DEPARTMENT OF AGRICULTURE
REGIONAL FIELD OFFICE 02

A Climate Risk Vulnerability Assessment for the Adaptation and Mitigation Initiative in Agriculture Program in Cagayan Province

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CLIMATE RISK VULNERABILITY ASSESSMENT (SIMPLIFIED) for CAGAYAN PROVINCE

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Department of Agriculture Regional Field Office 02

RATIONALE

Vulnerability assessment (VA) is a key approach in building resilient communities. It is composed of various tools and processes to understand the risks and priority needs of the community to manage impacts and stressors (i.e., climate). Based on the level of exposure to climate stressors and capacities of the community specific package of interventions can be developed to support adaptation. Agriculture being heavily dependent to climate is one of the most vulnerable sector to climate change, variability and extremes. Climate drives the decisions of the farmers on when to plant, what variety to plant, and where to plant. Typhoon, drought, and flood are the most damaging climate extremes that cause significant losses to the agricultural sector and affects food security. Prices of agricultural commodities is also heavily affected during extreme events. Climate change and variability will continue to exert increasing pressure upon the agricultural sector of the Philippines. A better understanding of major agricultural vulnerabilities to climate risks is fundamental to achieving resilient farming systems, especially among poor rural households.

Introduction and Framework

Climate change and variability continue to exert increasing pressure upon the agricultural sector of the Philippines. The three sectors that record the highest economic damage resulting from geophysical hazards in the Asia Pacific region are transport, housing and agriculture, whereas the agricultural sector is recognized as the most vulnerable of all sectors (UNESCAP 2015). Therefore, it is necessary to identify and prioritize at a high resolution scale the municipalities and relevant crops that are most vulnerable to climate risks. In this context, building resilience is not perceived as the ultimate goal, but rather as the intermediate main outcome contributing to the long-term goal of improved communities' coping capacities to a high degree of climate risks (Béné et al. 2015).

Under the umbrella of the Department of Agriculture project “Adaptation and Mitigation Initiative in Agriculture” (AMIA), a climate risk vulnerability assessment for 10 selected provinces (figure 1) has being conducted to guide AMIA targeting and planning for building climate-resilient agri-fisheries communities. In 2017, DA-AMIA launched integrated field-level action for establishing climate-resilient agri-fisheries (CRA) communities. It also attempted to introduce complementary activities for building appropriate climate responsive financial and other key support services. A key step in the targeting and planning for CRA communities is to assess climate-risk vulnerability in the proposed AMIA sites. This ensures that AMIA investments are cost-effectively channeled to support its overall goals and outcomes. Furthermore, it addresses the inherent spatial and temporal variabilities within and across sites.

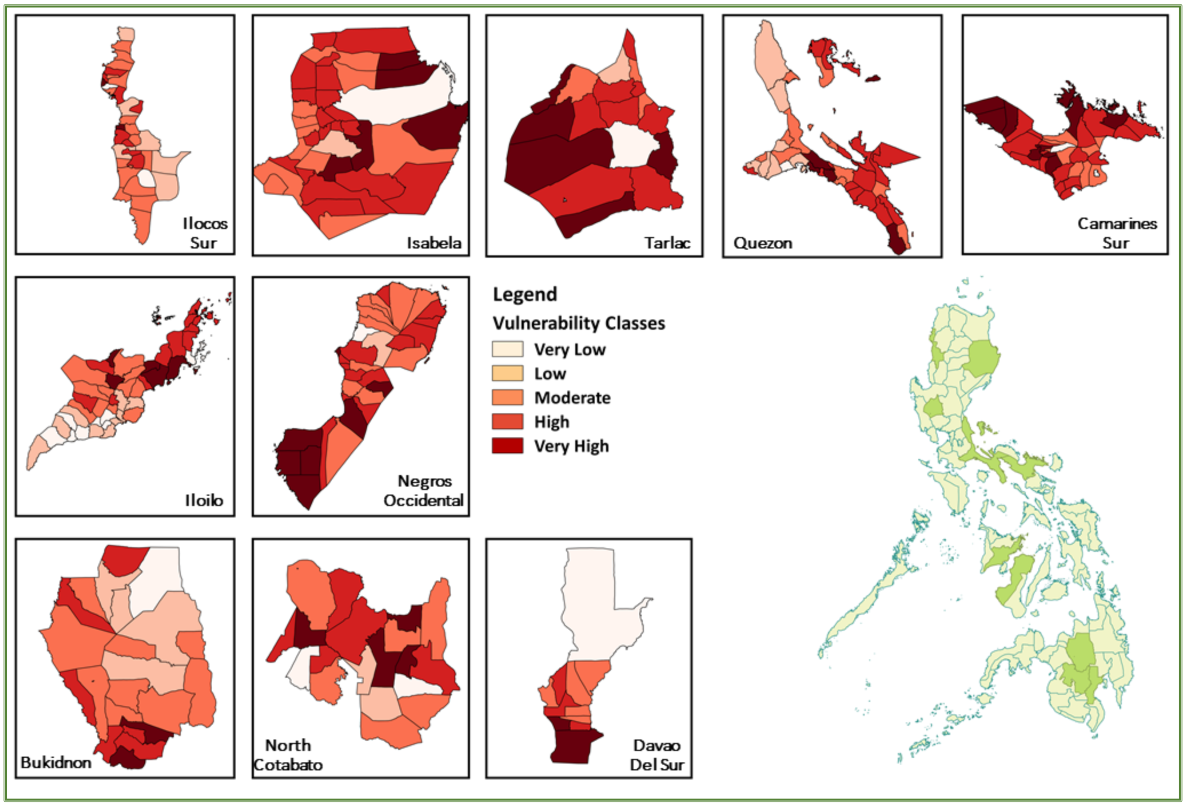


Figure 1. AMIA1 Pilot Provinces with their Climate Vulnerability Classes

Objective of the Assessment

The Climate-Risk Vulnerability Assessment (CRVA) was developed with a clear mindset that the information derived from this will be used by the Department of Agriculture to support the initiative to build resilient communities. **The main purpose of the VA is (1) to identify the exposure of the communities to climate risks (long term, and recurring climate variability and extremes) which threaten their production systems and livelihoods, as well as (2) to determine their capacities to respond to these threats.** With these information, short term and long term priority action needs can be identified for the agricultural sector.

The CRVA framework (figure 2) developed for DA was based on the Intergovernmental Panel on Climate Change (IPCC) construct which includes the three dimension to assess vulnerability of the agricultural sector to climate change: **Exposure** to climate-induced shocks (a biophysical phenomenon); **Sensitivity** of the unit to such shocks; the **Adaptive Capacity** to deal with such shocks (a social phenomenon). Each of the dimension and indicators is used to assess the vulnerability of each municipality within the province.

1) Sensitivity: The increase or decrease of climatic suitability of selected crops to changes in temperature and precipitation (Parker et al., 2019).

2) Exposure/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 sensitivity analysis is based on the assumption of a high emission scenario by 2050 (RCP 8.5) whereas the adaptive capacity component is derived from the most up-to date available data mainly from 2015. The detailed composition of each component is visualized in Figure 2. The resulting vulnerability assessment enables evidence-based spatial targeting of agricultural extension and financial investment in areas most at risk or tailored to a specific hazard, crop or lack of adaptive capacity.

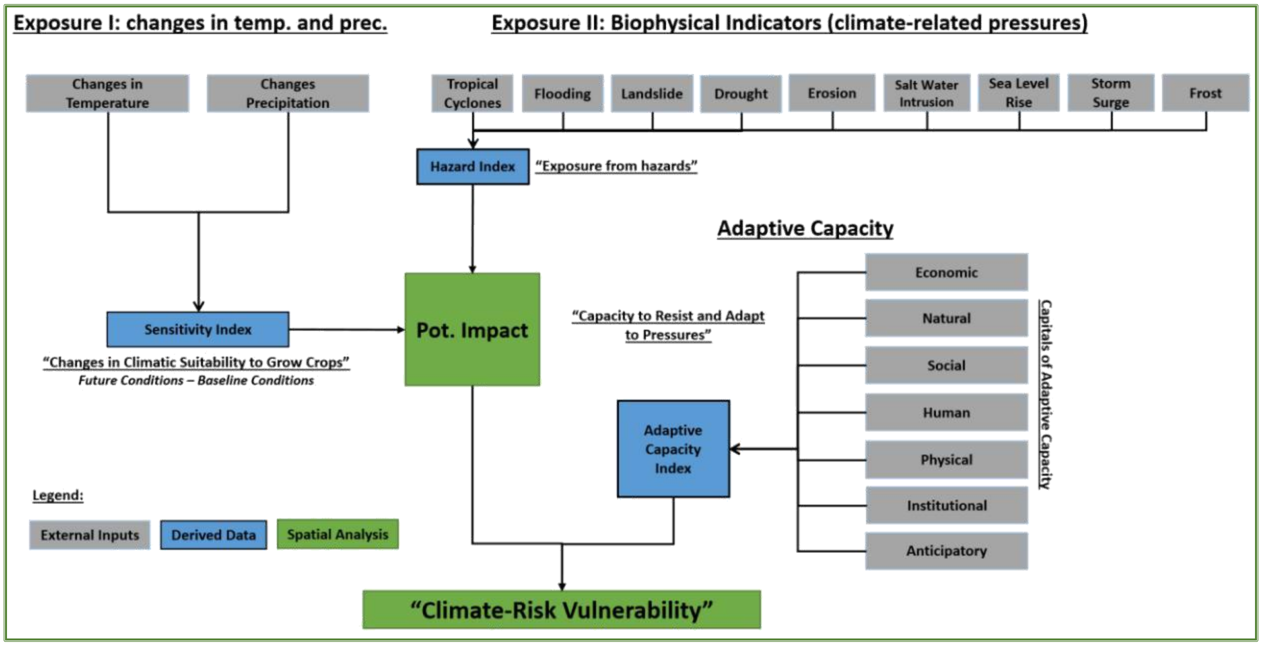


Figure 2. The Climate Risk Vulnerability Assessment Framework

Each dimension of vulnerability is represented by a set of diverse proxy indicators which is a measure of the degree of risks and adaptive capacity. The indicators are quantitatively assessed based on empirical data. For adaptive capacity, each indicator is linked to a capital where the index represents an aggregated value of the indicators which helps in simplifying the narrative for the adaptive capacity. The resolution of the data is collected at the municipality level based on the availability and accessibility of data. One of the bases for selecting the municipality as the resolution of the analysis is that major decision-making and support for agriculture happens at the municipality (MAO and MPDC).

Recent Studies on Climate Change Vulnerability Assessment in the Philippines

Several vulnerability assessments have already been conducted in the Philippines agricultural sector. The climate change vulnerability assessments in the Philippines vary greatly in terms of the following: **1)** assessment of each component were highly variable, and impact of climate change where not explicitly analyzed. This means that most of the impacts that were attributed to climate change were based mainly on perceptions and less on empirical evidence; **2)** coverage is sparse. Studies have already been conducted at a single city or municipality; **3)** coverage was broad but resolution was coarse; and **4)** climate change was assessed using a single weather event (typhoon); and **5)** some are context specific (agriculture) while others are general. This can be useful for different objectives and institutions, but the context, component indicators, and analyses are of limited use if impacts of climate change will be assessed for the agricultural sector. Some are looking at short term climate variability or don't have any climate impact dimension in the analysis. In studies where vulnerability assessment was conducted at sub municipal and sub city scale, most of the data are based on perceptions, whereas studies conducted at regional level (inter-country comparison) the empirical data was aggregated at the coarse level. Some of the studies does not have any climate dimension in any of the components of vulnerability.

SCOPE – THE PROVINCE OF CAGAYAN

The province is among the major agricultural products suppliers of the National Capital Region, especially for grains and legumes. Rice, corn, vegetables, sugar, mango, cassava, banana, cacao, coffee, tubers, watermelon and other agricultural crops abound in the Province.

Cagayan is also Region 2's major livestock producer. It has the third largest population of carabaos in the entire country while majority of Cagayan's stocks are native carabaos, however, new breeds are being introduced for meat and dairy.

Production of cattle, carabao, goat, and sheep, both for meat and dairy, has a great potential for development in Cagayan owing to the wide expanse of available pasture lands and disease free local stock. Commercial hog and poultry raising are also growing industries in the Province. The Province's sizeable food harvests can support large-scale food processing and animal feed milling industries.

Cagayan's coastline is one of the longest in the country having almost 73% of Cagayan Valley Region's coasts. This is aside from the large rivers and their tributaries, lakes, creeks and streams which are also rich fishing and aquaculture grounds. Untapped coastal fishing grounds stretch from the towns of Sta. Praxedes in the west to Sta. Ana on the east, on its northern coast facing the Babuyan Channel (China Sea); and from Sta. Ana down to Peñablanca on its eastern coast facing the Philippine Sea (Pacific Ocean). Despite this endowment, the Province's fish production is not even enough to supply and sustain its own fish requirements.

Deep sea fishing is not a common occurrence in the Province – thus, foreign poachers are the ones reaping the bounties of its seas. Cagayan's deep seas are known for species like tuna, tuna-like fishes, hairtail, snapper, scad, slipmouth, mullet, grouper, shrimp, squid, and lobsters. The inland waters are used primarily by subsistence fishermen. Few privately-operated fishponds and fish cages contribute to the overall fish supply of the Province. Only about 1,893.84 are used for fishpond operations. Out of which, 1,369.22 hectares are used for brackish fishpond operations. A total of 46,303 cubic meters are used by various cooperators for fish cage operations. Out of which, 41,034 cubic meters are used for brackish fish caging. Buguey has the widest area for fishponds and Sanchez Mira has the highest fish cage cooperators. Tilapia, bangus, tiger prawn, mud crab, shrimp and siganid are commonly raised and cultured (Cagayan PCIP 2019).

About 91 hectares are used for other aquaculture activities like oyster, mussel and seaweeds culture.

The beaches and waters surrounding Port Sta. Ana up to Cape Engaño in Palaui Island offer a haven for fishing and scuba enthusiasts. This area is known for the prime fish catches of various species of tuna, tuna-like species, snappers and other fishes. The area is said to have the largest blue fin tuna catch in the entire country. This may be due to the fact that it is part of the Luzon Strait which is a known migratory path and feeding ground of tuna and other prime fishes.

CLIMATE

Cagayan, exemplifies tropical Philippines, thus, is generally warm, humid and sunny throughout the year. It has three types of climates. Type I climate prevails in Santa Praxedes and in western Claveria, which have two pronounced seasons: wet, May to October and dry, the rest of the year. Type III climate is experienced in the eastern part of the Sierra Madre mountains and in the Babuyan group of islands, where rainfall is evenly distributed throughout the year mainly because of the northeast tradewinds. This further enhances the economic potential of the sea level lands along the pacific coast of the Province.

The rest of the province, which consists of the valley floor, has Type II climate, and that means no pronounced season; relatively wet from May to October. Maximum rain periods are not very pronounced and dry seasons last from one to three months.

From November to January, the northwest monsoon from East Asia brings dry and cool winds to this valley floor. Because of the open coastline in the north, this part of the province feels the full impact of this phenomenon, which could mean cold mornings and evenings, with average temperatures ranging from 18 to 21 degrees Celsius. The tradewinds from the Pacific are blocked by the Sierra Madre range. Being on the leeward, this part has hot and dry climate in summers from February to May, with average temperatures ranging from 30 to 38 degrees Celsius. From June to October, the southwest monsoon from the Southern Hemisphere brings heavy rainfall as it blows over the mountains. This heavy rainfall extends to the early part of November. During these months, rainy days could average 11 to 20 days a month. Being sheltered by the Sierra Madre Mountains the prevailing winds are north and northwest in the valley floor of Cagayan. This part of the province is driest in February to March (Cagayan PCIP 2019).

GEOGRAPHICAL PROFILE
Location and Boundaries of the Province

Cagayan lies in the north-eastern part of mainland Luzon, and has coordinates approximately at 17°30' north and 121°15' east. It is one of the five provinces of Region 02, otherwise known as the Cagayan Valley Region.

It is bounded by the Sierra Madre and Cordillera Mountain Ranges on the eastern and western part, respectively – the borders make the Province a valley. The Cagayan River, the country's longest river runs through the middle of the Province.

Located in the north coast, the Province has major islands, which is known as Babuyan Group of Islands.

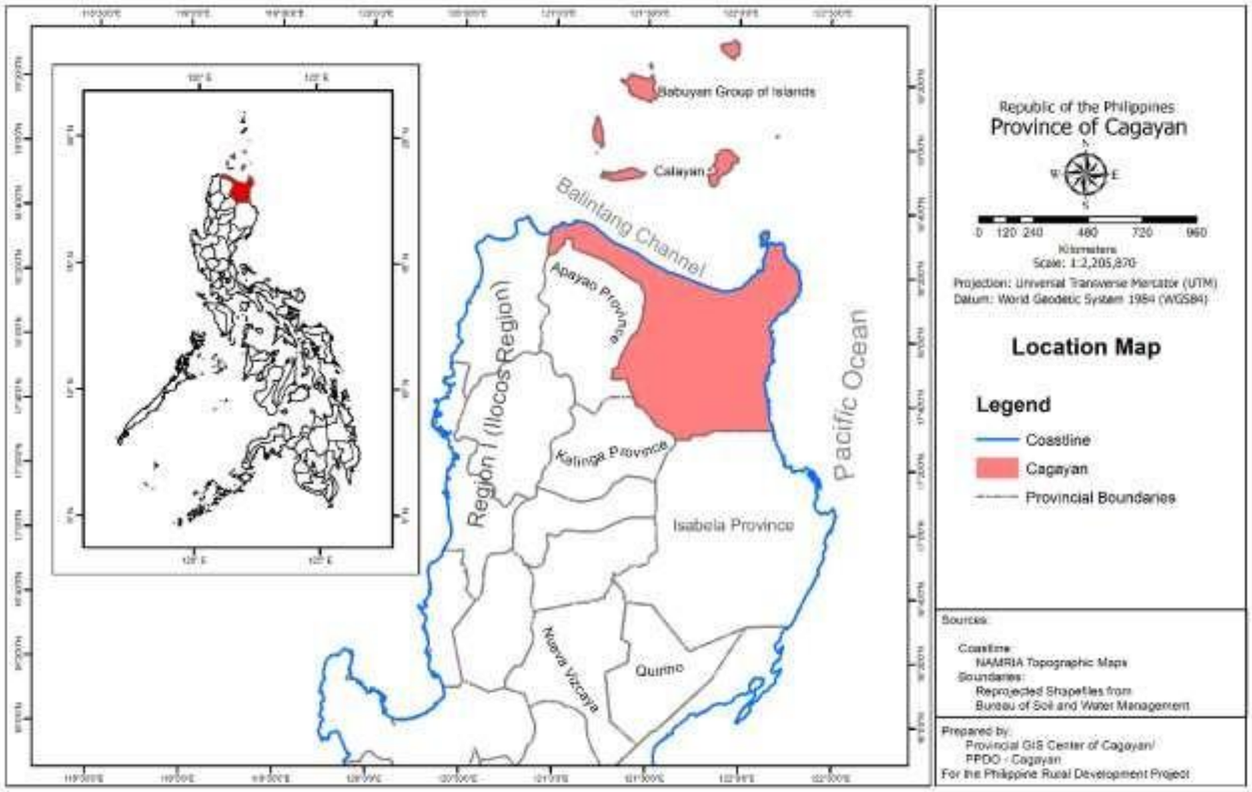


Figure I-1
Location Map

B.2. Topography

The province has varied land characteristics. As to slope, 28.19% or 253,831 hectares are flat to nearly level land which largely consist of alluvial plains traversed by the Cagayan River and other major rivers, and where the agricultural production is concentrated; while the gently sloping and moderately sloping lands constitute 6.08% and 13.48% respectively. The rolling terrain of the Province, suitable for extensive livestock raising especially for carabao, cattle and other ruminants, is also extensive.

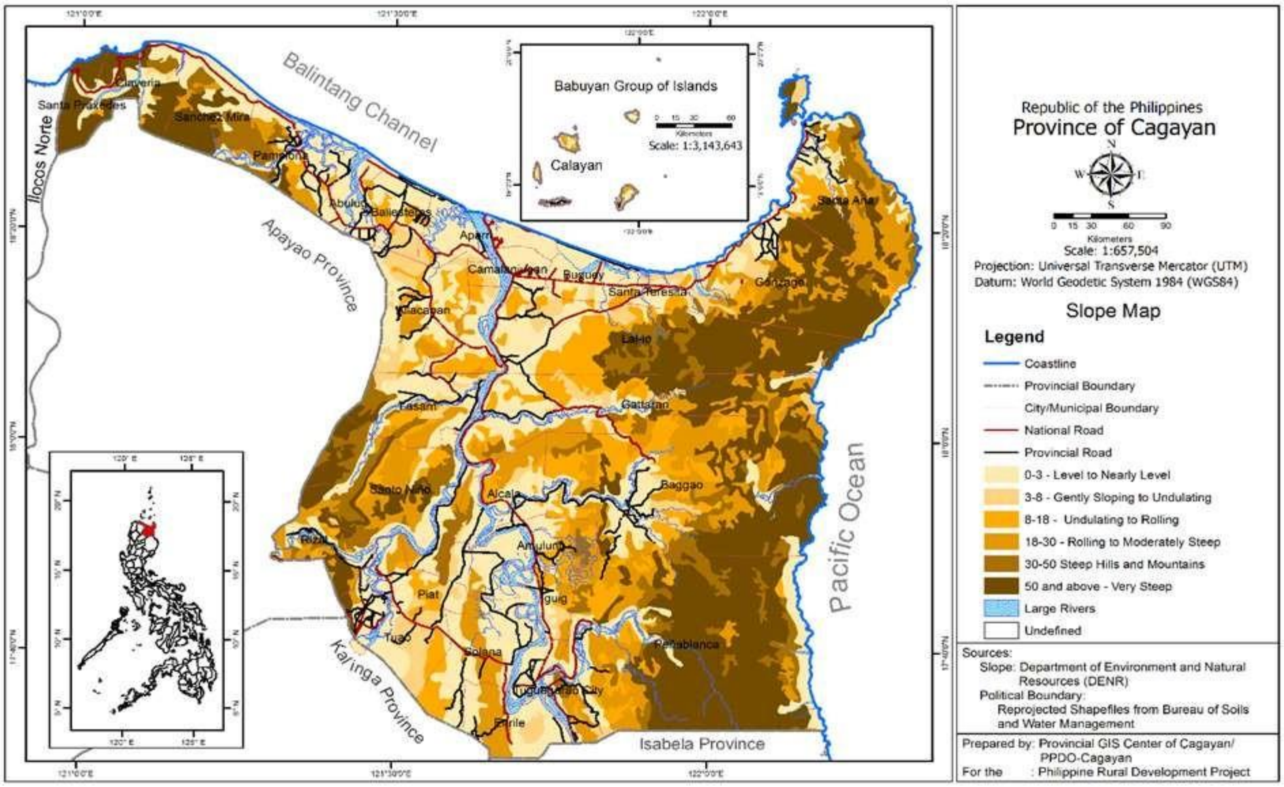


Figure I-2
Slope Map

B.3. Land Area

A first class province, Cagayan, including the Babuyan Group of Islands, has an aggregate land area of approximately 9,002.70 square kilometers. It is composed of one component city and 28 municipalities. It has a total of 820 barangays.

Table I-1. Land Area by Municipality

Municipality	Land Area (Square Kilometers)	Percentage Share
1. Abulug	162.6	1.81
2. Alcala	187.2	2.08
3. Allacapan	306.8	3.41
4. Amulung	242.2	2.69
5. Aparri	264.6	2.94
6. Baggao	920.6	10.23
7. Ballesteros	120	1.33
8. Buguey	138.2	1.54
9. Calayan	506.8	5.63
10. Camalaniugan	76.5	0.85
11. Claveria	194.8	2.16
12. Enrile	184.5	2.05

13. Gattaran	707.5	7.86
14. Gonzaga	486.2	5.4
15. Iguig	108.1	1.2
16. Lal-lo	702.8	7.81
17. Lasam	213.7	2.37
18. Pamplona	173.3	1.92
19. Peñablanca	1,193.20	13.25
20. Piat	139.6	1.55
21. Rizal	124.4	1.38
22. Sanchez Mira	198.8	2.21
23. Santa Ana	441.3	4.9
24. Santa Praxedes	110	1.22
25. Santa Teresita	25	0.28
26. Santo Niño	512.9	5.7
27. Solana	200.8	2.23
28. Tuao	215.5	2.39
29. Tuguegarao City	144.8	1.61
TOTAL	**9,002.70**	**100**

Source: DENR and DBM

Among the municipalities, Peñablanca has the largest land area with 1,193 km^2 which account for 13% of the Province's total land area. Peñablanca is followed by the municipalities of Baggao, with 920 km^2, and Gattaran, with 707 km^2. The municipality with the smallest land area is Sta. Teresita with only 25 km^2.

B.4. Existing Land Use

With respect to land utilization, the production land covers about 456,421.37 hectares or constitutes half of the total land area of the province. Of the total area of the production land, 196,062 hectares or 42% are devoted to agriculture specifically for crop production. While the built-up area which is basically used for settlement constitutes 105,647.55, while the total area used for infrastructures like roads and ports comprises 9,754.90 hectares.

On the other hand, the Province's protection land includes biodiversity conservation areas and protected areas with an aggregate area of 341,690.59 hectares. Protected Areas include National Integrated Protected Areas (NIPAs), Military Reservation, and Watershed Forest Reserves (WFR) and the remaining old growth forest which are mostly found in the Sierra Madre Mountain. Of the total area of forestland, 7 percent are degraded areas needing rehabilitation.

Table I-2. General Existing Land Use (Broad Categories by Municipalities)

Municipality	Protection Land	Production Land	Settlement Land	Infra Land	Total
Abulug	1,709.96	11,457.43	3092.61	50.50	16,260.00
Alcala	2,408.11	15,077.54	891.88	342.47	18,720.00
Allacapan	12,742.28	14,594.74	2,789.98	553.00	30,680.00
Amulung	3,879.30	17,832.05	2,396.51	112.14	24,220.00
Aparri	2,562.00	10,450.71	12,832.10	615.11	26,460.00
Baggao	18,323.13	67,756.55	5,246.67	733.45	92,060.00

Ballesteros	1,206.00	8,614.78	2,017.22	162.00	12,000.00
Buguey	1,553.49	8,368.18	3,476.86	131.47	13,820.00
Calayan	45,910.85	3,540.44	1,178.71	50.00	50,680.00
Camalaniugan	287.77	5,723.61	1,561.45	77.17	7,650.0 0
Claveria	6,465.77	9,843.73	3,047.08	122.61	19,480.00
Enrile	4,300.62	11,164.17	2,787.02	198.19	18,450.00
Gattaran	21,430.25	46,495.72	2,563.00	261.03	70,750.00
Gonzaga	18,498.12	27,230.45	2,531.33	360.1	48620.00
Iguig	1,671.31	4,464.74	4,212.95	461.00	10,810.00
Lal-lo	44,995.21	18,140.88	6,482.91	661.00	70,280.00
Lasam	2,687.72	16,422.25	2,000.03	260.00	21,370.00
Pamplona	327.60	16,814.05	113.91	74.44	17,330.00
Peñablanca	68,135.92	39,953.31	10,467.08	763.69	119,320.00
Piat	6,717.00	4,981.83	2,200.17	61.00	13,960.00
Rizal	3,284.72	7,969.67	1,100.61	85.00	12,440.00
Sanchez Mira	2,874.00	13,440.52	3,431.09	134.39	19,880.00
Solana	2,739.97	13,882.04	3,034.99	423.00	20,080.00
Sta. Ana	21,122.28	21,000.78	1,637.00	369.94	44,130.00
Sta. Praxedes	8,874.20	1,097.99	698.15	326.66	11,000.00
Sta. Teresita	4,276.00	6,323.29	5,884.17	214.54	2,500.0 0
Sto. Niño	30,088.50	12,643.37	8,000.13	558.00	51,290.00
Tuao	1,671.31	16,569.67	2,525.02	784.00	21,550.00
Tuguegarao City	947.20	4,566.88	7,156.92	809.00	14,480.00
Total -Cagayan	**341,690.59**	**456.421.37**	**105,647.55**	**9,754.90**	**900,270.00**

Source: DBM and DENR PENRO and CENRO

Note: The total area of the province/per municipality under this land use plan is based on DBM Land Area

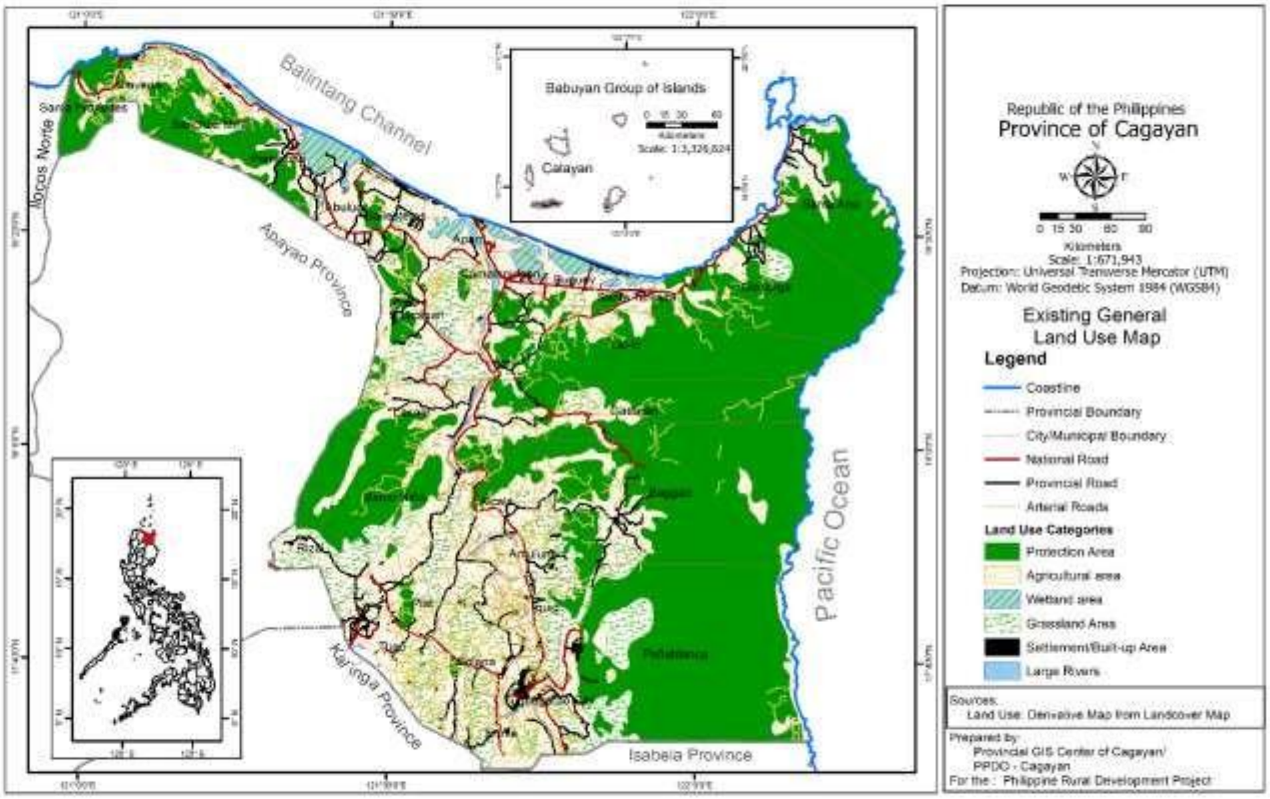


Figure I-3
General Land Use Map

B.5. Land Classification

Of the total 900,270 hectares' land area of the Province, 353,195 hectares or 39 percent is classified as Alienable and Disposable (A&D) lands, while 547,074 hectares or 61 percent is forestland.

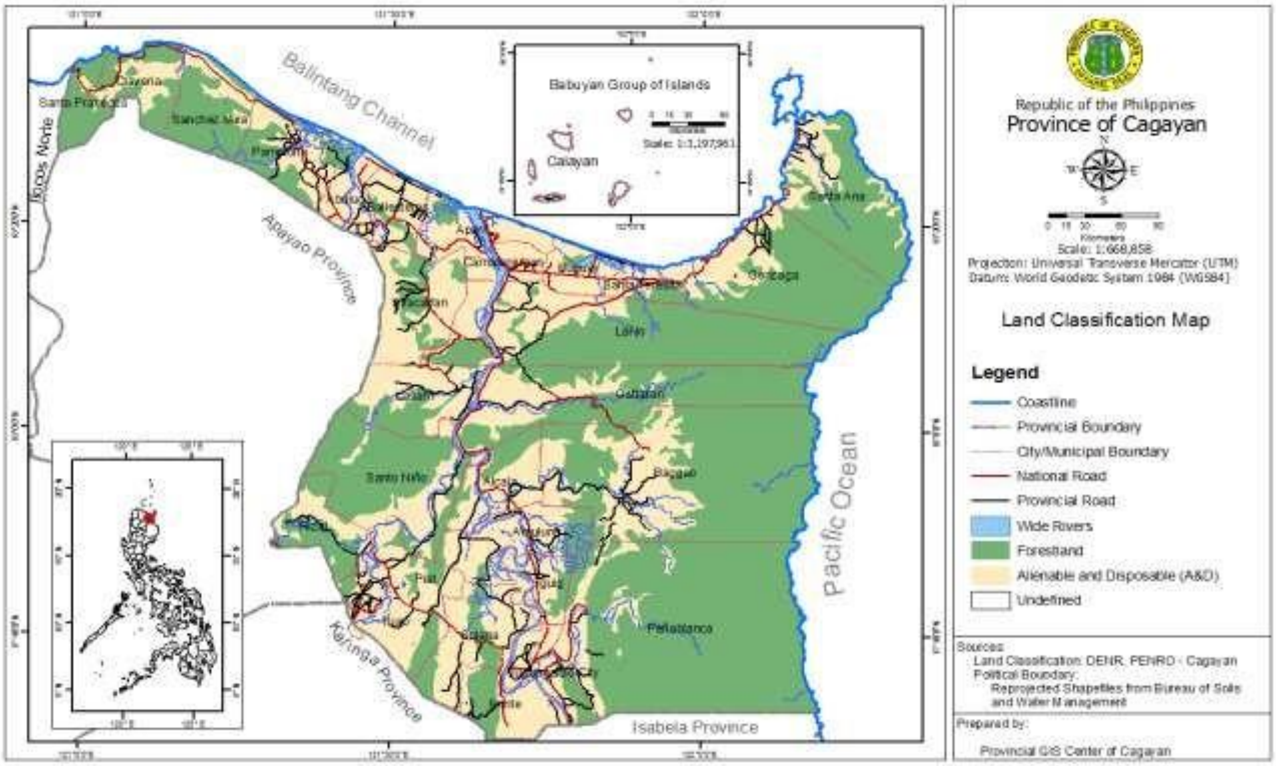


Figure I-4
Land Classification Map

B.6. Land Suitability

Based on the land suitability assessment of the Bureau of Soils and Management, the lands suitable for agriculture is estimated at 278,600 hectares which constitute 32% of the total land area of the Province. The effective present area cultivated to crops is estimated at 190,600 hectares, while the expansion area to be used for crop production and agricultural production related activities is estimated at 88,100 hectares. The grasslands with below 18° slope are the possible expansion areas for cultivation and other agricultural purposes.

Table I-3. Distribution of Lands as to Use/Suitability

Use/Suitability	Area (Hectares)	Percent Distribution
Agriculture	**278,600.00**	**32.0**
Crop Production	190,600.00	22.0
Expansion Area	88,100.00	10.0
Forestry	**58,740.00**	**65.0**
Preservation Area	54,680.00	61.0
Rehabilitation Area	4,040.00	5.0
Wetland Areas	**1,580.00**	**2.0**
Miscellaneous	**1,860.00**	**2.0**
Total Land Area	**900,270.00**	**100.0**

***Source**: ALMED Bureau of Soils and Water Management, Department of Agriculture*

B.7. Areas Susceptible to Flood

Among hazards, Flooding is the major hazard which the Province is most susceptible to. Flooding is experienced in 259 barangays in 18 municipalities. Among the municipalities, the most barangays affected are found in Baggao, Gattaran, Santo Niño and Buguey.

In terms of population affected, about 83.33% of the total population or 750,615 people are exposed to a moderate and high flooding event. For highly susceptible flooding 29.11% or 262,150 people will be affected.

Flooding for most municipalities was due to the flood inundation along the Cagayan River and its major tributaries like, Chico River, Pared River, Dummun River and Pinacanauan River. Also, flooding in Cagayan is further aggravated by the flood water run-off that naturally drains and comes as far as Ifugao and Nueva Vizcaya, through the Magat River, and other major river tributaries from Quirino and Isabela. Water run-off from the Sierra Madre Mountain in the east also contributes to inundation. The most vulnerable to flooding are the municipalities Enrile, Solana, Iguig, Amulung, Alcala, Gattaran, Penablanca, Lasam, Baggao, Lallo and Tugegarao City.

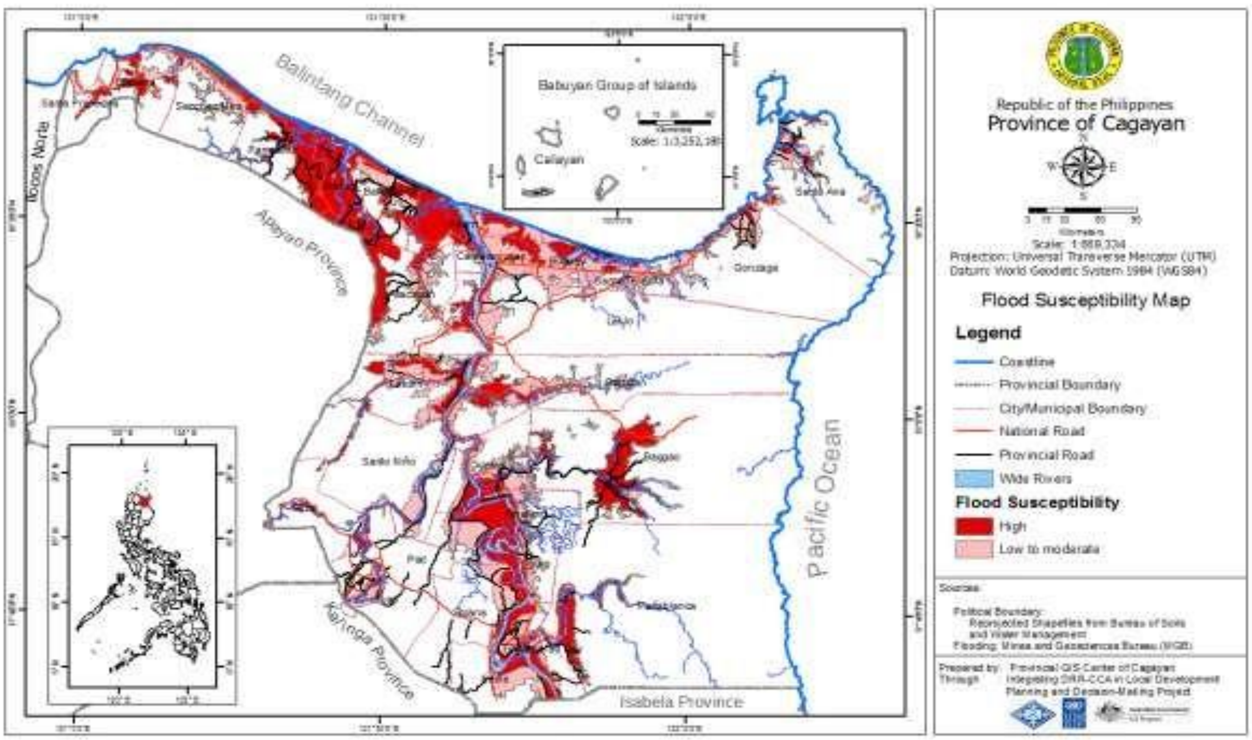


Figure I-5

Flood Susceptibility Map

B.8. Agricultural Land

The production lands of the province consisting of agricultural areas, grasslands and wetlands cover a total area of approximately 403,121.78 hectares.

The agricultural areas chiefly devoted for crop production consist of 276,777.86 hectares, and are mostly located within the alienable and disposable lands. The grasslands, consisting about 109,897 hectares, are practically located at forestland and agricultural areas and substantially used for grazing and agroforestry. While, primarily used for aquaculture, the wetlands cover about 16,446.55 hectares. The fish production areas exist largely in the municipalities of Buguey, Sta Teresita, Sta Ana, and Abulug, Claveria and Sanchez Mira.

As to distribution, about 130,521 hectares are currently cultivated to rice production and 61,784 hectares for corn production. The irrigated lands cover 93,274 hectares. While the lands cultivated to High Value Commercial Crops like mango, peanut, vegetables, sugarcane, legumes and other industrial crops cover approximately 3,107 hectares.

The province's potential expansion area for crop production is estimated at around 81,364 hectares. The expansion areas are the identified idle agricultural land and underutilized grassland.

Table I-4. Area of Agricultural Production Land by Municipality

Municipalities	Agricultural Area							Grassland	Wetland Area
	Palay	**Corn**	**Carabao Mango**	**Peanut**	**Others**	**Expansion Area**	**Total**		
Abulug	5,510.17	1,377.00	46.99			1,266.27	8,200.43	285.75	3,155.70
Alcala	4,398.16	4,137.00		118.00	86.00	953.36	9,606.52	1,984.10	
Allacapan	9,666.29	663.00	10.30		0.75	1,360.58	11,700.92	7,443.68	93.16
Amulung	6,276.66	5,397.00	233.00	13.00	28.00	1,284.95	13,204.61	6,305.31	
Aparri	8,227.35	792.00	15.98			909.33	9,944.66	1,136.48	3,192.75
Baggao	8,105.30	8,711.00	3.83	77.00	16.63	1,262.0324	18,175.79	2,348.69	
Ballesteros	5,468.19					1,150.41	6,618.60	1,483.38	
Buguey	5,419.50	624.00	5.94			909.33	6,958.77	420.50	3,147.70
Calayan	838.02	307.00	19.60			9,644.36	10,808.98	9,092.26	
Camalaniugan	4,700.19	134.00	0.94		12.20	909.33	5,744.46	1,094.78	1,570.91
Claveria	3,683.42					1,913.44	5,596.86	3,005.56	
Enrile	4,062.60	1,325.00	117.26	600.00		3,663.84	9,768.70	5,555.02	
Gattaran	7,078.52	6,521.00	261.44	33.00	26.00	1,136.66	15,030.62	3,482.12	
Gonzaga	4,584.72	2,720.00	12.56	12.00		1,136.66	8,465.94	3,417.02	247.51
Iguig	1,522.12	1,400.00	102.80	31.00	15.50	1,077.15	4,133.07	4,574.67	
Lal-lo	5,636.01	2,173.00	148.21	102.00	33.00	6,345.54	14,404.76	7,937.54	
Lasam	6,852.25	769.00	45.50		63.66	4,251.06	11,981.47	1,986.87	
Pamplona	4,406.08	728.00				2,282.09	7,416.17	406.62	3,126.29
Pe±ablanca	1,203.73	4,577.00	105.44	63.00	12.50	4,770.21	10,731.88	15,317.54	
Piat	2,196.55	2,605.00	41.37	21.00		5,014.04	9,877.96	2,243.35	
Rizal	1,178.00	3,248.00	232.00	54.00	0.95	1,136.66	5,849.61	7,141.74	
Sanchez Mira	2,866.00					3,840.82	6,706.82	413.68	773.91
Santa Ana	9,374.56	3,764.00	58.07	103.00	65.00	909.33	14,208.96	948.97	416.20
Santa Praxedes	3,113.35	263.00	11.65			909.33	4,297.33		
Santa Teresita	384.86					3,442.66	3,827.52		722.41
Santo Niño	2,277.19	1,079.00	15.25			8,425.25	11,796.69	6,241.25	
Solana	3,190.68	1,970.00	78.08	23.00		9,364.86	14,626.62	6,995.83	
Tuao	7,351.30	3,665.00	89.50	8.00		1,136.66	12,250.46	3,222.96	
Tuguegarao City	949.96	2,835.00		99.00	62.00	958.70	4,842.66	5,411.69	
Totals	**130,521.73**	**61,784.00**	**1,655.71**	**1,357.00**	**94.49**	**81,364.93**	**276,777.86**	**109,897.37**	**16,446.55**

Source: PPDO-Cagayan, OPA-Cagayan and PENRO-Cagayan

C. Demographic and Socio- Economic Profile

C.1 Population, Annual Population Growth Rate, and Density

The population of Cagayan was 1,119,320 in year 2015. The population share of the Province was 1.11 % of the national figure while 34.74% of the Cagayan Valley size. The rural population is 85% of the total figure.

