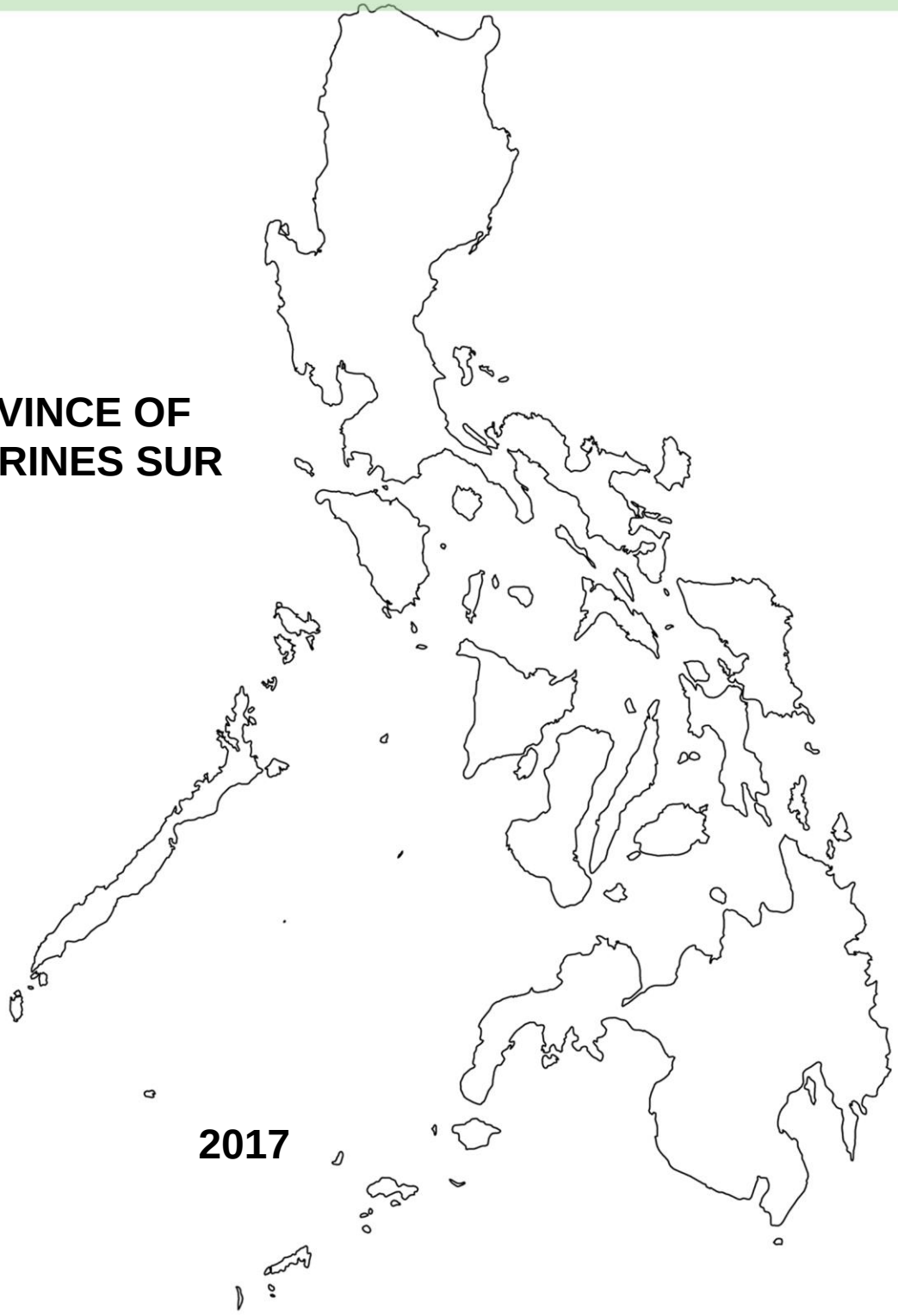
DEPARTMENT OF AGRICULTURE
Bureau of Soils and Water Management

Agricultural Land Management and Evaluation Division

National Mapping, Characterization and Development of Spatial Database for the Coastal Areas Affected by Salinity



PROVINCE OF CAMARINES SUR

2017

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RATIONALE

Salinity is long time known as one of the problem soils. It directly affects the agriculture and fishery sector in terms of productivity and income. Seriously salt-affected soils result to a total crop failure. The reasons for salinity are 1) increasing trend in sea level rise, 2) over pumping of the aquifers, and 3) seepage along the river — that is, when seawater moves upstream into the river during periods of high tide and low river flow.

The Bureau of Soils and Water Management (BSWM) have initiated several studies regarding soil salinity, but a nationwide information system has never been developed for areas affected by salinity. A baseline information on salinity will be a significant input in infrastructure planning in agriculture and fishery, risk management — particularly disaster risk management and climate change adaptation, — and policy recommendations.

Based on BSWM Reconnaissance Survey in 1988, forty five (45) provinces are identified affected by salinity. They represent more than half of the country's provinces. However, the extent of this condition to Philippine soils is not yet established and thus the subject of this project.

