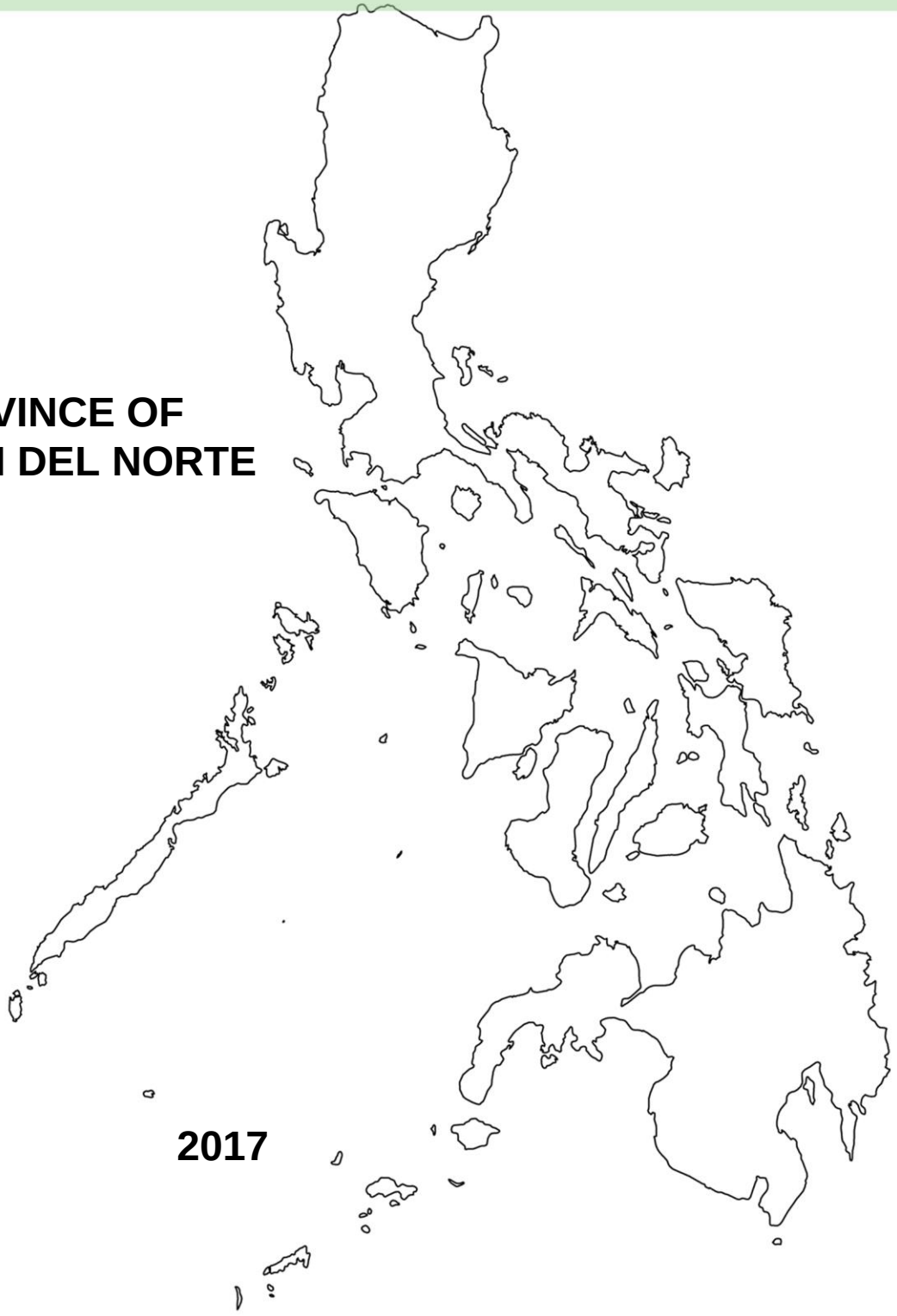
DEPARTMENT OF AGRICULTURE
Bureau of Soils and Water Management

Agricultural Land Management and Evaluation Division

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



PROVINCE OF AGUSAN DEL NORTE

2017

TABLE OF CONTENTS

	RATIONALE	1
I	Soil Physical Characteristics	2
A	General Description of the Site	2
B	Land Management Unit (LMU)	2
C	Elevation	3
D	Agro-Climate	3
E	Land Use	4
II	Soil Chemical Characteristics	4
A	Salinity Classification	6
B	Suitability Assessment	7
C	Rice Yield by Degree of Salinity	7
III	Soil Physico-Chemical Characteristics	
Table 1.1	Coastal Areas and Municipalities in Agusan del Norte	2
Table 1.2	Land Use/Vegetation in Agusan del Norte Sampling Sites.	4
Table 2.1	Salinity Classification	6
Table 2.2	Distribution of Coastal Land Area at Different Degree of Salinity	6
Table 2.3	Average Rice Yield by Degree of Salinity, Agusan del Norte CY 2016-2017	7
Table 2.4	Coastal Land Area (in hectares) per Municipality at Different Degree of Salinity Agusan del Norte(0-30 cm depth)	7
Table 2.5	Coastal Land Area (in hectares) per Municipality at Different Degree of Salinity Agusan del Norte (30-60 cm depth)	8
Table 2.6	Coastal Land Area (in hectares) per Municipality at Different Degree of Salinity Agusan del Norte (60-90 cm depth)	8
Table 2.7	Legend fo the Rice Suitability Map	9
Figure 1.1	Mean Monthly Rainfall, Butuan City	3
	Salinity Map- Province of Agusan del Norte (0-30cm depth)	10
	Salinity Map- Province of Agusan del Norte (30-60cm depth)	11
	Salinity Map- Province of Agusan del Norte (60-90cm depth)	12
	Rice Suitability Map- Province of Agusan del Norte	13
	References	
	Working Group	
	Photos	

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.