With an average growth rate of 1.24%, the population size of the Province is calculated to double in 32 years.

Cagayan's population density is 133 persons per square kilometer. Tuguegarao City, the capital of Province and also the regional center of the Cagayan Valley Region, is the most populated area.

Table I-5. Population, Annual Population Growth Rate, Density, by Municipality

Municipality	Population	Percentage Share	Annual Growth 2000-2015	Density
	2010			
Abulug	32,497	2.73	1.30	200
Alcala	38,883	3.36	0.88	208
Allacapan	33,571	2.81	1.45	109
Amulung	47,860	4.02	0.74	198
Aparri	65,649	5.44	0.70	248
Baggao	85,782	6.95	1.47	93
Ballesteros	34,299	2.86	1.45	286
Buguey	30,175	2.53	0.88	218
Calayan	16,702	1.44	1.02	33
Camalaniugan	24,923	2.08	1.07	326
Claveria	29,921	2.71	0.14	154
Enrile	35,834	2.89	1.38	194
Gattaran	56,661	4.88	1.12	80
Gonzaga	38,892	3.23	1.27	80
Iguig	27,862	2.27	1.60	258
Lal-lo	44,506	3.68	1.30	63
Lasam	39,135	3.29	0.91	183
Pamplona	23,596	2.07	1.04	136
Peñablanca	48,584	3.8	1.65	41
Piat	23,597	2.04	0.92	169
Rizal	17,994	1.65	1.23	145
Sanchez Mira	24,541	2.07	0.88	123
Santa Ana	32,906	2.71	2.79	75
Santa Praxedes	4,154	0.32	2.26	38
Santa Teresita	19,038	1.56	2.13	762
Santo Niño	27,219	2.32	1.18	53
Solana	82,502	6.81	1.32	411
Tuao	61,535	5.12	0.92	286
Tuguegarao City	153,502	12.35	1.59	1060
CAGAYAN	**1, 199, 320**	**100**	**1.24**	**133**

Source: Philippine Statistical Authority

C.2 Economic Structure of the Province

The economy is characterized by the dominance of agriculture sector where it provides income, employment and livelihood to the people. In the distribution of families by income, it reflects that more than 75% of the families are engaged in farming and related activities. Likewise, as described by the results of surveys on employment in industries, the primary (agriculture) sector largely absorbed huge chunk of the labor force. On the average, about 75% of employed persons were in agriculture.

As to industry concentration, Cagayan indicates a high concentration on agriculture, fishery and forestry. It likewise shows fair concentration community and personal services, and the least is manufacturing.

C.3 Households Engaged in Agriculture

Based on BAS Survey, the total number of households engaged in agricultural activities is accounted at 233,108; of which 164,194 or a little more than 71% is engaged in farming.

Table I-6. Number of Household by Type of Agricultural Activity, 2013

Municipality	Total Household	Farming	Non-Farming
Abulug	9,275	7,446	1,829
Alcala	8,063	6,910	1,153
Allacapan	6,447	5,501	946
Amulung	9,301	6,563	2,738
Aparri	12,894	6,989	5,905
Baggao	16,608	15,288	1,320
Ballesteros	6,599	2,591	4,008
Buguey	6,788	6,127	661
Calayan	3,356	3,091	265
Camalaniugan	5,011	2,907	2,104
Claveria	6,656	5,146	1,510
Enrile	6,220	4,377	1,843
Gattaran	10,911	9,817	1,094
Gonzaga	7,202	5,616	1,586
Iguig	4,897	2,558	2,339
Lal-lo	8,766	5,739	3,027
Lasam	7,494	7,026	468
Pamplona	5,161	4,050	1,111
Penablanca	8,595	5,912	2,683
Piat	4,927	4,311	616
Rizal	3,792	3,189	603
Sanchez Mira	5,403	3,309	2,094
Solana	15,415	12,678	2,737
Sta. Ana	5,177	3,981	1,196
Sta. Praxedes	727	486	241
Sta. Teresita	3,285	3,104	181
Sto. Nino	5,546	4,650	896
Tuao	12,326	10,224	2,102
Tuguegarao City	26,266	4,608	21,658

TOTAL	**233,108**	**164,194**	**68,914**

Source: Office of the Provincial Agriculturist – Cagayan

C.4 Agricultural Labor Force and Employment

The working-age population (15-65 years old) is accounted at 773,944 which comprise 64.50% of the total population size. This population class also represents the strength of the Province's labor force. The bulk of the labor force, estimated at 75% are engaged in agriculture and related activities.

C.5 Poverty

The poverty incidence among families of the Province was estimated at 13.3%, that is, 35,986 persons are poor. As to magnitude, there are 189,581 persons accounted as poor.
The annual per capita poverty threshold was approximated at P21,094.00 in 2015.

Table I-7. Poverty Incidence, 2015

Indicator	Level/Number
Annual Per Capita Poverty Threshold (in Pesos)	21,094
Poverty Incidence Among Families (%)	13.3
Magnitude of Poor Families	35,986
Poverty Incidence Among the Population (%)	15.8
Magnitude of Poor Population	189,581

Source: National Statistics Office

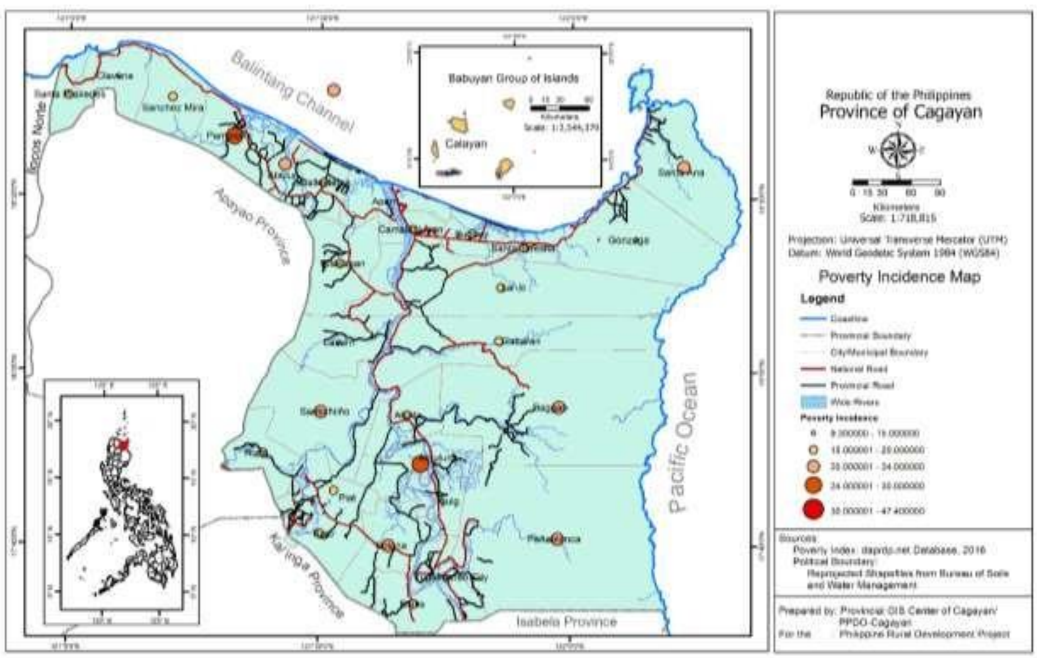
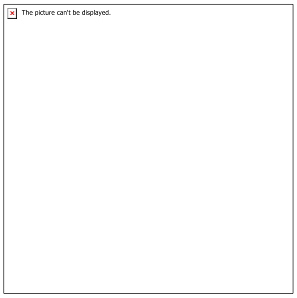


Figure I-7
Poverty Incidence Map

METHODOLOGY



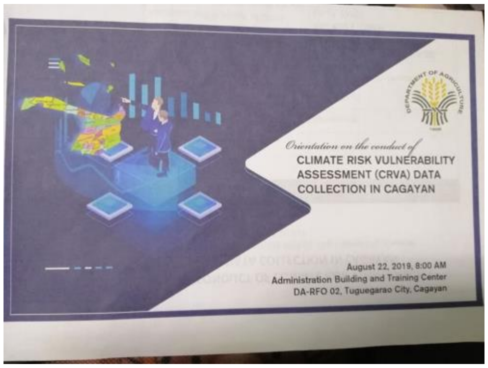
STEP 1) COLLECT

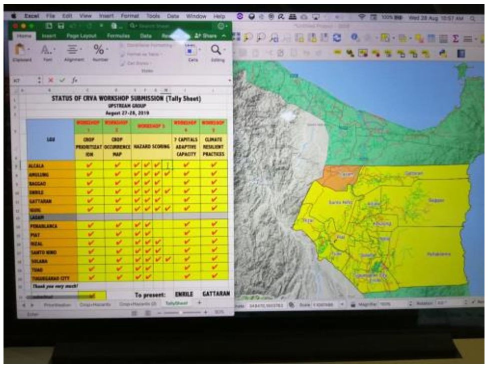
SENSITIVITY – species distribution modelling (SDM) is used to assess the impact of climate change on crop suitability. The simplest [open-sourced and with graphical user interface] implementation of SDM is MaxEnt (Maximum Entropy) from MIT (https://biodiversityinformatics.amnh.org/open_source/maxent/) (Phillips, et al., 2019). SDMs uses two types of data:

Samples/occurrences – crop occurrences (presence location with longitude and latitude attributes). Data on crop occurrences can be found from open-sourced online databases:

- Global Biodiversity Information Facility (**GBIF**) - https://www.gbif.org/en/
- **Genesys** - https://www.genesys-pgr.org/welcome
- **Earthstat** - http://www.earthstat.org/
- Spatial Production Allocation Model (**MAPSPAM**) - http://mapspam.info/

Participatory workshops were done to collect more crop occurrence data since records in the online databases are not sufficient and not location specific. Participatory mapping workshops were initiated as data collection method that involves rapid identification of crop locations based on local knowledge and secondary data. Orientation of the assessment was done last August 21, 2019. The workshop proper were done in two batches, Cagayan downstream and Cagayan upstream, both done during the month of September.


DEPARTMENT OF AGRICULTURE
Orientation on the conduct of
CLIMATE RISK VULNERABILITY ASSESSMENT (CRVA) DATA COLLECTION IN CAGAYAN
August 22, 2019, 8:00 AM
Administration Building and Training Center
DA-RFO 02, Tuguegarao City, Cagayan


STATUS OF CRVA WORKSHOP SUBMISSION (Tally Sheet)
UPSTREAM GROUP
August 27-28, 2019
LGU
CROP PRIORITIZATION
CROP OCCURRENCE MAP
HAZARD SCORING
7 CAPITALS ADAPTIVE CAPACITY
CLIMATE RESILIENT PRACTICES
ALCALA
TUGUEGARAO CITY
To present:
ENRILE
GATTARAN

The following gives a simplified overview of the process in the collection of crop occurrences using a participatory approach.

- Big maps (A3 size) were printed/prepared to show various geographic features that can help participants to locate the crops. Features include river, known landmark, topography, road network, satellite images from Google Earth (not all maps), and municipal and barangay boundary were overlayed (figure 3). A fishnet (1x1 km polygon) which represents the extent of the climate pixel were created and included in the map. The participants were asked to identify crops present for each square polygon of the fishnet. The printed maps were aided by Google Earth. Some municipalities have GIS experts and existing shapefiles of standing crops in their respective municipalities were utilized.

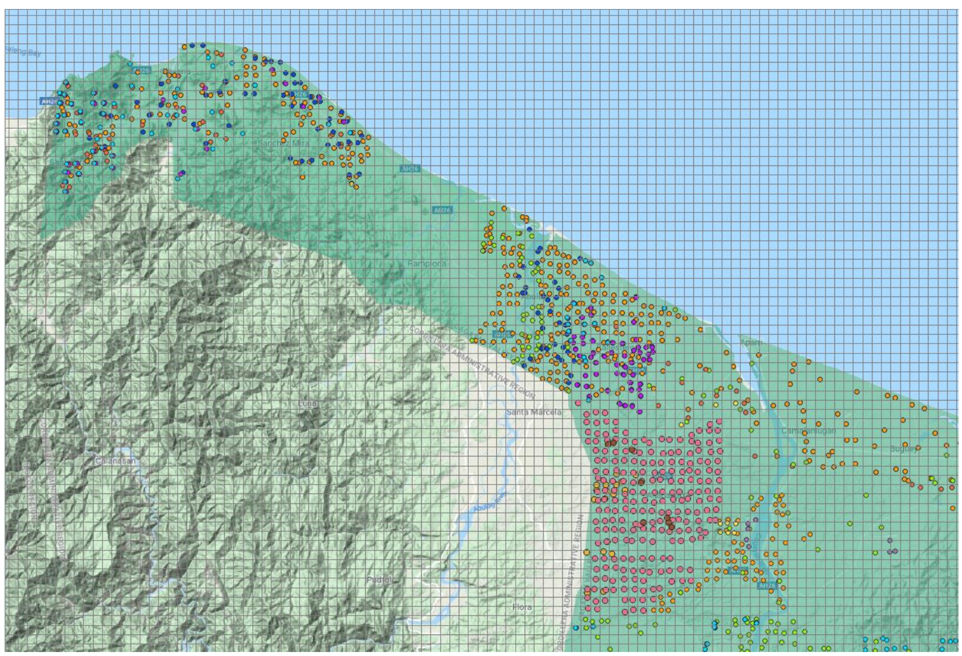
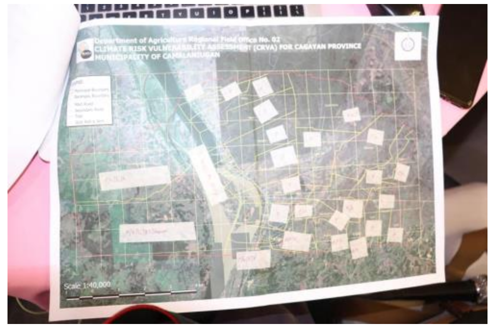
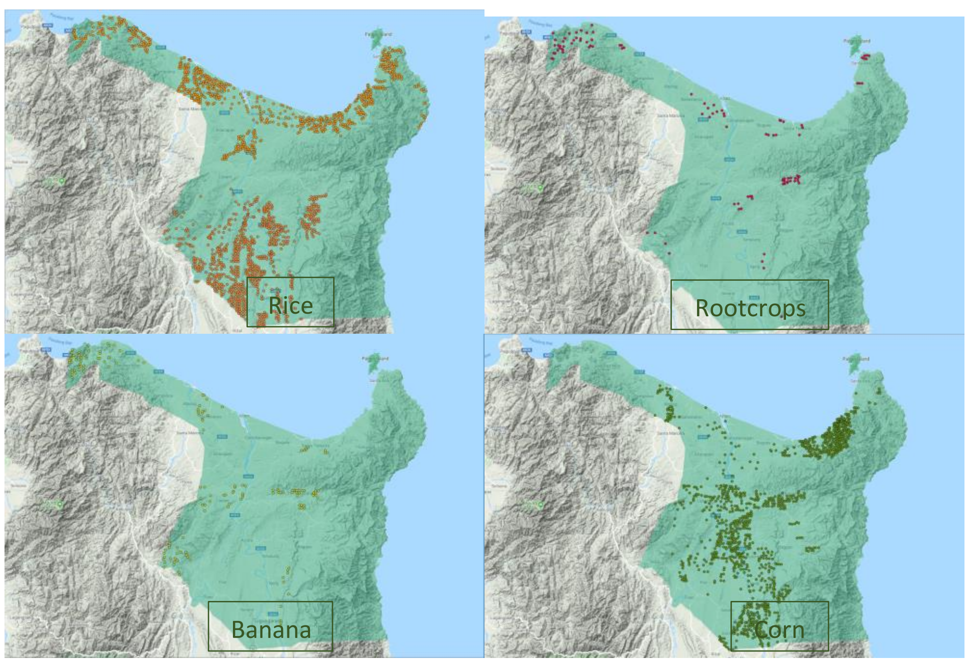


Figure 3. Map layout used for locating crops using participatory mapping



- Field and front line experts knowledgeable on agriculture crops in the province were also invited to a workshop and were asked to locate the location of crops based on their field knowledge and crop records. To identify the location of the crops, the experts based their location estimates using the area and production data at the barangay level. For each square polygon, the participants were asked to identify the presence of crops. In addition, these were the rules that was set during the mapping workshop:
  - One crop per pixel is allowed. For instance, even if rice is present in multiple locations within the pixel, it can only be marked once.
  - Multiple crops are allowed per pixel. For instance, rice and maize are present within the pixel, then the pixel can be marked as both rice and maize.
  - A small or large production area should be marked if the crop is present in the pixel.
  - The maps with markings will be scanned, georeferenced, and will be converted as point vector data in shapefile or CSV [comma separated value] format (figure 4).

410000
421000
432000
LOCATION MAP
BABUYAN CHANNEL
PHILIPPINE SEA
2055000
2044000
2033000
2022000



Rice
Rootcrops
Banana
Corn

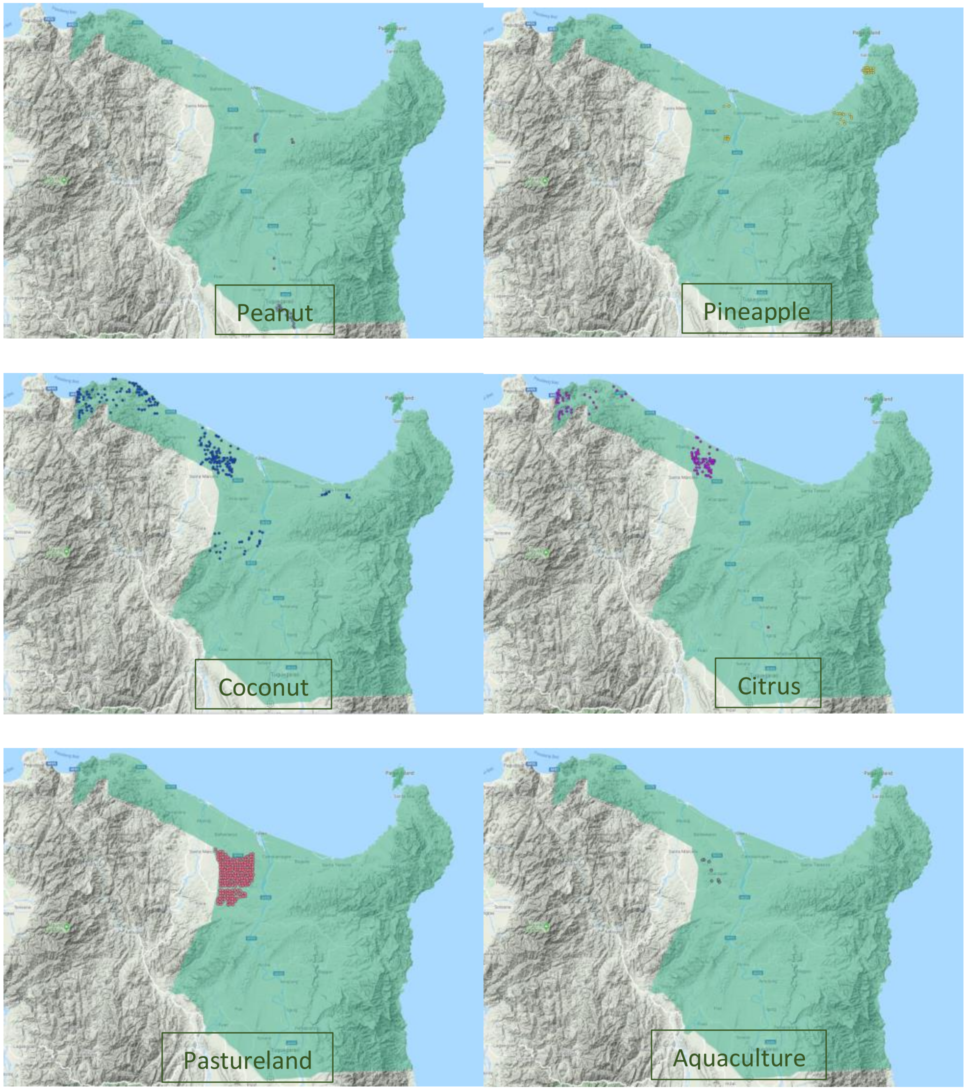
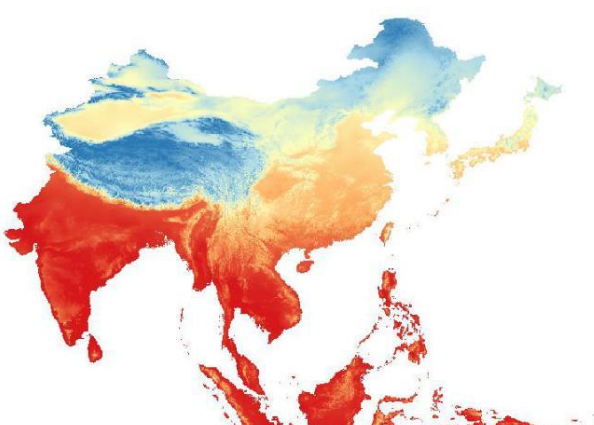


Figure 4. The markings on the map in Sta. Ana, Cagayan during the participatory mapping workshop converted to GIS data

Predictors – bioclimatic data in gridded format was downloaded for baseline and future conditions in the following websites:

- Worldclim (https://www.worldclim.org/) - a set of global climate layers (gridded data) used for mapping and spatial modelling with a spatial resolution of about 1 km^2 (figure 5) representing baseline climate conditions (1970-2000).



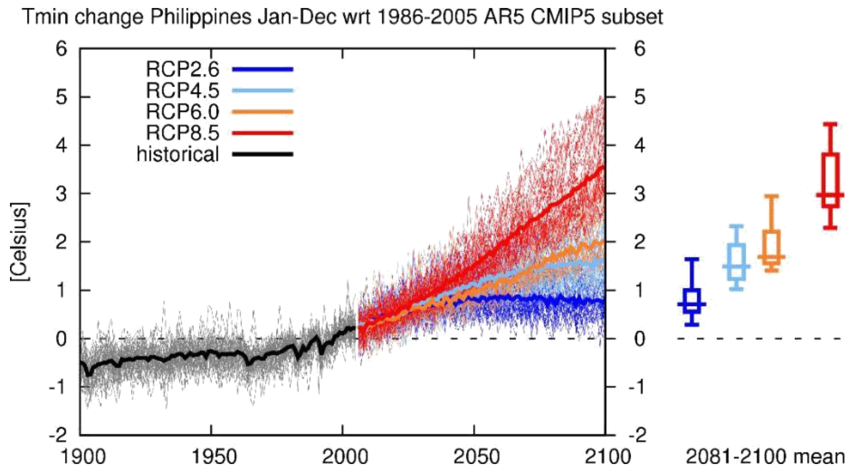


Figure 5. Mean annual temperature (Bio 1) data from worldclim

- CCAFS [Climate Change Agriculture and Food Security] (http://www.ccafs-climate.org/data_spatial_downscaling/) – we selected the year 2050 time period as basis for assessing impact of climate change to agriculture. Climate data for future conditions is based on representative concentration pathways (RCPs) 8.5 scenario using CMIP5 GCMs (figure 6).

Figure 6. Different temperature regimes and uncertainty for 2030s, 2050s, 2070s, and 2090s in the Philippines

HAZARDS – hazard data is provided by DA-SWCCO. Most of these hazard data were collected during the implementation of AMIA-1. Hazard data can be also downloaded from online databases that are listed in the CRVA indicators but not available in the DA database. Although global and open-sourced databases exist, it is still advised to use locally developed hazard data (LiDAR flood maps). Some of the portals and agencies that provide hazard data are the following:

- Global Risk Data Platform of UNEP/UNISDR (https://preview.grid.unep.ch/index.php?preview=data&events=cyclones&evcat=2&lang=eng) – global information on risk and natural hazards
- Climate Hazard Group InfraRed Precipitation with Station data (CHIRPS) (https://chg.geog.ucsb.edu/data/chirps) – 30+ year quasi-global rainfall dataset spanning 50 50°S-50°N for all longitudes with data availability lag time of 1-month
- TERRACLIMATE (http://www.climatologylab.org/terraclimate.html) – set of monthly climate and climate water balance for global terrestrial surfaces from 1958-2015.
- Department of Environment and Natural Resources (DENR) – Mines and Geoscience Bureau (MGB) – flood risk map at 1:10,000 scale.

- DENR MGB – landslide risk map at 1:10,000 scale
- DA Bureau of Soils and Water Management (BSWM) – soil erosion risk map at 1:10,000 scale
- Department of Science and Technology (DOST) – storm surge map developed by the DREAM project.

The hazard data from DA SWCCO and other open data sources has been validated by the partner state university or college (SUC) of the 17 provinces representing the 17 regions covered by the AMIA 1. Further validation by local stakeholders like the MDRRMCs were done thru a workshop before replicating the CRVA process for the remaining provinces in the Philippines not covered in 17 pilot provinces covered by AMIA1.

The table below was used by the municipal disaster risk reduction officers (4 in each municipality – getting the average) to assess the probability occurrences and impact of the 8 hazards being evaluated.

Hazard Scoring (for the hazard index)

Instruction: Please weight the climate hazards according to the identified criteria using the weighing standards provided below.

CRITERIA	Typhoon	Flooding	Drought	Erosion	Landslide	Storm Surge	Sea Level Rise	Salt Water Intrusion
Probability of occurrence								
Impact to national/local economy								
Impact to local household income								
Impact to key natural resources to sustain productivity (i.e. water quality & quantity, biodiversity, soil fertility)								
TOTAL								

Weighing standard for the natural hazards into a climate risk exposure:

Probability of occurrence

5	Once in every year
3	Once in every 5 years
1	Once every 10 years or less

Impact

5	Disastrous
4	Significant
3	Moderate
2	Minor
1	Insignificant

Table below shows the normalized hazard ratings tallied by the different municipalities of Cagayan.

Municipality	Tropical Cyclone	Flood	Drought	Sea Level Rise	Storm Surge	Erosion	Landslide
Piat	0.67	0.60	0.07	-	-	0.45	0.21
Aparri	0.34	0.90	0.25	1.00	1.00	-	0.12
Baggao	0.90	0.30	1.00	0.02	0.02	0.73	0.80
Allacapan	0.52	0.40	0.24	0.11	-	0.19	0.55
Tuguegarao City	0.76	1.00	0.07	-	-	0.30	0.26
Amulung	0.76	0.70	0.21	0.01	-	0.53	0.35
Gattaran	0.81	0.20	0.60	0.07	0.01	0.65	0.84

Santa Ana	0.89	-	0.49	0.23	0.29	0.60	0.94
Gonzaga	1.00	0.20	0.29	0.09	0.16	0.74	0.72
Santa Praxedes	-	0.20	0.01	-	-	0.93	0.99
Ballesteros	0.33	0.70	0.05	0.32	0.18	0.15	0.08
Lasam	0.65	0.80	0.27	0.03	-	0.34	0.18
Buguey	0.51	0.70	0.04	0.51	0.44	0.14	0.10
Pamplona	0.27	0.50	0.18	0.45	0.27	0.47	0.40
Abulug	0.30	0.90	0.02	0.46	0.33	0.03	-
Solana	0.71	0.40	0.25	-	-	0.24	0.36
Alcala	0.79	0.50	0.18	0.05	-	0.58	0.51
Tuao	0.56	0.70	0.03	-	-	0.34	0.17
Claveria	0.12	0.50	0.12	0.13	0.05	0.56	0.44
Enrile	0.69	0.50	0.06	-	-	0.42	0.44
Rizal	0.54	0.10	0.33	-	-	0.99	0.88
Sanchez Mira	0.19	0.40	0.14	0.17	0.12	0.56	0.42
Iguig	0.80	0.30	0.06	-	-	0.42	0.61
Santa Teresita	0.73	0.40	0.11	0.12	0.13	0.38	0.39
Lallo	0.78	0.20	0.50	0.17	0.01	0.72	0.78
Santo Nino	0.72	0.40	0.44	0.03	-	0.72	0.54
Calayan	0.60	-	0.25	0.04	0.05	1.00	0.80
Camalaniugan	0.63	1.00	-	0.46	0.31	0.14	0.08
Penablanca	0.97	0.20	0.80	0.01	0.02	0.87	1.00

If the hazard data overestimates or underestimates the incidence, secondary data were collected and used for crop damages. The collected secondary data were also used to correct the hazard incidence.

Translating it to be normalized across the country, experts from CIAT has come up with hazard weights across island groups.

Hazards	Luzon	Visayas	Mindanao
Typhoon	20.00	18.21	16.95
Flood	19.05	16.40	15.25
Drought	14.25	16.17	16.95
Erosion	11.43	12.57	12.71
Landslide	8.57	10.72	14.41
Storm Surge	9.52	10.39	8.47
Sea Level Rise	5.71	8.33	5.08
Saltwater Intrusion	11.43	7.21	10.17

ADAPTIVE CAPACITY – thirty-six (36) indicators and sub-indicators were used to measure adaptive capacity. Each of the indicators were aggregated into one of the seven (7) capitals to simplify the interpretation and contextualization of the information (figure 7). The data sources were collected from several local data (municipal/city), national and international databases.

- Philippine Statistics Authority – provides poverty incidence data at municipality-level
- National Competitive Council – provides socio-economic data at the municipality-level
- National Mapping and Resource Information Authority – provides land cover data for Philippines
- Globcover 2009 – global land cover map

- International Water Management Institute – global irrigated map of the world.

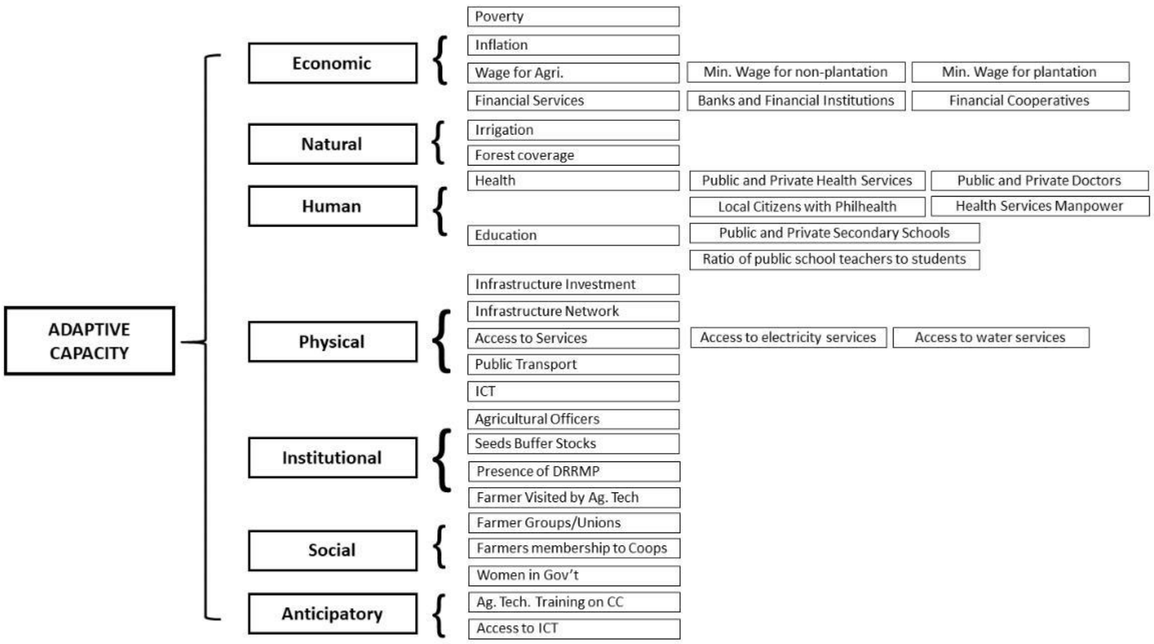


Figure 7. The list of indicators and sub-indicators used to assess adaptive capacity for the CRVA expansion phase, Cagayan Province.

The table below was used for the data capture from among the municipalities of Cagayan.

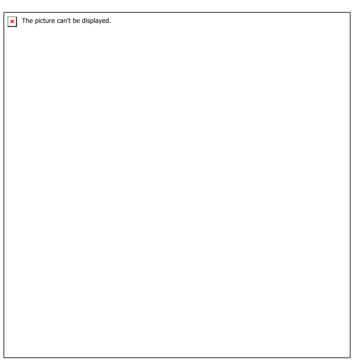
CAPITALS OF ADAPTIVE CAPACITY	
Instruction: Please answer either the main parameter asked or if not available, its proxy parameter.	
Economic	**Proxy**
Total Agricultural Production (limit to target commodity systems, MT)	
Income level	Municipality class
Access to credit	Total number of financial institutions*
	Number of finance cooperatives*
Commodity price fluctuation	Average inflation rate*
Agricultural insurance	% of farmers covered with insurance
% Employment in agriculture	% of total population
Agriculture minimum wage (plantation / non plantation)*	
% Poverty incidence*	
% of farmers covered by crop insurance	
Natural	
Soil organic matter (soil fertility)	Soil type
Supporting ecosystems and their health (e.g. mangroves, forests, lakes, coral reefs)*	Forest cover (intact)
Groundwater availability	Proportion of shallow and deep wells
Reliable water for irrigation/Presence of irrigation	
Agriculture production area (has)	
Social	
Existence of farmer's groups or unions	Number of registered farmer groups or unions
Participation / Activity of farmer's groups or unions	% of farmers who are members of coops/unions/groups
Equity of women and men in decision making	% of women in government (i.e., elected officials)
Inclusion of ethnic minorities	% of ethnic minorities in government (i.e., elected officials)

Human	
Education level (literacy rate)	
Quality of education in local schools	Ratio of school teachers to students*
	Number of public secondary schools*
	Number of private secondary schools*
	Number of secondary schools*
	Number of public tertiary schools*
	Number of public technical vocational schools*
Health	
Nutrition sufficiency (% prevalence rate of malnourished children under 7 years old)	Calorie intake per day and/or data on nutrient deficiency
Total number of doctors (public) and total public health facilities	Public health services*
	Private doctors*
	Private health services*
	Health services manpower*
	Public doctors*
	Local citizen with Philhealth*
Adults in household	% of > 18 y.o
Prevalence rate of malnourished children	
Age-dependency ratio	
Physical	
Land tenure	% of farmers owning their agricultural production land
Farm size	hectare average
Value of machinery and equipment owned (# of machineries)	number of equipment
Value of livestock owned	
Access to irrigation infrastructure (total irrigated area in hectares)*	% of crops irrigated
Access to post-harvest infrastructure (number of post-harvest infrastructure)	% of farmers with access, No. of farmers
Access to quality seeds	% of farmers with access, No. of seed growers or ha.
Access to fertilizer and pesticides	% of farmers with access, No. of dealers
Reliable infrastructure (total length of concrete roads)	Total length of concrete roads
Percent of HH with water services*	
Percent of HH with electricity services*	
Anticipatory	
Farmer/Fisher awareness of climate change and local impacts	Number of registered trainings held
Disaster preparedness committee (Yes or No)	Presence of functioning MDRRMC
Existing early warning systems (Yes or No)	Presence of early warning system
Access to early warning information via Radio, TV, or meetings	Access to ICT
Access to communication technology: cell phone, internet	% coverage
Telephone companies and mobile services*	
Institutional	
Effective government and/or CSO programs for climate change (Yes or No)	
Adequate government response to previous shocks (Yes or No)	
Farmers visited by or consulted with agricultural extension officer	% coverage
Number of Agricultural officers*	
Buffer stocks (limited to target commodity systems)*	
Presence of DRRMP*	
Number of farmers visited or consulted with ag extension staff	

After collating the adaptive capacity forms, this is the normalize table:

Muni_City	Economic	Natural	Social	Human	Health	Physical	Anticipatory	AC	AC_norm	1-AC_norm
Abulug	0.44407	0.44182	0.56452	0.20101	0.08848	0.46827	0.57333	2.78151	0.42696	0.57304
Alcala	0.41910	0.38307	0.50774	0.14104	0.13846	0.56573	0.76667	2.92181	0.45876	0.54124
Allacapan	0.39753	0.86341	0.00000	0.19366	0.09987	0.23348	0.00000	1.78796	0.20176	0.79824

Amulung	0.67715	0.71863	0.83806	0.18303	0.16937	0.32293	1.00000	3.90917	0.68256	0.31744
Aparri	0.35997	0.33771	0.75161	0.14544	0.26754	0.62655	0.60000	3.08881	0.49661	0.50339
Baggao	0.59758	0.81595	0.40645	0.34966	0.26085	0.26059	0.75333	3.44442	0.57722	0.42278
Ballesteros	0.14541	0.15652	0.72258	0.15806	0.10410	0.68836	0.68600	2.66101	0.39965	0.60035
Buguey	0.24134	0.94056	0.86290	0.40739	0.09277	0.21904	0.62933	3.39333	0.56564	0.43436
Calayan	0.00000	0.05069	0.83419	0.00000	0.00000	0.34086	0.58467	1.81041	0.20685	0.79315
Camalaniugan	0.30347	0.36731	0.69503	0.38718	0.15662	0.36860	0.30800	2.58620	0.38269	0.61731
Claveria	0.72577	0.38520	0.88387	0.37198	0.09796	0.74000	0.88533	4.09012	0.72357	0.27643
Enrile	0.15012	0.49915	0.19161	0.38069	0.13544	0.34646	0.51000	2.21347	0.29821	0.70179
Gattaran	0.35405	0.73991	0.81290	0.24003	0.10726	0.27833	0.85333	3.38581	0.56393	0.43607
Gonzaga	0.53876	0.69336	0.94645	0.21965	0.09772	0.12114	0.62000	3.23709	0.53022	0.46978
Iguig	0.27642	0.27365	0.23626	0.32479	0.10113	0.31034	0.52000	2.04258	0.25947	0.74053
Lal-lo	0.57787	0.68449	1.00000	0.22696	0.14698	0.52388	0.65600	3.81619	0.66148	0.33852
Lasam	0.57917	0.48645	0.67623	0.06211	0.11923	0.36699	0.67333	2.96351	0.46821	0.53179
Pamplona	0.08569	0.41036	0.00000	0.12058	0.06513	0.21607	0.00000	0.89782	0.00000	1.00000
Peñablanca	0.37152	0.54678	0.31200	0.39525	0.17057	0.45285	0.84267	3.09163	0.49725	0.50275
Piat	0.48909	0.20738	0.59068	0.24477	0.18019	1.00000	0.64000	3.35210	0.55629	0.44371
Rizal	0.22674	0.19766	0.00000	0.12201	0.09820	0.19021	0.32667	1.16148	0.05976	0.94024
Sanchez Mira	0.43767	0.10791	0.78581	0.35187	0.09925	0.45141	0.76200	2.99592	0.47556	0.52444
Santa Ana	0.19034	0.42191	0.40645	0.33657	0.14217	0.00000	0.51400	2.01144	0.25241	0.74759
Santa Praxedes	0.35105	0.00000	0.59806	0.11445	0.12104	0.24744	0.50600	1.93803	0.23578	0.76422
Santa Teresita	0.41844	0.45055	0.32452	0.26581	0.11542	0.34555	0.80933	2.72961	0.41520	0.58480
Santo Niño	0.17688	0.45340	0.45806	0.17151	0.04666	0.49335	0.70000	2.49987	0.36312	0.63688
Solana	0.46599	1.00000	0.40645	0.44902	0.12286	0.60411	0.68333	3.73177	0.64235	0.35765
Tuao	0.54116	0.92832	0.40645	0.34756	0.10150	0.29642	0.82333	3.44474	0.57729	0.42271
Tuguegarao City	1.00000	0.18621	0.33871	1.00000	1.00000	0.96609	0.81867	5.30968	1.00000	0.00000



STEP 2) ANALYZE

The weighted overlay of **Sensitivity**, **Exposure**, and **Adaptive Capacity** were used to assess municipality-level vulnerability within Cagayan province. Experts from the MLGU, academe, development organizations and gov't agencies provided the weights for each dimension and indicators of the VA thru a workshop. Result of the workshop revealed that adaptive capacity received more weights (70%) compared to impact (30%). This shows that experts consider the value of strengthening community capacity as an important factor for climate change adaptation.

ANALYZING SENSITIVITY – crop suitability is used as a basis to assess the impact of climate change. SDM is a widely used tool to map suitability using monthly-climatic and monthly-derived bioclimatic variables. Maximum

Entropy (**MaxEnt**) model was used to map crop suitability in the Philippines using bioclimatic data for baseline and future conditions. However, other tools can also be used to map species distribution such as Biomod2 (Thuiller, 2019 – biomod2: Ensemble Platform for Species Distribution Modeling). Suitability change for each crop is obtained as the difference between the projected and baseline suitability values in each pixel (Bouroncle, et al., 2016, **Eq. 1**). The resulting pixel values will have a range from the negative to positive – negative pixel values means suitability has decreased in the future relative to baseline suitability values. For each municipality, the mean suitability change for each crop were derived. The mean values across municipalities per crop will be normalized using Eq. 2 and ranked from lowest to highest.

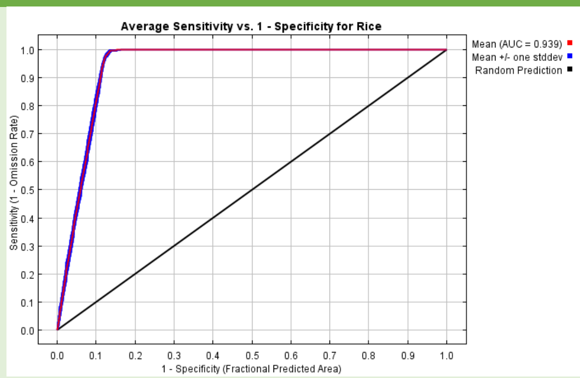
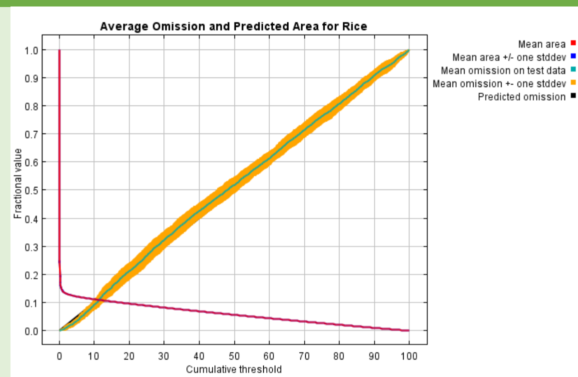
$$\boldsymbol{Suitability\ change} = \left(\left(\frac{\boldsymbol{Suitability_{future} - Suitability_{baseline}}}{\boldsymbol{Suitability_{baseline}}}\right) \div \boldsymbol{Suitability_{baseline}}\right)\boldsymbol{x\ 100} \quad \textbf{Eq. 1}$$

Where: future = result of species distribution model for future conditions, and baseline = result of the species distribution model for baseline condition

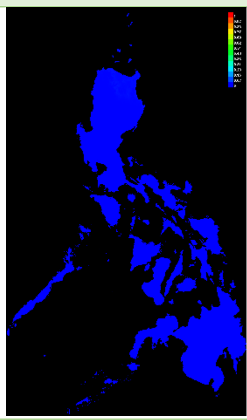
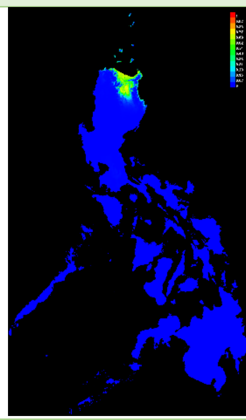
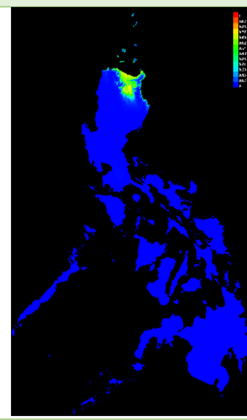
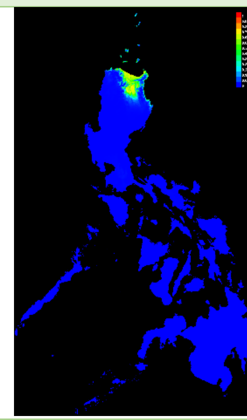
These are the results of the MaxEnt analysis for the different priority crops as identified by the MLGUs in Cagayan.