This project generally aims to develop a national information system for the coastal areas affected by salinity. Specifically, it aims to:

1. describe the soil physico-chemical characteristics;
2. generate salinity maps;
3. develop spatial database on salinity for the coastal areas;
4. undertake suitability evaluation for agriculture and fisheries and prepare scenarios as input to policy.

CAMARINES SUR

I. Soil Physical Characteristics

A. General Description of the Site

Camarines Sur is geographically located in the central part of the Bicol Peninsula which forms the southwestern part of the island of Luzon. It is about 450 kilometers from Manila and is located between 13^0 15' and 14^0 10' North Latitude and between 122^0 40' and 124^0 10'East Longitude. It is bounded on the north by the province of Quezon and Camarines Norte, San Miguel Bay and Pacific Ocean. On the south by the province of Albay, Lagonoy Gulf on the east and on the west by Ragay Gulf. The province has a total land area of 526,682 hectares of which 295,111 hectares or 56.03% are devoted to agriculture.

There are seventeen (17) coastal municipalities and eighty one (81) barangays susceptible to salinity, hence the sites for soil sampling are as follows:

Table 1.1 Coastal Municipalities in Camarines Sur

No.	Municipality	No. of Brgys.	No. of Sampling Sites	No. of Soil Samples Collected
1	Cabusao	4	4	27
2	Libmanan	10	10	30
3	Pamplona	5	5	15
4	Milaor	5	5	15
5	Minalabac	1	1	3
6	Gainza	2	2	6
7	San Fernando	5	5	15
8	Calabanga	8	8	24
9	Bombon	1	1	3
10	Magarao	7	7	21
11	Canaman	4	4	12
12	Camaligan	2	2	6
13	Tinambac	5	5	15
14	Lagonoy	4	4	15
15	San Jose	7	7	19
16	Tigaon	7	7	19
17	Sagñay	4	4	12
	TOTAL	**81**	**81**	**243**

B. Land Management Unit (LMU)

Land Management Unit is a recurring pattern of land which possesses similar physical characteristics such as soil type associated with relatively uniform land use or vegetation cover and parent material. It is the building block of the pedo -ecological zone, which represents a broader landscape grouping such as lowland, upland, hillyland and highland.

Table 1.2 Land Management Unit Symbols and Descriptions

Symbol	Land Management Unit
O1	Active tidal flat (developed fishpond/ salt beds), level to gently sloping, moderately flooded
O2	Active tidal flat (Natural mangrove / nipa), level to gently sloping, severely flooded
O8	Beach ridges & swales, level to gently sloping
O9	Broad alluvial plain,level to gently sloping
O9J	Broad alluvial plain, level to gently sloping, with slight seasonal flooding
10	Former / old tidal flats,level to gently sloping
10J	Former / old tidal flats, level to gently sloping, with slight seasonal flooding
12	Lower river terrace, level to gently sloping, with slight seasonal flooding
16	Infilled / localized valley,level to gently sloping
29	Lower footslope, level to gently sloping

C. Elevation

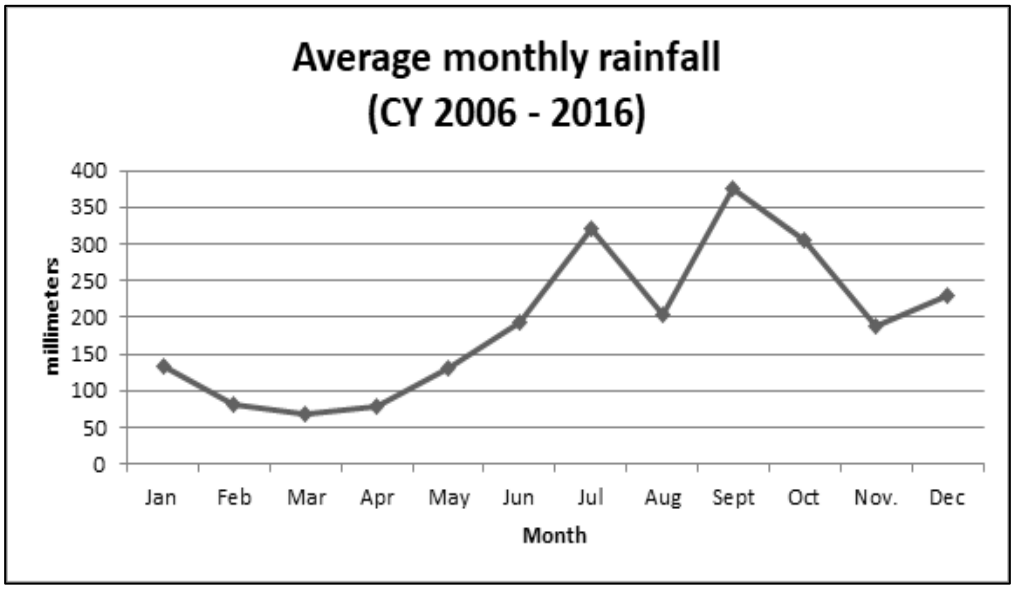
In this study, the landscape is under the warm-lowland pedo-ecological zone. These are low-lying areas characterized by low elevation (< 100 meters above sea level), with level to undulating topography (0-8% slope) and average temperature of >25°C.

