities have barangays in far flung areas but in the city of Mati Davao Oriental is more accessible. In some municipalities internet connection and mobile phone networks are available. Therefore, information dissemination is not that difficult except in remote and far-flung areas. Also, numerous programs and projects for agriculture and fisheries were implemented. However, trainings and seminars for disaster risk reduction every year is fewer.

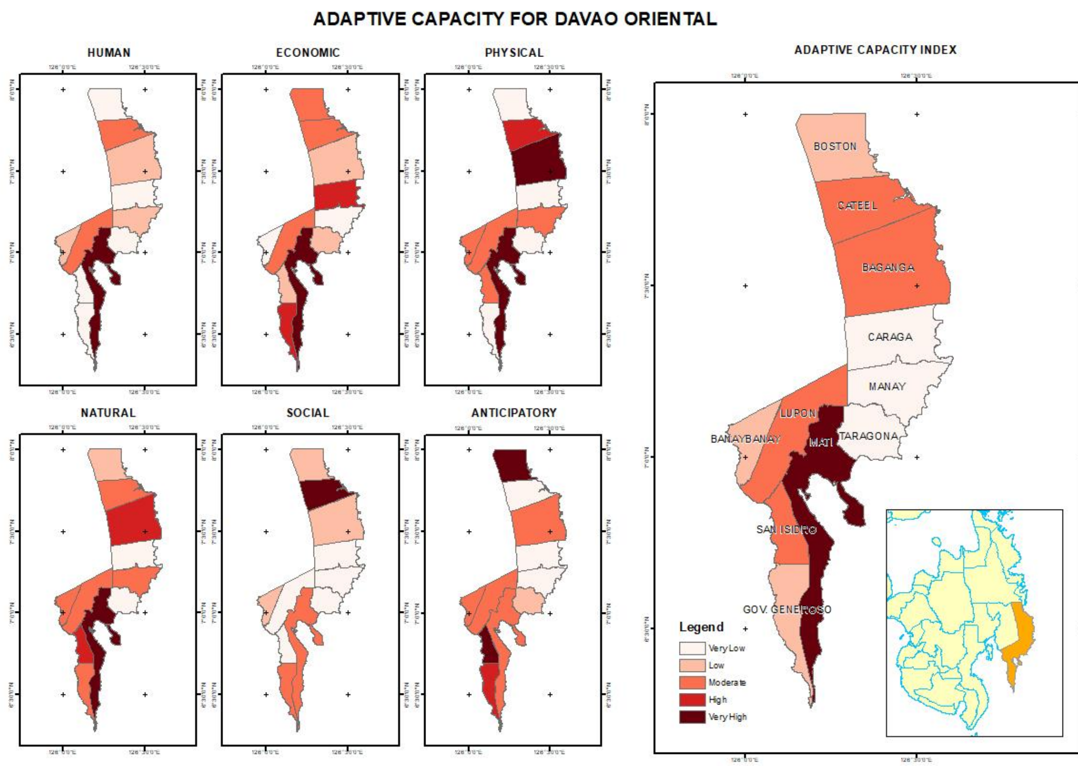


Figure 12. Adaptive capacity for Davao Oriental

1.1.4. OVERALL VULNERABILITY

The final climate risk vulnerability map in Davao Oriental for the year 2050 is an integration of the exposure, sensitivity and adaptive capacity components with a weight of 15%, 15% and 70% respectively. The weight of these three (3) components was discussed during a workshop which was participated by different experts from DA (from different agencies), NEDA, FAO, NGOs, and Academe.

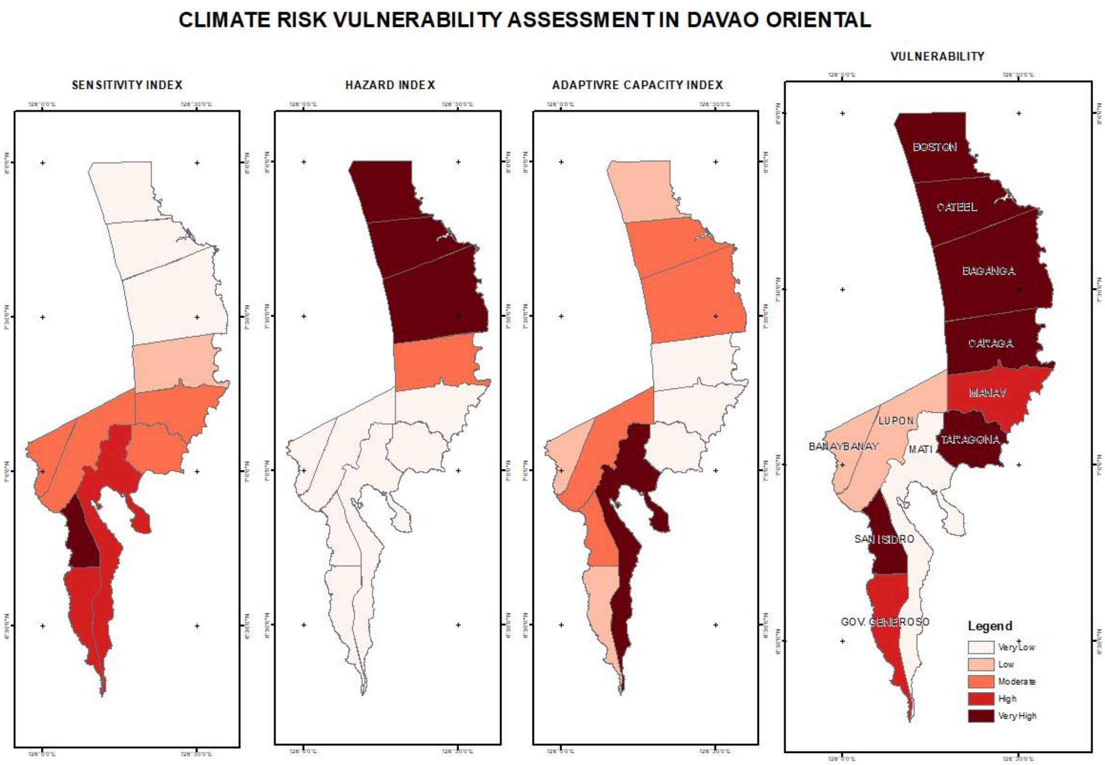


Figure 13. Vulnerability map for Davao Oriental

Table 7. Climate-Risk Vulnerability Index of the towns in Davao Oriental.

Municipal	Sensitivity Index	Hazard Index	Adaptive Capacity Index	Vulnerability	Category
BAGANGA	0.171	1.000	0.583	0.920	Very High
BANAYBANAY	0.434	0.071	0.389	0.351	Low
BOSTON	0.000	0.997	0.342	1.000	Very High
CARAGA	0.291	0.448	0.140	0.932	Very High
CATEEL	0.145	0.950	0.530	0.892	Very High
GOV. GENEROSO	0.775	0.095	0.397	0.781	High
LUPON	0.546	0.095	0.486	0.397	Low
MANAY	0.567	0.000	0.185	0.671	High
MATI	0.778	0.047	1.000	0.000	Very Low
SAN ISIDRO	1.000	0.056	0.466	0.922	Very High
TARAGONA	0.528	0.092	0.000	0.958	Very High

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