RICE

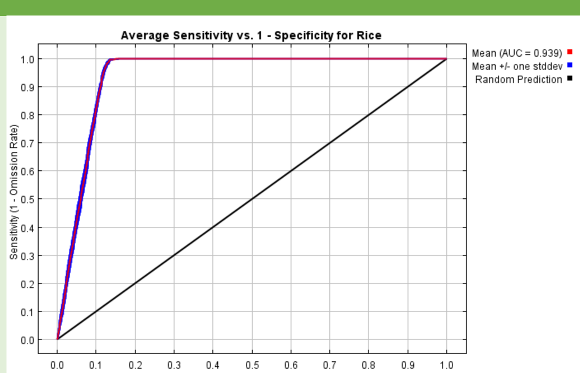
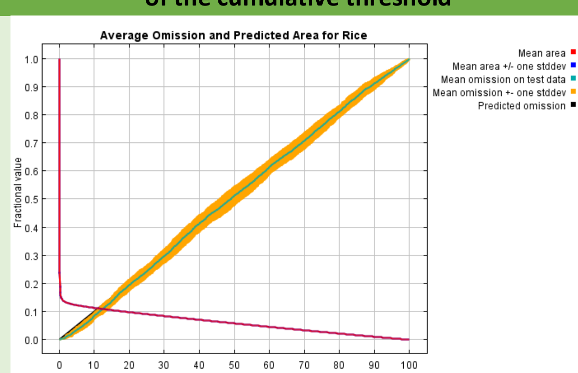
Baseline 2019

Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold
	

Summary Grids

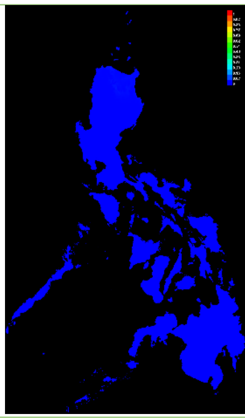
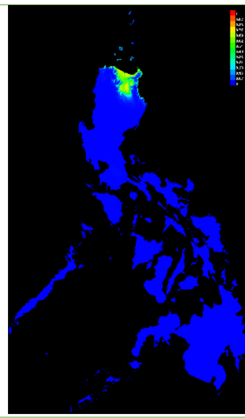
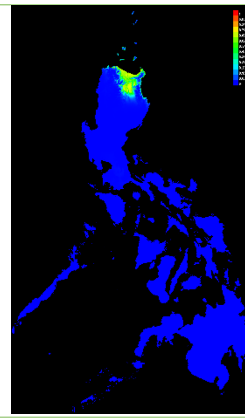
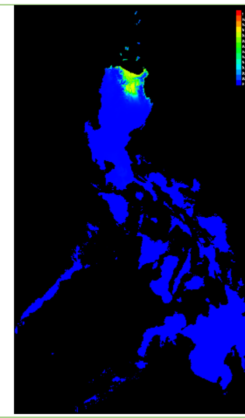
Standard Deviation	Min	Median	Max
			

Year 2050

Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold
	

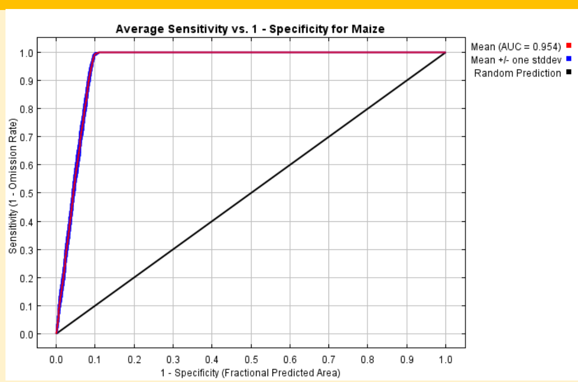
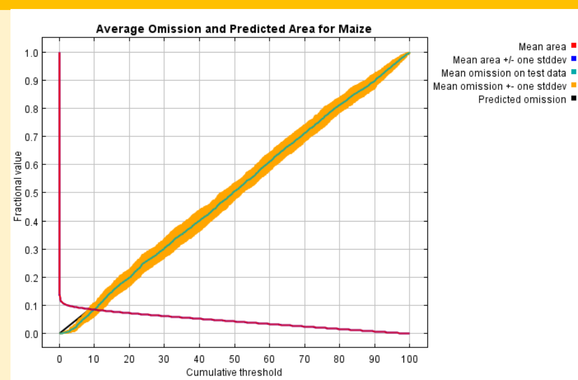
Summary Grids

Standard Deviation	Min	Median	Max

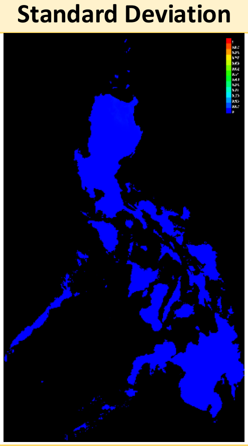
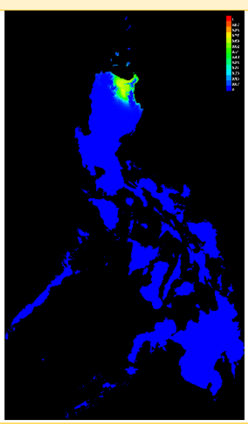
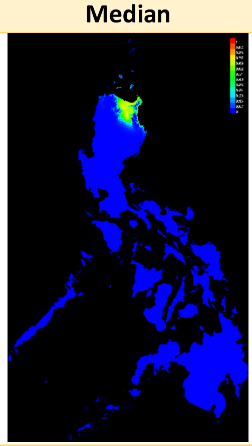
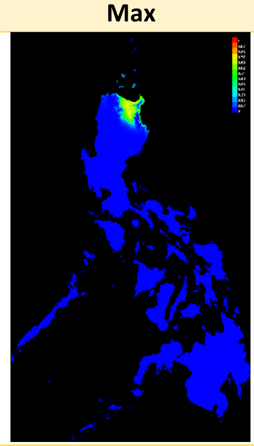
   

CORN

Baseline 2019

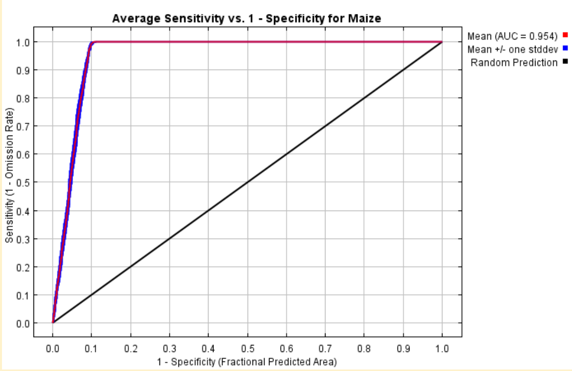
Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold
	

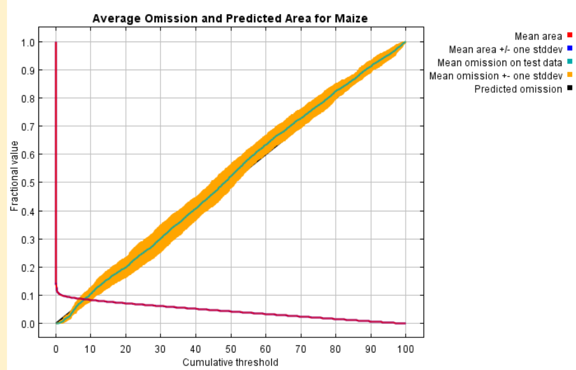
Summary Grids

Standard Deviation	Min	Median	Max
			

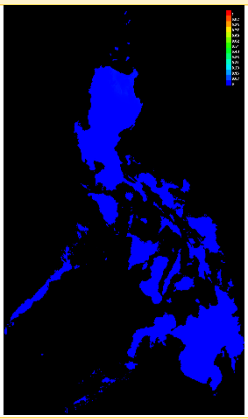
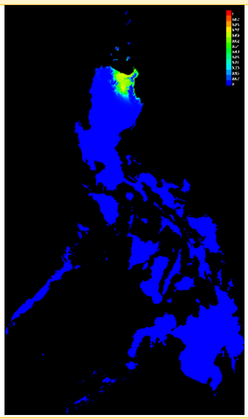
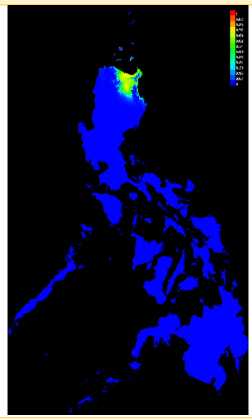
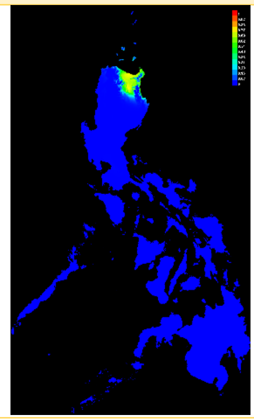
Year 2050

Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold



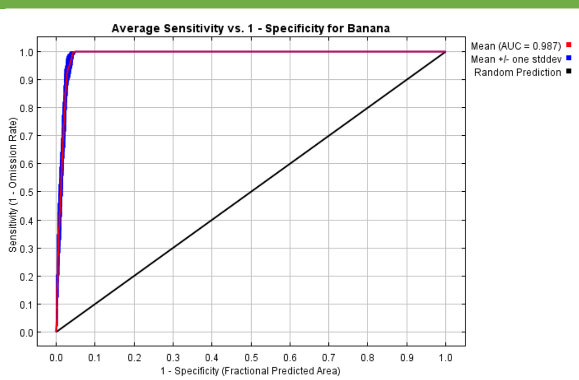
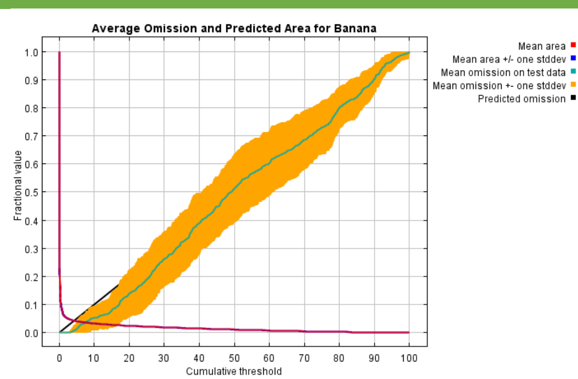


Summary Grids

Standard Deviation	Min	Median	Max
			

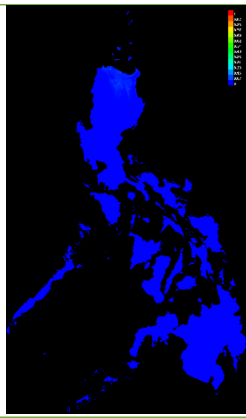
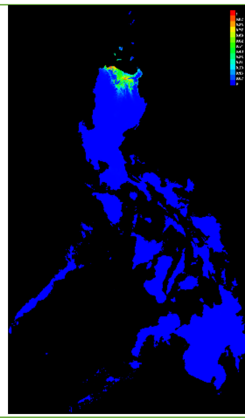
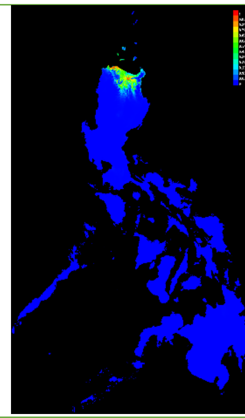
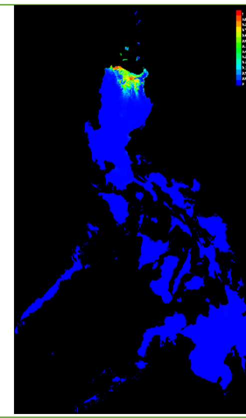
BANANA

Baseline 2019

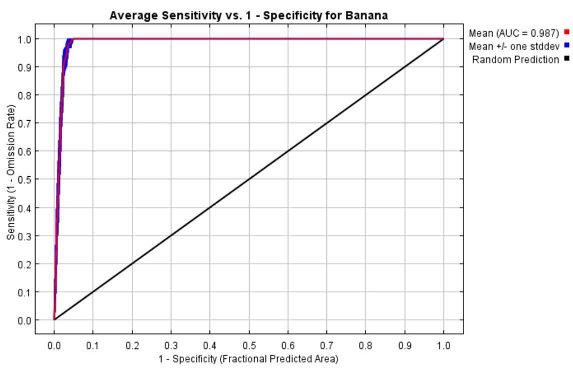
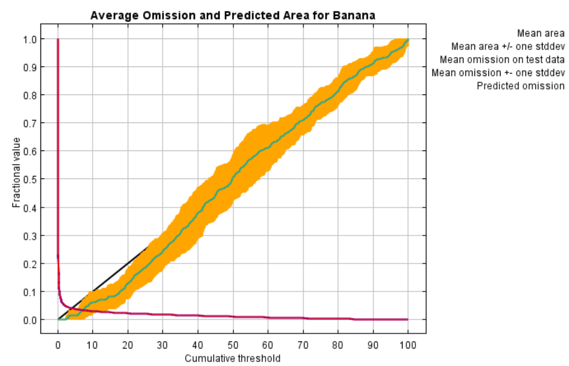
Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold
	

Summary Grids

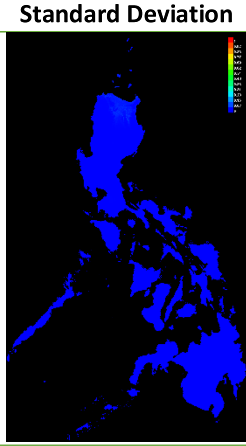
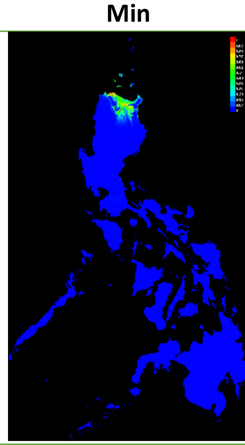
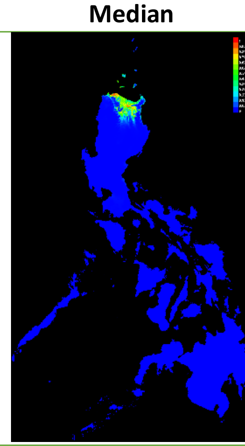
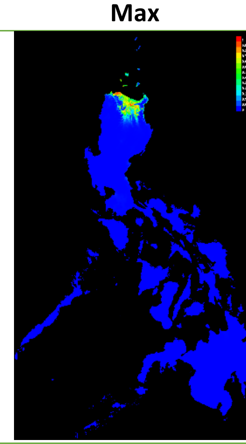
Standard Deviation	Min	Median	Max

Year 2050

Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold
	

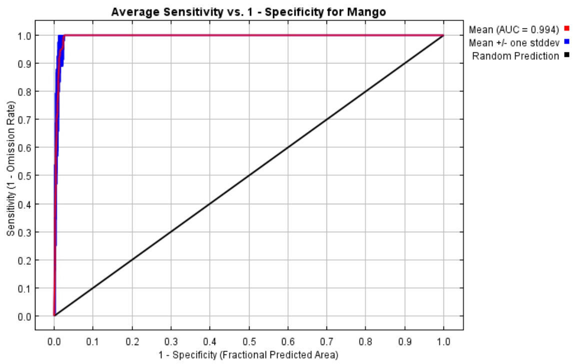
Summary Grids

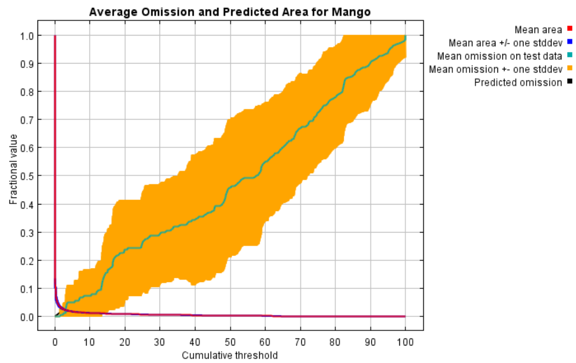
Standard Deviation	Min	Median	Max
			

MANGO

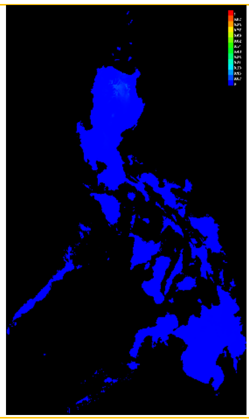
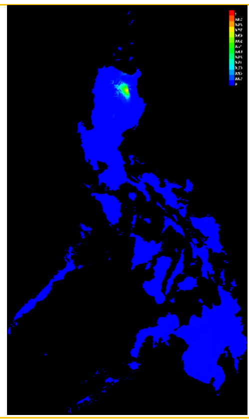
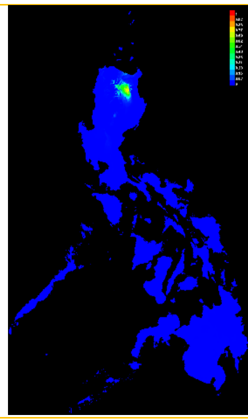
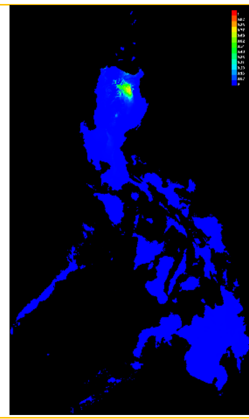
Baseline 2019

Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold

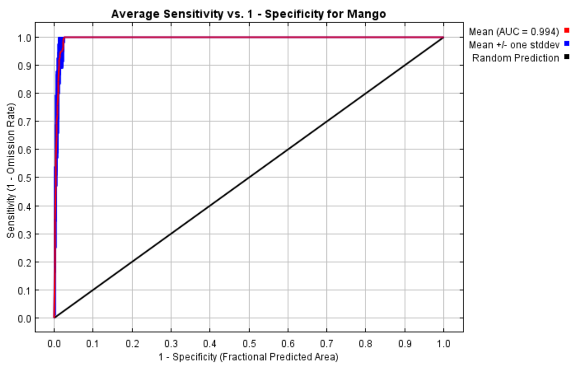
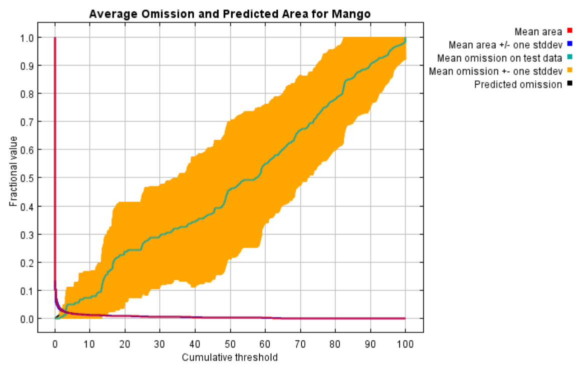




Summary Grids

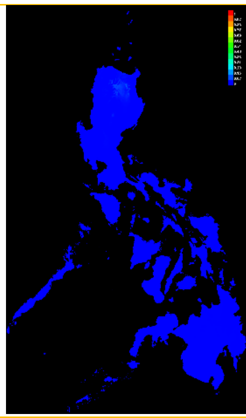
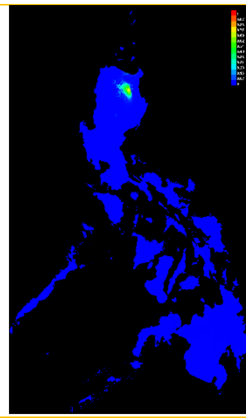
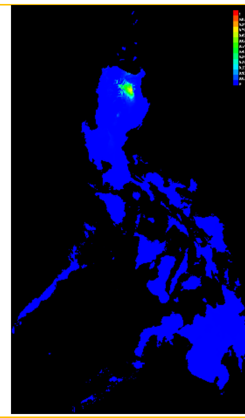
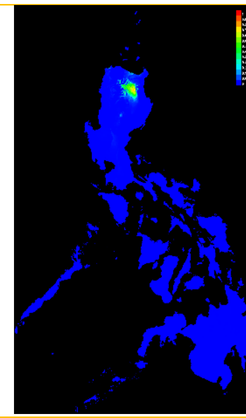
Standard Deviation	Min	Median	Max
			

Year 2050

Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold
	

Summary Grids

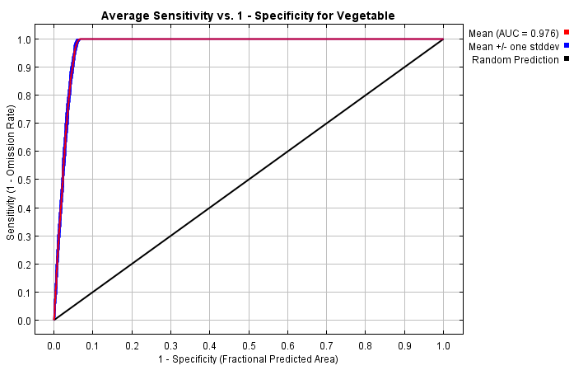
Standard Deviation	Min	Median	Max

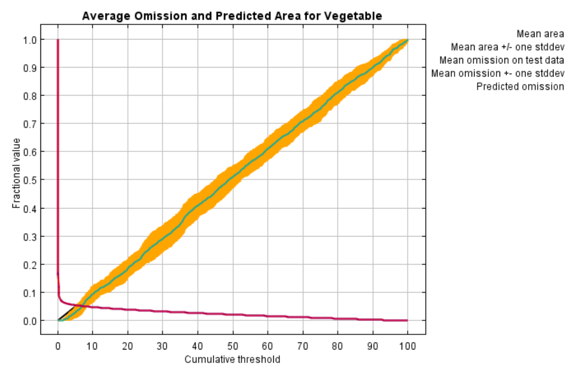





VEGETABLES

Baseline 2019

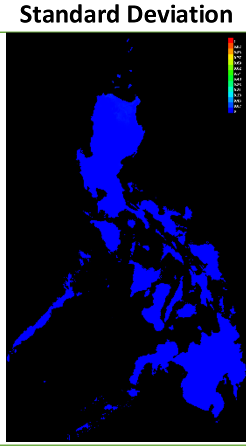
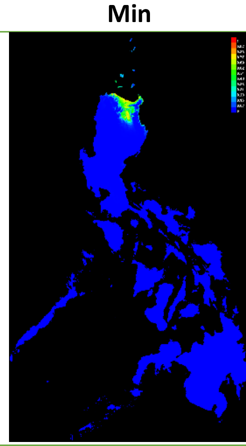
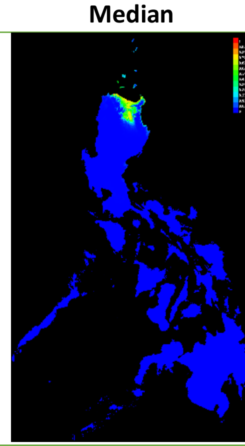
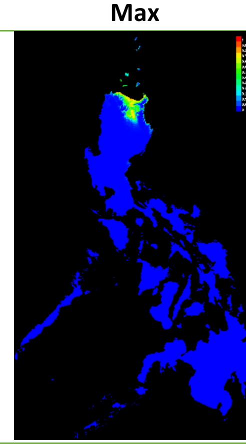
Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold





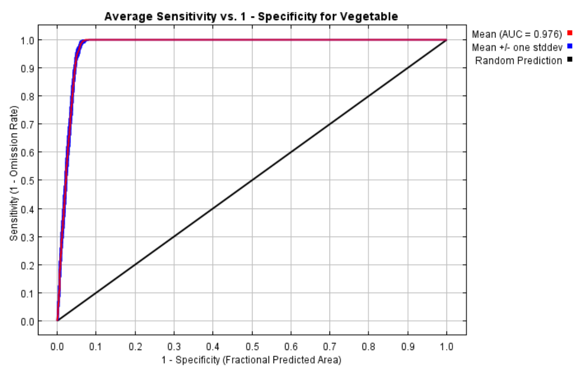
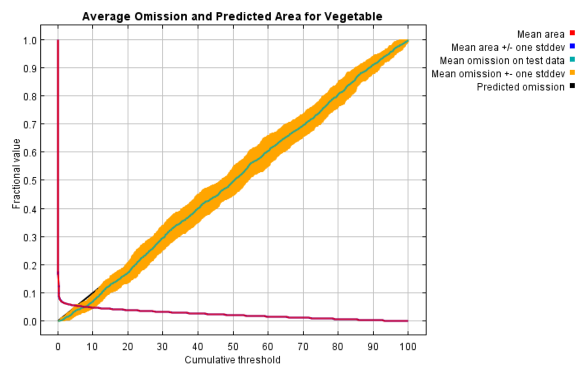
Summary Grids

Standard Deviation	Min	Median	Max

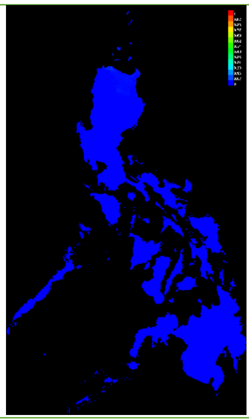
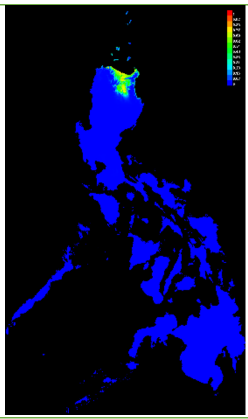
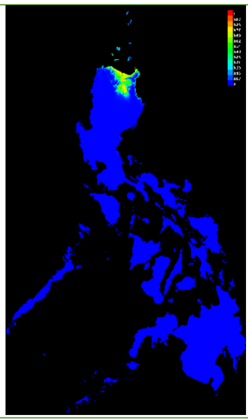
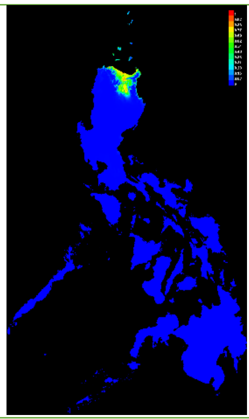





Year 2050

Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold

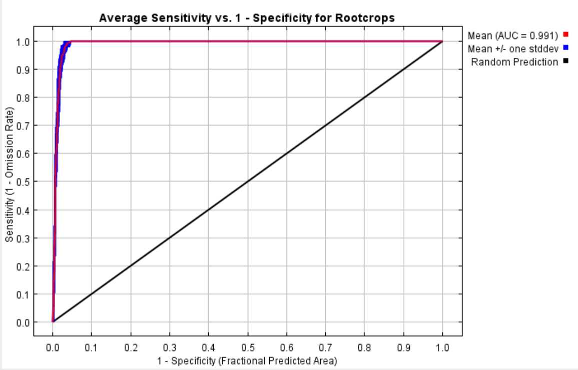
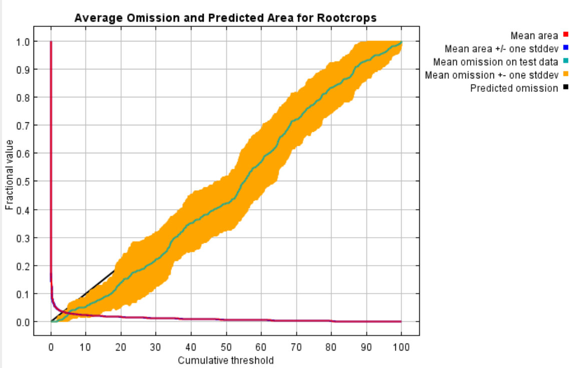
	

Summary Grids

Standard Deviation	Min	Median	Max
			

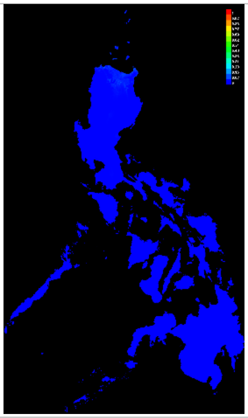
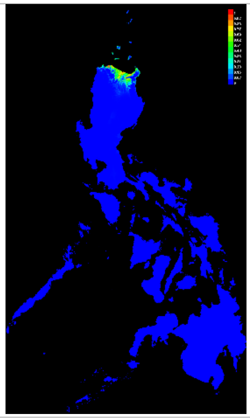
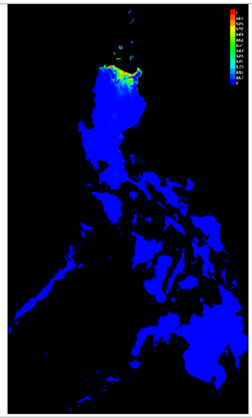
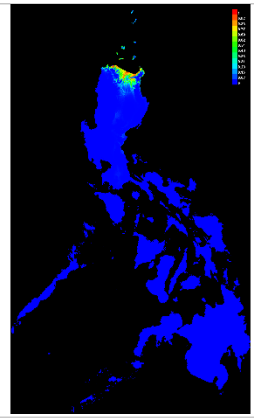
ROOTCROPS

Baseline 2019

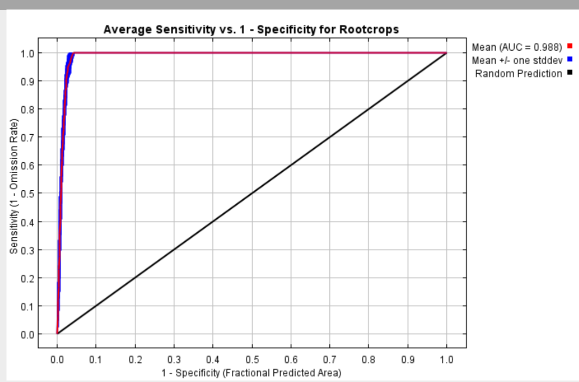
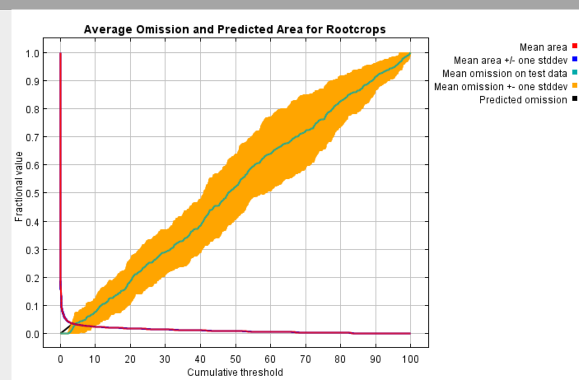
Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold
	

Summary Grids

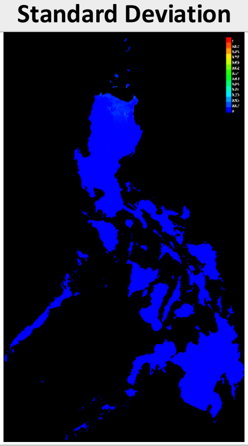
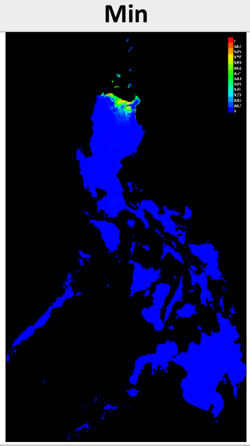
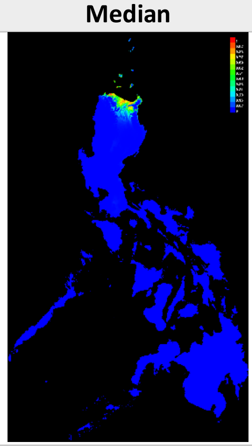
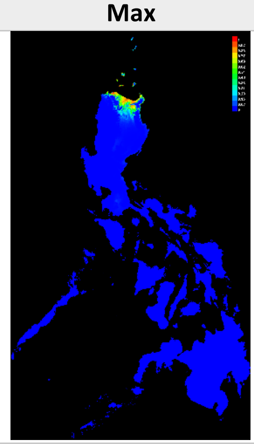
Standard Deviation	Min	Median	Max

Year 2050

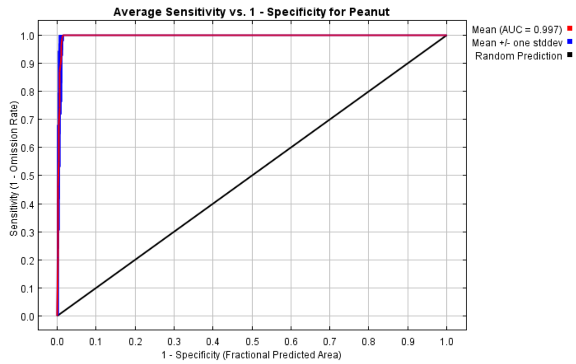
Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold
	

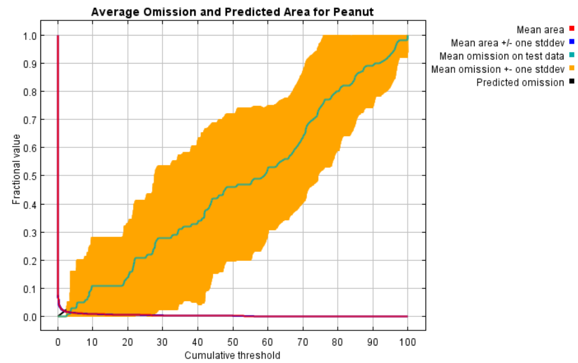
Summary Grids

Standard Deviation	Min	Median	Max
			

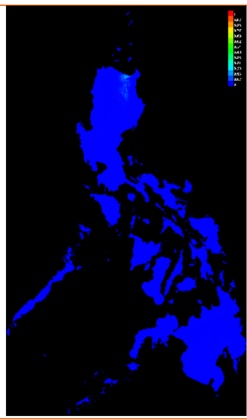
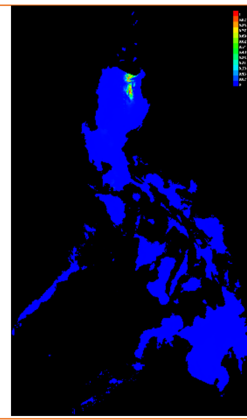
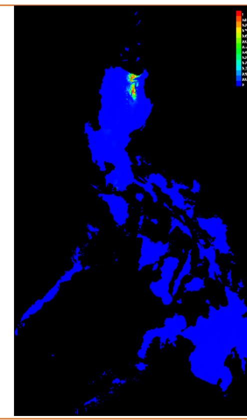
PEANUT
Baseline 2019

Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold



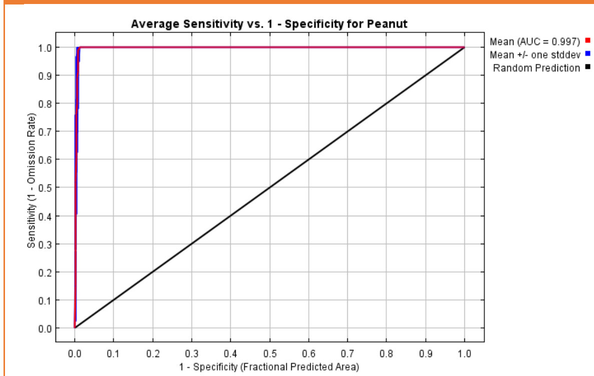


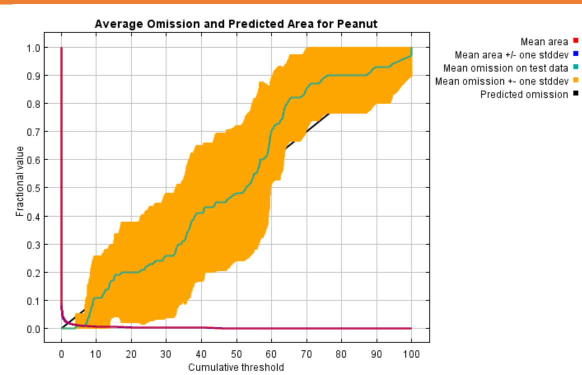
Summary Grids

Standard Deviation	Min	Median	Max
			

Year 2050

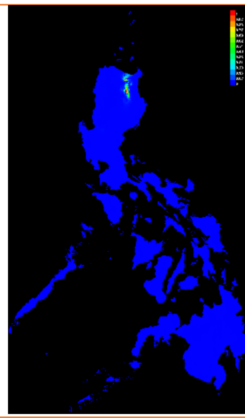
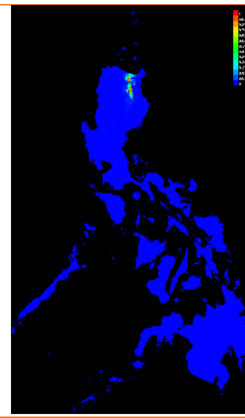
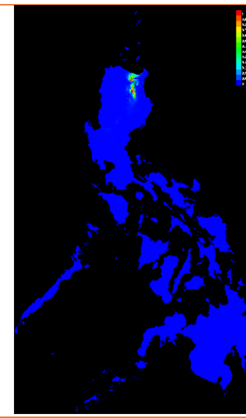
Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold



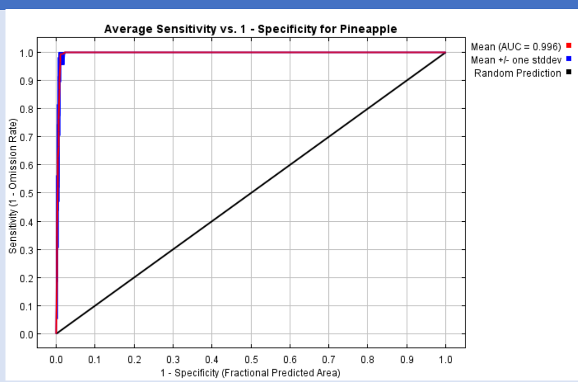
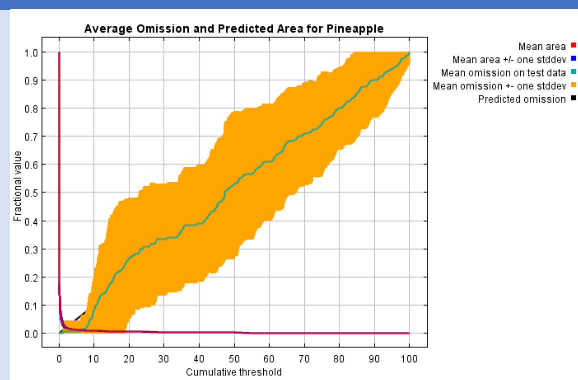


Summary Grids

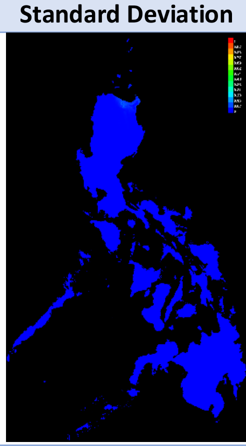
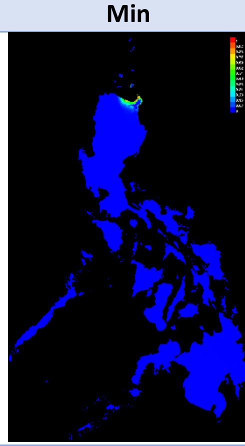
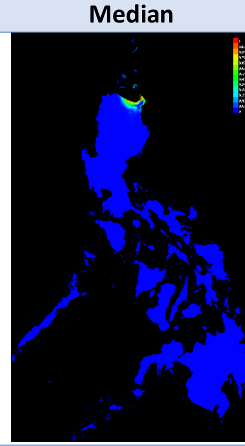
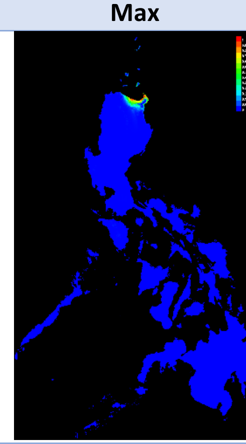
Standard Deviation	Min	Median	Max

Pineapple
Baseline 2019

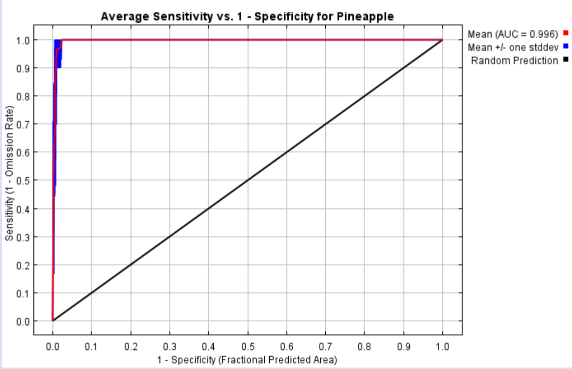
Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold
	

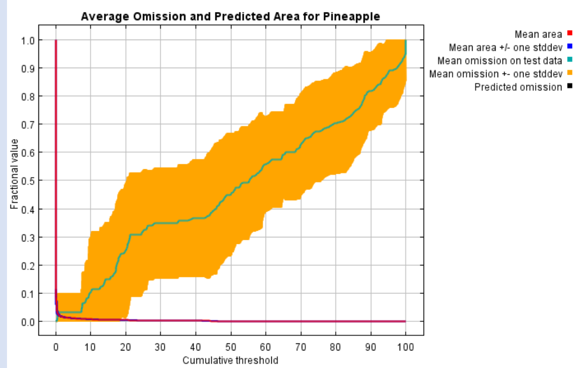
Summary Grids

Standard Deviation	Min	Median	Max
			

Year 2050

Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold



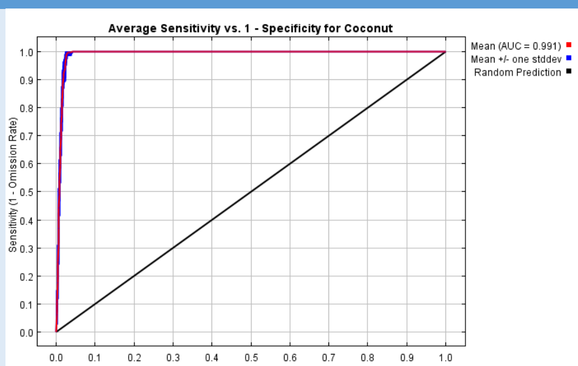
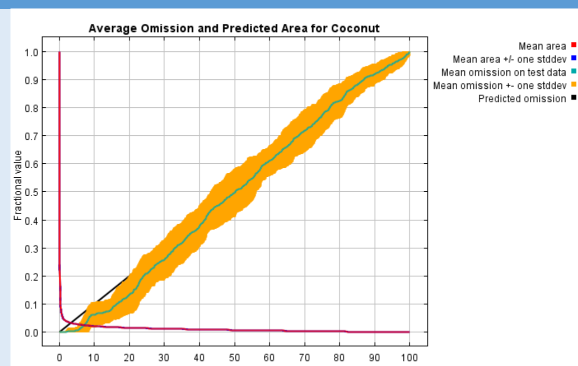