D. Agro-Climate

According to the Modified Corona's Classification of Climate, Camarines Sur is in Type II. It is characterized by having a very pronounced maximum rain period from July to December and no dry season. The minimum monthly rainfall occurs during the months of February to May, as shown in Figure 1.1 Average Monthly Rainfall from PAGASA weather station in Pili.

Soil sampling was done in April until May of 2017 when rainfall is minimum.

Figure 1.1 Average Monthly Rainfall, Province of Camarines Sur



Source: PAGASA- Central Bicol State University, Pili, Camarines Sur

E. Land Use

Land use involves the management and modification of natural environment. It also has been defined as "the total of arrangements, activities, and inputs that people undertake in a certain land cover type". Land use and vegetation plays an important role in the identification of areas affected by salinity. It provides indicative information primarily on the physical and socio-economic activities prevailing in the area. On the other hand, salinity reduces the kinds of crops that can be grown for economic purposes due to chemical reactions between salt water and soil clay particles.

The common land use/ vegetation in Camarines Sur sampling sites are presented in Table 1.3. Some indicators of salinity per municipality are also indicated in this table.

Table 1.3 Land Use/ Vegetation in Camarines Sur Sampling Sites.

Municipality	Land Use/ Vegetation	Some indicators of salinity
CABUSAO	Paddy Rice, Melon	low yield, white crust, Nipa
LIBMANAN	Paddy Rice, Melon, Bitter Gourd, Watermelon, Mungbean	rice leaf color turns red, stunted growth, sudden death of crop, Nipa
PAMPLONA	Irrigated Paddy Rice	sudden death of crop
SAN FERNANDO	Paddy Rice	wilting of rice, water hyacinth
MINALABAC	Irrigated Paddy Rice	
MILAOR	Irrigated Paddy Rice	
GAINZA	Irrigated Paddy Rice	Nipa
CALABANGA	Paddy Rice, Corn, Nipa, Coconut	Nipa
BOMBON	Irrigated Paddy Rice	
MAGARAO	Paddy Rice, Watermelon	Nipa
CANAMAN	Irrigated Paddy Rice	sudden death of crop, stunted growth of rice
CAMALIGAN	Irrigated Paddy Rice	
LAGONOY	Paddy Rice, Coconut	Nipa
SAN JOSE	Irrigated Paddy Rice, Corn	
TIGAON	Irrigated Paddy Rice	
SAGÑAY	Irrigated Paddy Rice, Squash	
TINAMBAC	Paddy Rice, Corn	

II. Soil Chemical Characteristics

To test the salinity of the soil, samples are taken for laboratory analysis and the following are determined:

1. **Electrical Conductivity (EC)** – is a measurement of the dissolved material in an aqueous solution, which relates to the ability of the material to conduct electrical current through it. It is measured in Seimens per unit area (e.g. mS/cm)

2. **pH** is a measure of the acidity of the soil on its hydrogen ion concentration. The pH ranges on a logarithmic scale from 1-14, where pH 1-6 are acidic, pH 7 is neutral, and pH 8-14 are basic. Lower pH corresponds with higher [H^+], while higher pH is associated with lower [H^+].

3. **Sodium Adsorption Ratio (SAR**) – is a measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste.

$$SAR = \frac{[Na^{+}]}{\sqrt{\frac{([Ca^{2+}]+[Mg^{2+}])}{2}}}$$

Soil water salinity can affect soil physical properties by causing fine particles to bind together into aggregates. This process is known as flocculation and is beneficial in terms of soil aeration, root penetration, and root growth. Although increasing soil solution salinity has a positive effect on soil aggregation and stabilization, at high levels salinity can have negative and potentially lethal effects on plants. As a result, salinity cannot be increased to maintain soil structure without considering potential impacts on plant health.

Sodium has the opposite effect of salinity on soils. The primary physical processes associated with high sodium concentrations are soil dispersion and clay platelet and aggregate swelling. The forces that bind clay particles together are disrupted when too many large sodium ions come between them. When this separation occurs, the clay particles expand, causing swelling and soil dispersion.

Soil dispersion causes clay particles to plug soil pores, resulting in reduced soil permeability. When soil is repeatedly wetted and dried and clay dispersion occurs, it then reforms and solidifies into almost cement-like soil with little or no structure. The three main problems caused by sodium-induced dispersion are reduced infiltration, reduced hydraulic conductivity, and surface crusting.

Salts that contribute to salinity, such as calcium and magnesium, do not have this effect because they are smaller and tend to cluster closer to clay particles. Calcium and magnesium will generally keep soil flocculated because they compete for the same spaces as sodium to bind to clay particles. Increased amounts of calcium and magnesium can reduce the amount of sodium-induced dispersion.

A. Salinity Classification

Table 2.1 Salinity Classification (Crop-based , Rice) (BSWM/FAO Salinity Project, 1999)

Electrical Conductivity (*mS/cm*)	Soil Salinity Class	Effect on Plants
0 - 2	Non Saline	Very little chance of injury on all plants.
2.1 - 4	Slightly Saline	Sensitive plants and seedlings may show injury
4.1 - 8	Moderately Saline	Most non-salt tolerant plants will show injury; salt-sensitive plants will show severe injury.
> 8	Severely Saline	Very few plants will tolerate and grow

The laboratory results for salinity testing of this project are classified using Table 2.1, based from the BSWM/FAO Salinity Project in 1999. This salinity classification is rice-based and applicable to Philippine setting.

Salinity maps (@pages 10-12) are produced at three different depths: 0-30, 30-60 and 60-90cm. Table 2.2 summarizes the coastal land area of Camarines Sur per degree of salinity. Based from this table, saline areas are generally higher at 0-30cm depth at 6.5% and 1.7% of the total area. This can be due to the surface accumulation of salts during dry months (April-May, when soil sampling was done).

Table 2.2 Distribution of Coastal Land Area at Different Degree of Salinity, Camarines Sur

Salinity Class	Soil Depth					
	0-30cm		30-60		60-90	
	hectares	%	hectares	%	hectares	%
Non saline	11,927.4	83.5	12,108.1	84.8	12,401.8	86.9
Slightly Saline	1,169.9	8.2	1,029.9	7.2	992.6	7.0
Moderately saline	934.5	6.5	1,020.7	7.2	806.2	5.6
Severely Saline	246.0	1.7	119.1	0.8	77.1	0.5
TOTAL	**14,277.8**	**100**	**14,277.8**	**100**	**14,277.8**	**100**

B. Suitability Assessment

The Rice Suitability Map is an overlay of the Salinity map (0-30cm depth) and the 2016 Rice Suitability Map for the coastal rice area.

The Rice Suitability Map of Camarines Sur (@page 13), shows that the Highly Suitable (S1) area for rice is 0.54% of the total coastal area, Moderately Suitable (S2) with varying limitations is 98.17 % of the total coastal area, Marginally Suitable (S3) is 1.25% and Not Suitable (Nn) is 0.04% of the total coastal area. S3 and Nn can be promoted to S2 if the limiting factors (listed in the suitability map) will be corrected.

C. Rice Yield by Degree of Salinity

Salinity problem affects water uptake of crops, slows down rate of growth and results to yield losses. Table 2.4 shows the percent decrease in average yield of farmers per degree of salinity. Based from the key informant interview and the results of the laboratory soil analysis, Table 2.3 shows that there is 29% decrease in yield on slightly saline irrigated paddy rice area, and 56% decrease in yield for moderately saline area. While for non-irrigated paddy rice, there is a 28%

decrease in yield for moderately saline, and 3.3% decrease for severely saline areas. This generally shows that as the degree of salinity increases, the decrease in yield also increases.

Table 2.3 Average Rice Yield by Degree of Salinity, Camarines Sur, CY 2015-2016

Degree of Salinity	Average Yield Irrigated Paddy Rice (kg/ha)	% Decrease in Yield	Average Yield Non- Irrigated Paddy Rice (kg/ha)	% Decrease in Yield
Non-saline	4,259.00		2,740.63	
Slightly saline	3,034.25	29		
Moderately saline	1,892.75	56	1,980	28
Severely saline			2,650	3.3

Table 2.4 Coastal Land Area (in hectares) per Municipality at Different Degree of Salinity
(Table for Salinity Map of Camarines Sur @ 0-30cm depth, page 10)

	Municipality	Non-Saline	Slightly Saline	Moderately Saline	Severely Saline
1	CABUSAO	2,237	396	428	63
2	CALABANGA	8,602	424	1	
3	TINAMBAC	1,088	350	506	183
	TOTAL	**11,927**	**1,170**	**935**	**246**

Table 2.5 Coastal Land Area (in hectares) per Municipality at Different Degree of Salinity
(Table for Salinity Map of Camarines Sur @ 30-60cm depth, page 11)