Summary Grids

Standard Deviation	Min	Median	Max
			

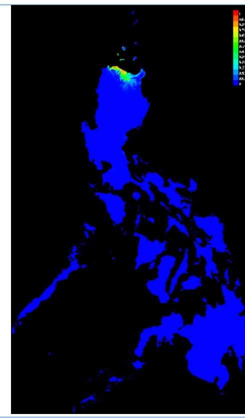
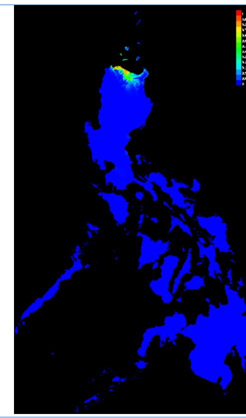
COCONUT

Baseline 2019

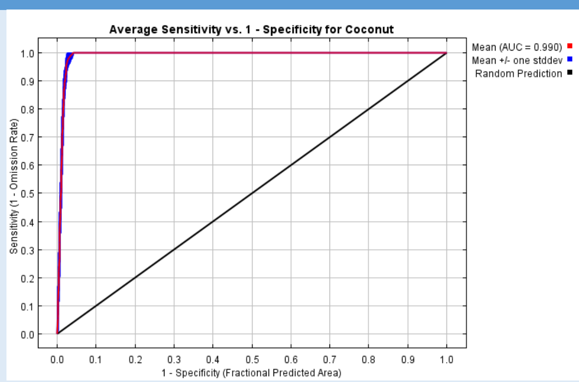
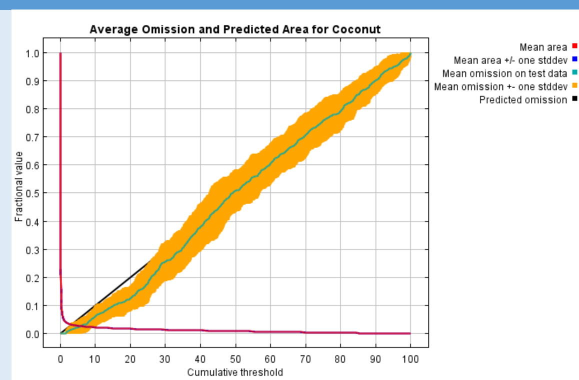
Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold
	

Summary Grids

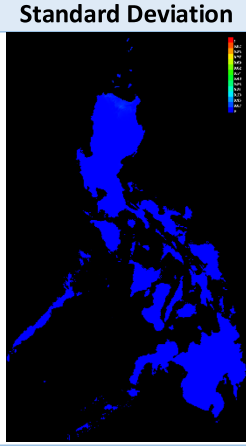
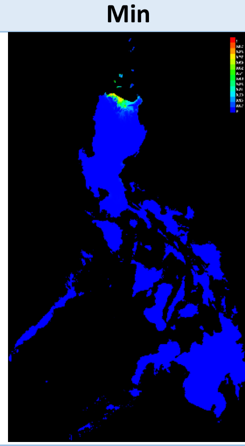
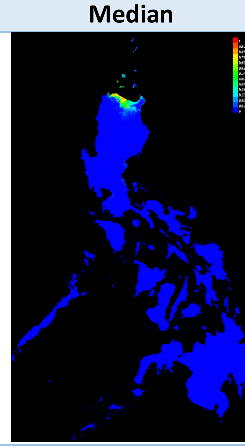
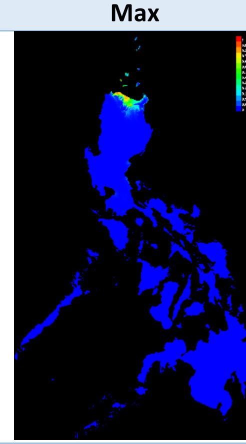
Standard Deviation	Min	Median	Max

Year 2050

Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold
	

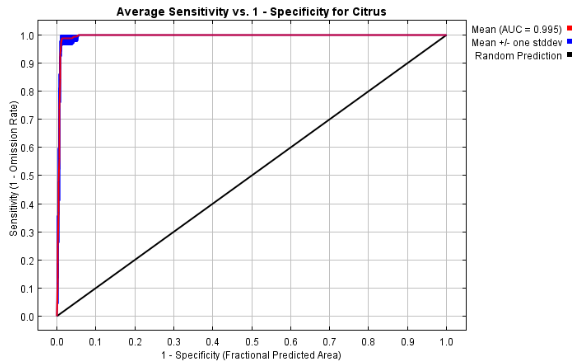
Summary Grids

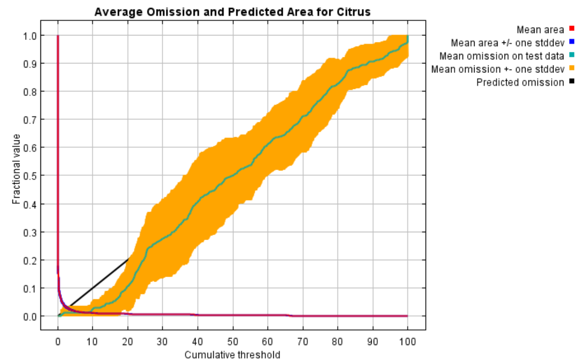
Standard Deviation	Min	Median	Max
			

CITRUS

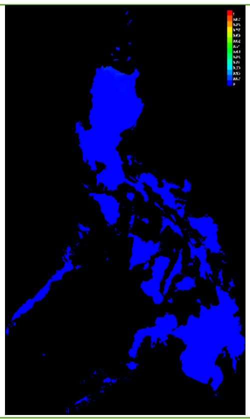
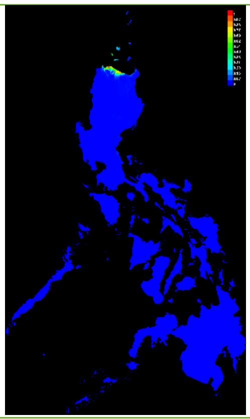
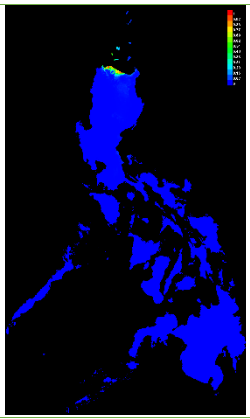
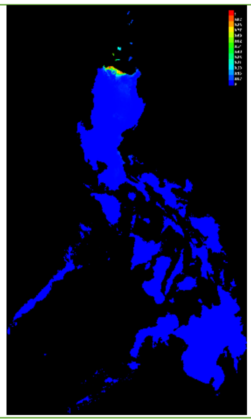
Baseline 2019

Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold



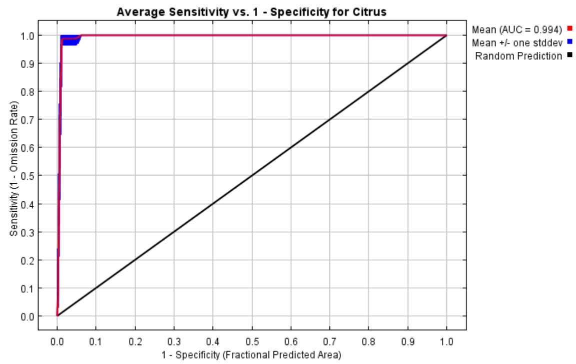


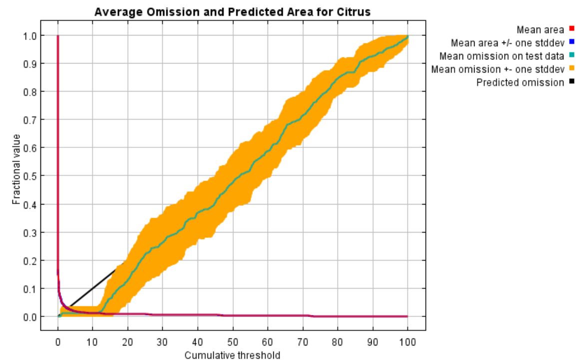
Summary Grids

Standard Deviation	Min	Median	Max
			

Year 2050

Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold



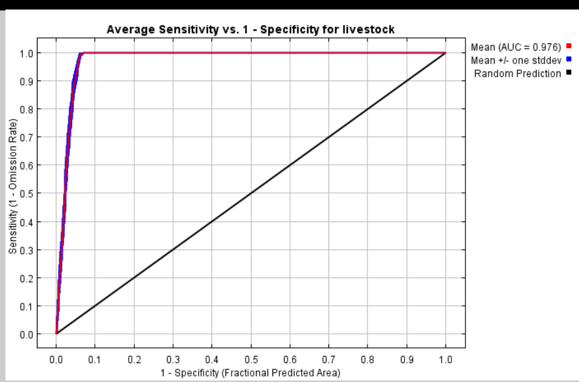
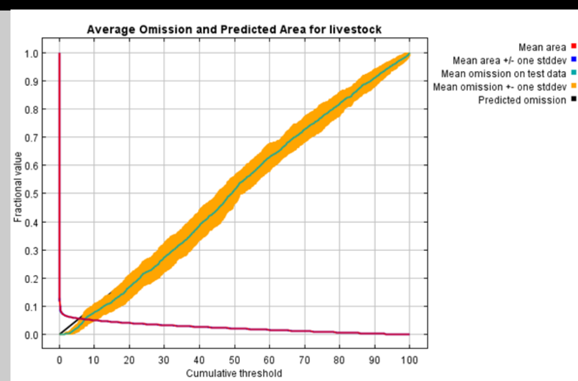


Summary Grids

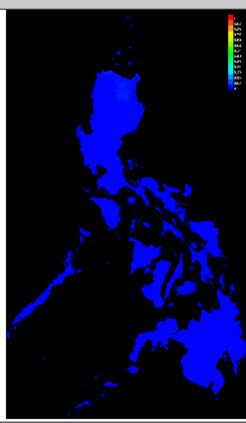
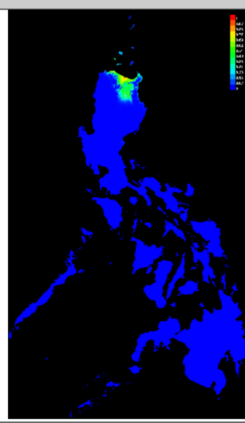
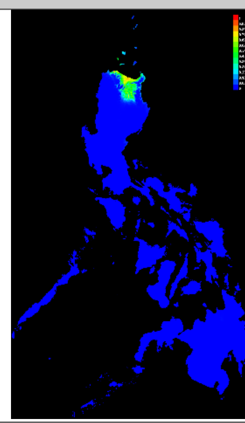
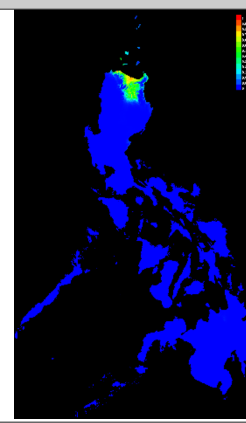
Standard Deviation	Min	Median	Max

LIVESTOCK (PASTURELAND)

Baseline 2019

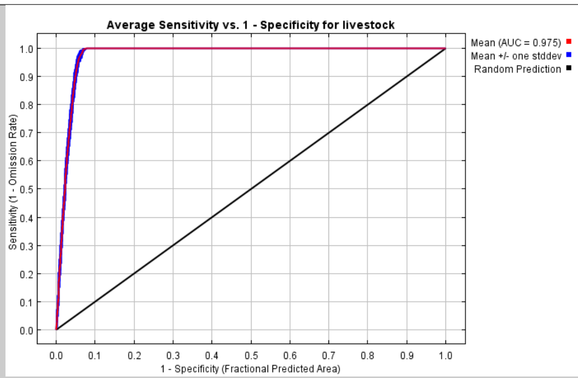
Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold
	

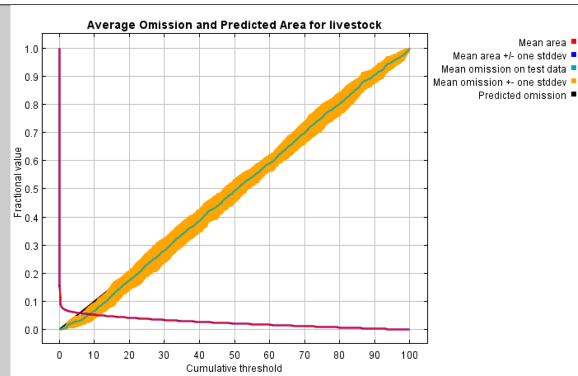
Summary Grids

Standard Deviation	Min	Median	Max
			

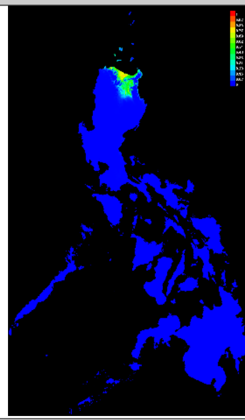
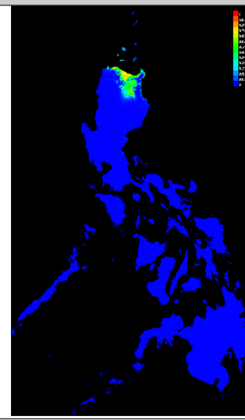
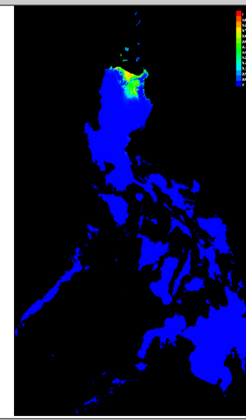
Year 2050

Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold

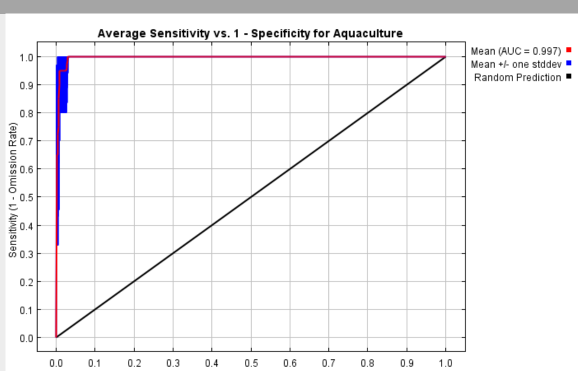
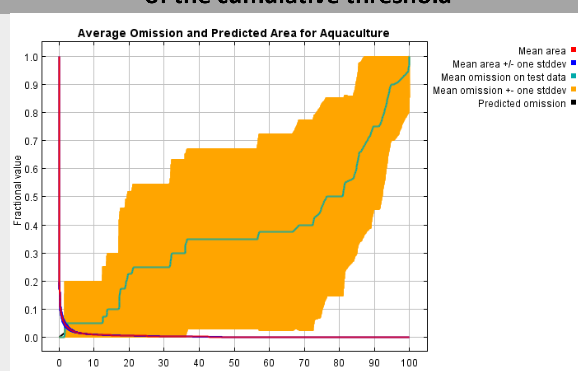




Summary Grids

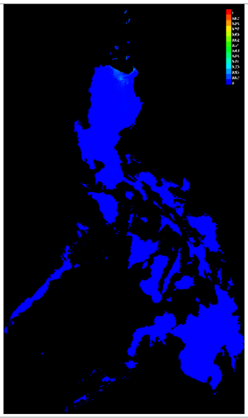
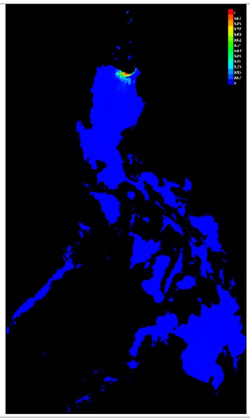
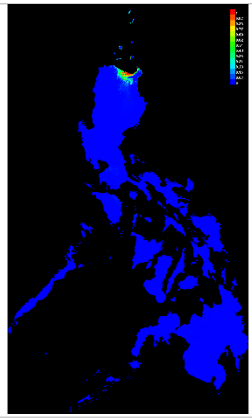
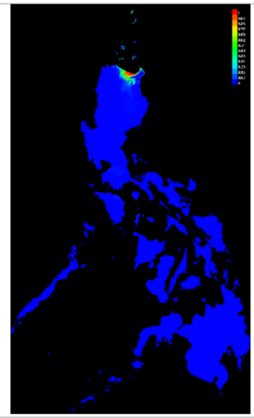
Standard Deviation	Min	Median	Max
			

AQUACULTURE
Baseline 2019

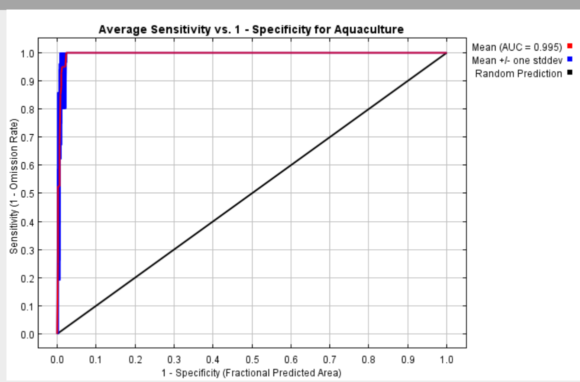
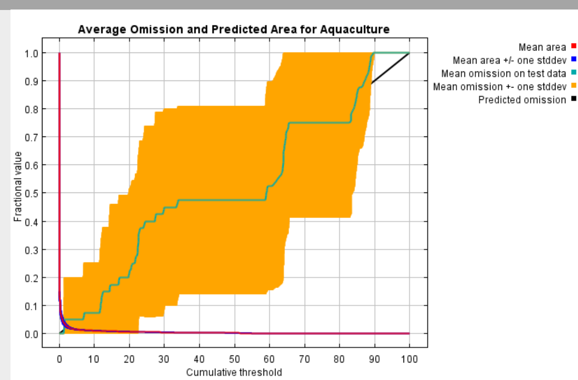
Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold
	

Summary Grids

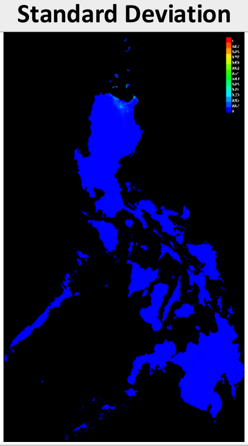
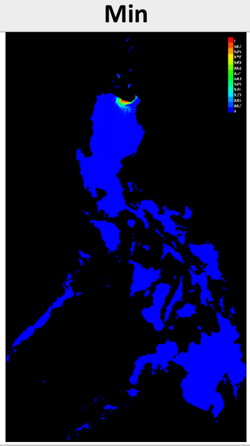
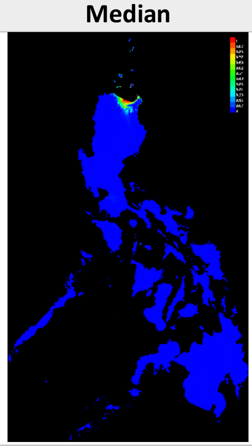
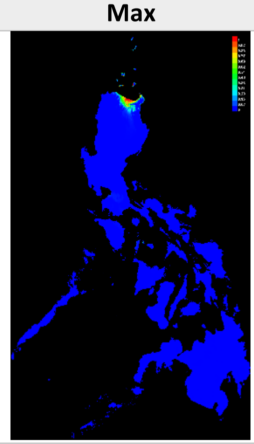
Standard Deviation	Min	Median	Max

Year 2050

Receiver Operating Characteristics (ROC) curve	Test omission rate and predicted area as a function of the cumulative threshold
	

Summary Grids

Standard Deviation	Min	Median	Max
			

ANALYZING HAZARDS – hazard data were assessed using overlay analysis of climate-related natural hazards. Hazards were identified based on its known potential impact on the agricultural sector. They have different degrees of impact based on their extent, magnitude, and variability. Therefore, weights were assigned through experts' consultation and/or workshops. The different weights set during the consultative process were used in the overlay analysis to take into account each hazard's degree of impact to agriculture. In the Philippines, higher weights are usually assigned to typhoon, flood and drought. Historically, these are the climate pressures causing significant production losses which negatively affect food security. For each municipality, the mean values of the pixel of hazard were derived. The values across municipalities were normalized using Eq. 2 and can be used as a proxy value for exposure dimension.

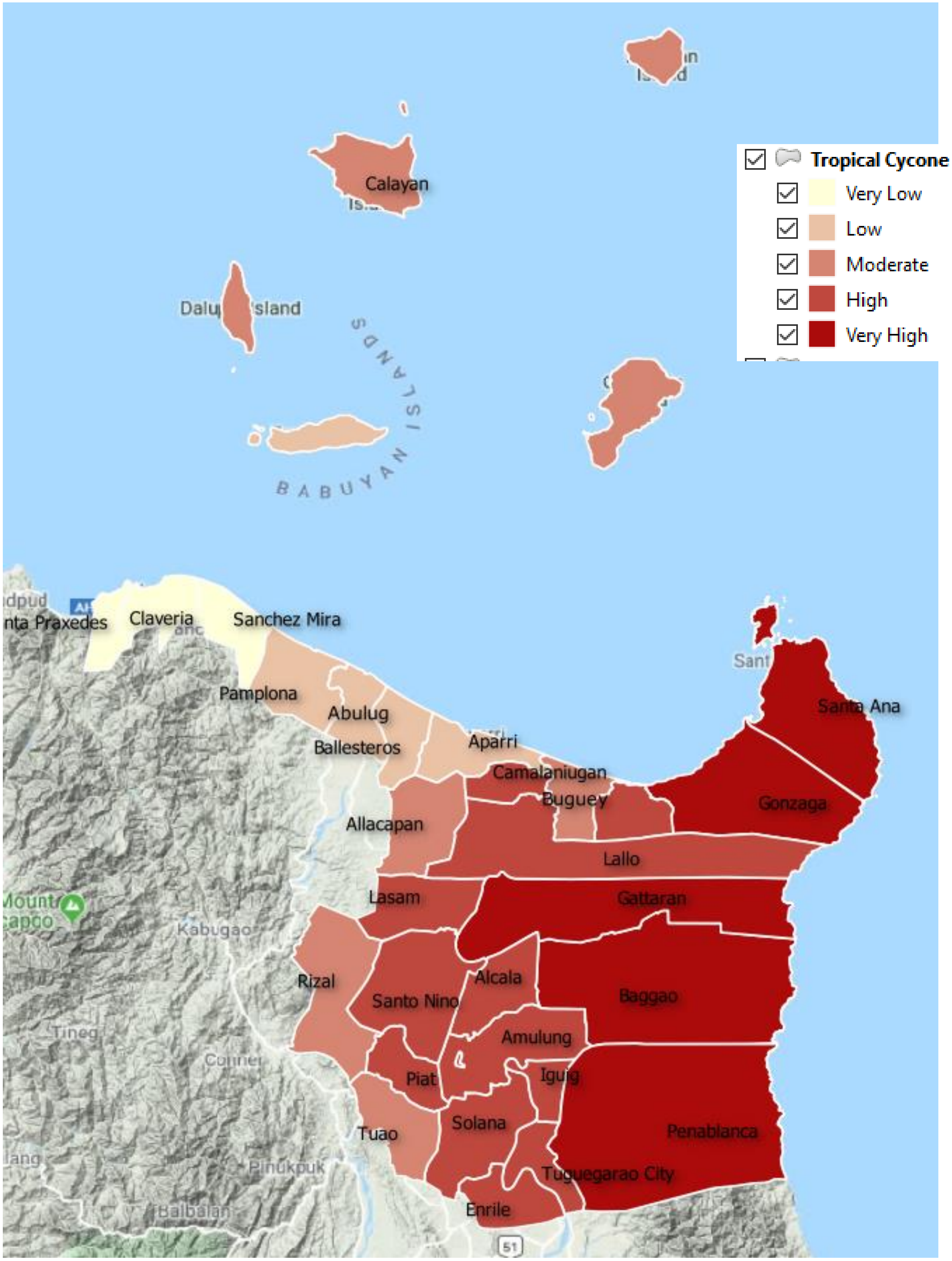
Box 2: Weights development for hazard.

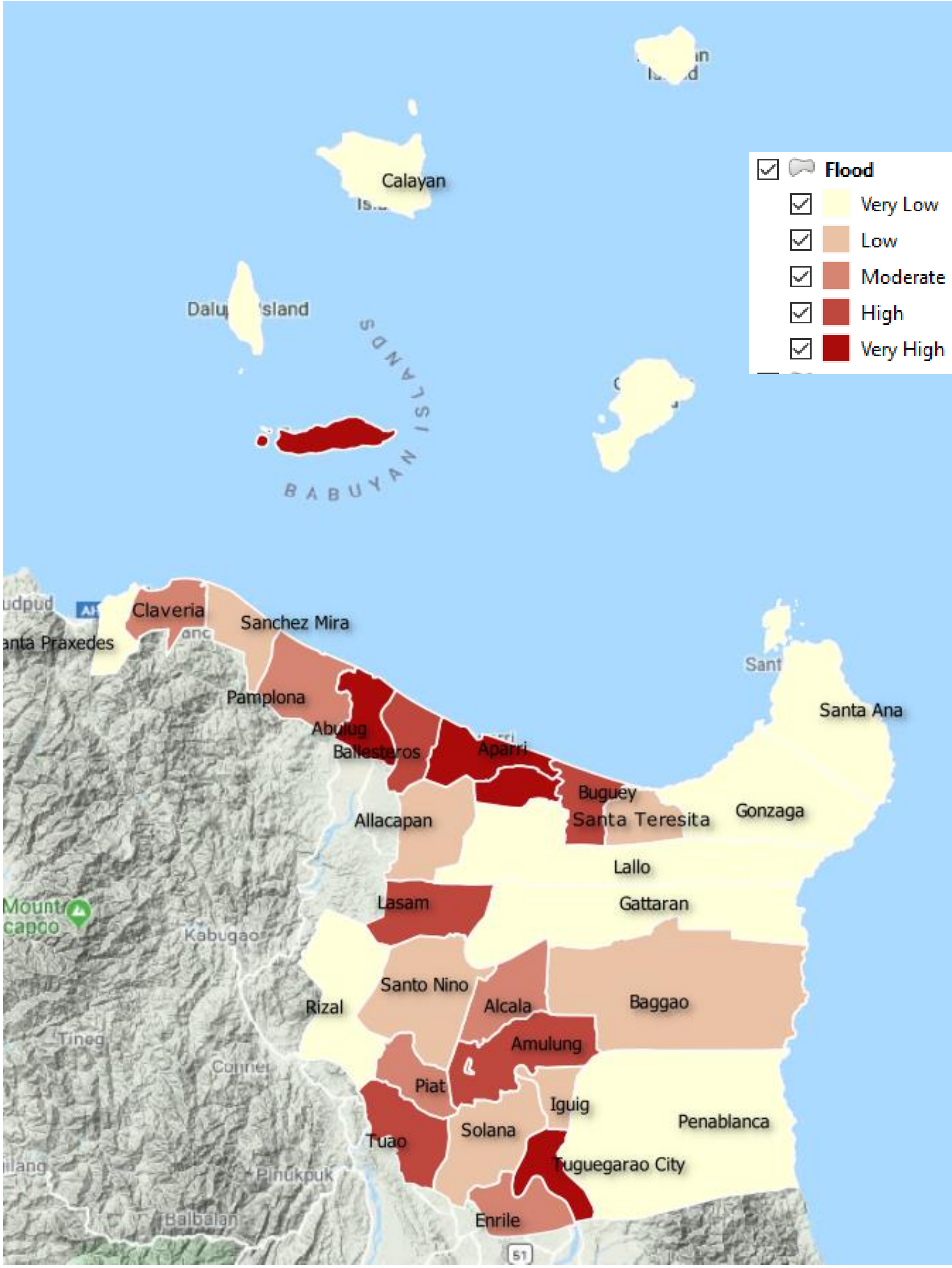
Weights were provided by the experts from University and Colleges and agricultural experts thru a consultation workshop. Three sets of weights were developed for Luzon, Visayas, and Mindanao. The weights analysis was based on the frequency of occurrence and impacts on food security, livelihoods, income, and key natural resources (biodiversity, soil fertility, etc.).

$$Normalize = \frac{X - X_{min}}{X_{max} - X_{min}} \quad \textbf{Eq. 2}$$

Where: X = the target value to normalize, X_{min} = the minimum value from a range of values usually in a column, X_{max} = the maximum value from a range of values usually in a column

HAZARD MAP RESULT:

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Low
Moderate
High
Very High
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BABUYAN ISLANDS
Claveria
Sanchez Mira
Santa Praxedes
Pamplona
Abulug
Ballesteros
Aparri
Buguey
Santa Teresita
Gonzaga
Santa Ana
Allacapan
Lallo
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Gattaran
Santo Nino
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Baggao
Amulung
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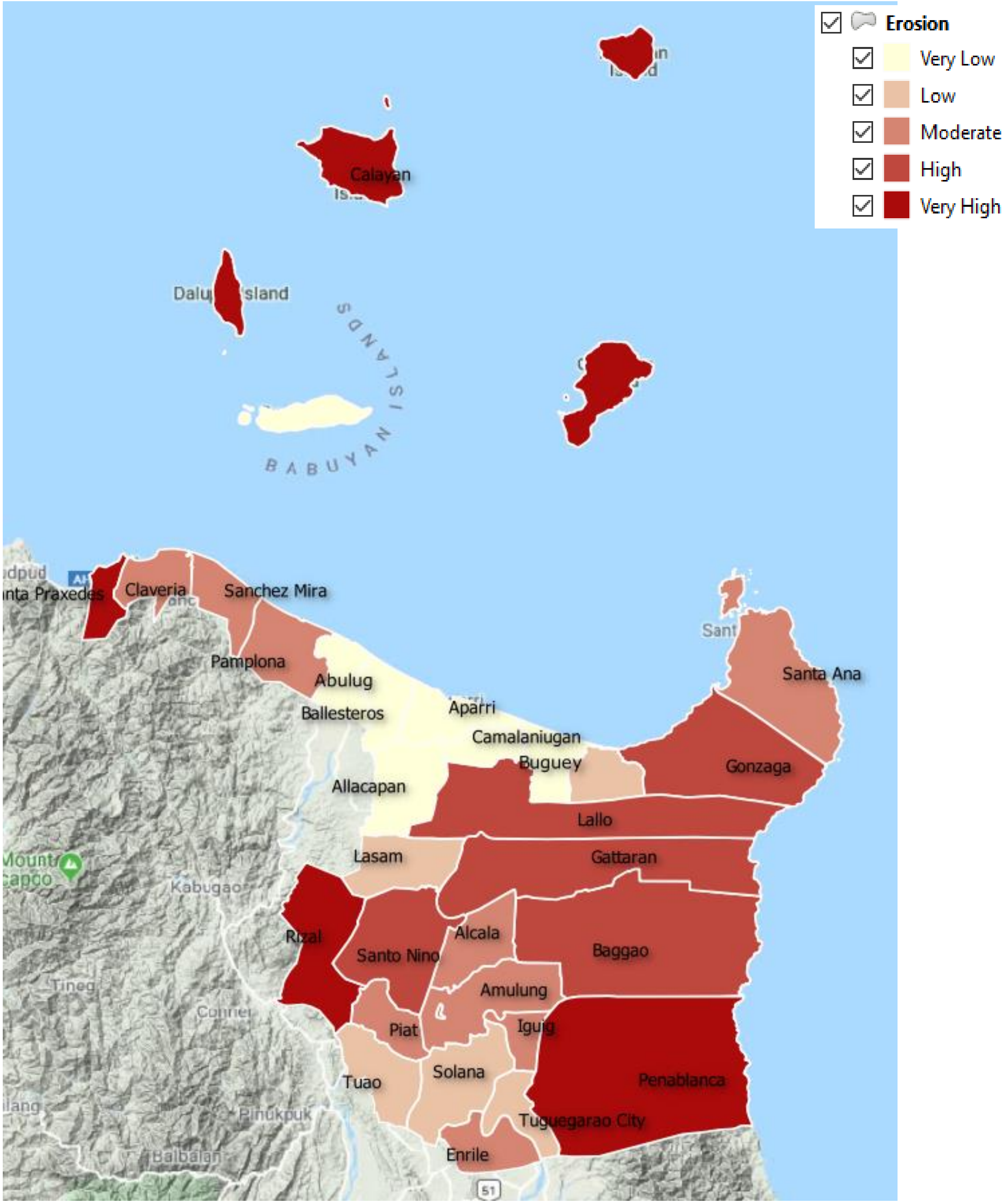
Enrile
Kabugao
Conner
Pinukpuk
Balbalan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High
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Abulug
Ballesteros
Aparri
Camalaniugan
Buguey
Allacapan
Santa Ana
Gonzaga
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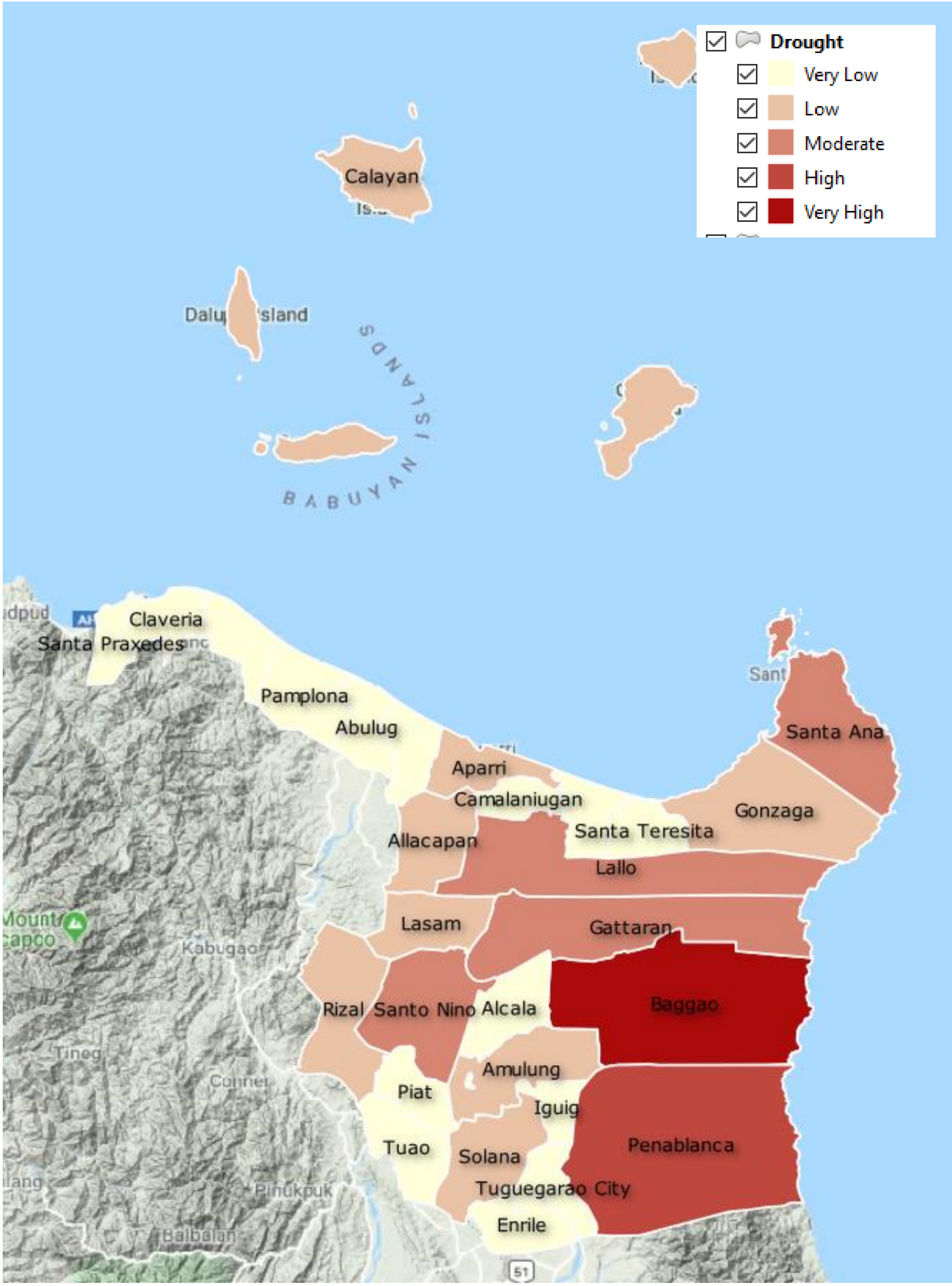
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Santa Teresita
Gonzaga
Santa Ana
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Conner
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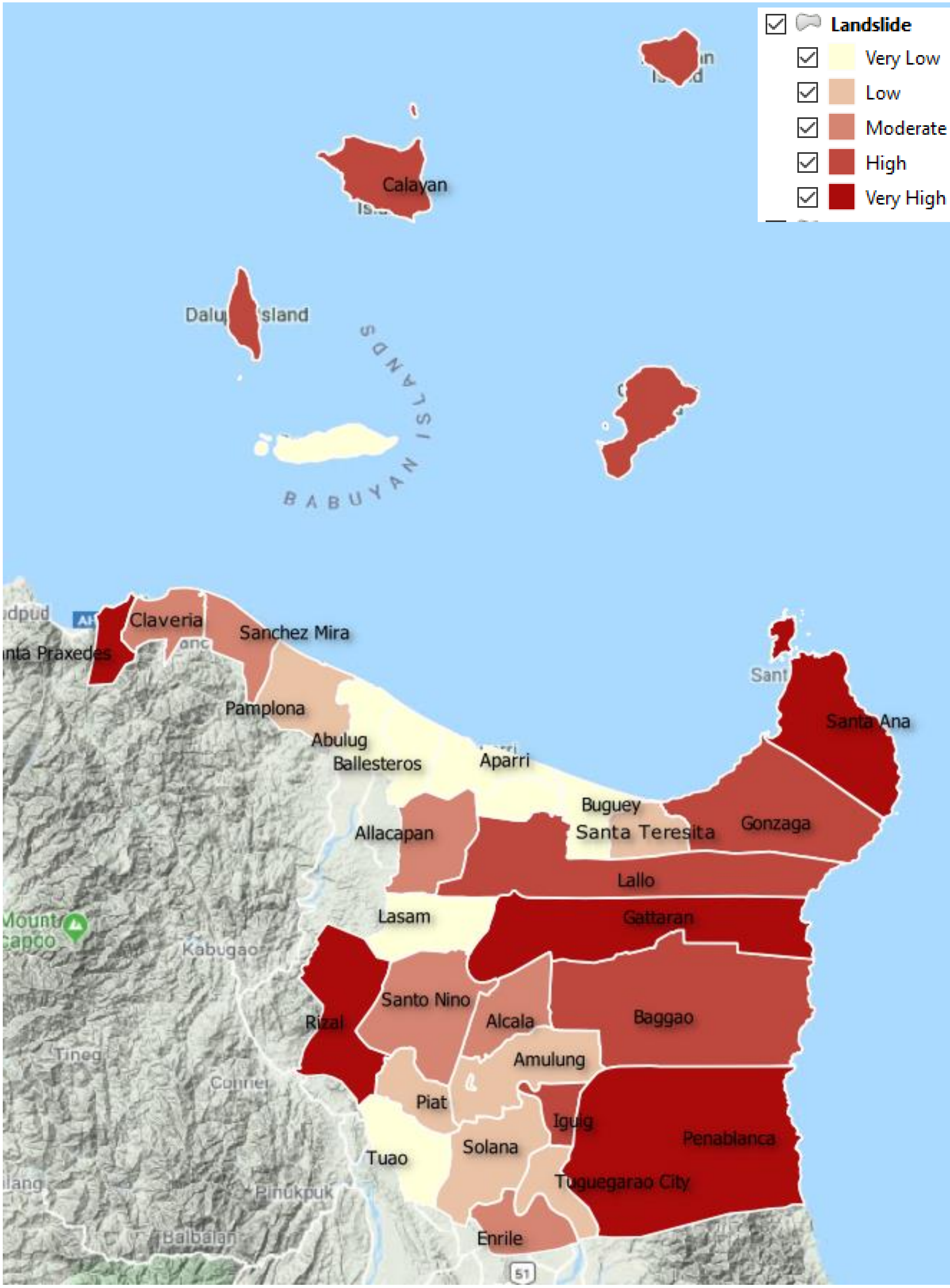
B A B U Y A N I S L A N D S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Santa Ana
Buguey
Santa Teresita
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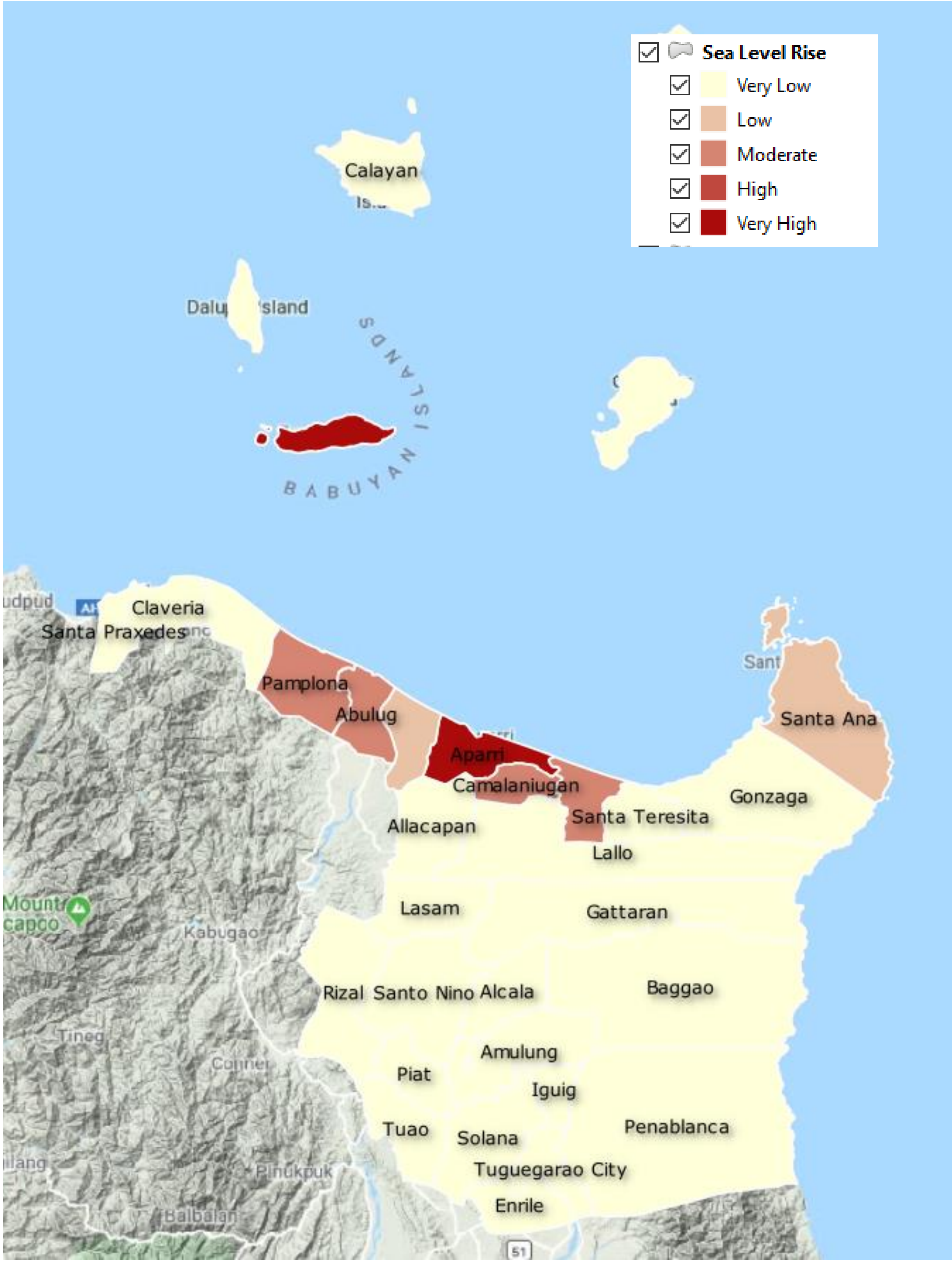
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Santa Ana
Gonzaga
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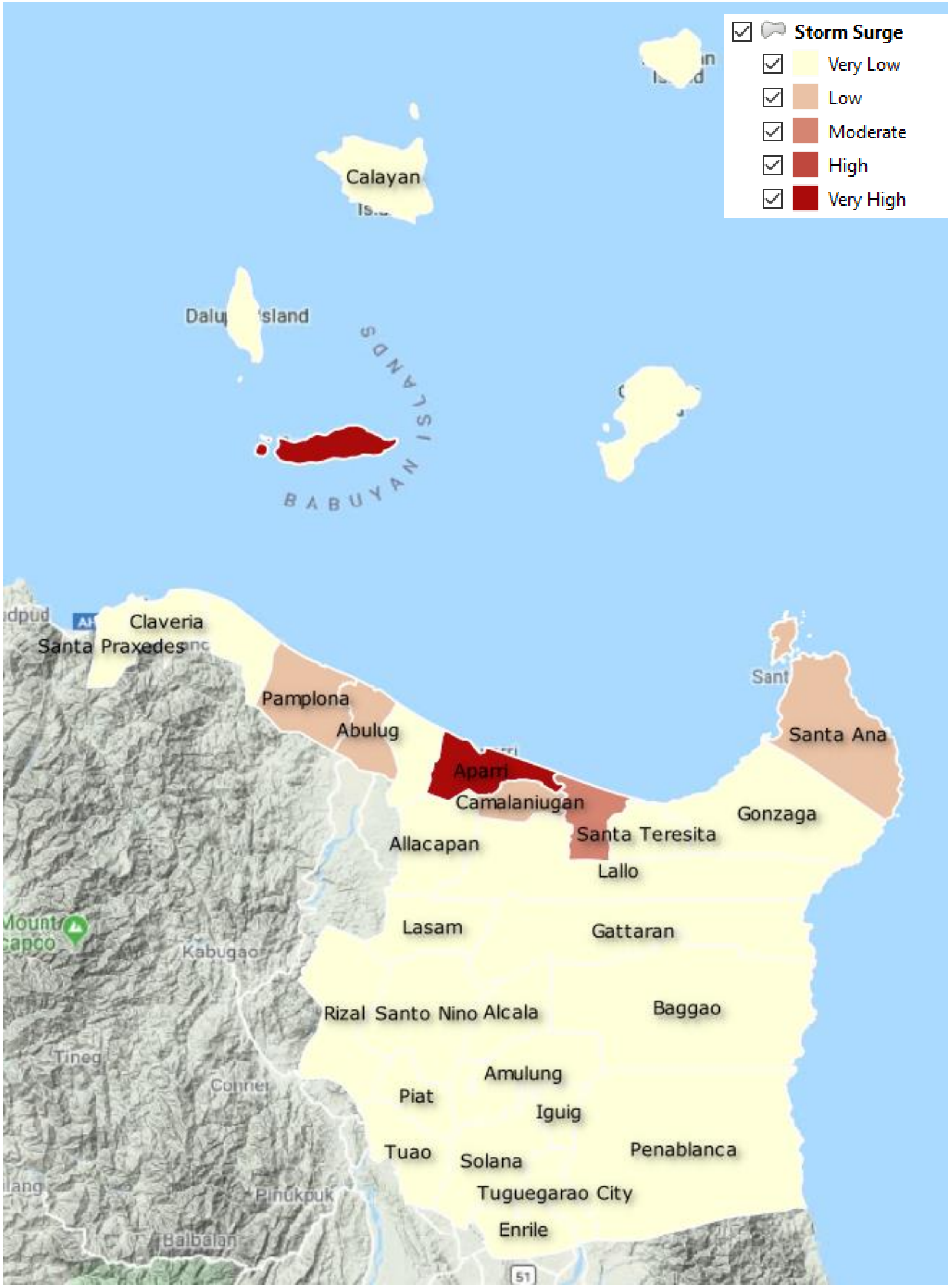
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Moderate
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Santa Ana
Gonzaga
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Lallo
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Gattaran
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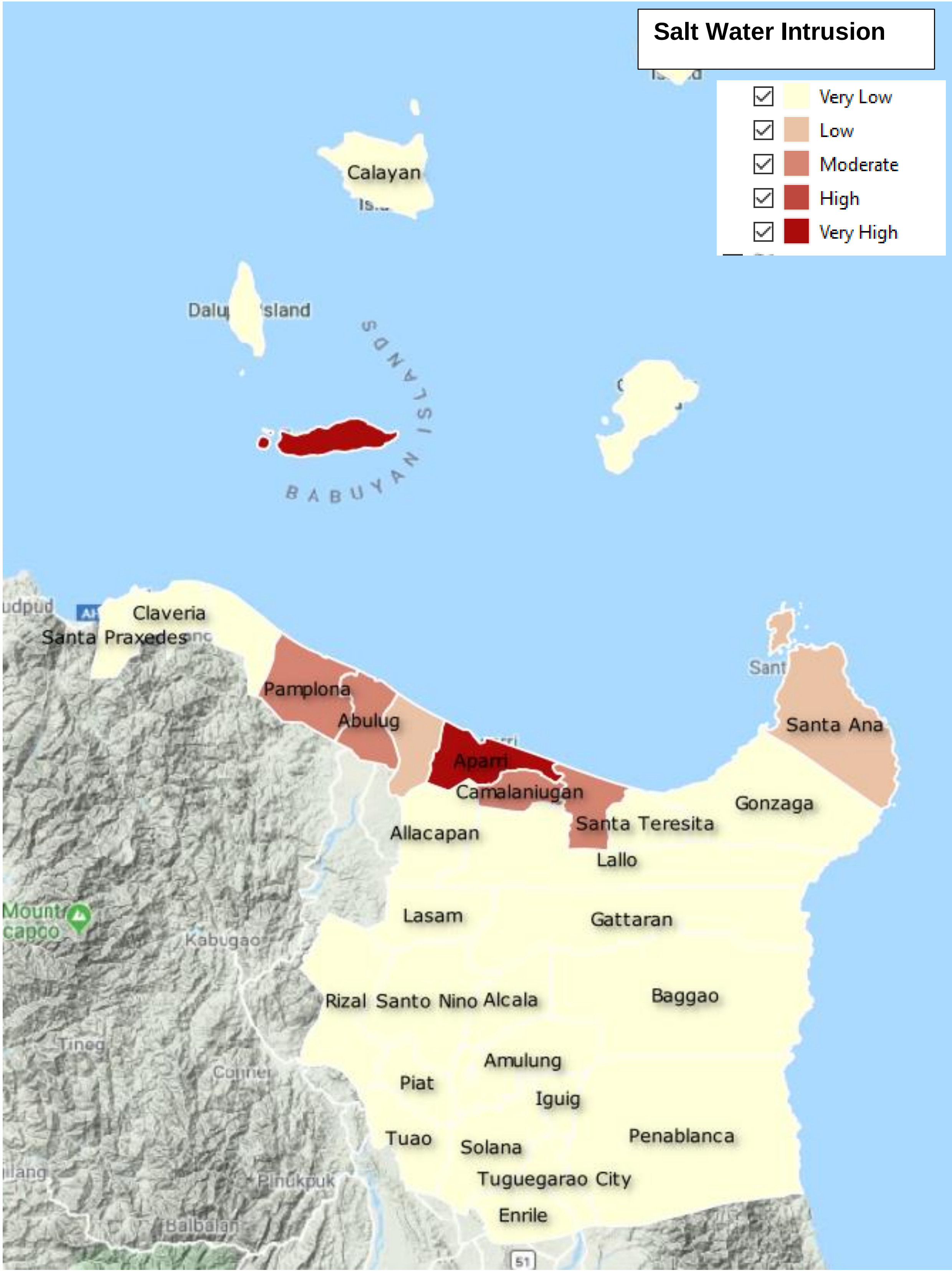
Tuguegarao City
Enrile
BABUYAN ISLANDS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Low
Moderate
High
Very High
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Abulug
Aparri
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Santa Ana
Gonzaga
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Lallo
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Rizal
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Piat
Iguig
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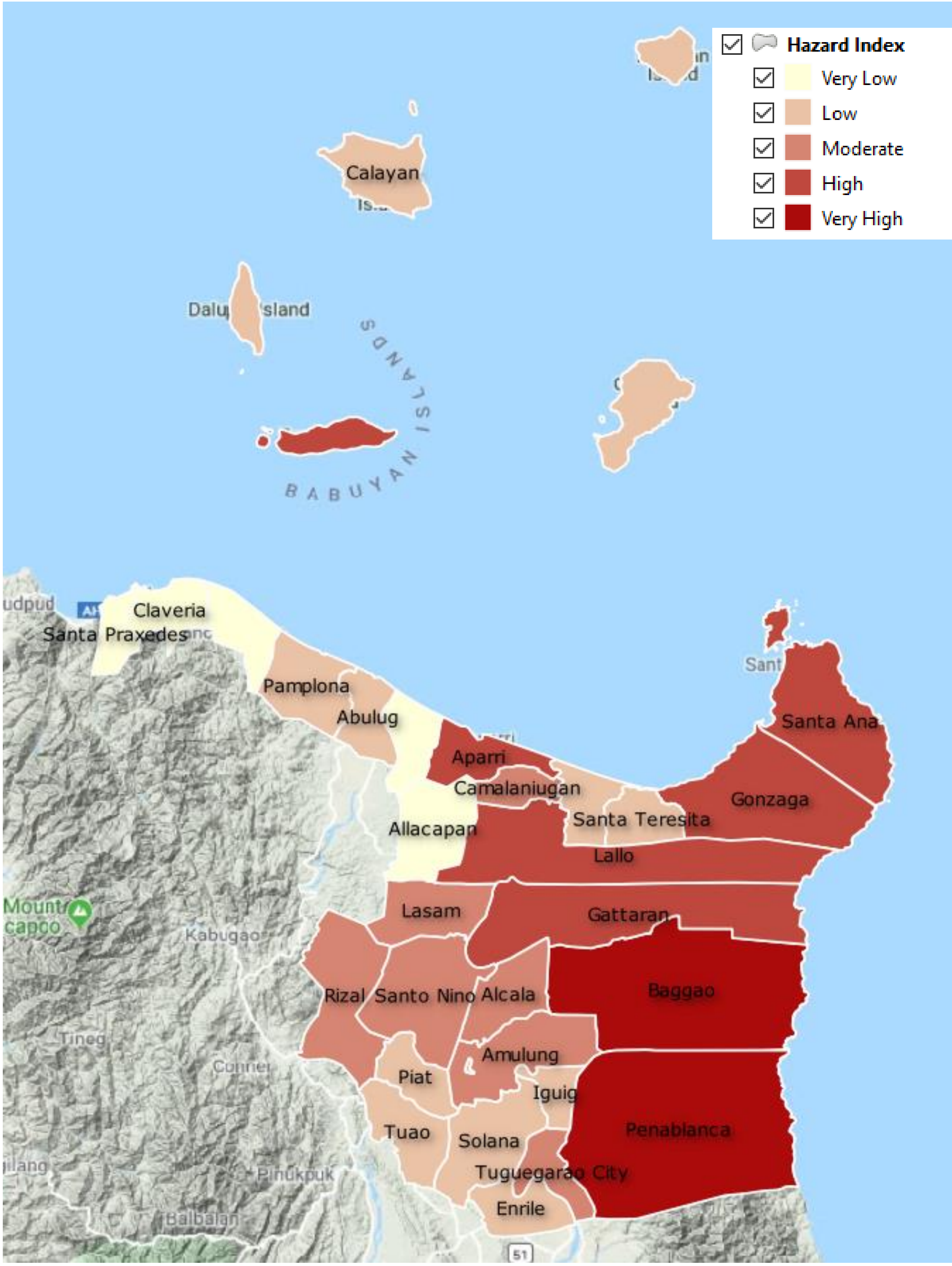
Penablanca
Tuguegarao City
Enrile