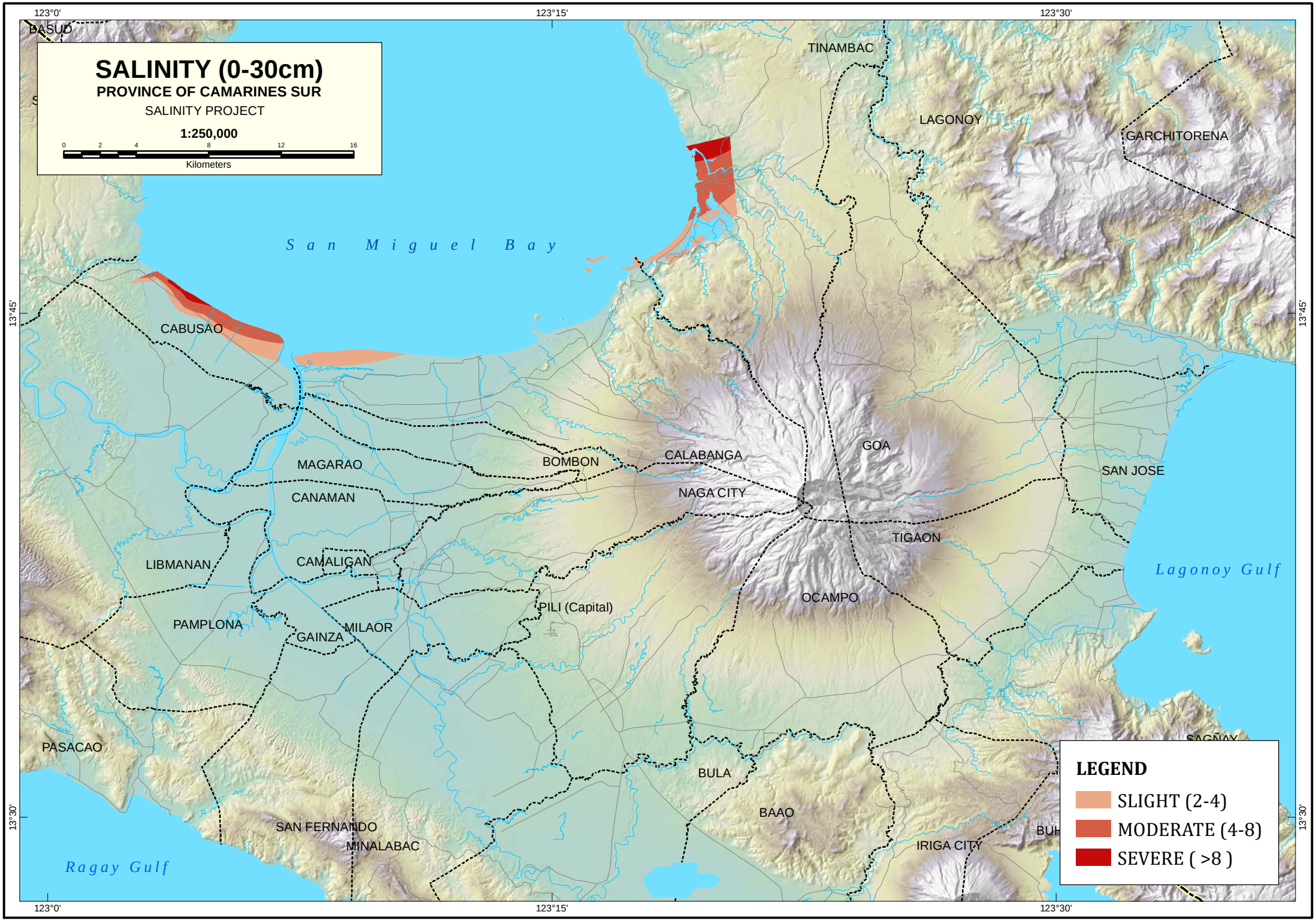
	Municipality	Non Saline	Slightly Saline	Moderately Saline	Severely Saline
1	CABUSAO	2,265.25	331.11	432.82	94.54
2	CALABANGA	8,619.65	406.95		
3	TINAMBAC	1,223.20	291.84	587.87	24.52
	Total	**12,108.10**	**1,029.91**	**1,020.69**	**119.06**