Overall Hazard Map



ANALYZING ADAPTIVE CAPACITY –

each of the indicators and sub-indicators per municipality were aggregated for each capital (see figure 8). The capitals were aggregated using equal weights to develop the adaptive capacity index, and the values will be normalized linearly to 0 to 1 using Eq. 2

Box 3: Development of Adaptive Capacity Indicators

Adaptive capacity indicators were collected from online and local databases which provided more than 200 indicators of socio-economic and biophysical data. Statistical analysis was used to identify indicators that are highly correlated with other indicators. The trimmed dataset were further desk-reviewed to select the indicators that are used by other literature. The indicators were then presented to the experts and we ask score from 1 to 5 (5 highest) each indicator through a workshop. Only the indicators that have a score of 4 and 5 were retained. Each indicator was treated with equal weights.

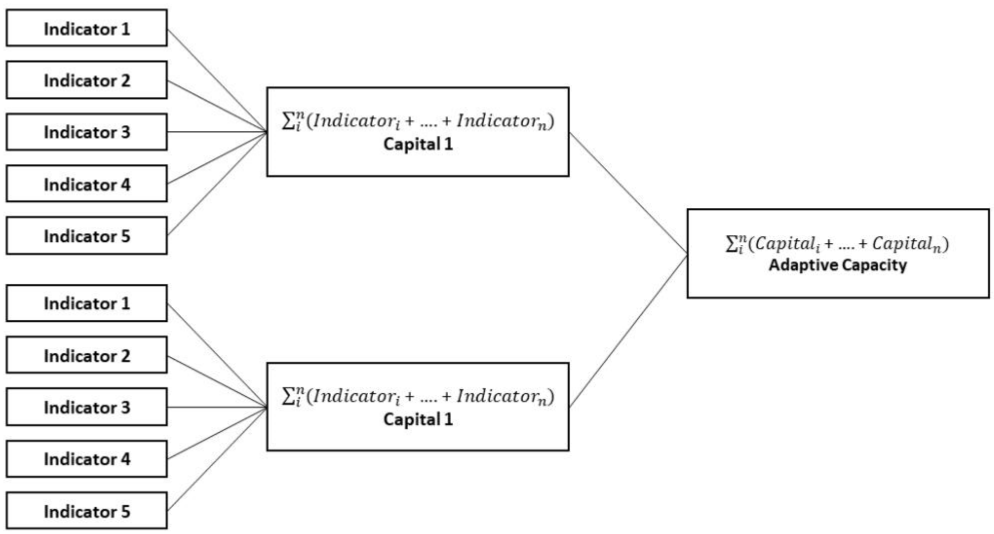
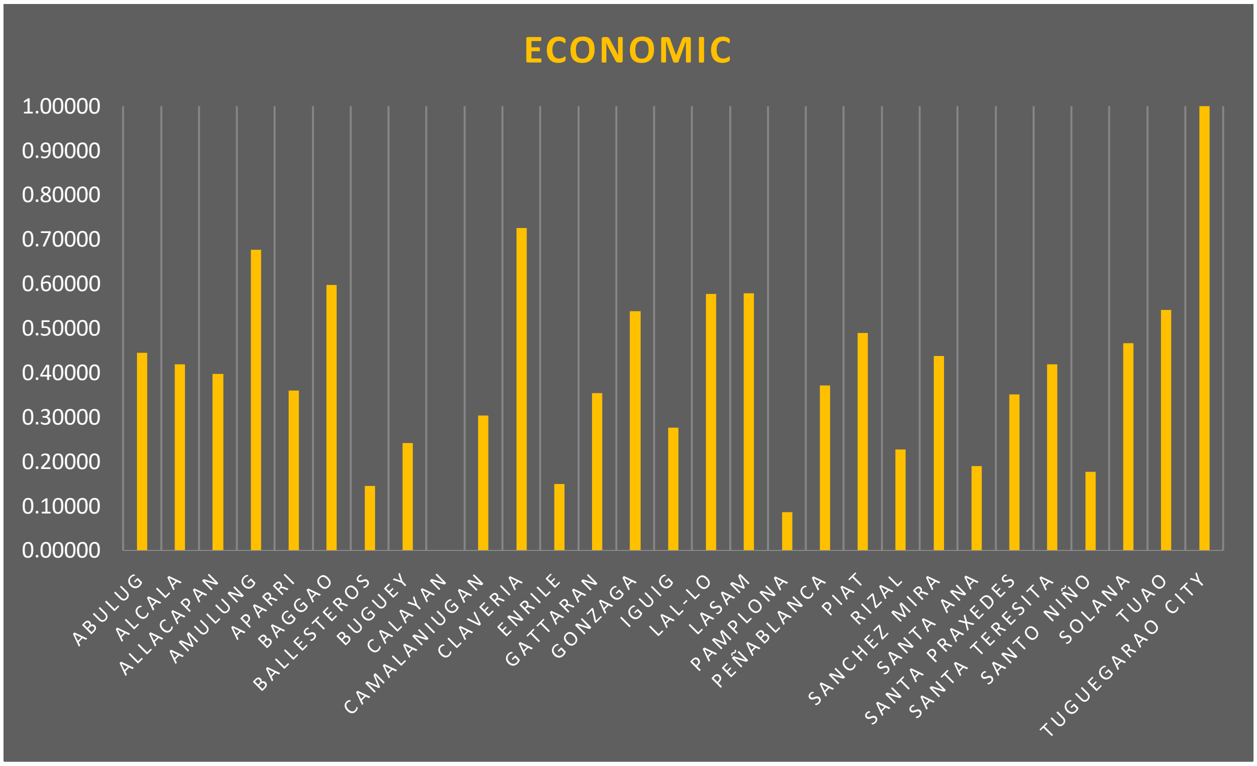


Figure 8. Simplified process flow to derive adaptive capacity index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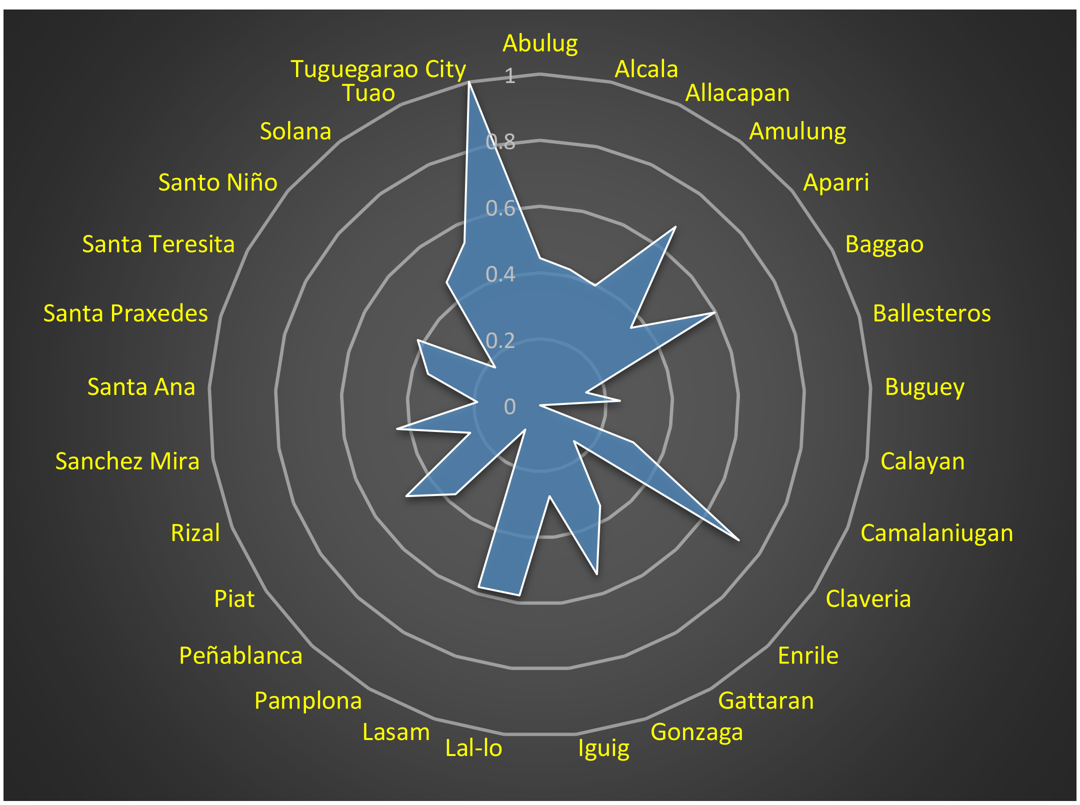
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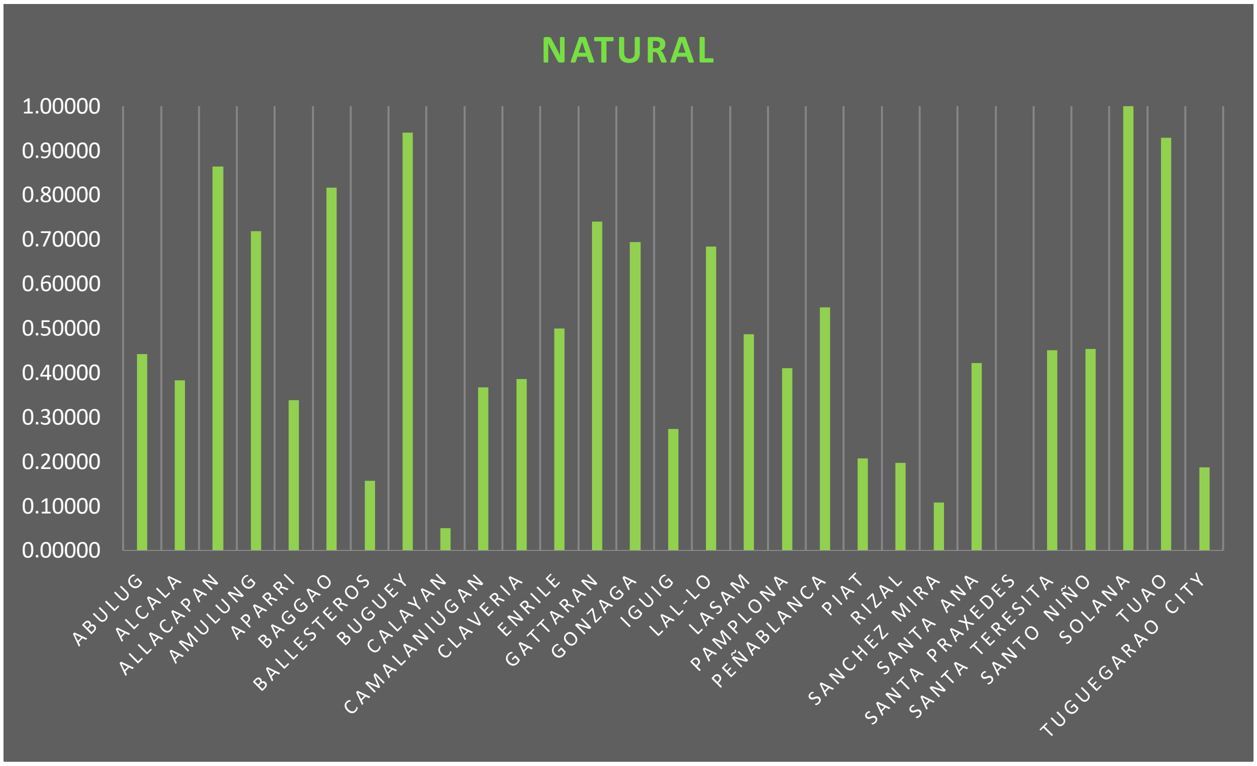
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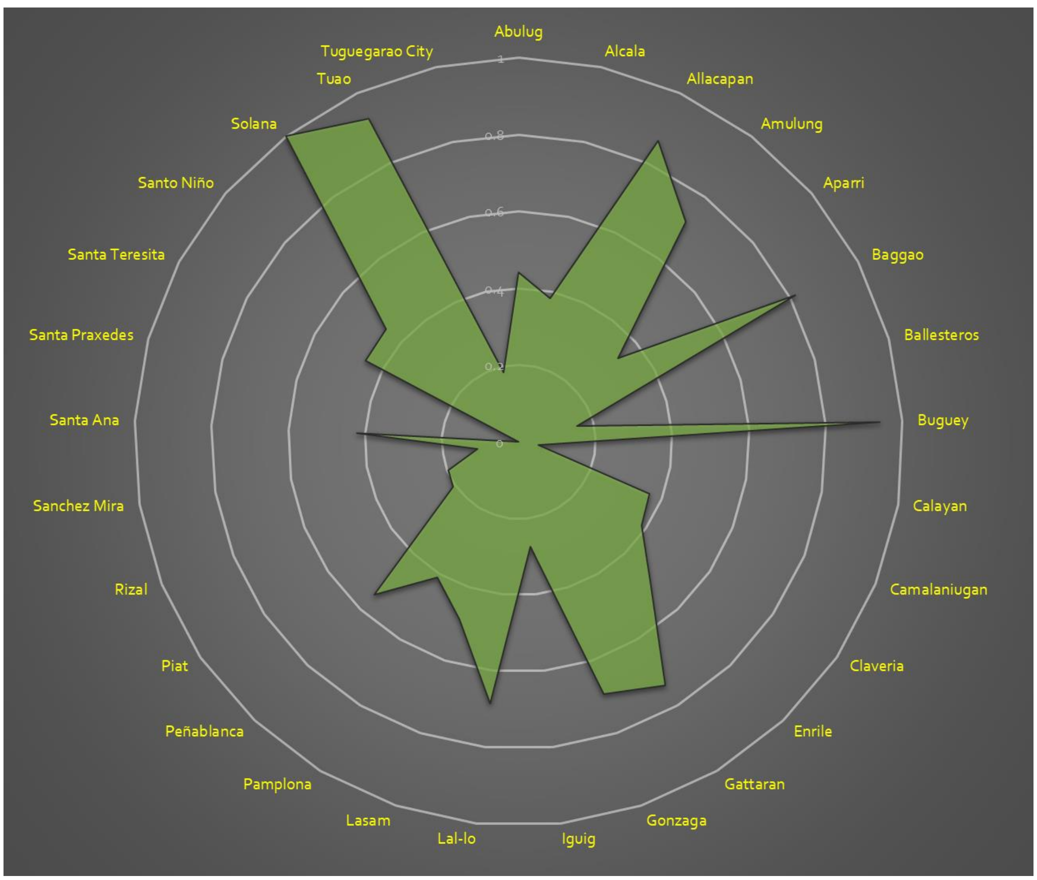
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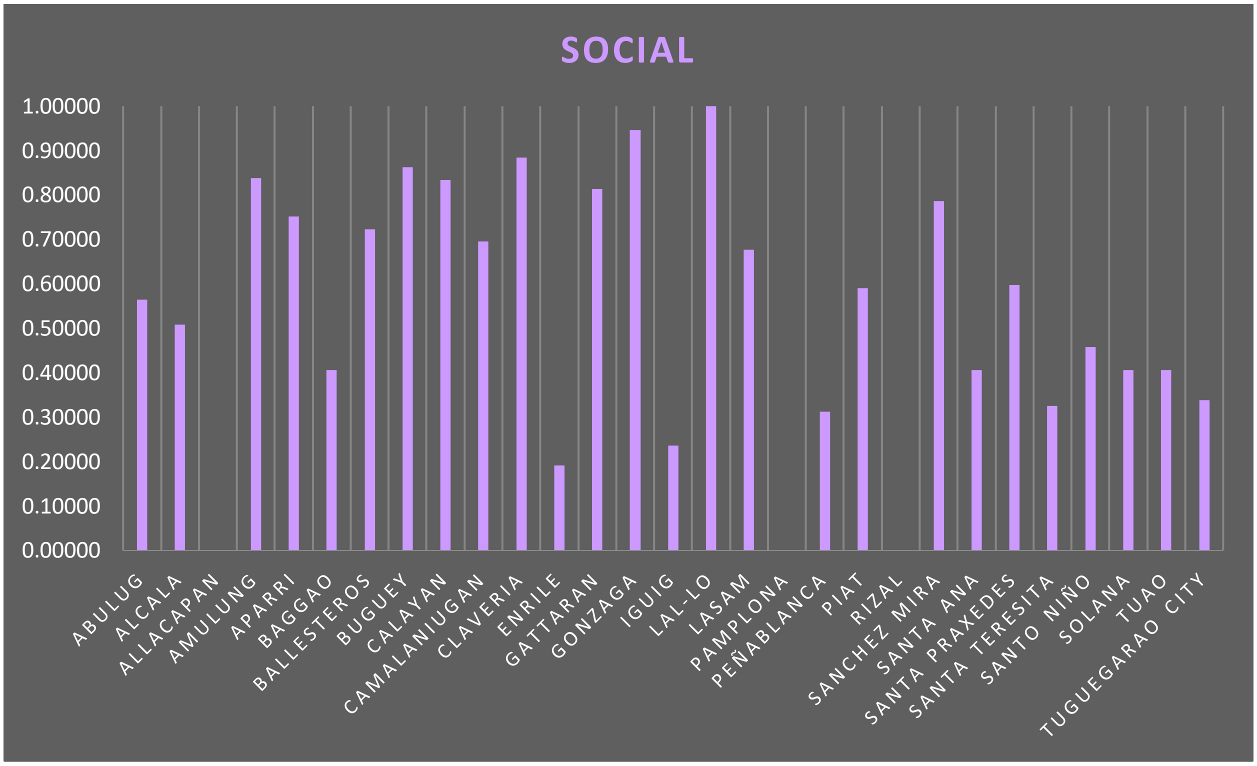
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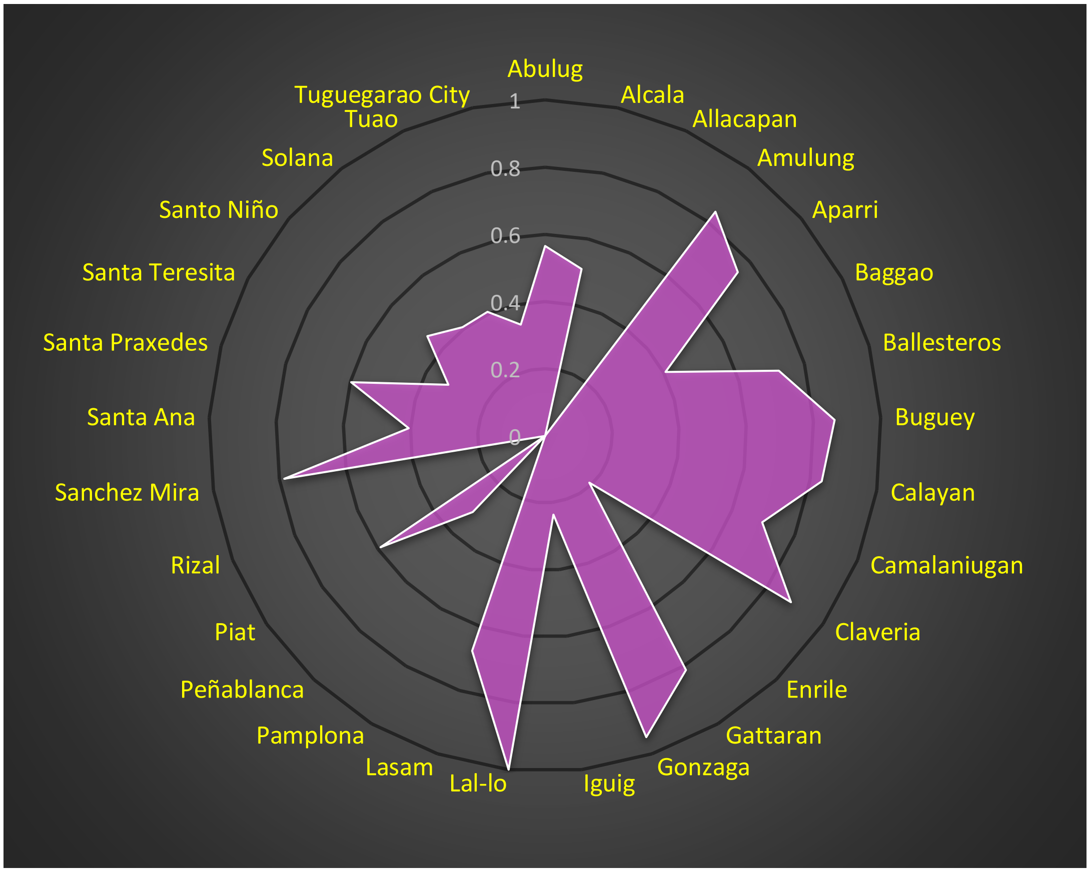
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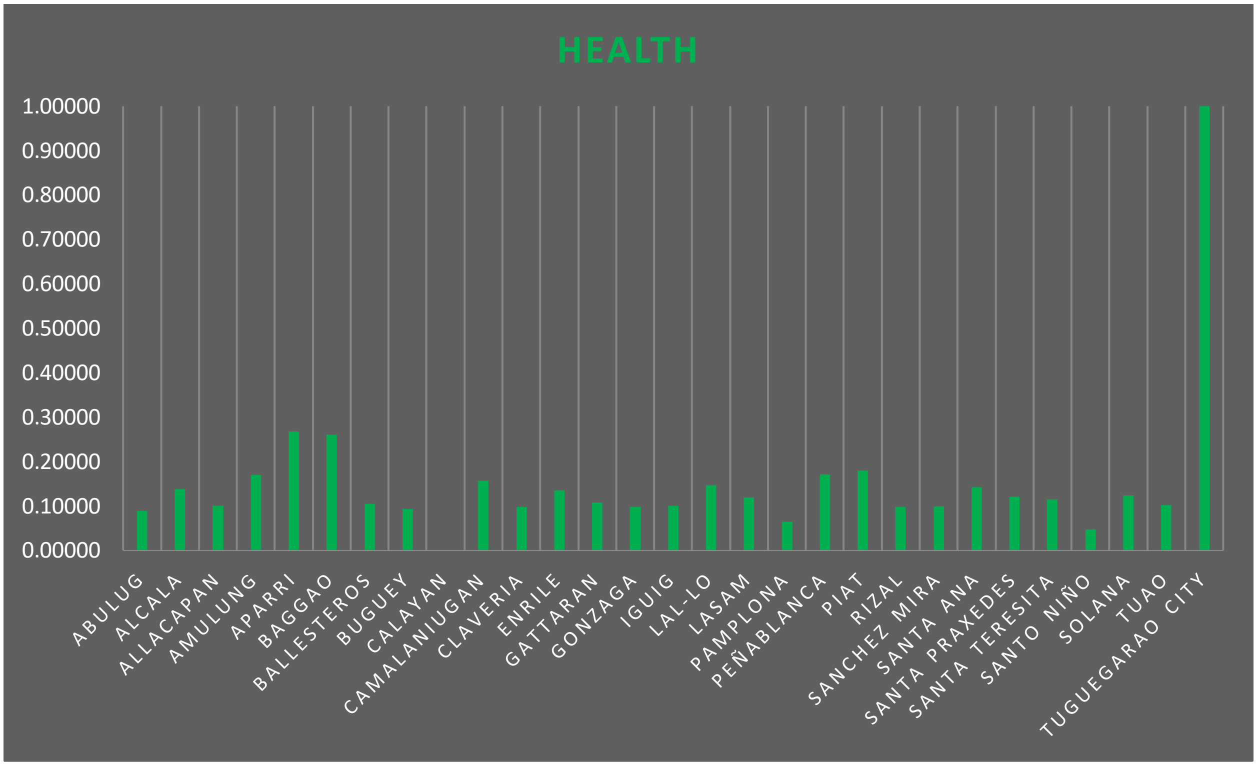
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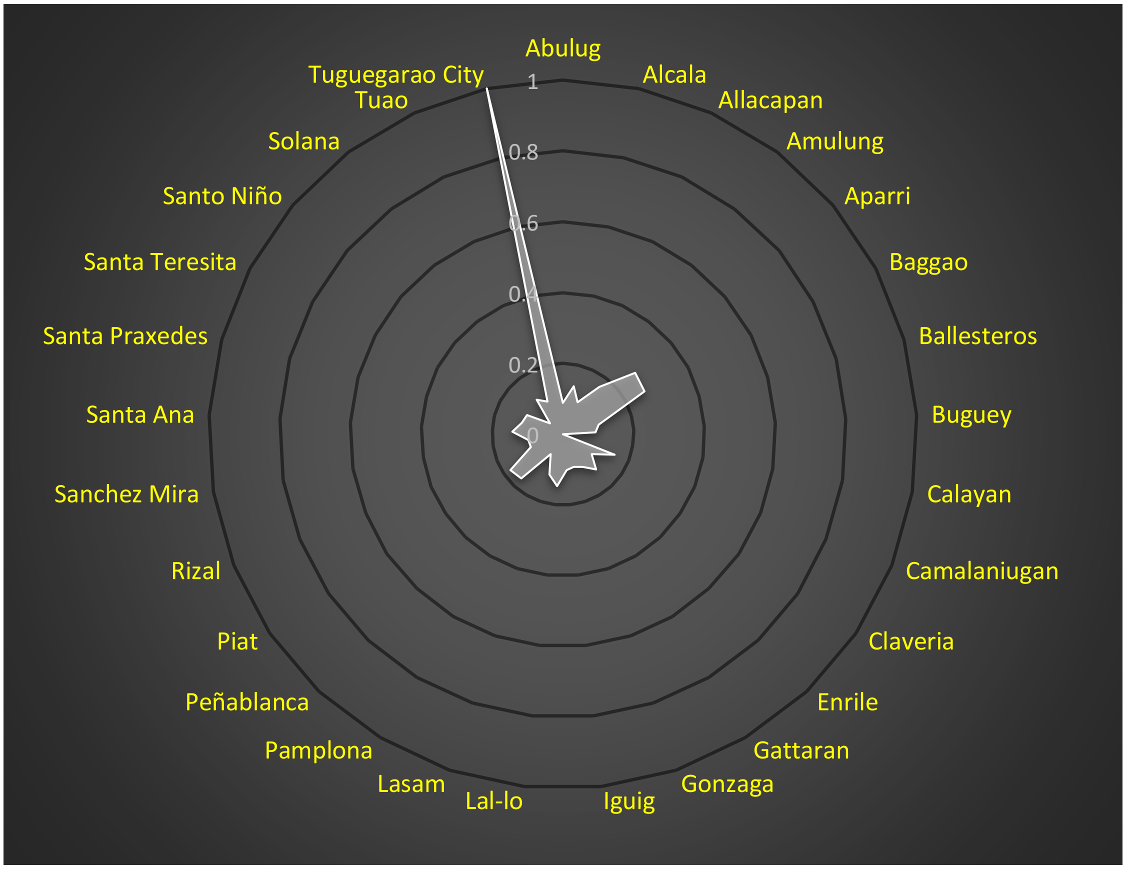
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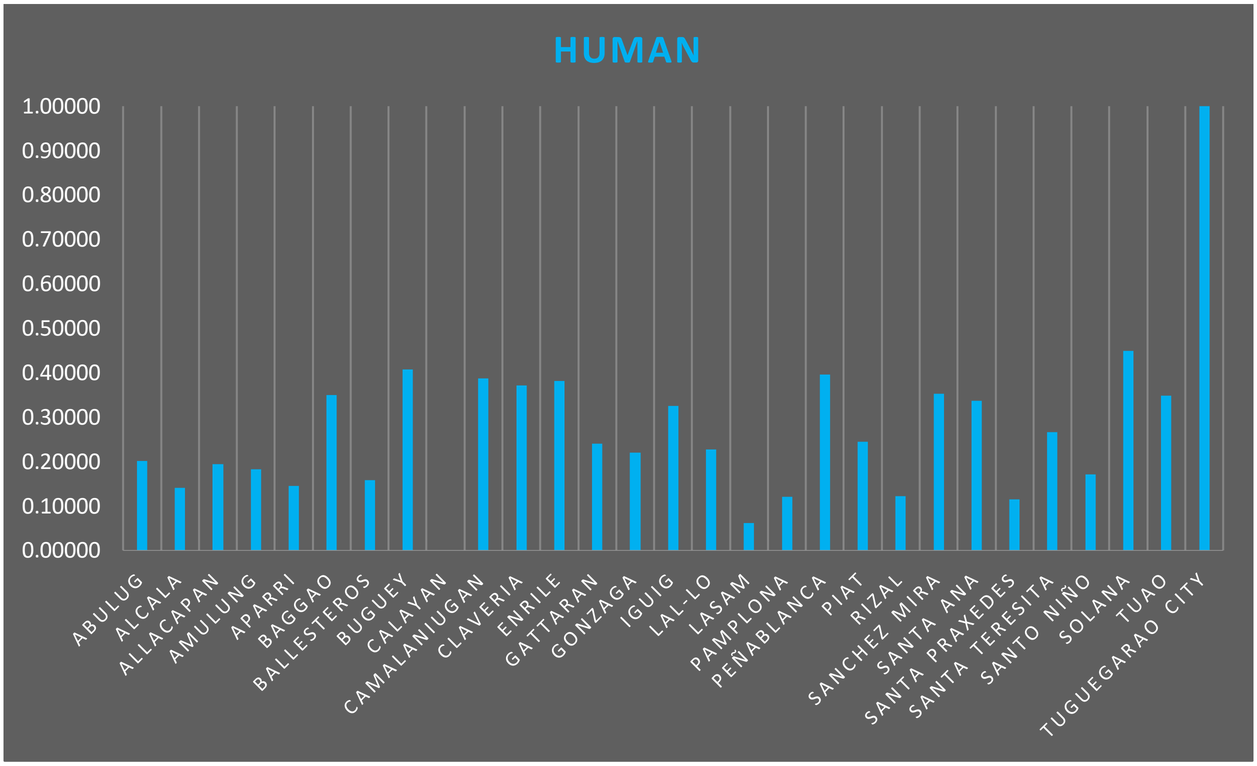
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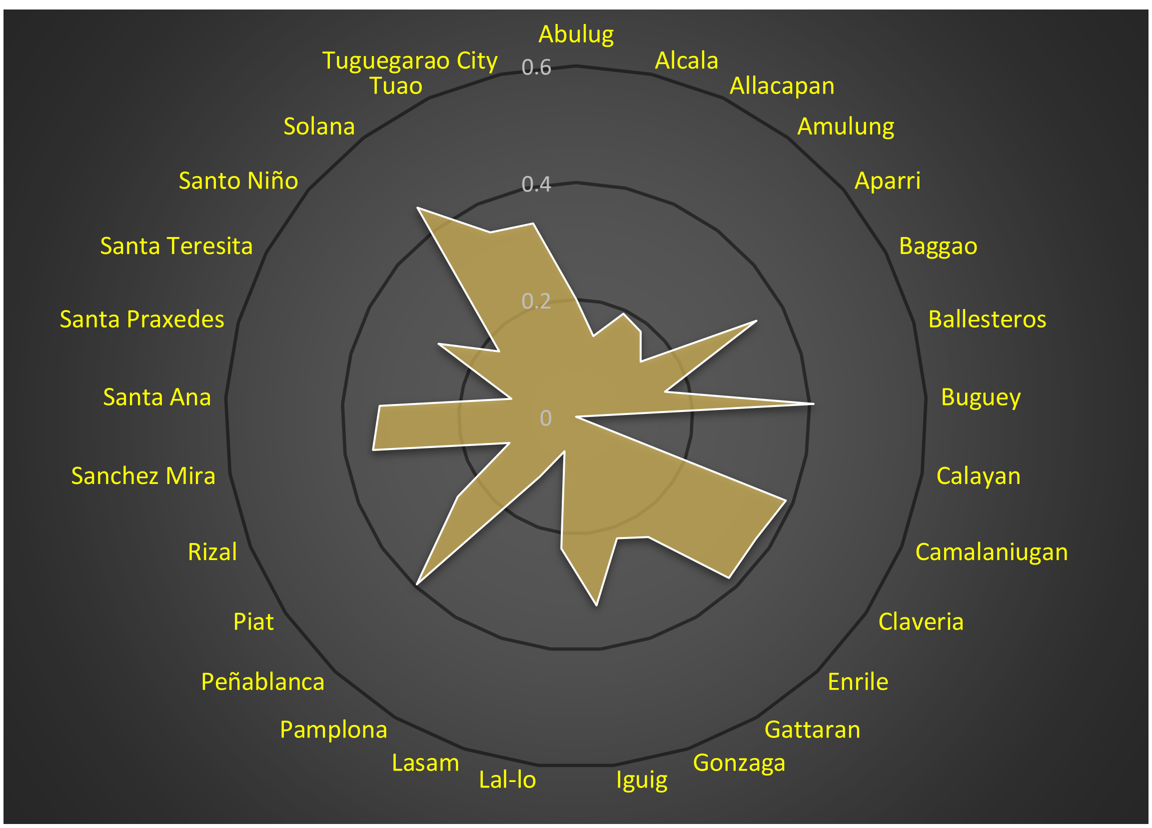
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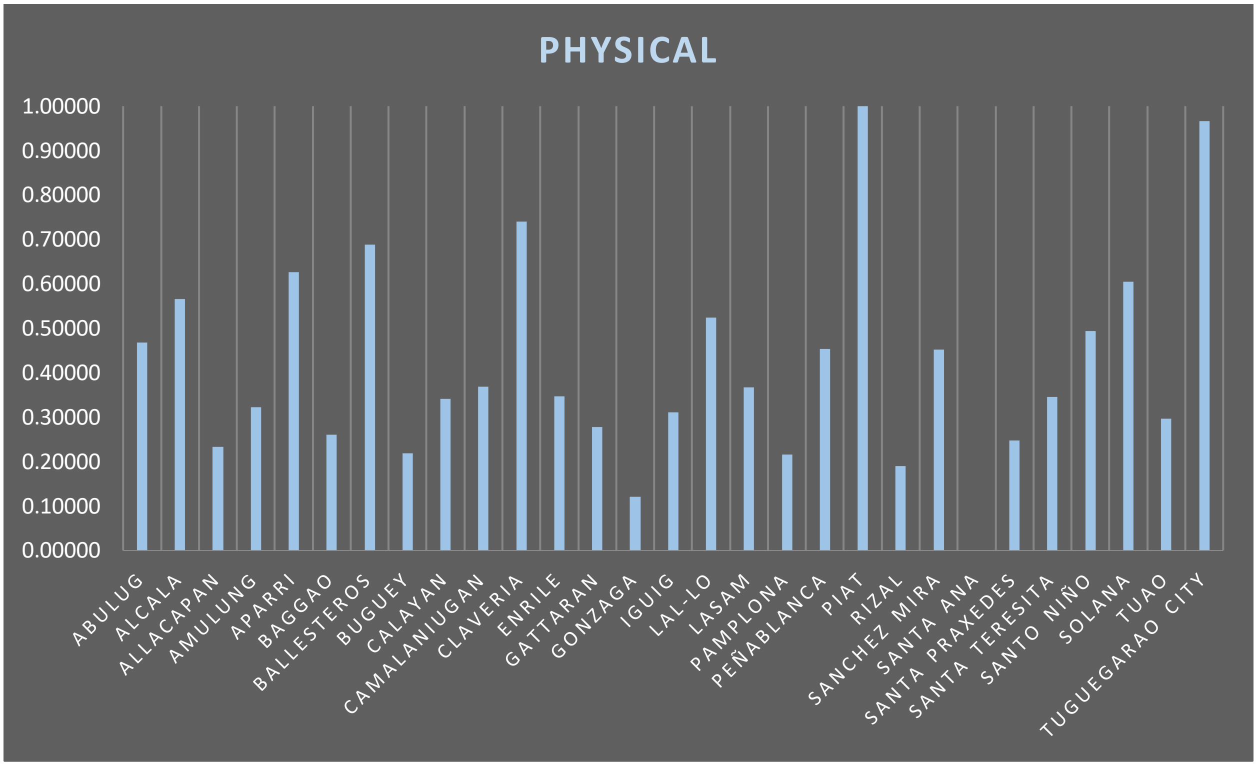
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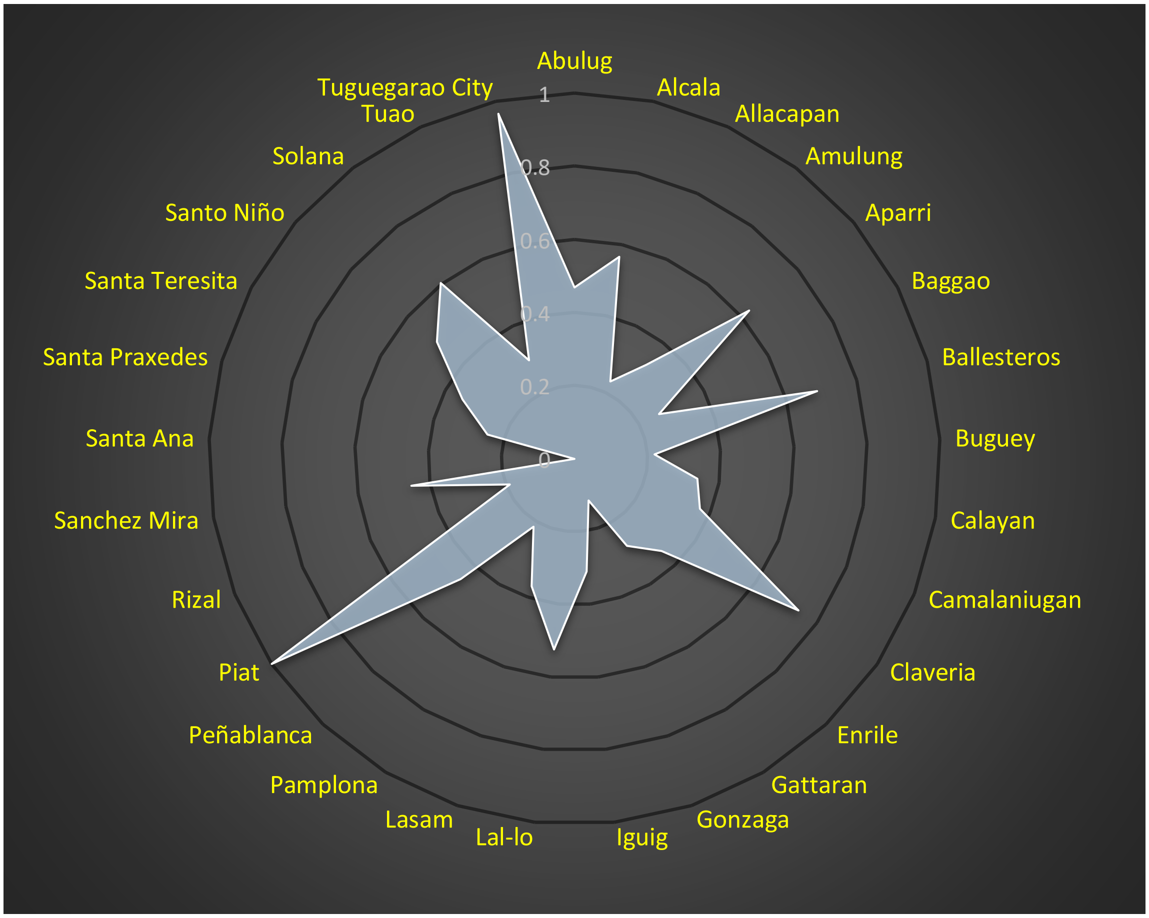
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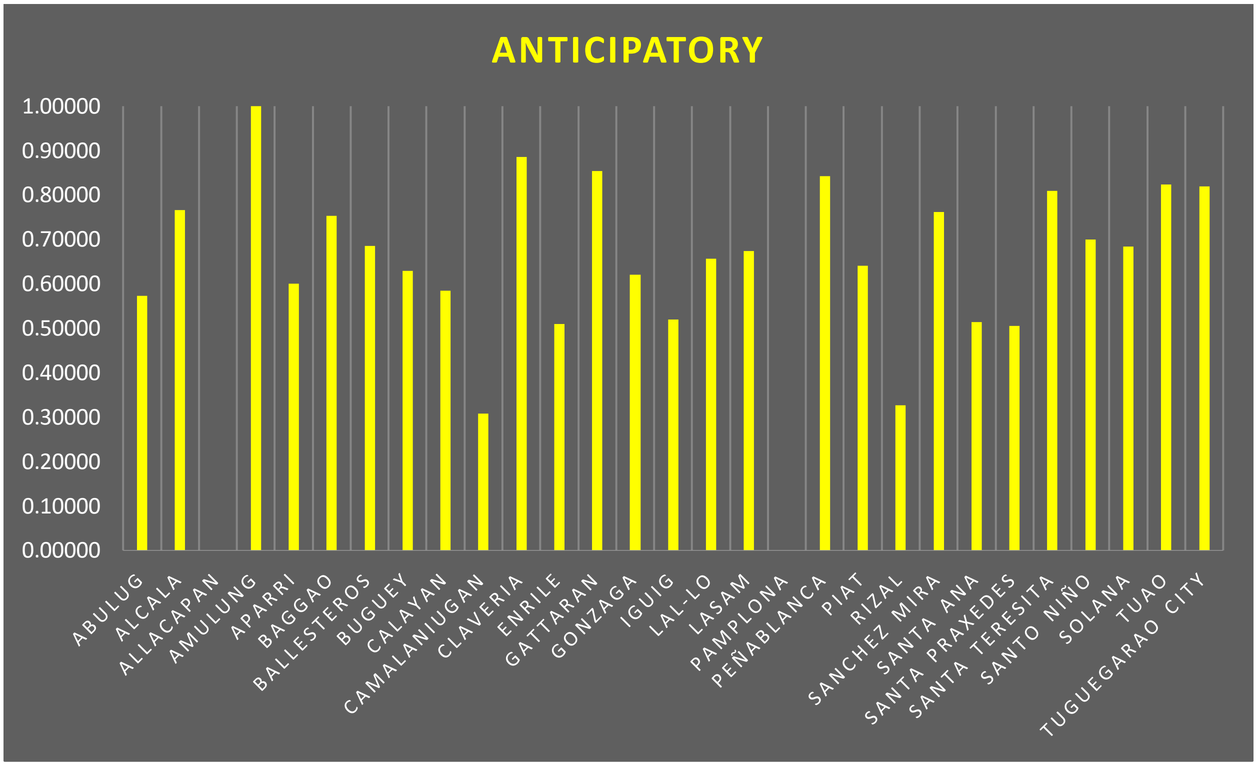
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SOLANA
TUAO
TUGUEGARAO CITY