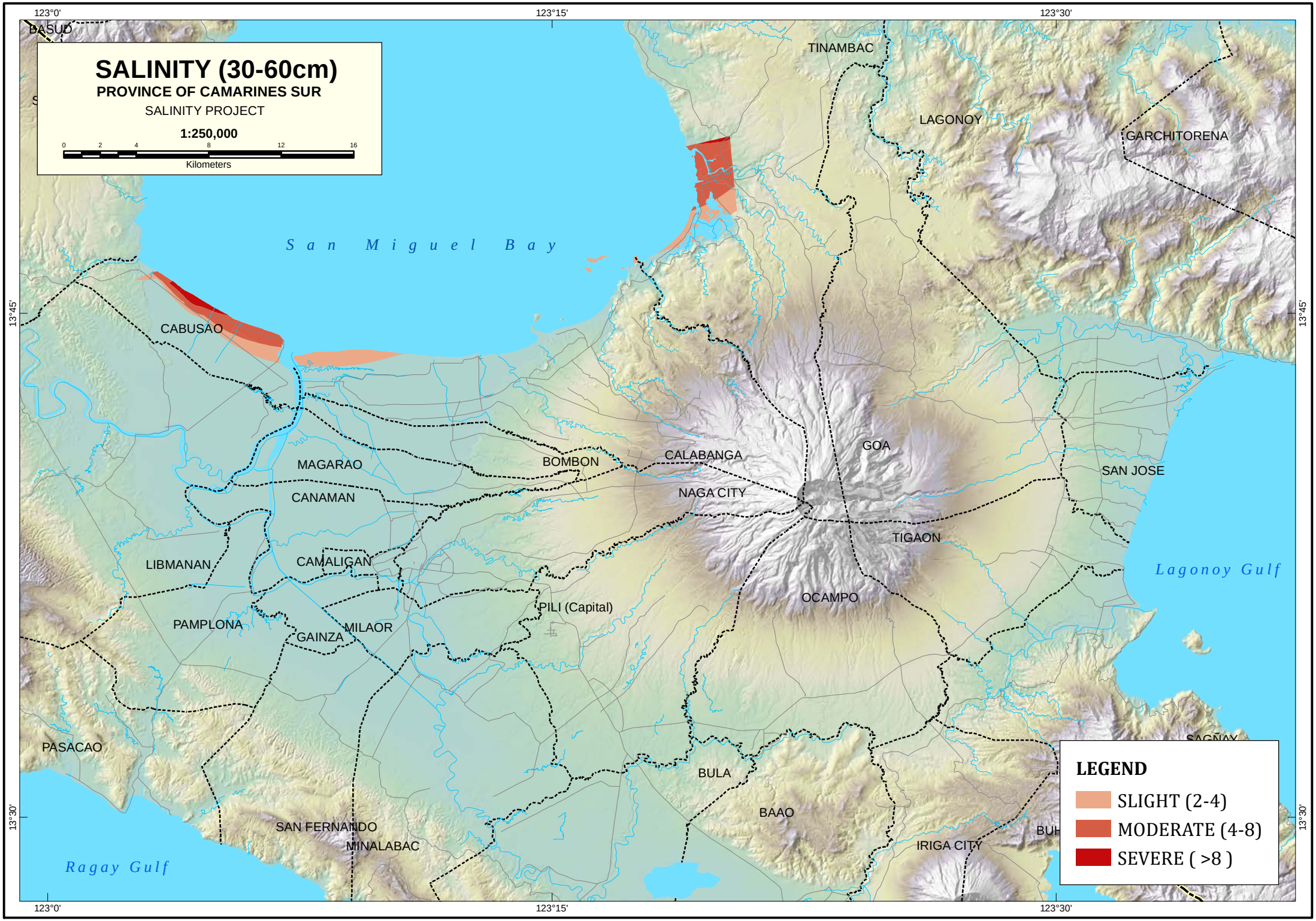
Table 2.6 Coastal Land Area (in hectares) per Municipality at Different Degree of Salinity
(Table for Salinity Map of Camarines Sur @ 60-90cm depth, page 12)

	Municipality	Non Saline	Slightly Saline	Moderately Saline	Severely Saline
1	CABUSAO	2,292.05	591.96	239.72	
2	CALABANGA	8,923.61	103.00		
3	TINAMBAC	1,186.14	297.65	566.49	77.13
	Total	**12,401.80**	**992.60**	**806.21**	**77.13**

Table 2.7 Legend for the Rice Suitability Map (@page 13)
Coastal Rice Area - Province of Camarines Sur

LEGEND						
SUITABILITY RATING	DESCRIPTION	LIMITING FACTORS			AREA	
		Moderate	Marginal	Severe	ha	%
S1	Highly Suitable				188	0.54
S2f	Moderately Suitable	f			2833	8.08
S2d		d			695	1.98
S2df		d,f			3195	9.11
S2i		i			493	1.41
S2in		i,n			32	0.09
S2if		i,f			6852	19.54
S2ifn		i,f,n			269	0.77
S2id		i,d			1734	4.95
S2idf		i,d,f			18308	52.22
S2idfn		i,d,f,n			7	0.02
S3n	Marginally Suitable	i	n		81	0.23
S3n		i,f	n		215	0.61
S3f		i,d	f		144	0.41
Nn	Not Suitable	i		n	4	0.01
Nn		i,f		n	9	0.03
				TOTAL	**35,059**	100


SALINITY (0-30cm)
PROVINCE OF CAMARINES SUR
SALINITY PROJECT
1:250,000
0 2 4 8 12 16
Kilometers
123°0'
123°15'
123°30'
13°45'
13°30'
BASUD
TINAMBAC
LAGONOY
GARCHITORENA
San Miguel Bay
CABUSAO
MAGARAO
CANAMAN
BOMBON
CALABANGA
NAGA CITY
GOA
SAN JOSE
TIGAON
OCAMPO
Lagonoy Gulf
LIBMANAN
CAMALIGAN
PILI (Capital)
PAMPLONA
GAINZA
MILAOR
PASACAO
BULA
BAAO
SAN FERNANDO
MINALABAC
IRIGA CITY
Ragay Gulf
LEGEND
SLIGHT (2-4)
MODERATE (4-8)
SEVERE (>8)


SALINITY (30-60cm)
PROVINCE OF CAMARINES SUR
SALINITY PROJECT
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Kilometers
123°0'
123°15'
123°30'
13°45'
13°30'
BASUD
TINAMBAC
LAGONOY
GARCHITORENA
San Miguel Bay
CABUSAO
MAGARAO
CANAMAN
BOMBON
CALABANGA
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GOA
SAN JOSE
TIGAON
OCAMPO
LIBMANAN
CAMALIGAN
PILI (Capital)
PAMPLONA
GAINZA
MILAOR
Lagonoy Gulf
PASACAO
BULA
BAAO
SAN FERNANDO
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IRIGA CITY
Ragay Gulf
LEGEND
SLIGHT (2-4)
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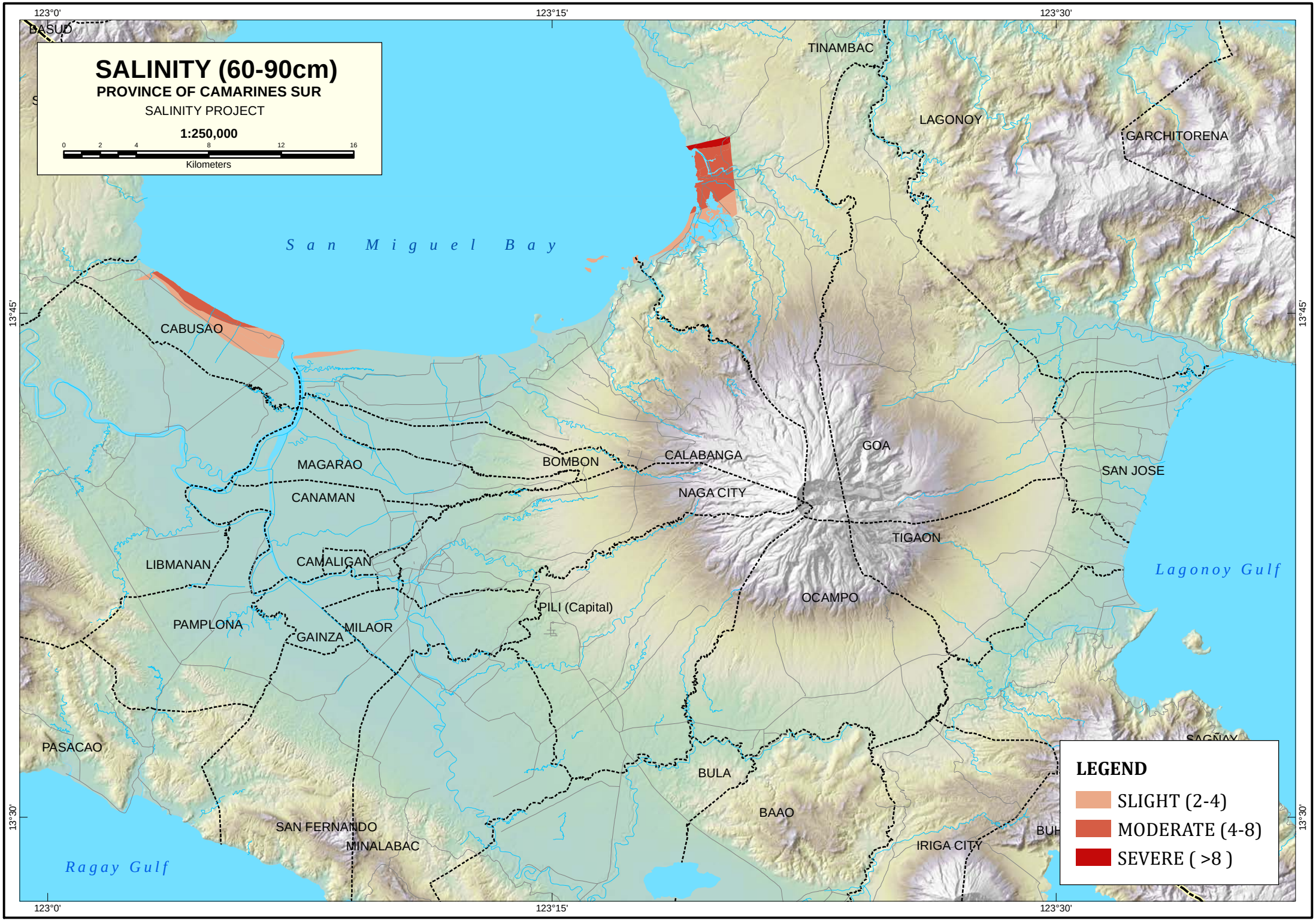
SEVERE (>8)