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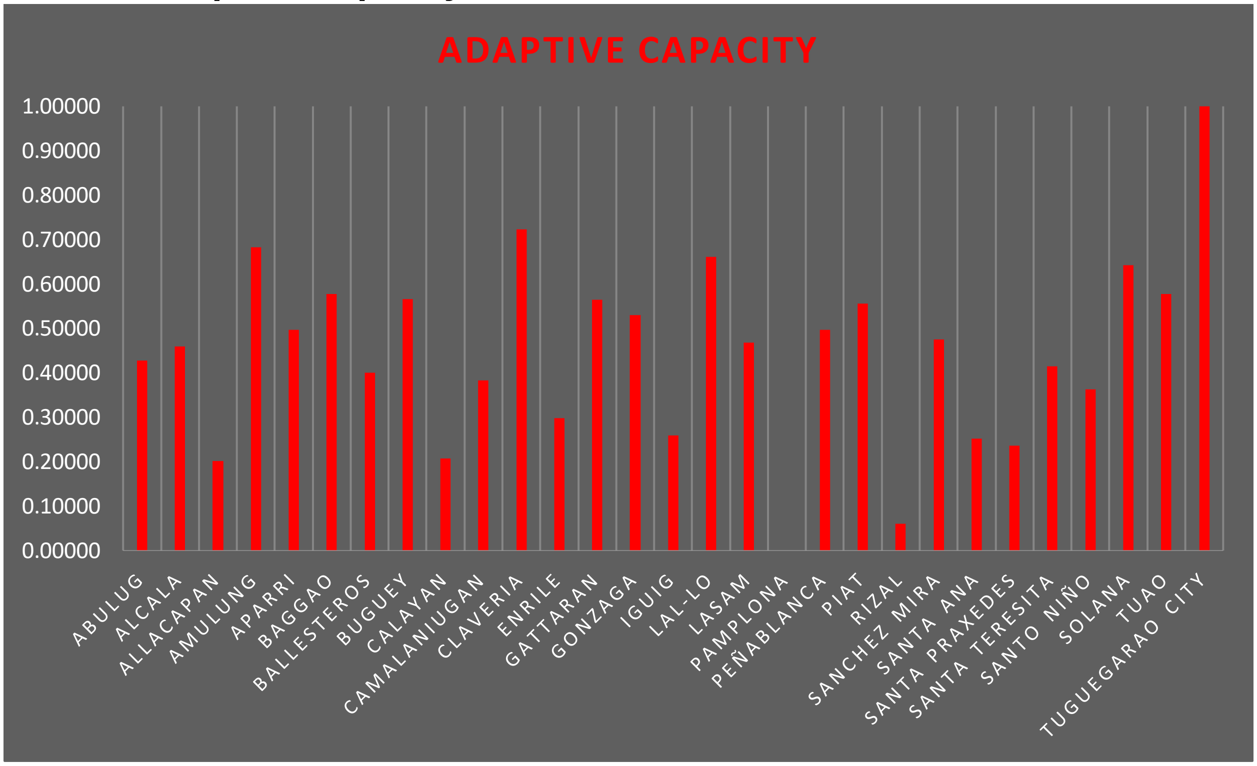
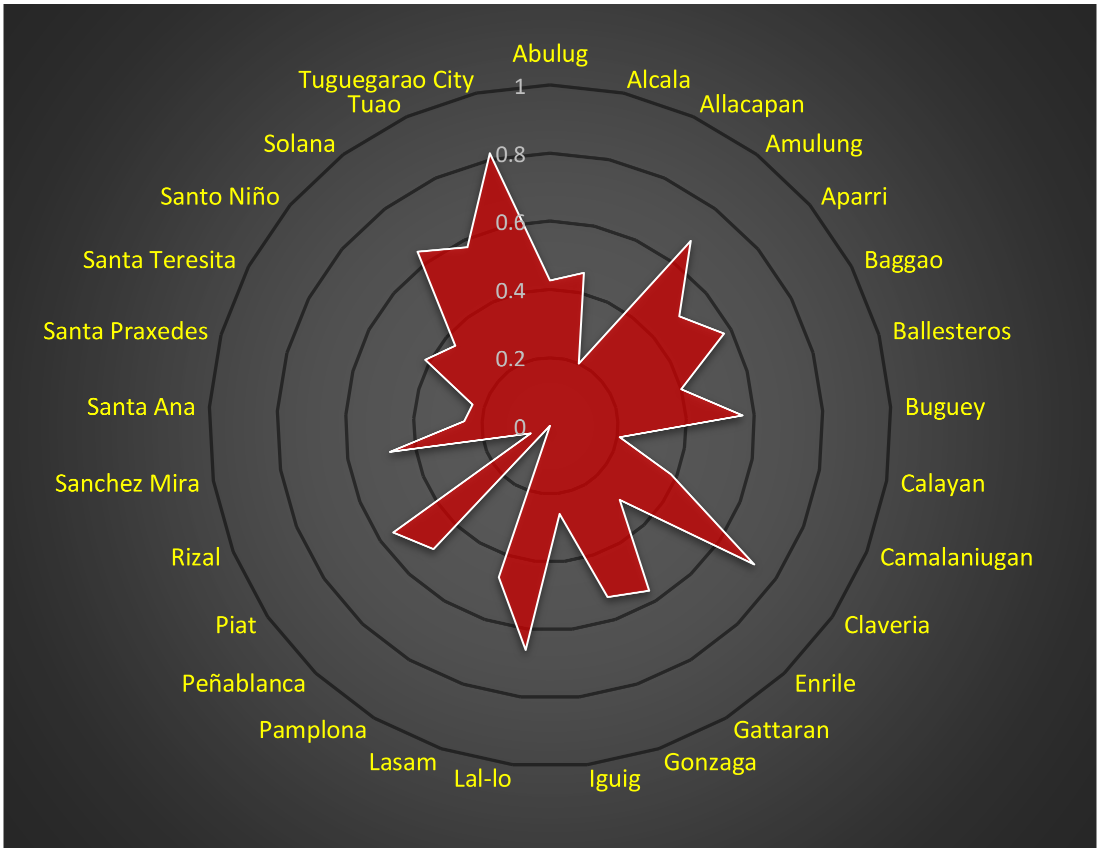
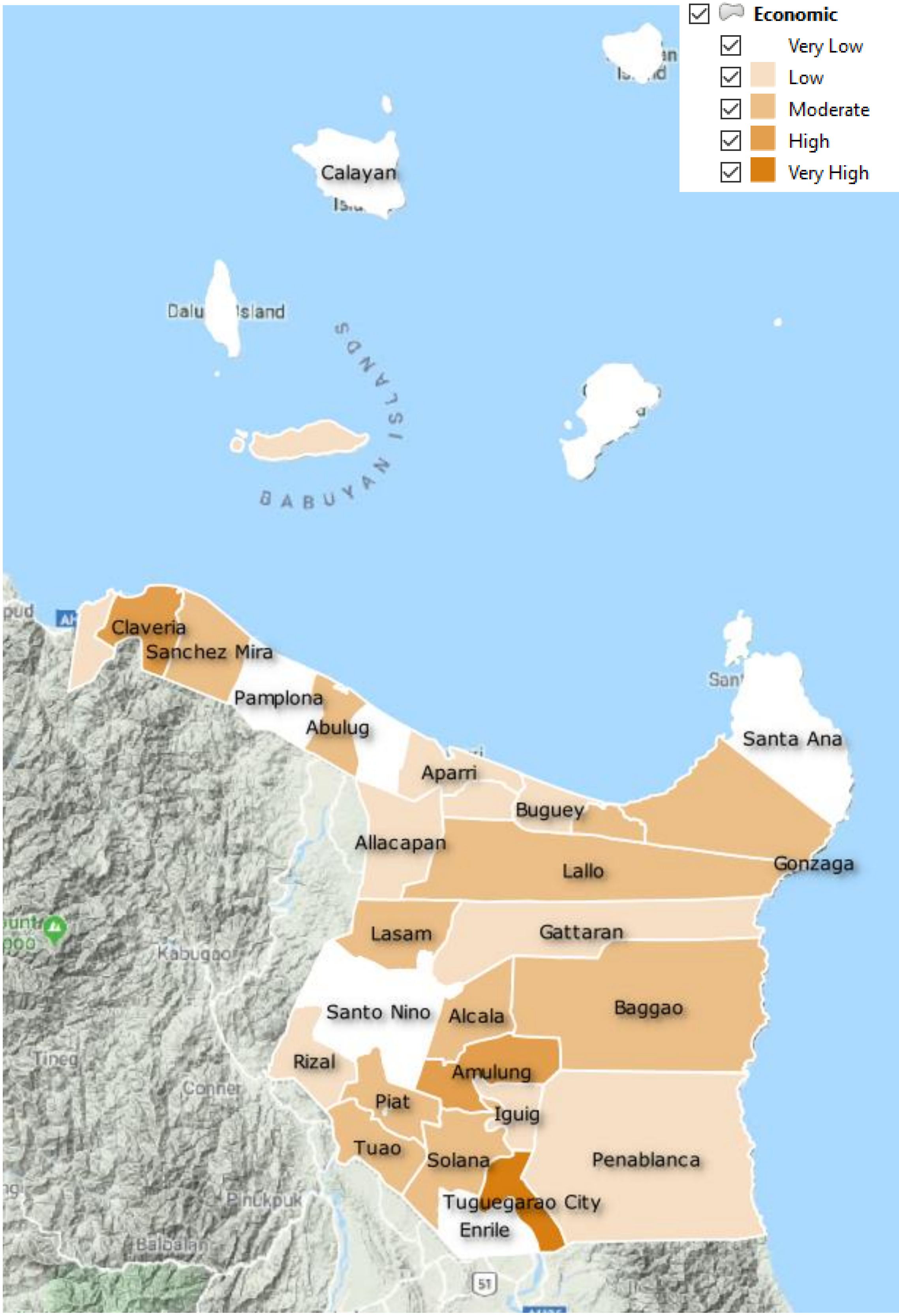
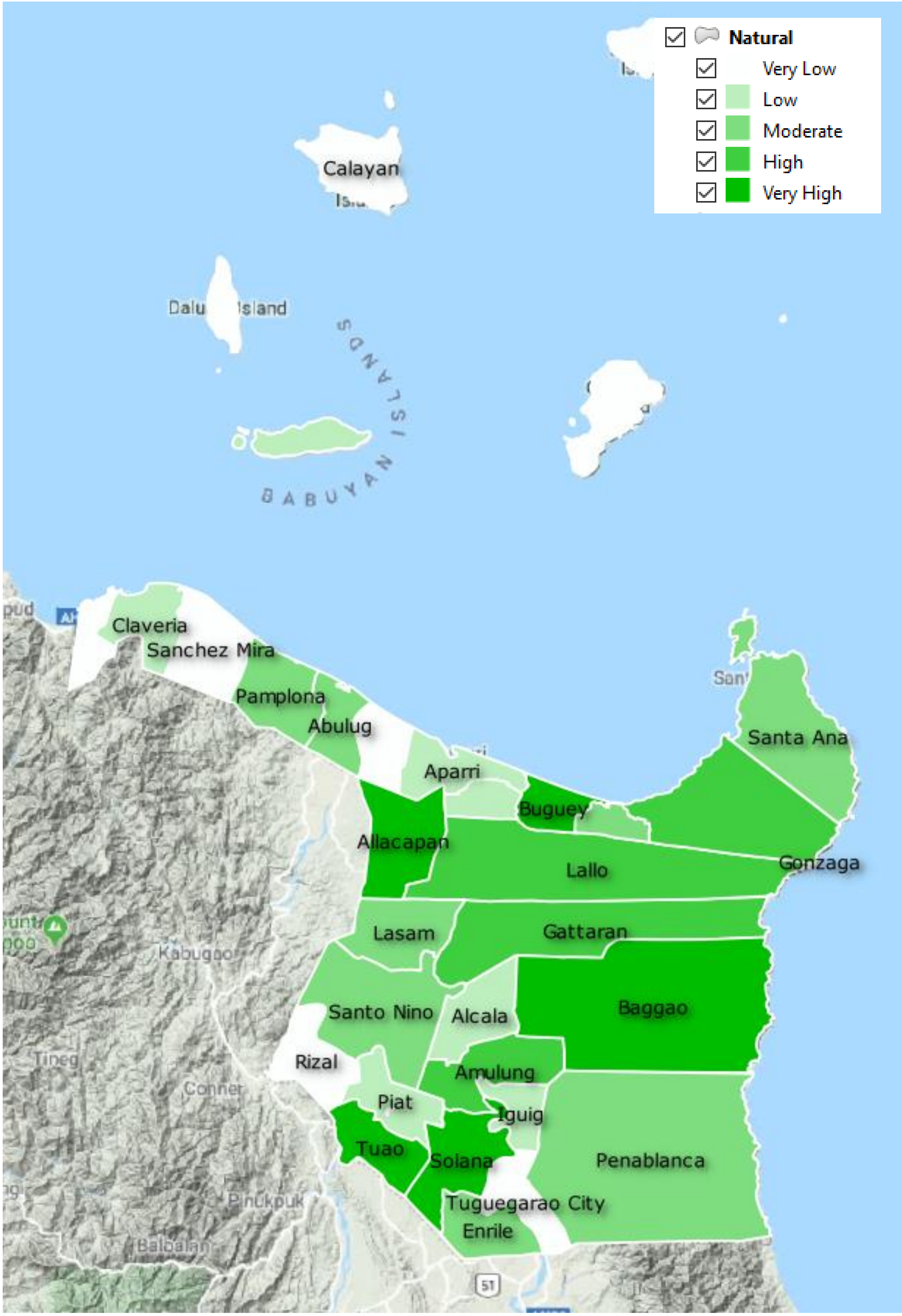
Overall Adaptive Capacity





Adaptive Capacity Maps

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Aparri
Santa Ana
Buguey
Allacapan
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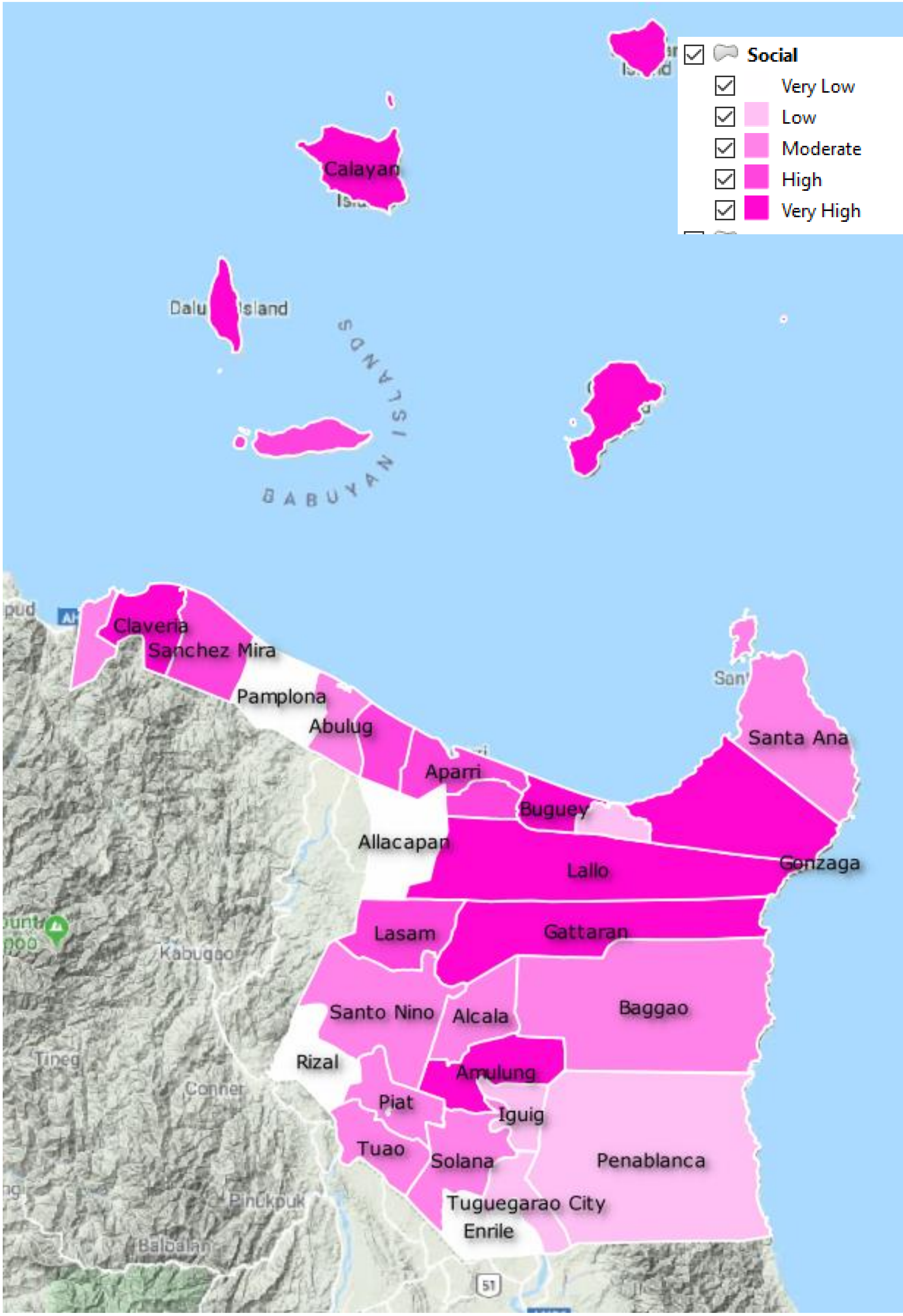
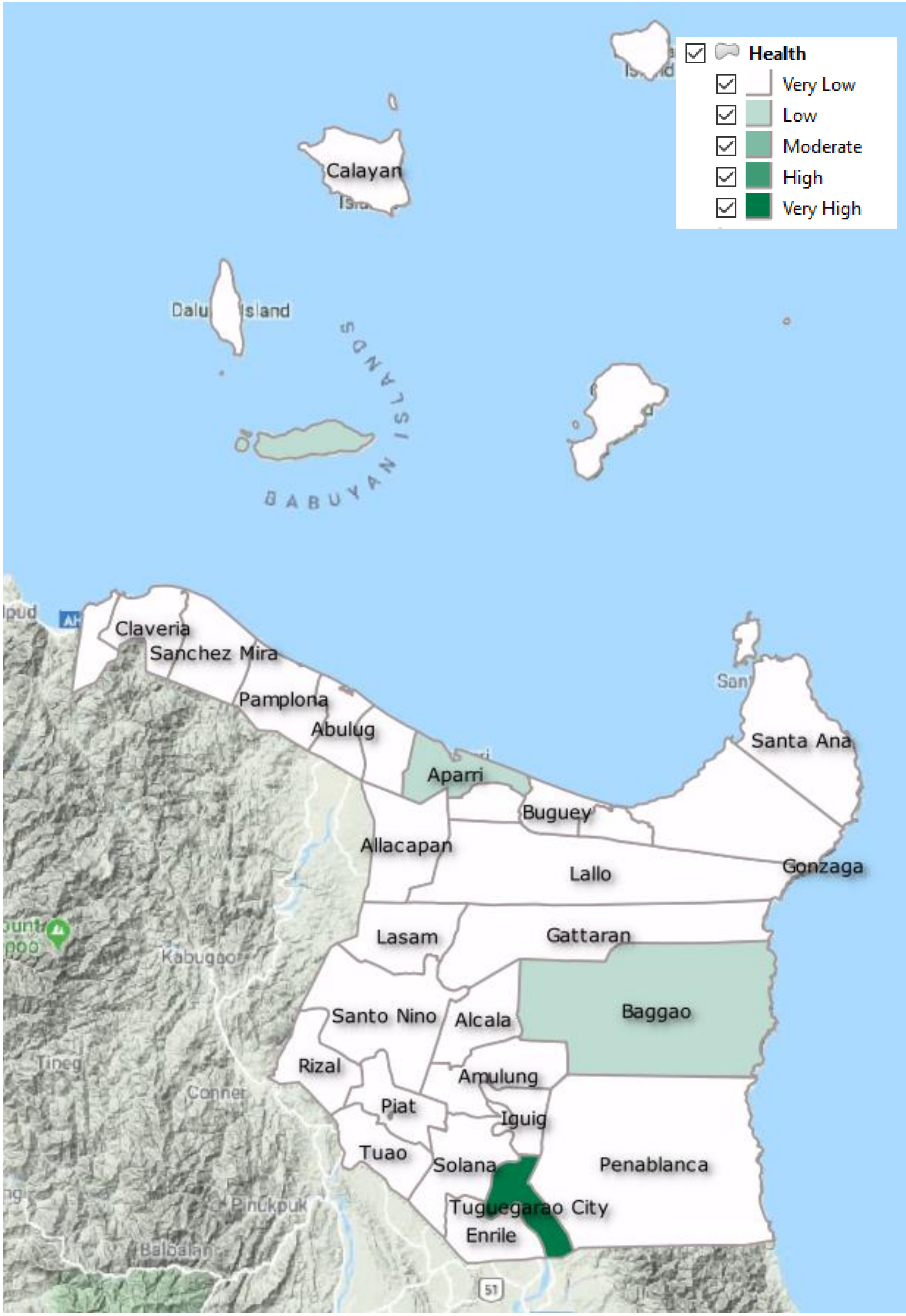
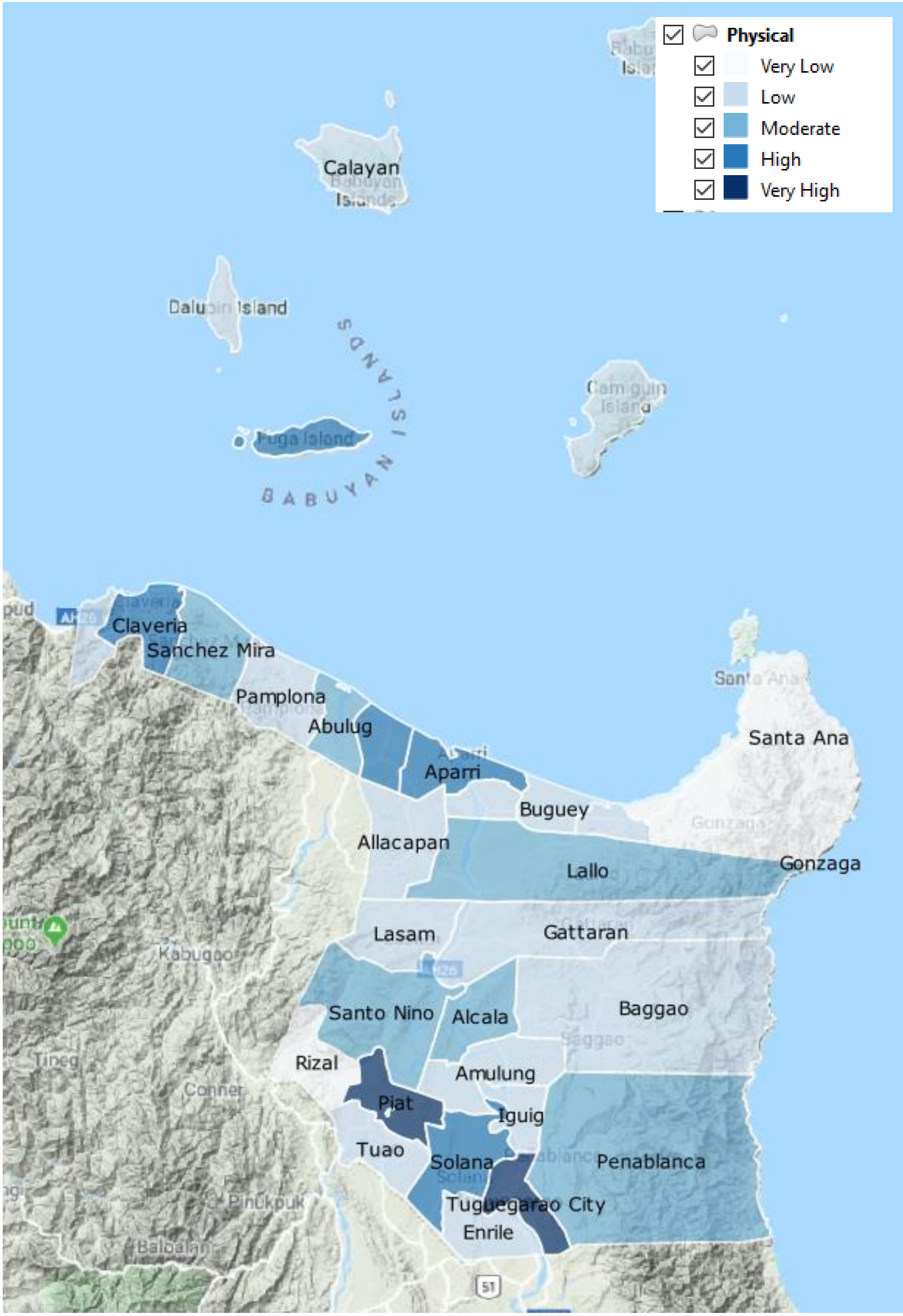
Enrile
Pinukpuk
Balbalan

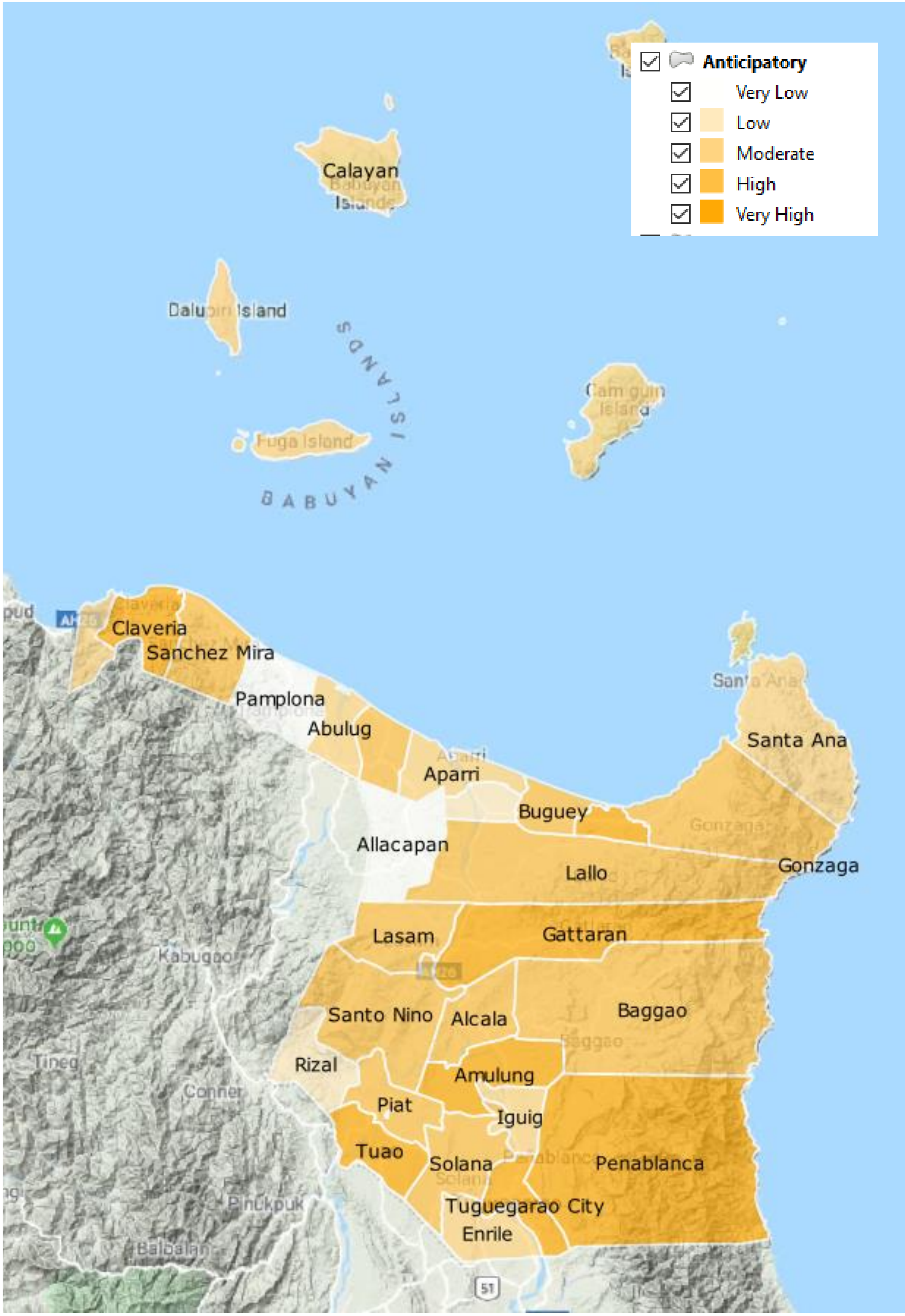

Social
Very Low
Low
Moderate
High
Very High
Calayan
Dalu
Island
BABUYAN ISLANDS
Claveria
Sanchez Mira
Pamplona
Abulug
Aparri
Buguey
Santa Ana
Allacapan
Lallo
Gonzaga
Lasam
Gattaran
Kabugao
Santo Nino
Alcala
Baggao
Rizal
Amulung
Tineg
Conner
Piat
Iguig
Tuao
Solana
Penablanca
Pinukpuk
Tuguegarao City
Enrile
Balbalan
51

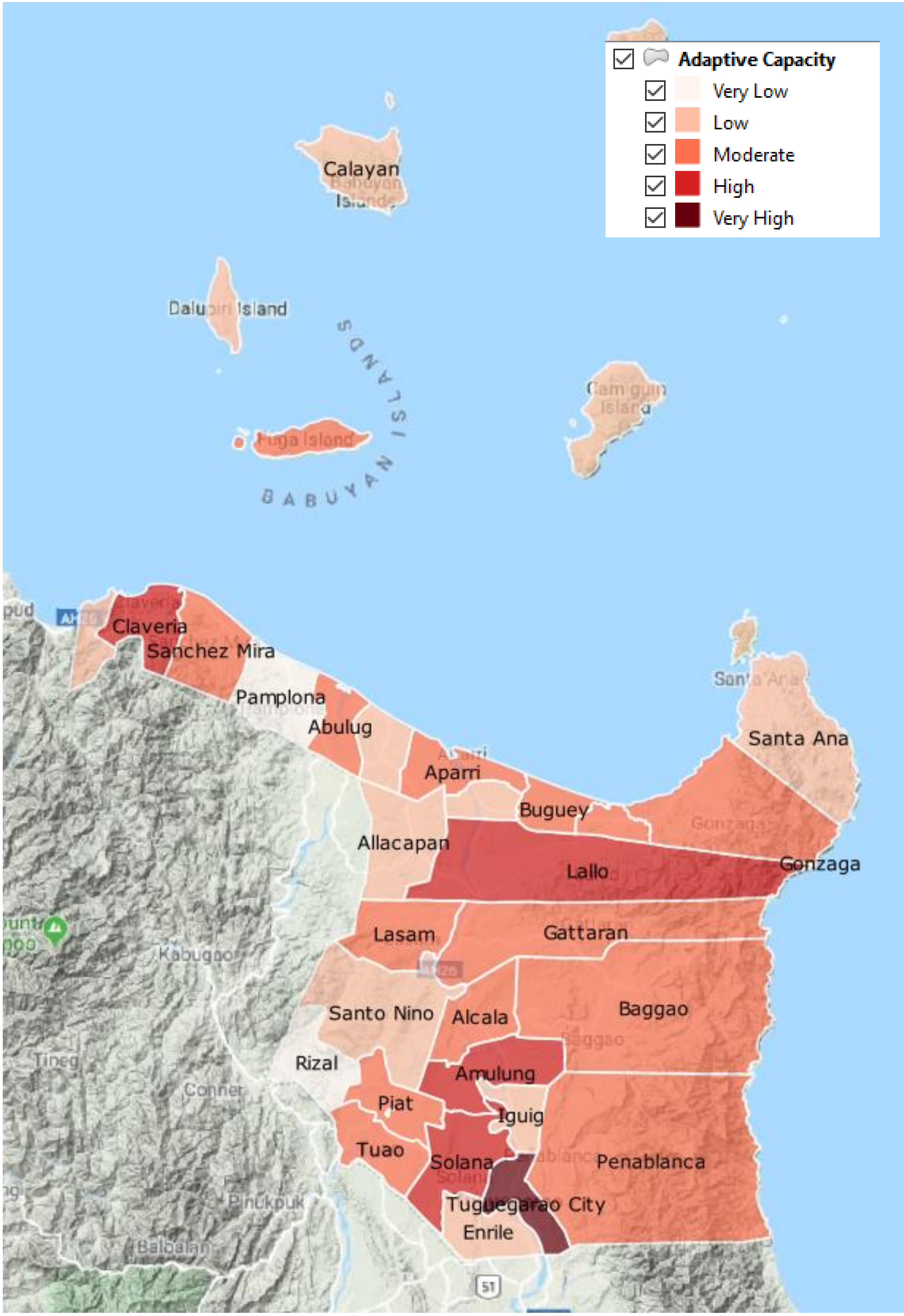


Health
Very Low
Low
Moderate
High
Very High
Calayan
Claveria
Sanchez Mira
Pamplona
Abulug
Aparri
Buguey
Santa Ana
Allacapan
Lallo
Gonzaga
Lasam
Gattaran
Baggao
Santo Nino
Alcala
Rizal
Amulung
Piat
Iguig
Tuao
Solana
Penablanca
Tuguegarao City
Enrile


Human
Very Low
Low
Moderate
High
Very High
Calayan
Claveria
Sanchez Mira
Pamplona
Abulug
Aparri
Buguey
Santa Ana
Allacapan
Lallo
Gonzaga
Lasam
Gattaran
Santo Nino
Alcala
Baggao
Rizal
Amulung
Piat
Iguig
Tuao
Solana
Penablanca
Tuguegarao City
Enrile


Physical
Very Low
Low
Moderate
High
Very High
Calayan
Babuyan Islands
Dalupiri Island
Fuga Island
BABUYAN ISLANDS
Camiguin Island
Claveria
Sanchez Mira
Pamplona
Abulug
Aparri
Buguey
Santa Ana
Allacapan
Lallo
Gonzaga
Lasam
Gattaran
Santo Nino
Alcala
Baggao
Rizal
Amulung
Piat
Iguig
Tuao
Solana
Penablanca
Tuguegarao City
Enrile


Anticipatory
Very Low
Low
Moderate
High
Very High
Calayan
Dalupiri Island
Fuga Island
Camiguin Island
BABUYAN ISLANDS
Claveria
Sanchez Mira
Pamplona
Abulug
Aparri
Buguey
Santa Ana
Allacapan
Lallo
Gonzaga
Lasam
Gattaran
Santo Nino
Alcala
Baggao
Rizal
Amulung
Piat
Iguig
Tuao
Solana
Penablanca
Tuguegarao City
Enrile


Adaptive Capacity
Very Low
Low
Moderate
High
Very High
Calayan
Dalupiri Island
Fuga Island
BABUYAN ISLANDS
Camiguin Island
Claveria
Sanchez Mira
Pamplona
Abulug
Aparri
Buguey
Santa Ana
Allacapan
Lallo
Gonzaga
Lasam
Gattaran
Santo Nino
Alcala
Baggao
Rizal
Amulung
Piat
Iguig
Tuao
Solana
Penablanca
Tuguegarao City
Enrile

DEVELOPING THE VULNERABILITY INDEX – the vulnerability index (VI) for each municipality is the sum of the potential impact (PI) and the inverted AC (figure 9) for each crop using Eq. 3 and the values obtained should be normalized linearly from an interval of 0 to 1. Based on the minimum and maximum values, the municipalities should be classified from very high to very low using five (5) equal breaks: 0-20 (Very Low); 20-40 (Low); 40-60 (Moderate); 60-80 (High); and 80-100 (Very High).

$$\boldsymbol{f(Haz, Sens, AC) = \sum_{n=i}^{n}\left(Haz_{(w_h)} + Sens_{(w_s)}\right) + \left(1 - AC_{(w_a)}\right)} \quad \textbf{Eq. 3}$$

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

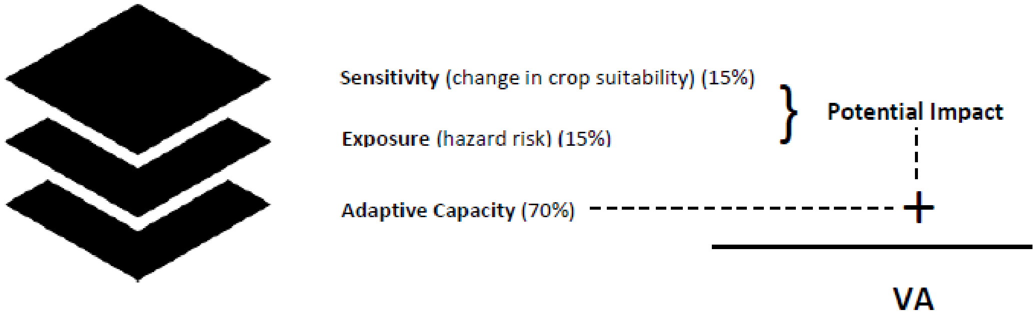


Figure 9. Illustrative guide on how to combine the different dimensions of vulnerability

STEP 5) PRIORITIZE

Vulnerability assessment is a key step in building climate resilient communities. It gives the user a sense of the geographical areas that are in most need of interventions, and types of interventions appropriate for each geographical area. Recently, the focus of vulnerability has shifted to a wider social and economic drivers that affect people's response to climate pressures.

Adaptation prioritization is framed using major vulnerabilities and priority adaptation activities based on the level of exposure to long term climate change and climate hazards. The focus of this vulnerability assessment is to identify key climate risk per municipality as a result of long term impact to crop suitability and exposure to climate extreme events and variability. And then assess the different levels of capacity for adaptation using the 7 capitals of adaptive capacity (figure 7).

CASE OF CAGAYAN PROVINCE

Based on the result of the vulnerability assessment in Cagayan, the DA-Regional Field Office selected Buguey as the focus municipality to establish a climate resilient village (CRV a.k.a climate smart village) since it was classified as moderately vulnerable. Other factors such as strong LGU partner and number of farmers, presence of drought, Storm surges and sea level rise were also considered during the selection of the target site. In designing the packages of interventions for Buguey, one should look at as many factors significantly affecting the vulnerability – one may focus on a specific factor that poses the highest climate risk, but without undermining other existing factors contributing to vulnerability. To properly design the package of interventions for CRV, the three lenses of information should be used to prioritize adaptation needs.

INFORMATION LENS 1 (EXPOSURE TO HAZARDS) - the main driving factor for high exposure to hazard in Daanbantyan are typhoon and drought (figure 11). While this is an important consideration in designing the package of agricultural interventions, the design should also not neglect addressing other climate risks (i.e., storm surge and sea level rise). This is the first lens of information in properly designing a CRA that addresses short term and recurring risks in the municipality. For instance, in the design of CRA, the introduction of drought tolerant varieties during the dry season or changing the cropping pattern to mitigate the effect of typhoons during wet season should be considered.

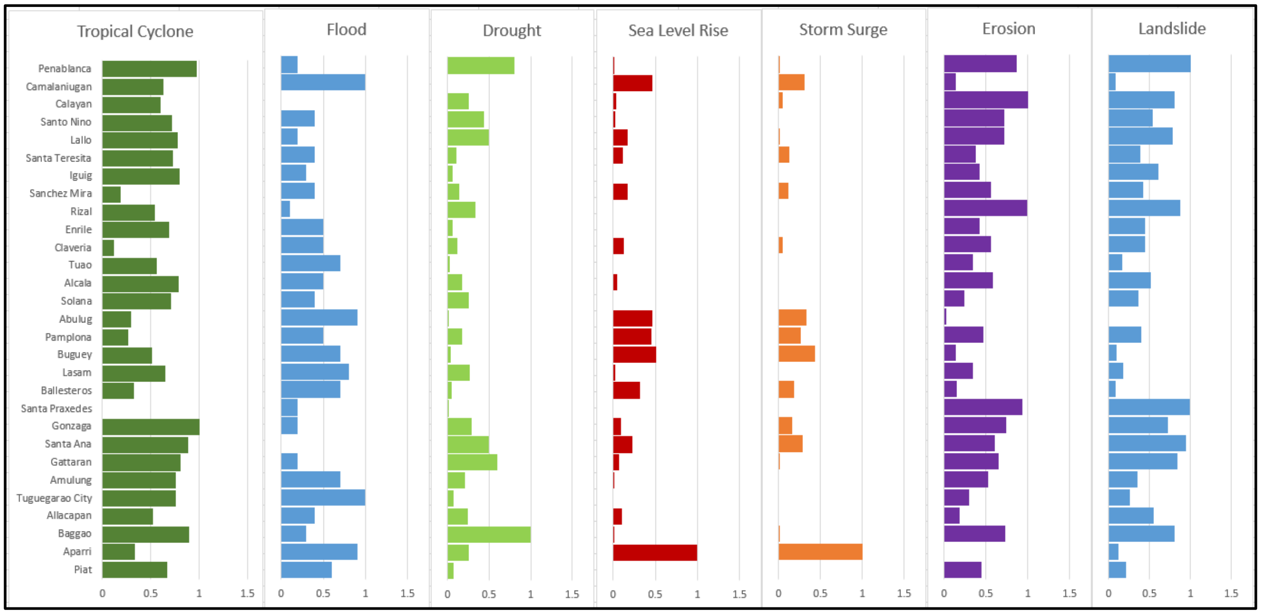


Figure 10. Ratings of 7 hazards in Cagayan Province.

INFORMATION LENS 2 (SENSITIVITY) - the second lens of information that should be considered in the design is the long term adaptation needs of the municipality to avoid future maladaptation. Based on the crop model simulation, Buguey will experience potential loss of crop suitability for Rice and

Corn (Maize) (figure 11). With this information, the design of the agricultural interventions should consider CRA practices to ensure the sustainability of water supply to withstand increasing temperatures (vis-à-vis higher evapotranspiration), or introducing new and/or improved varieties tolerant to heat and drought.

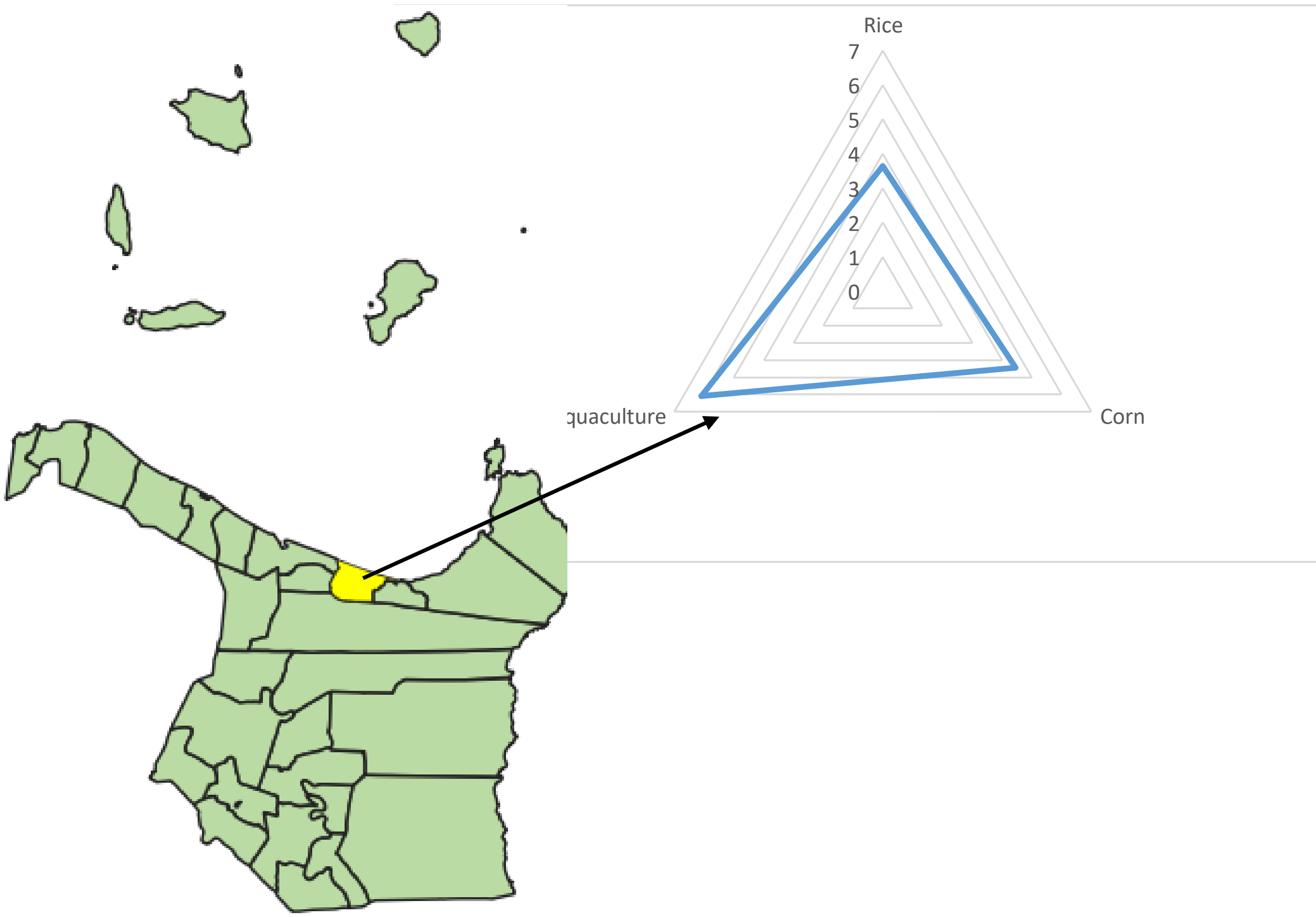


Figure 11. Change in crop suitability represented by sensitivity. Higher values means higher sensitivity which equates to higher losses of suitability.

INFORMATION LENS 3 (ADAPTIVE CAPACITY) – the third lens that should be considered is the capacity of the community to respond to climate change. Figure 12 shows the current strengths and weakness of Buguey. It shows farmers in the municipality are well organized and are active members of cooperatives which make it easier to provide support through extension services. However, to improve their resilience to climate risks, the priority actions need to focus on improving the economic, health, anticipatory, and human capitals. The learning capacity (sub-indicator of human capital) of the community is a critical factor for adaptation as it is a pre-requisite for innovation and capacity for action of the community. Improving the economic and anticipatory capitals should also be considered in the overall design of CRA. This can be done through the conduct of trainings and seminars on climate change and CRA, as well as provision for improved access to communication channels to mitigate impacts of climate variability and extreme events

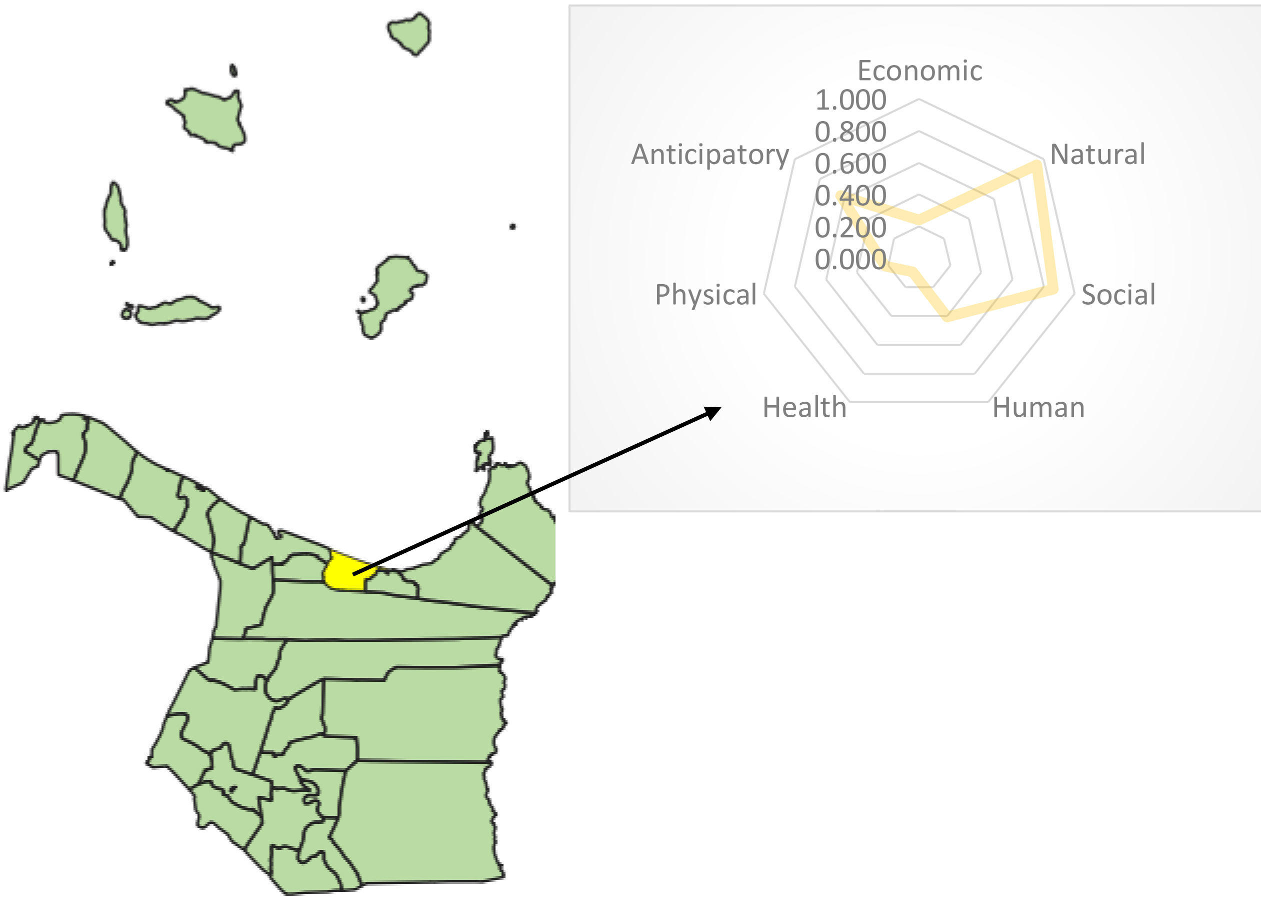


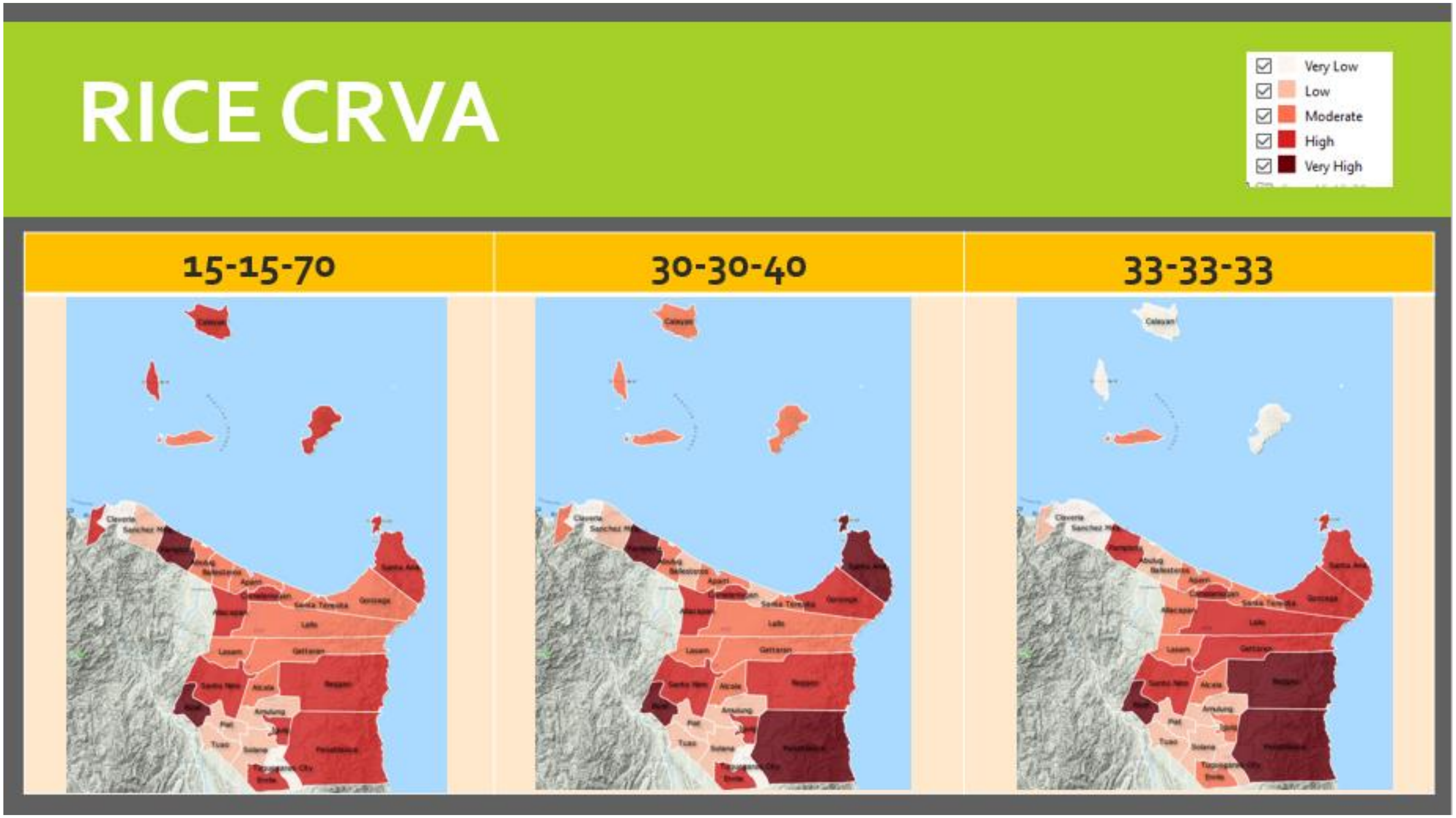
Figure 12. Adaptive capacity ratings for the municipality of Buguey

OVERALL VULNERABILITY INDEX

The final climate risk vulnerability map (fig. 13) for the year 2050 is an integration of the exposure, sensitivity and adaptive capacity components. The weighting of each of these indicators was discussed during expert workshops and resulted in 15% for exposure, 15% for sensitivity and 70% for adaptive. Each crop was assessed for vulnerability using the equation stated previously. Key findings about commodity vulnerability by municipality is shown in table 8.

The province show municipalities that are particularly vulnerable to climate risks. As this assessment focuses on the agricultural sector, urban areas appear throughout the country as comparatively less vulnerable than rural areas. The results were validated during several workshops with all participating SUCs, RFOs, AMIA partner institutions and other stakeholders.

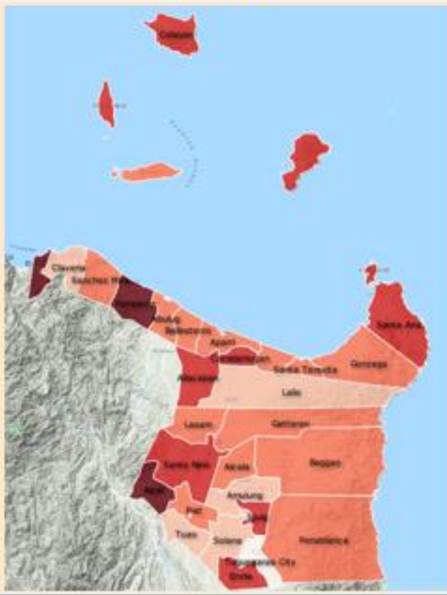
Figure 13. Vulnerability map in Cagayan Province by Commodity with different scenario on each indexes



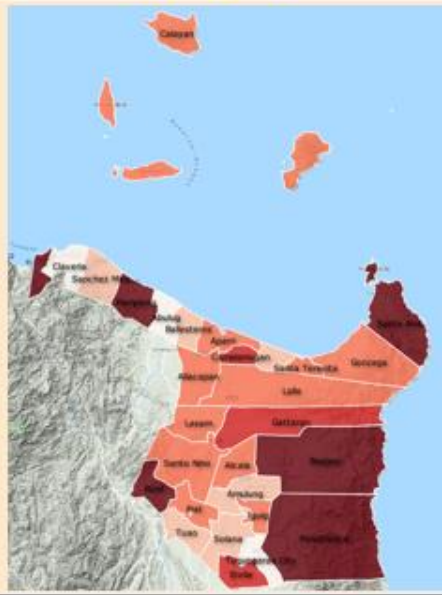
CORN CRVA

- Very Low
- Low
- Moderate
- High
- Very High

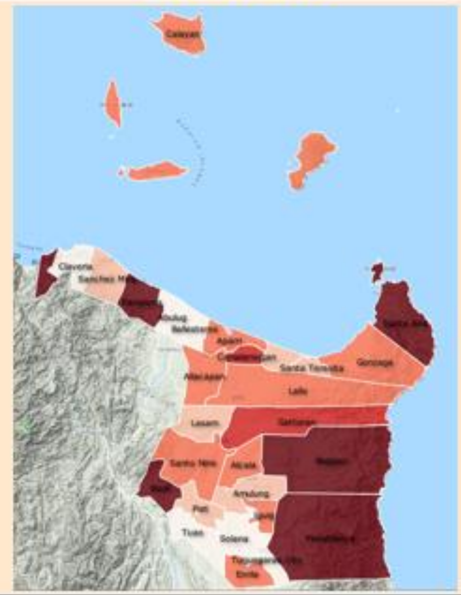
15-15-70



30-30-40

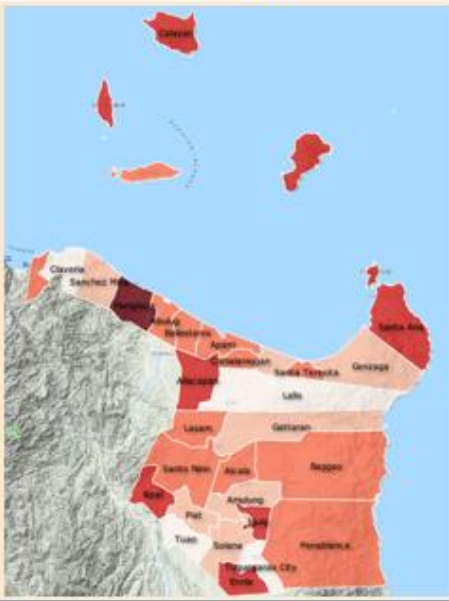
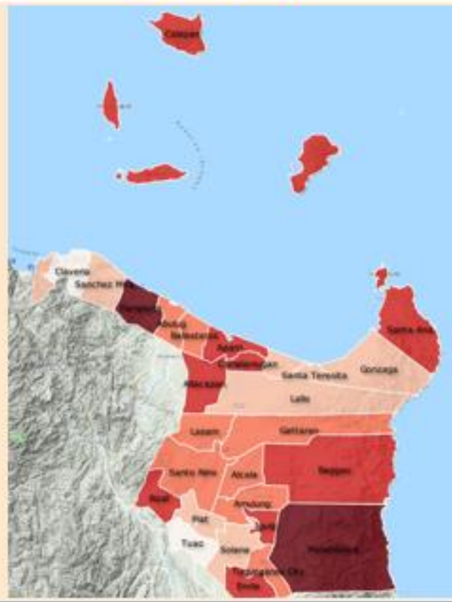
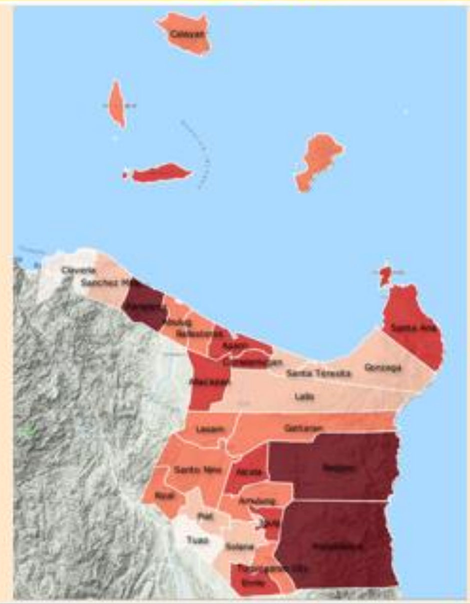


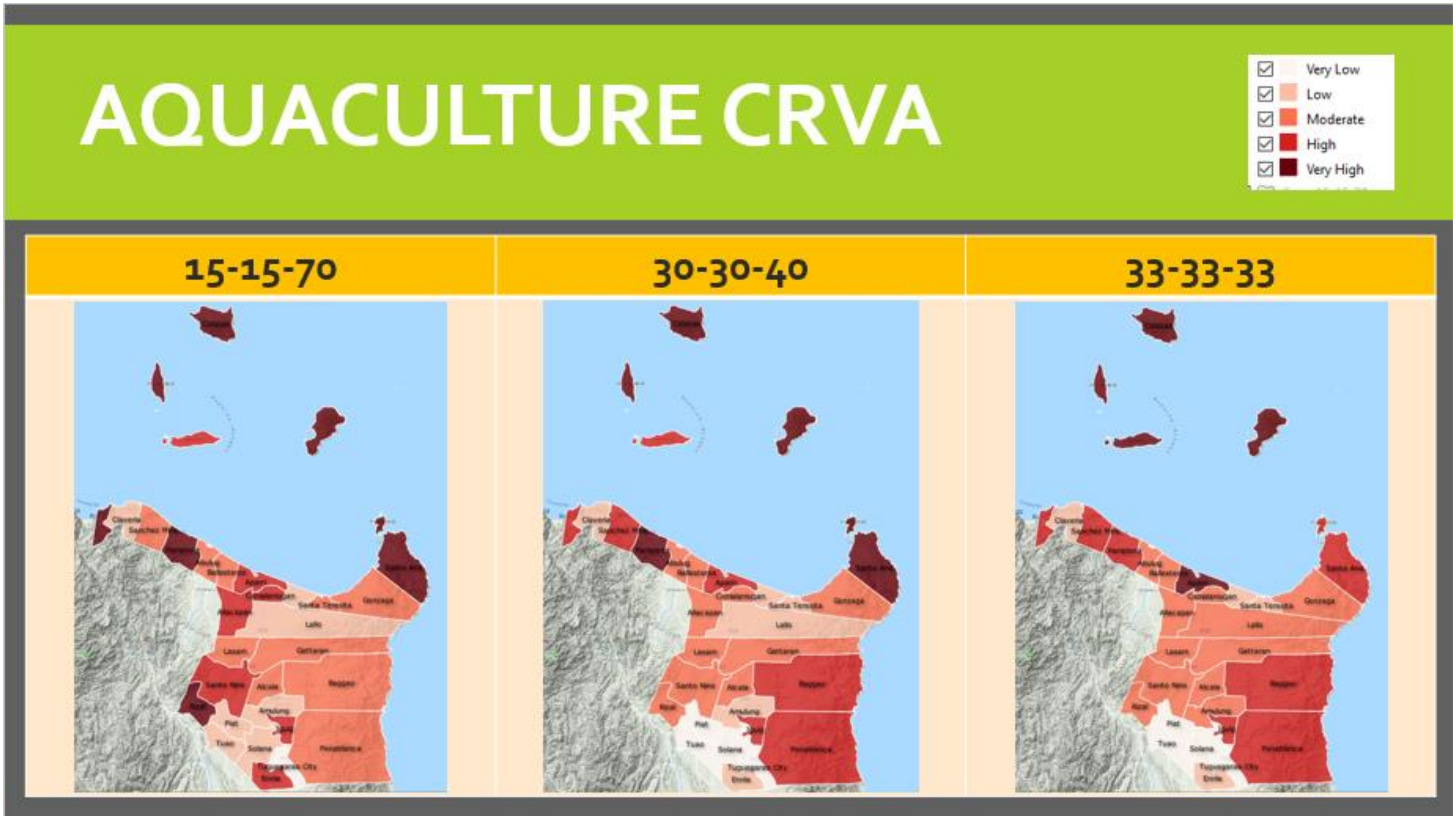
33-33-33

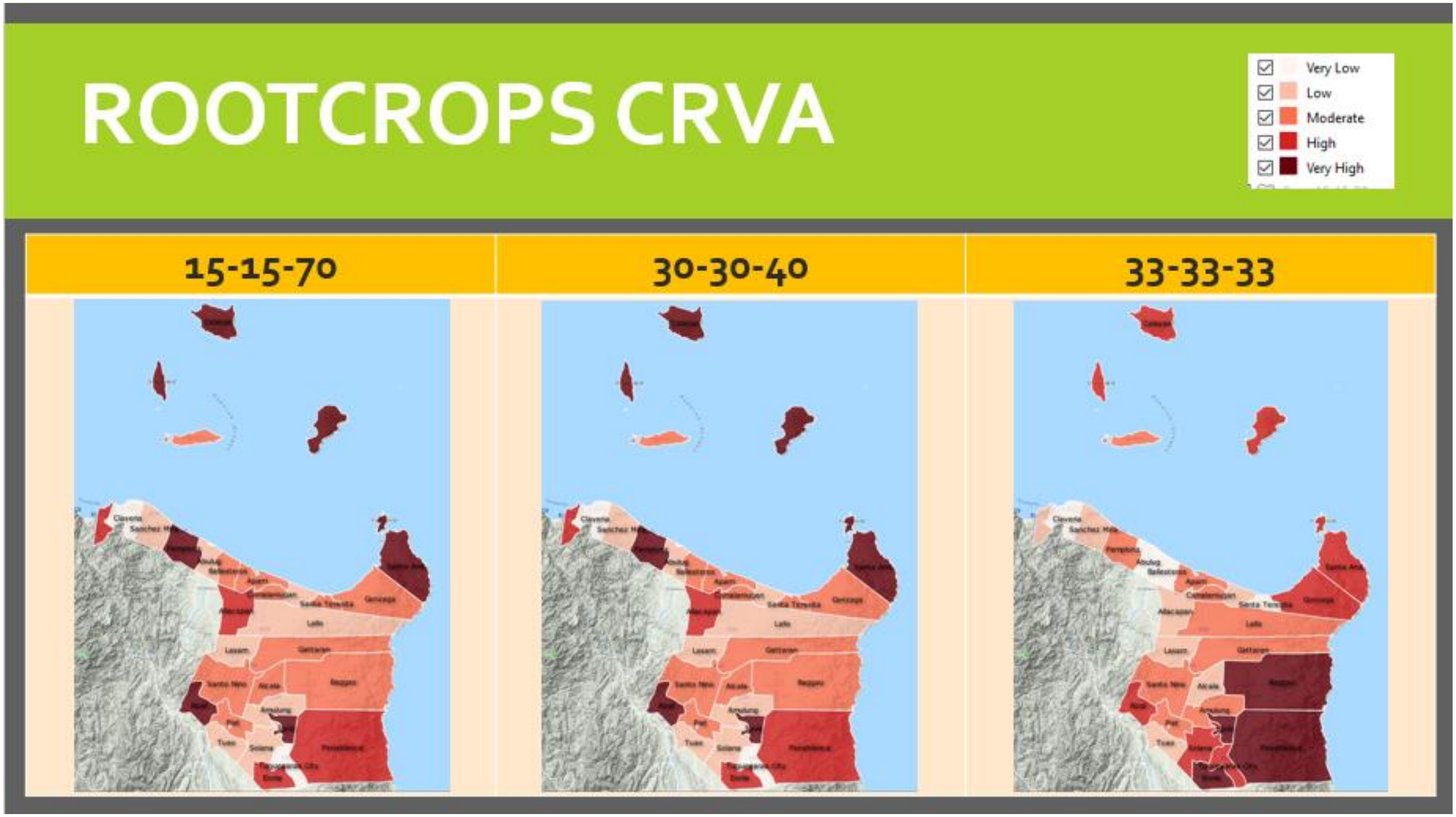


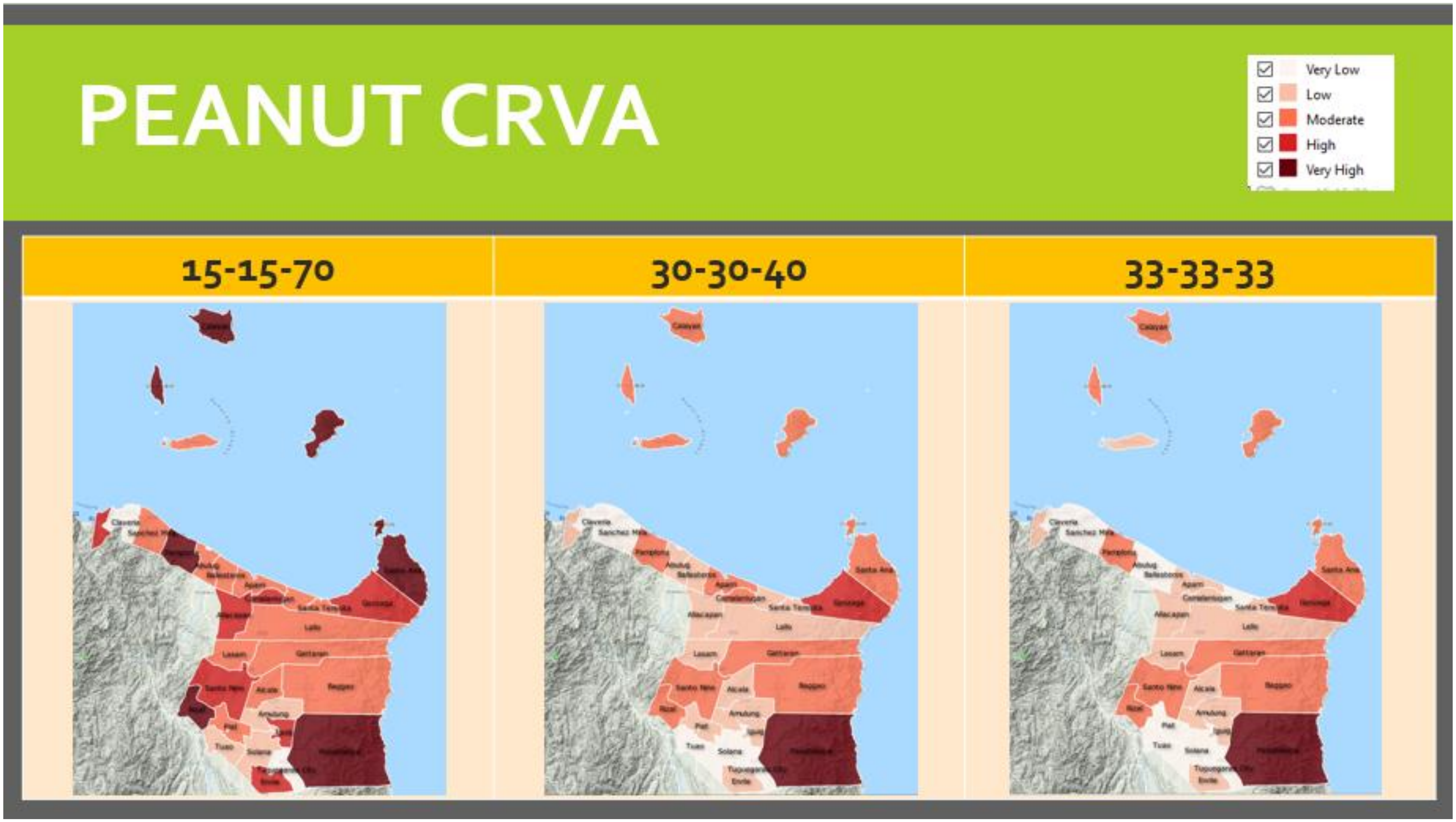
LIVESTOCK CRVA

- Very Low
- Low
- Moderate
- High
- Very High

15-15-70	30-30-40	33-33-33
		


AQUACULTURE CRVA
Very Low
Low
Moderate
High
Very High
15-15-70
30-30-40
33-33-33

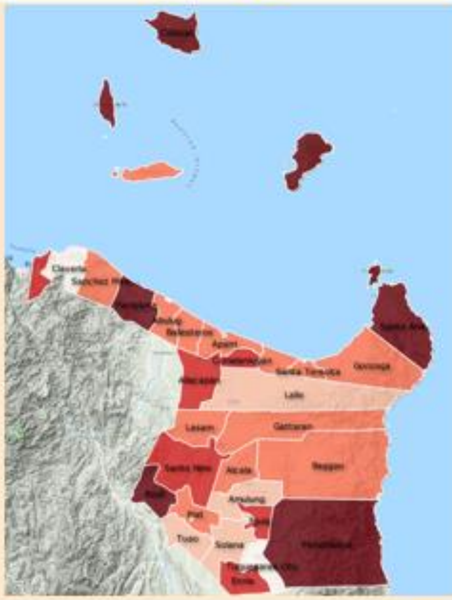

ROOTCROPS CRVA
Very Low
Low
Moderate
High
Very High
15-15-70
30-30-40
33-33-33


PEANUT CRVA
Very Low
Low
Moderate
High
Very High
15-15-70
30-30-40
33-33-33

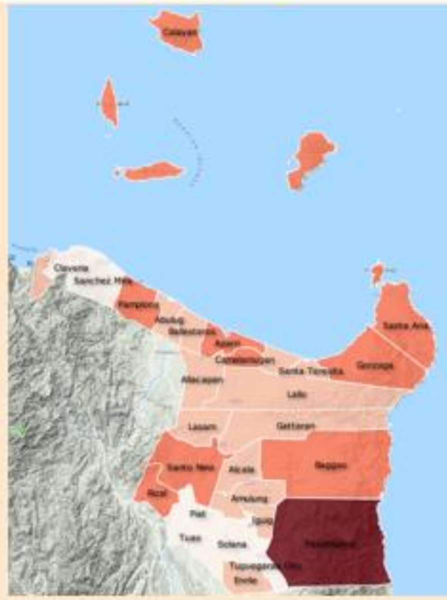
PINEAPPLE CRVA

- Very Low
- Low
- Moderate
- High
- Very High

15-15-70

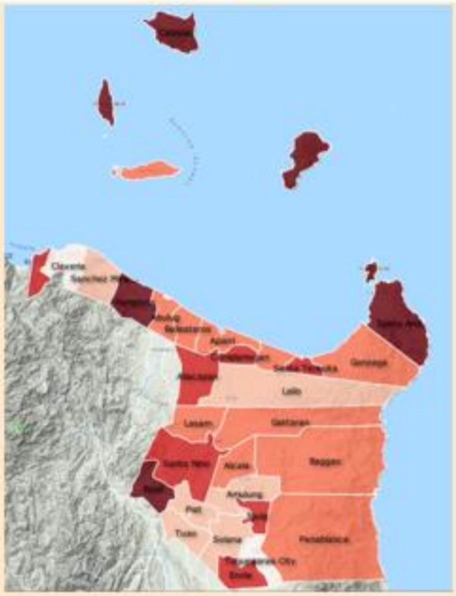
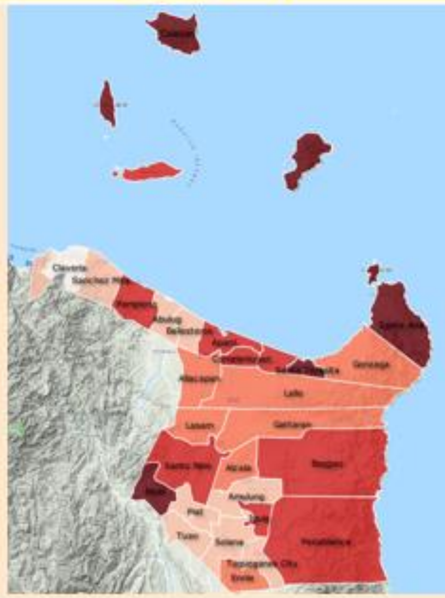
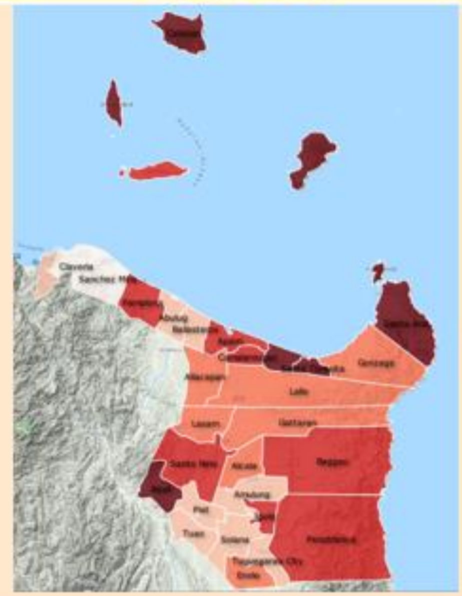