SALINITY (60-90cm)
PROVINCE OF CAMARINES SUR
SALINITY PROJECT
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0 2 4 8 12 16
Kilometers
123°0'
123°15'
123°30'
13°45'
13°30'
BASUD
TINAMBAC
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San Miguel Bay
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LEGEND
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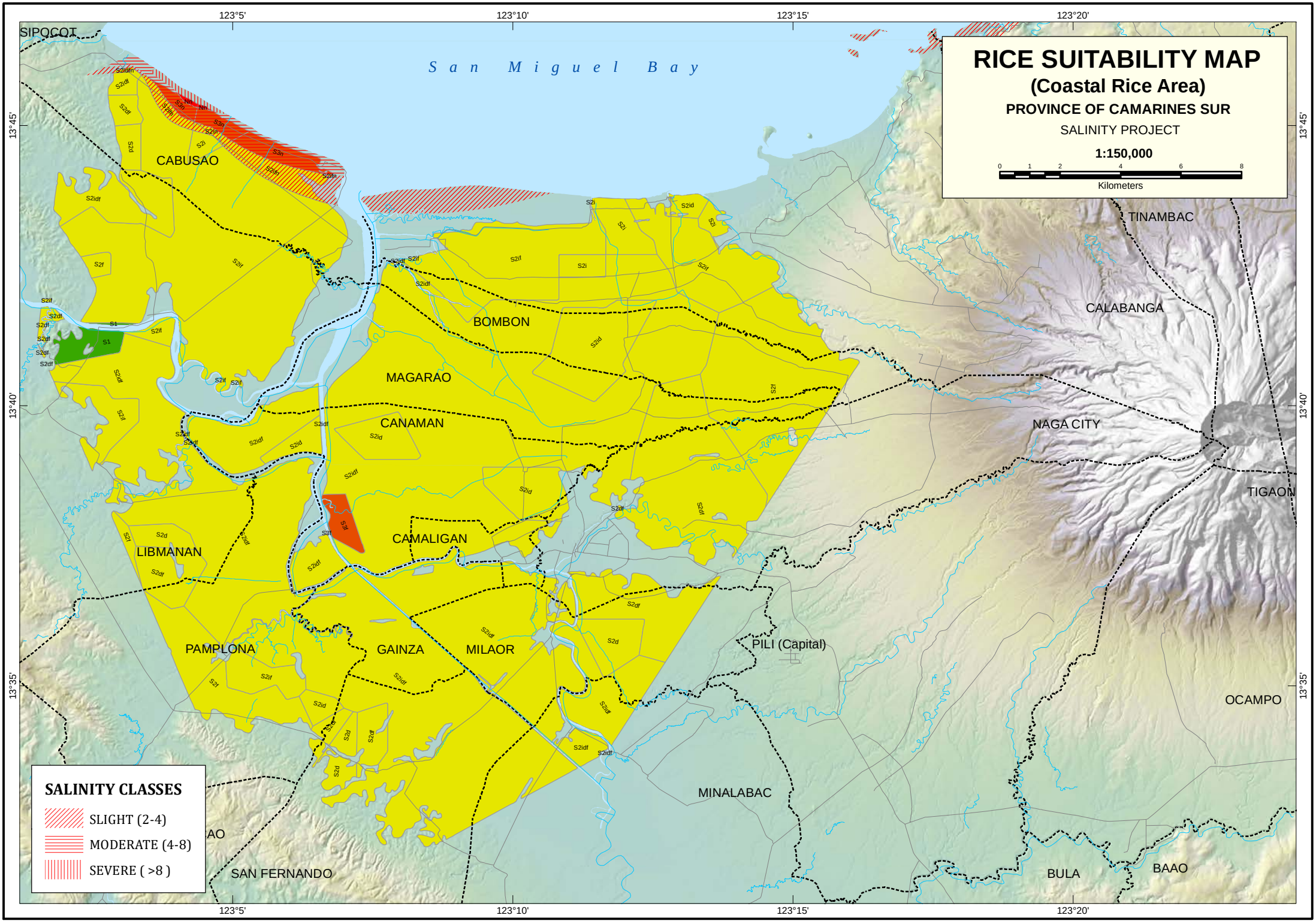
SEVERE (>8)


RICE SUITABILITY MAP
(Coastal Rice Area)
PROVINCE OF CAMARINES SUR
SALINITY PROJECT
1:150,000
0 1 2 4 6 8
Kilometers
San Miguel Bay
SIPOCOT
CABUSAO
BOMBON
MAGARAO
CANAMAN
CAMALIGAN
LIBMANAN
PAMPLONA
GAINZA
MILAOR
PILI (Capital)
MINALABAC
SAN FERNANDO
BULA
BAAO
OCAMPO
TIGAON
NAGA CITY
CALABANGA
TINAMBAC
SALINITY CLASSES
SLIGHT (2-4)
MODERATE (4-8)
SEVERE (>8)
123°5'
123°10'
123°15'
123°20'
13°45'
13°40'
13°35'

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National Mapping, Characterization, and Development of Spatial Database for the Coastal Areas Affected by Salinity (2017)

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Courtesy call to Local Government Units of Camarines Sur


Briefing/Orientation

Auger Boring and Soil Sampling



Test pit and Soil Sampling

Air Drying of Soil Samples

On-site Electrical Conductivity (EC) Testing

Key Informant Interviews

Implementation Group