30-30-40



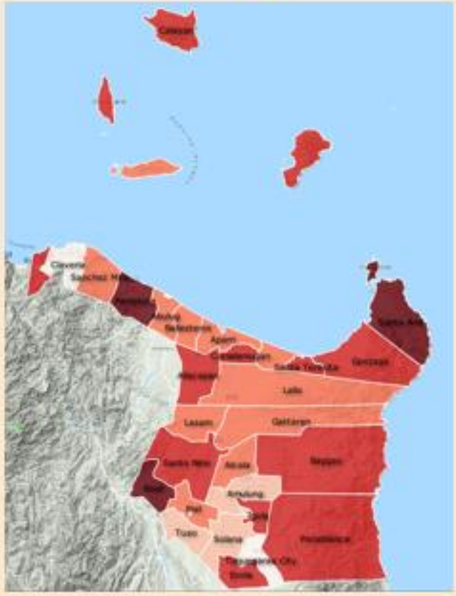
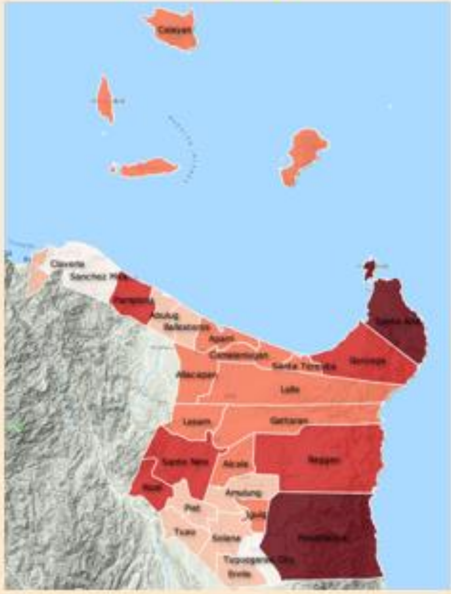
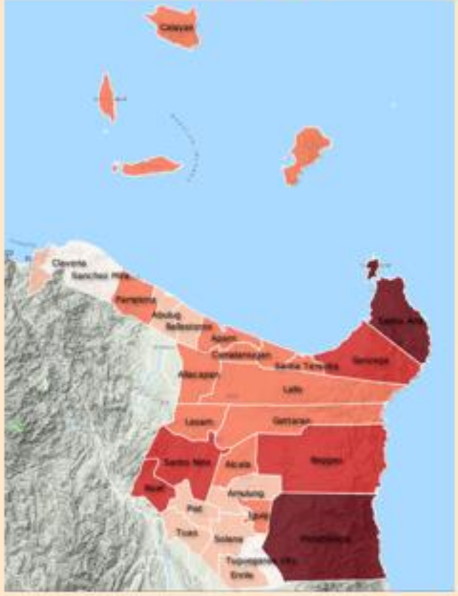
33-33-33

COCONUT CRVA

15-15-70	30-30-40	33-33-33
		

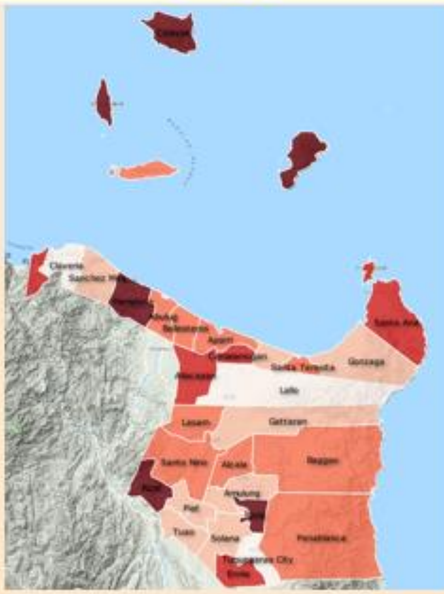
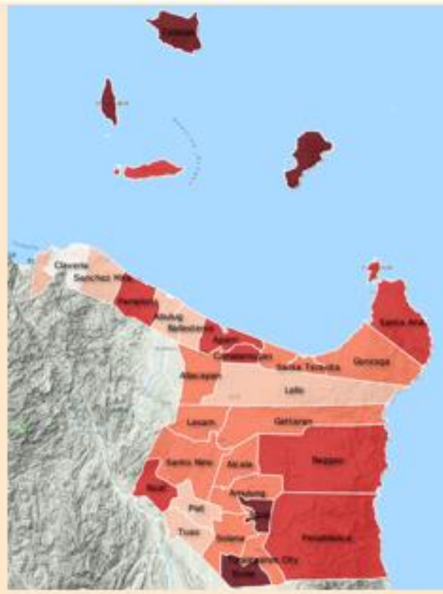
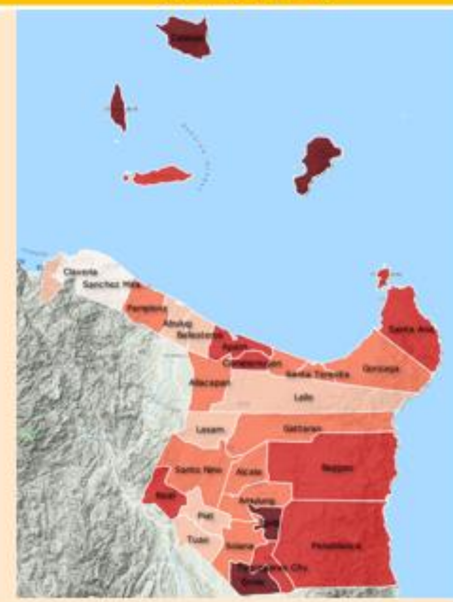
CITRUS CRVA

Very Low
Low
Moderate
High
Very High

15-15-70	30-30-40	33-33-33
		

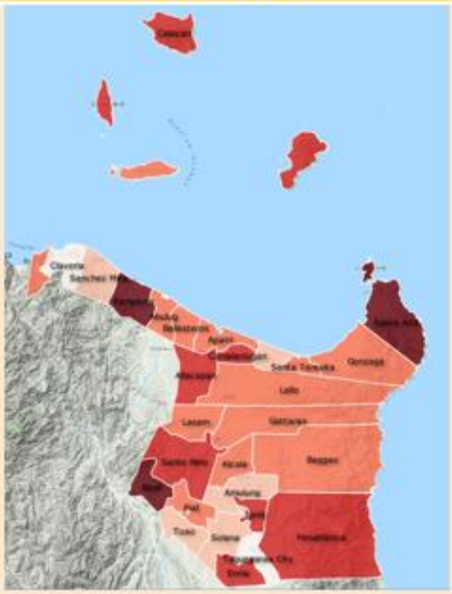
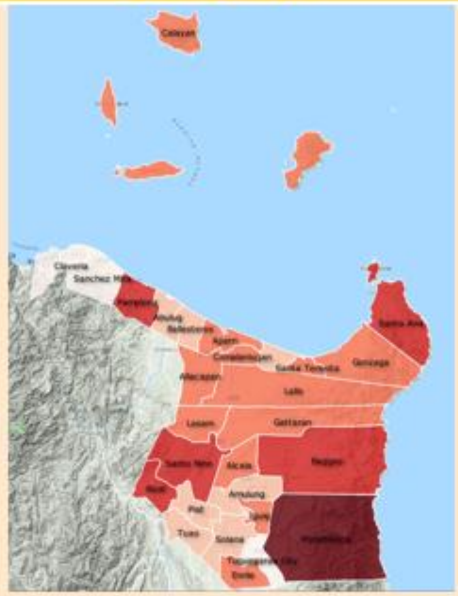
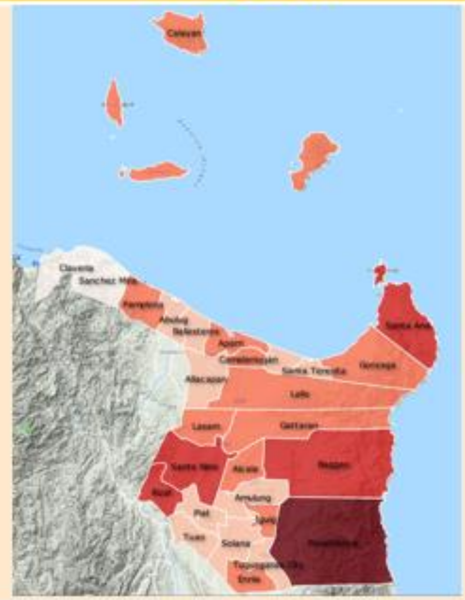
BANANA CRVA

- Very Low
- Low
- Moderate
- High
- Very High

15-15-70	30-30-40	33-33-33
		

VEGETABLES CRVA

Very Low
Low
Moderate
High
Very High

15-15-70	30-30-40	33-33-33
		


MANGO CRVA
Very Low
Low
Moderate
High
Very High
15-15-70
30-30-40
33-33-33

Table 8. Key Findings on commodity vulnerability by municipality

MANGO

Municipality	Mango Prod. Area	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Abulug	50	Mango will have a slight decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **Low**, Very High in Flood, but Very Low in Erosion, Landslide, and Drought **Classified as Moderate Vulnerability**	Classified with **Moderate** AC, Moderate in Economic, Natural, Social, and Anticipatory capitals, but Low Human and Very Low Health capitals
Amulung	233	Mango will remain suitable with no change at all by year 2050	Overall hazard is **Moderate**, High in Typhoon and Flood, but no occurrence of Sea Level Rise and Storm Surge **Classified as Very Low Vulnerability**	Classified with **High** AC, Very High in Social and Anticipatory, High in Economic, but Very Low in Human and Health capitals
Aparri	16	Mango will have a slight decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **High**, Very High in Flood, Sea Level Rise, and Storm Surge, but Very Low in Erosion and Landslide **Classified as Moderate Vulnerability**	Classified with **Moderate** AC, High in Social and Physical, but Very Low in Human and Low in Health capitals
Enrile	117	Mango will remain suitable with no change at all by year 2050	Overall hazard is **Low**, High in Typhoon with Moderate Flood, Erosion, and Landslide, but Very Low occurrence of Drought **Classified as Moderate Vulnerability**	Classified with **Low** AC, Very Low in Economic Social, and Human capitals, Moderate in Anticipatory
Gattaran	261	Mango will remain suitable with no change at all by year 2050	Overall hazard is **High**, Very High in Typhoon and Landslide, but Very Low occurrence of Flood, Sea Level Rise, and Salt Water Intrusion **Classified as Moderate Vulnerability**	Classified with **Moderate** AC, Very High in Social and Anticipatory, High in Natural, but Low in Economic, Human, and Physical capitals

Municipality	Mango Prod. Area	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Lal-Lo	148	Mango will remain suitable with no change at all by year 2050	Overall hazard is **High**, High in Typhoon, Erosion, and Landslide, but Low occurrence of Flood **Classified as Very Low Vulnerability**	Classified with **High** AC, Very High in Social, High in Natural and Anticipatory, and Moderate in Economic and Physical capitals
Penablanca	105	Mango will remain suitable with no change at all by year 2050	Overall hazard is **Very High**, Very High in Typhoon, Erosion, Landslide, and Drought, but Low in Flood **Classified as High Vulnerability**	Classified with **Moderate** AC, Very High in Anticipatory, Moderate in Natural, Human, and Physical, but Low Economic capital
Rizal	232	Mango will remain suitable with no change at all by year 2050	Overall hazard is **Moderate**, Very High in Erosion and Landslide, but Low in Flood with no occurrence of Sea Level Rise and Storm Surge **Classified as Very High Vulnerability**	Classified with **Very Low** AC, Low in Economic, Natural, and Anticipatory, and Very Low in Social, Human, Health, and Physical capitals

RICE

Municipality (D1)	Rice Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Alcala	4,398	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Moderate,** High in Typhoon, moderate in Flood, Landslide, and Erosion, Low occurrence of Drought **Classified as Moderate Vulnerability**	Classified as **Moderate** AC, High in Anticipatory and Social, Moderate in Physical, but low in Natural, Economic, Human and Health
Aparri	8,227	Palay will remain suitable with no change at all by year 2050	Overall hazard is **High**, Very High in Flood, Sea Level Rise, and Storm Surge, Low in Typhoon, and	Classified as **Moderate** AC, High in Social and Physical, but Very Low in Human and Low in Health capitals

Municipality (D1)	Rice Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
			Drought, but Very Low in Erosion and Landslide **Classified as High Vulnerability**	
Baggao	8,105	Palay will have a slight decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **Very High,** Very High in Typhoon, and Drought, High occurrence of Landslide, and Erosion, Low on Flood **Classified as Very High Vulnerability**	Classified as **Moderate** AC, Very High in Natural, High in Anticipatory and Economic, Moderate in Social and Human, but Low in Health and Physical
Buguey	5,420	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Low,** High in Flood, Moderate occurrence of Typhoon, Sea Level Rise, and Storm Surge **Classified as Low Vulnerability**	Classified as **Moderate** AC, Very High in Natural and Social, High in Anticipatory and Human, Low in Physical and Economic and Very Low in Health
Camalaniugan	4,700	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Moderate,** Very High in Flood, High in Typhoon, Moderate in Sea Level Rise **Classified as Moderate Vulnerability**	Classified as **Low** AC, Only High in Social but Low in Economic, Anticipatory, Physical, Natural and Human and further Very Low in Health
Gattaran	7,079	Palay will have a slight decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **High**, Very High in Typhoon and Landslide, but Very Low occurrence of Flood, Sea Level Rise, and Salt Water Intrusion **Classified as High Vulnerability**	Classified as **Moderate** AC, Very High in Social and Anticipatory, High in Natural, but Low in Economic, Human, and Physical capitals
Gonzaga	4,585	Palay will have a slight decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **High,** Very high in Typhoon, High in Landslide, and Erosion, Low occurrence of Flood, and Drought, Very Low on Sea Level Rise, and Storm Surge **Classified as High Vulnerability**	Classified as **Moderate** AC, Very High in Social, High in Anticipatory, Natural and Economic, but Low in Physical and Very Low in Health

Municipality (D1)	Rice Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Lallo	5,636	Palay will have a slight decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **High**, High in Typhoon, Erosion, and Landslide, but Low occurrence of Flood **Classified as High Vulnerability**	Classified with **High** AC, Very High in Social, High in Natural and Anticipatory, and Moderate in Economic and Physical capitals
Sta. Ana	3,113	Palay will remain suitable with no change at all by year 2050	Overall hazard is **High,** Very high in Typhoon, and Landslide, Moderate in Erosion, Flood, and Drought, Low on Sea Level Rise, and Storm Surge **Classified as High Vulnerability**	Classified as **Low** AC, Moderate in Anticipatory, Social and Natural, Low in Human, Very Low in Physical, Health and Economic capitals
Sta. Teresita	1,667	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Low,** High in Typhoon, Low on Flood, Landslide and Erosion, Very Low in Drought, Sea-Level Rise and Sotrm Surge	Classified with **Moderate** AC, Very High in Anticipatory, Moderate in Natural and Economic, Low in Physical, Human and Social, Very Low in Health capital

RICE

Municipality (D2)	Rice Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Abulug	5,510	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Low**, Very High in Flood, but Very Low in Erosion, Landslide, and Drought **Classified as Low Vulnerability**	Classified with **Moderate** AC, Moderate in Economic, Natural, Social, and Anticipatory capitals, but Low Human and Very Low Health capitals
Allacapan	9,666	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Very Low,** Low occurrence of Flood, and Drought, Very Low in Erosion **Classified as Very Low Vulnerability**	Classified with **Low** AC, Very High in Natural but Low in Physical and Economic, further Very Low in Anticipatory, Human, Health and Social capitals

Municipality (D2)	Rice Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Ballesteros	5,468	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Very Low,** Low occurrences of Flood, and Sea Level Rise, Very Low in Erosion, Landslide, Drought, and Storm Surge **Classified as Very Low Vulnerability**	Classified as **Low** AC, High in Anticipatory, Physical, Social capitals but Very Low in Human, Health, Natural and Economic capitals
Calayan	838	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Low,** Very High in Erosion, High occurrence of Typhoon, Landslide, Low in Drought, Very Low in Flood, Sea Level Rise, and Storm Surge **Classified as Low Vulnerability**	Classified with **Low** AC, High in Social, Moderate in Anticipatory, Low in Physical and Very Low in Human, Health, Natural and Economic capitals
Claveria	3,683	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Very Low,** Very Low in Typhoon, Drought, Sea Level Rise, and Storm Surge, Moderate in Flood, Landslide, and Erosion, **Classified as Very Low Vulnerability**	Classified with **High** AC, Very High in Anticipatory and Social, High in Physical and Economic, Low in Human and Natural, Very Low in Heath capital
Lasam	6,852	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Moderate,** High in Typhoon, Flood, Low in Erosion, and Drought, Very Low in Landslide, **Classified as Moderate Vulnerability**	Classified with **Moderate** AC, High in Anticipatory and Social, Moderate in Natural and Economic, Low in Physical, Very Low in Human and Health capitals
Pamplona*	4,416	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Low**, Moderate in Flood, Erosion, Sea Level Rise, Low in Typhoon, Landslide, and Storm Surge, but Very Low in Drought **Classified as Low Vulnerability**	Classified with **Low** AC, Moderate in Natural capital, Low in Physical, Very Low in Anticipatory, Human, Health, Social and Economic
Piat	2,197	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Low**, High in Typhoon, Moderate in Flood, and Erosion, but Low Landslide, and Very Low in Drought with no	Classified with **Moderate** AC, Very High in Physical, High in Anticipatory, Moderate in Social and Economic, Low in Human and Natural, Very Low in Health

Municipality (D2)	Rice Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
			occurrence of Sea Level Rise and Storm Surge **Classified as Low Vulnerability**	
Rizal	1,178	Palay will have a slight decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **Moderate**, Very High in Erosion and Landslide, but Low in Flood with no occurrence of Sea Level Rise and Storm Surge **Classified as Moderate Vulnerability**	Classified with **Very Low** AC, Low in Economic, Natural, and Anticipatory, and Very Low in Social, Human, Health, and Physical capitals
Sanchez Mira	2,866	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Very Low,** Very Low in Typhoon, Drought, Sea Level Rise, and Storm Surge, Moderate in Landslide, and Erosion, Low in Flood **Classified as Very Low Vulnerability**	Classified with **Moderate** AC, High in Anticipatory and Social, Moderate in Physical and Economic, Low in Human, Very Low in Health and Natural capital
Sta. Praxedes	385	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Very Low,** Very Low in Typhoon, Flood, Drought, Sea Level Rise, and Storm Surge, Moderate in Landslide, and Erosion, although Very High in Landslide **Classified as Very Low Vulnerability**	Classified with **Low** AC, Moderate in Anticipatory and Social, Low in Physical and Economic, Very Low in Human, Health and Natural capitals
Sto. Niño	3,191	Palay will have a slight decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **Moderate**, High in Typhoon, and Erosion, Moderate in Landslide, and Drought, Low in Flood, although no occurrence of Sea Level Rise and Storm Surge **Classified as Moderate Vulnerability**	Classified with **Low** AC, High in Anticipatory, Moderate in Physical, Social and Natural, but Very Low in Human, Health and Economic capitals

RICE

Municipality (D3)	Rice Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Amulung	6,277	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Moderate**, High in Typhoon and Flood, Low in Landslide, Erosion, and Drought, but no occurrence of Sea Level Rise and Storm Surge **Classified as Moderate Vulnerability**	Classified with **High** AC, Very High in Social and Anticipatory, High in Economic, but Very Low in Human and Health capitals
Enrile	4,063	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Low**, High in Typhoon with Moderate Flood, Erosion, and Landslide, but Very Low occurrence of Drought **Classified as Low Vulnerability**	Classified with **Low** AC, Very Low in Economic Social, and Human capitals, Moderate in Anticipatory
Iguig	1,522	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Low**, High in Typhoon, Landslide, with Moderate Erosion, and Landslide, Low in Flood, and Very Low occurrence of Drought **Classified as Low Vulnerability**	Classified with **Low** AC, Moderate in Anticipatory, Low in Physical, Human, Social, Natural and Economic, Very Low in Health
Peñablanca	1,204	Palay will have a slight decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **Very High**, Very High in Typhoon, Erosion, Landslide, and Drought, but Low in Flood **Classified as Very High Vulnerability**	Classified with **Moderate** AC, Very High in Anticipatory, Moderate in Natural, Human, and Physical, but Low Economic capital
Solana	9,375	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Low**, High in Typhoon with Low in Flood, Erosion, Landslide, and Drought **Classified as Low Vulnerability**	Classified with **High** AC, Very High in Natural, High in Anticipatory and Physical, Moderate in Human, Social and Economic capitals, but Very Low in Health
Tuao	7,351	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Low**,	Classified with **Moderate** AC,

Municipality (D3)	Rice Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
			High in Flood, Moderate in Typhoon with Low in Erosion, Very Low in Landslide, and Drought **Classified as Low Vulnerability**	Very High Anticipatory and Natural, Moderate in Social and Economic, Low in Physical and Human, Very Low in Health
Tuguegarao City	950	Palay will remain suitable with no change at all by year 2050	Overall hazard is **Moderate**, Very High in Flood, High in Typhoon, Low in Landslide, Erosion, and Drought, but no occurrence of Sea Level Rise and Storm Surge **Classified as Moderate Vulnerability**	Classified with **Very High** AC, Very High in Anticipatory, Health, Physical, Human and Economic capitals but Low in Social and Very Low in Natural capital

CORN

Municipality (D1)	Corn Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Alcala	4,137	Corn will remain suitable with no change at all by year 2050	Overall hazard is **Moderate,** High in Typhoon, moderate in Flood, Landslide, and Erosion, Low occurrence of Drought **Classified as Moderate Vulnerability**	Classified as **Moderate** AC, High in Anticipatory and Social, Moderate in Physical, but low in Natural, Economic, Human and Health
Aparri	792	Corn will remain suitable with no change at all by year 2050	Overall hazard is **High**, Very High in Flood, Sea Level Rise, and Storm Surge, Low in Typhoon, and Drought, but Very Low in Erosion and Landslide **Classified as High Vulnerability**	Classified as **Moderate** AC, High in Social and Physical, but Very Low in Human and Low in Health capitals

Municipality (D1)	Corn Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Baggao	8,711	Corn will have a slight decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **Very High,** Very High in Typhoon, and Drought, High occurrence of Landslide, and Erosion, Low on Flood **Classified as Very High Vulnerability**	Classified as **Moderate** AC, Very High in Natural, High in Anticipatory and Economic, Moderate in Social and Human, but Low in Health and Physical
Buguey	624	Corn will remain suitable with no change at all by year 2050	Overall hazard is **Low,** High in Flood, Moderate occurrence of Typhoon, Sea Level Rise, and Storm Surge **Classified as Low Vulnerability**	Classified as **Moderate** AC, Very High in Natural and Social, High in Anticipatory and Human, Low in Physical and Economic and Very Low in Health
Camalaniugan	134	Corn will have a slight decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **Moderate,** Very High in Flood, High in Typhoon, Moderate in Sea Level Rise **Classified as Moderate Vulnerability**	Classified as **Low** AC, Only High in Social but Low in Economic, Anticipatory, Physical, Natural and Human and further Very Low in Health
Gattaran	6,521	Corn will remain suitable with no change at all by year 2050	Overall hazard is **High**, Very High in Typhoon and Landslide, but Very Low occurrence of Flood, Sea Level Rise, and Salt Water Intrusion **Classified as High Vulnerability**	Classified as **Moderate** AC, Very High in Social and Anticipatory, High in Natural, but Low in Economic, Human, and Physical capitals
Gonzaga	2,720	Corn will remain suitable with no change at all by year 2050	Overall hazard is **High,** Very high in Typhoon, High in Landslide, and Erosion, Low occurrence of Flood, and Drought, Very Low on Sea Level Rise, and Storm Surge **Classified as High Vulnerability**	Classified as **Moderate** AC, Very High in Social, High in Anticipatory, Natural and Economic, but Low in Physical and Very Low in Health
Lallo	2,173	Corn will have a slight decrease in suitability, but	Overall hazard is **High**, High in Typhoon, Erosion, and Landslide, but Low occurrence of Flood	Classified with **High** AC,

Municipality (D1)	Corn Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
		will still remain suitable by year 2050	**Classified as High Vulnerability**	Very High in Social, High in Natural and Anticipatory, and Moderate in Economic and Physical capitals
Sta. Ana	3,764	Corn will remain suitable with no change at all by year 2050	Overall hazard is **High,** Very high in Typhoon, and Landslide, Moderate in Erosion, Flood, and Drought, Low on Sea Level Rise, and Storm Surge **Classified as High Vulnerability**	Classified as **Low** AC, Moderate in Anticipatory, Social and Natural, Low in Human, Very Low in Physical, Health and Economic capitals

CORN

Municipality (D2)	Corn Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Abulug	1,377	Corn will remain suitable with favorable change by year 2050	Overall hazard is **Low**, Very High in Flood, but Very Low in Erosion, Landslide, and Drought **Classified as Low Vulnerability**	Classified with **Moderate** AC, Moderate in Economic, Natural, Social, and Anticipatory capitals, but Low Human and Very Low Health capitals
Allacapan	663	Corn will remain suitable with no change at all by year 2050	Overall hazard is **Very Low,** Low occurrence of Flood, and Drought, Very Low in Erosion **Classified as Very Low Vulnerability**	Classified with **Low** AC, Very High in Natural but Low in Physical and Economic, further Very Low in Anticipatory, Human, Health and Social capitals
Calayan	307	Corn will remain suitable with favorable change by year 2050	Overall hazard is **Low,** Very High in Erosion, High occurrence of Typhoon, Landslide,	Classified with **Low** AC,

Municipality (D2)	Corn Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
			Low in Drought, Very Low in Flood, Sea Level Rise, and Storm Surge **Classified as Low Vulnerability**	High in Social, Moderate in Anticipatory, Low in Physical and Very Low in Human, Health, Natural and Economic capitals
Lasam	769	Corn will remain suitable with no change at all by year 2050	Overall hazard is **Moderate,** High in Typhoon, Flood, Low in Erosion, and Drought, Very Low in Landslide, **Classified as Moderate Vulnerability**	Classified with **Moderate** AC, High in Anticipatory and Social, Moderate in Natural and Economic, Low in Physical, Very Low in Human and Health capitals
Pamplona*	728	Corn will remain suitable with no change at all by year 2050	Overall hazard is **Low**, Moderate in Flood, Erosion, Sea Level Rise, Low in Typhoon, Landslide, and Storm Surge, but Very Low in Drought **Classified as Low Vulnerability**	Classified with **Low** AC, Moderate in Natural capital, Low in Physical, Very Low in Anticipatory, Human, Health, Social and Economic
Piat	2,605	Corn will have a slight decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **Low**, High in Typhoon, Moderate in Flood, and Erosion, but Low Landslide, and Very Low in Drought with no occurrence of Sea Level Rise and Storm Surge **Classified as Low Vulnerability**	Classified with **Moderate** AC, Very High in Physical, High in Anticipatory, Moderate in Social and Economic, Low in Human and Natural, Very Low in Health
Rizal	3,248	Corn will remain suitable with no change at all by year 2050	Overall hazard is **Moderate**, Very High in Erosion and Landslide, but Low in Flood with no occurrence of Sea Level Rise and Storm Surge	Classified with **Very Low** AC, Low in Economic, Natural, and Anticipatory, and Very Low in Social, Human, Health, and Physical capitals

Municipality (D2)	Corn Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
			Classified as Moderate Vulnerability	
Sta. Praxedes	263	Corn will have a high decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **Very Low,** Very Low in Typhoon, Flood, Drought, Sea Level Rise, and Storm Surge, Moderate in Landslide, and Erosion, although Very High in Landslide **Classified as Very Low Vulnerability**	Classified with **Low** AC, Moderate in Anticipatory and Social, Low in Physical and Economic, Very Low in Human, Health and Natural capitals
Sto. Niño	1,079	Corn will remain suitable with favorable change by year 2050	Overall hazard is **Moderate**, High in Typhoon, and Erosion, Moderate in Landslide, and Drought, Low in Flood, although no occurrence of Sea Level Rise and Storm Surge **Classified as Moderate Vulnerability**	Classified with **Low** AC, High in Anticipatory, Moderate in Physical, Social and Natural, but Very Low in Human, Health and Economic capitals

CORN

Municipality (D3)	Corn Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Amulung	233	Corn will remain suitable with favorable change by year 2050	Overall hazard is **Moderate**, High in Typhoon and Flood, Low in Landslide, Erosion, and Drought, but no occurrence of Sea Level Rise and Storm Surge	Classified with **High** AC, Very High in Social and Anticipatory, High in Economic, but Very Low in Human and Health capitals

Municipality (D3)	Corn Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
			Classified as Moderate Vulnerability	
Enrile	1,325	Corn will remain suitable with favorable change by year 2050	Overall hazard is **Low**, High in Typhoon with Moderate Flood, Erosion, and Landslide, but Very Low occurrence of Drought **Classified as Low Vulnerability**	Classified with **Low** AC, Very Low in Economic Social, and Human capitals, Moderate in Anticipatory
Iguig	1,400	Corn will remain suitable with favorable change by year 2050	Overall hazard is **Low**, High in Typhoon, Landslide, with Moderate Erosion, and Landslide, Low in Flood, and Very Low occurrence of Drought **Classified as Low Vulnerability**	Classified with **Low** AC, Moderate in Anticipatory, Low in Physical, Human, Social, Natural and Economic, Very Low in Health
Peñablanca	4,577	Corn will remain suitable with favorable change by year 2050	Overall hazard is **Very High**, Very High in Typhoon, Erosion, Landslide, and Drought, but Low in Flood **Classified as Very High Vulnerability**	Classified with **Moderate** AC, Very High in Anticipatory, Moderate in Natural, Human, and Physical, but Low Economic capital
Solana	1,970	Corn will have a slight decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **Low**, High in Typhoon with Low in Flood, Erosion, Landslide, and Drought **Classified as Low Vulnerability**	Classified with **High** AC, Very High in Natural, High in Anticipatory and Physical, Moderate in Human, Social and Economic capitals, but Very Low in Health
Tuao	3,665	Corn will remain suitable with favorable change by year 2050	Overall hazard is **Low**, High in Flood, Moderate in Typhoon with Low in Erosion, Very Low in Landslide, and Drought **Classified as Low Vulnerability**	Classified with **Moderate** AC, Very High Anticipatory and Natural, Moderate in Social and Economic, Low in Physical and Human, Very Low in Health

Municipality (D3)	Corn Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Tuguegarao City	2,835	Corn will remain suitable with favorable change by year 2050	Overall hazard is **Moderate**, Very High in Flood, High in Typhoon, Low in Landslide, Erosion, and Drought, but no occurrence of Sea Level Rise and Storm Surge **Classified as Moderate Vulnerability**	Classified with **Very High** AC, Very High in Anticipatory, Health, Physical, Human and Economic capitals but Low in Social and Very Low in Natural capital

PEANUT

Municipality (D1)	Peanut Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Alcala	118	Peanut will remain suitable with favorable change by year 2050	Overall hazard is **Moderate,** High in Typhoon, moderate in Flood, Landslide, and Erosion, Low occurrence of Drought **Classified as Moderate Vulnerability**	Classified as **Moderate** AC, High in Anticipatory and Social, Moderate in Physical, but low in Natural, Economic, Human and Health
Baggao	77	Peanut will have a high decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **Very High,** Very High in Typhoon, and Drought, High occurrence of Landslide, and Erosion, Low on Flood **Classified as Very High Vulnerability**	Classified as **Moderate** AC, Very High in Natural, High in Anticipatory and Economic, Moderate in Social and Human, but Low in Health and Physical
Gattaran	33	Peanut will have a high decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **High**, Very High in Typhoon and Landslide, but Very Low occurrence of Flood,	Classified as **Moderate** AC, Very High in Social and Anticipatory, High in Natural, but Low in Economic, Human, and Physical capitals

Municipality (D1)	Peanut Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
			Sea Level Rise, and Salt Water Intrusion **Classified as High Vulnerability**	
Gonzaga	12	Peanut will have a high decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **High,** Very high in Typhoon, High in Landslide, and Erosion, Low occurrence of Flood, and Drought, Very Low on Sea Level Rise, and Storm Surge **Classified as High Vulnerability**	Classified as **Moderate** AC, Very High in Social, High in Anticipatory, Natural and Economic, but Low in Physical and Very Low in Health
Lallo	102	Peanut will have a high decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **High**, High in Typhoon, Erosion, and Landslide, but Low occurrence of Flood **Classified as High Vulnerability**	Classified with **High** AC, Very High in Social, High in Natural and Anticipatory, and Moderate in Economic and Physical capitals
Sta. Ana	103	Peanut will have a high decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **High,** Very high in Typhoon, and Landslide, Moderate in Erosion, Flood, and Drought, Low on Sea Level Rise, and Storm Surge **Classified as High Vulnerability**	Classified as **Low** AC, Moderate in Anticipatory, Social and Natural, Low in Human, Very Low in Physical, Health and Economic capitals

PEANUT

Municipality (D2)	Peanut Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Piat	21	Peanut will remain suitable with favorable change by year 2050	Overall hazard is **Low**, High in Typhoon, Moderate in Flood, and Erosion, but Low Landslide, and Very Low in Drought with no occurrence of Sea Level Rise and Storm Surge **Classified as Low Vulnerability**	Classified with **Moderate** AC, Very High in Physical, High in Anticipatory, Moderate in Social and Economic, Low in Human and Natural, Very Low in Health
Rizal	54	Peanut will have a high decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **Moderate**, Very High in Erosion and Landslide, but Low in Flood with no occurrence of Sea Level Rise and Storm Surge **Classified as Moderate Vulnerability**	Classified with **Very Low** AC, Low in Economic, Natural, and Anticipatory, and Very Low in Social, Human, Health, and Physical capitals

PEANUT

Municipality (D3)	Peanut Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
Amulung	13	Peanut will remain suitable with no change at all by year 2050	Overall hazard is **Moderate**, High in Typhoon and Flood, Low in Landslide, Erosion, and Drought, but no occurrence of Sea Level Rise and Storm Surge **Classified as Moderate Vulnerability**	Classified with **High** AC, Very High in Social and Anticipatory, High in Economic, but Very Low in Human and Health capitals
Enrile	600	Peanut will remain suitable with no change at all by year 2050	Overall hazard is **Low**,	Classified with **Low** AC, Very Low in Economic Social, and Human capitals, Moderate in Anticipatory

Municipality (D3)	Peanut Prod. Area (has)	Crop Climate Sensitivity	Key Hazards	Adaptive Capacity
			High in Typhoon with Moderate Flood, Erosion, and Landslide, but Very Low occurrence of Drought **Classified as Low Vulnerability**	
Iguig	31	Peanut will remain suitable with favorable change by year 2050	Overall hazard is **Low**, High in Typhoon, Landslide, with Moderate Erosion, and Landslide, Low in Flood, and Very Low occurrence of Drought **Classified as Low Vulnerability**	Classified with **Low** AC, Moderate in Anticipatory, Low in Physical, Human, Social, Natural and Economic, Very Low in Health
Peñablanca	63	Peanut will have a high decrease in suitability, but will still remain suitable by year 2050	Overall hazard is **Very High**, Very High in Typhoon, Erosion, Landslide, and Drought, but Low in Flood **Classified as Very High Vulnerability**	Classified with **Moderate** AC, Very High in Anticipatory, Moderate in Natural, Human, and Physical, but Low Economic capital

Given the nature of data collection and availability, currently the vulnerability is displayed on a high, municipality-level resolution. However, climate risks and vulnerability of communities and ecosystem services do not have administrative boundaries. Thus the created municipality-level maps can be used to take the analysis a step further and assess vulnerability to climate change and sensitivity on a landscape dimension. In this context, a landscape/multi-sectoral approach would provide a more appropriate lens, based on a more holistic (systemic) risk analysis, which will bridge processes that occur at the household level with wider socio-economic and environmental landscape dynamics.

Applying the different versions in the provincial vulnerability map, the results shows consistent detection of highly vulnerable municipalities. For instance, Piat, Buguey, Ballesteros and Sta. Ana always comes up as highly vulnerable municipalities using different weights for sensitivity, hazards and adaptive capacity. This shows that the characteristic of vulnerability, in terms of component and indicators are not too sensitive to varying weight proportions. However, the reference wights of 15-15-70 is used in the final maps.

RECOMMENDATIONS

Typhoon early warning systems are in place in the Philippines and are essential to protect the lives and livelihoods (as productive assets, livestock and sometimes crops can be protected in the few days/hours before the storm makes landfall). Many weather facilities from government and private organizations have been established that provides real to near real-time weather information (i.e, weather condition, typhoon/cyclone updates, and 5 day weather forecast) for free of charge. One of these organizations is the Weather Philippines Foundation which have approximately 800 weather stations in the Philippines and provides critical weather information that is being used by local government units (https://weatherph.org/all-aws/). The information generated is an essential tool for farmer advisories and anticipating extreme climate conditions.

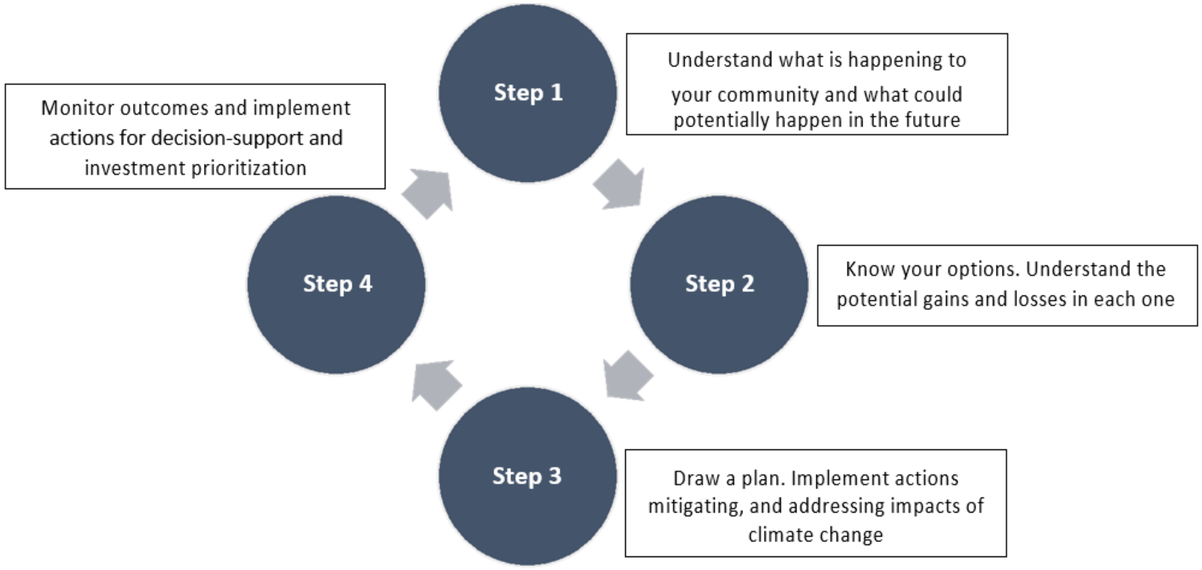
Response mechanisms, such as systems of rapid seed multiplication for post-typhoon agriculture were also recently introduced by the government of the Philippines. However, in addition to focusing on recovering efforts, a landscape resilience and preparedness approach that enhances the communities' ability to protect crops and surrounding ecosystems from being damaged by typhoons in the first place, would strengthen and complement the already existing initiatives. To achieve this landscape resilience, capacities of local communities, sub-national and national technicians in identifying areas at risk as well as site-specific adaptation options need to be developed. This will enable a response to the need for well-targeted and site-specific adaptation measures in the agricultural sector as highlighted in the National Climate Change Action Plan (2011-2028), a roadmap for adaptation planning in the Philippines. Appropriate policy strategies - including adaptation and risk reduction strategies specifically for the agricultural sector - will be necessary in order to provide the crucial institutional enabling environment to build resilience in the Philippines.

The result of the CRVA study will directly contribute to the Department of Agriculture's projects, programs, and interventions strategy in terms of planning and prioritization to step-up the efforts in identified areas to improve the capacity of communities, especially farmers, to cope with the impact of climate change and hazards. The CRVA also complements the Philippines Country Profile (Dikitanan, 2017) which highlight the different climate resilient/smart practices of communities in the Philippines. Prioritized CRA practices responding to the CRVA for trialing and out-scaling will need to be tailored to site-specific crop- and community-needs and their trade-offs will need to be assessed. The below list are based from the prioritized practices from the Philippines' Country Profile (Dikitanan, 2017) and IIRR (2015) that were assessed for various indicators of CRA smartness, e.g. yield, income, water, soil, risk/information, energy, carbon, and nutrient:

- Biodynamics/Organic
- Maize-banana crop diversification
- Sloping Agricultural Land Technology (SALT)
- Small Water Impounding Project (SWIP)
- Climate Smart Variety, adaptive crop calendar
- Short duration and/or drought tolerant varieties
- Rice-rice-mungbean rotation
- Post-rice legume systems
- System of rice intensification (SRI)
- Mango Integrated Pest Management (IPM)
- Rice-tomato rotation
- Rice-maize rotation
- Climate Smart Variety
- Organic
- Coconut-based integrated farming
- Rainwater harvesting
- Alternate Wetting and Drying (AWD)
- Climate Smart Variety
- Crop rotation, zero tillage
- Crop rotation, integrated nutrient management
- Intercropping
- Rice-duck farming

These considered CRA practices are important in climate change adaptation, greenhouse gas emission reduction, and food security. One of these practices should be introduced in climate smart villages to ensure that the practice is sustainable, productive, and economically viable.

The CRVA is a first step in building climate resilient agricultural communities to understand the potential impact of climate change in each municipality. DA-Regional Field Office 2 have already chosen a municipality where they will select a farming community to implement CRA actions and help build climate resilience in the food system. In the selected vulnerable communities, DA-RFO2 have the options to either implement actions for 1) hazard mitigation, such as improved access by farmers to high quality seeds, 2) coping capacity enhancement, such as giving farmers assistance to improve their land use to climate smart practices, 3) improved irrigation services, and so forth. The main idea is that, knowing the drivers of vulnerability allows for a more targeted actions.



CONCLUSION

Agricultural vulnerability to climate change was assessed and mapped in the province of Cagayan using modeling and statistical analysis of climate impacts, climate variability, and socio-economic variables. The analyses focused on key commodities in the province, such as rice, maize/corn, vegetables, aquaculture and trees. Some commodities were not yet included due to limited availability of data. It is important to understand that the results are based on modeling results, which have inherent uncertainties and limitation, such as the climate models, crop distribution model, and socio-economic variables used. In the Philippines, the municipal resolution was used because authors believed this is where significant decision making and planning takes place, especially in the agricultural sector. With inherent uncertainties, any planning and development initiative using the output of this research should be made with consideration of local conditions. However, with all these limitations, the results presented in this paper are in broad agreement with existing literatures on climate change impacts as well as realities in terms of vulnerability.

The CRVA output can be used to inform and guide decision makers from government agencies, extension staff, and private sectors on geographic areas that are in most need of interventions, and what package of interventions are needed for each geographical area. It also opens door for cross sectoral collaboration between different government agencies and private sectors. There are demands to scale-up the assessment to a landscape level vulnerability assessment. Impacts of climate change has been quantified using crop distribution models using baseline and future scenarios. These climate crop suitability scenarios are not just an important component of CRVA, but is essential in preparing research interventions in terms of improving agricultural practices and crop management to cope with climate change. The result of CRVA is now being used to apply for bigger funding from international donors to help Cagayan province adapt to climate change. Access to funds is vital in improving agriculture, to ensure that small-holder farmers can improve their coping capacity. Furthermore, it is used by the Department of Agriculture for planning and prioritizing interventions in the province.

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