AGUSAN DEL NORTE

I. Soil Physical Characteristics

A. General Description of the Site

Agusan del Norte is one of the five provinces in Region 13- CARAGA. It is a third class province and the second smallest in the region. It is bordered on the northwest by the Butuan Bay, northeast by Surigao del Norte; mid-east by Surigao del Sur; southeast by Agusan del Sur; and southwest by Misamis Oriental. It has a total land area of 354,686 hectares. Major crops being cultivated include rice, corn, coconut, banana and mango.

There are eight coastal municipalities and fifty six (56) barangays susceptible to salinity, hence the sites for soil sampling are the following:

Table1.1 Coastal Areas and Municipalities in Agusan del Norte

No.	Coastal Municipalities in Agusan del Norte	No. of Barangays	No. of sampling sites	No. of soil samples collected
1	Buenavista	6	19	57
2	Butuan City	36	61	183
3	Cabadbaran City	2	4	12
4	Las Nieves	3	3	9
5	Magallanes	1	1	3
6	Nasipit	5	5	15
7	Remedios T. Romualdez	1	1	3
8	Tubay	2	2	6
	TOTAL	**56**	**96**	**288**

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.

There are seven Land Management Units in the coastal areas of Agusan del Norte, where due to its physiography are affected by salinity. These are the following:

1. LMU 01 - Active Tidal Flats (fishpond)
2. LMU 02 - Active Tidal Flats (mangrove/ nipa)
3. LMU 03 - Swamps (tree type)

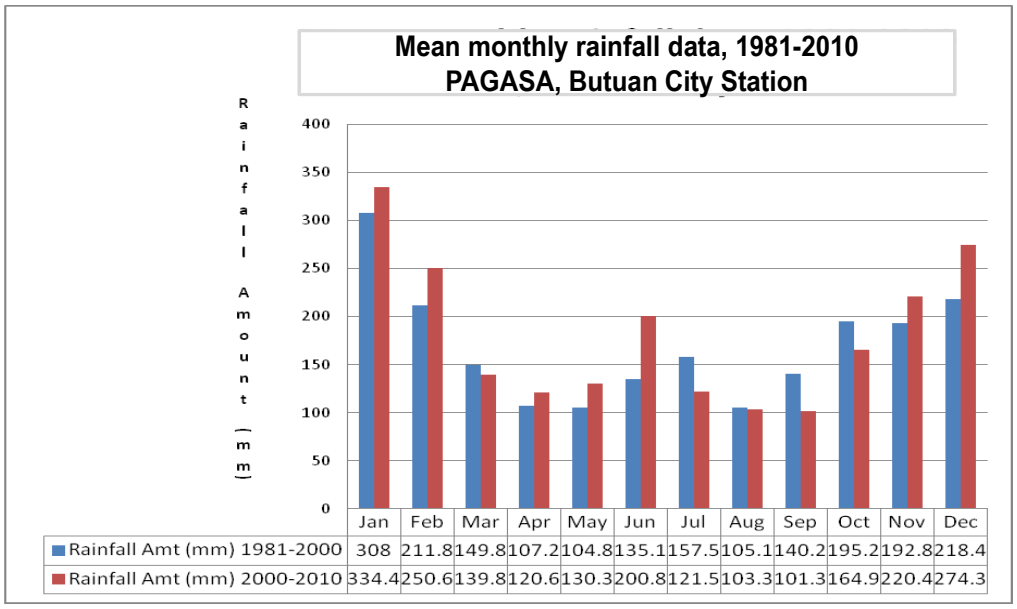
4. LMU 04 - Marshes (grassy type)
5. LMU 09 - Broad Alluvial Plains
6. LMU12 - Lower River Terraces
7. LMU 18 - Collu-Alluvial Fans

C. Elevation

The elevation of a geographic location is the height above sea level (meters above sea level). Soil sampling points are taken from the following elevation that ranges from 0-5 masl, 5-10 masl and 10-15 masl. In some cases however, soil sampling go beyond 15 masl (15-20 masl and 20-25 masl) depending on the suspected saline water intrusion in the area.

D. Agro-Climate

Figure 1.1 Mean Monthly Rainfall, Butuan City



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall Amt (mm) 1981-2000	308	211.8	149.8	107.2	104.8	135.1	157.5	105.1	140.2	195.2	192.8	218.4
Rainfall Amt (mm) 2000-2010	334.4	250.6	139.8	120.6	130.3	200.8	121.5	103.3	101.3	164.9	220.4	274.3

During dry months surface accumulation of salts increases in saline affected areas. On the other hand, during rainy months salts start to leach into lower depths.

Agusan del Norte belongs to Type II Climate: No dry season with a very pronounced maximum rain period from December to February. There is not a single dry month. Minimum monthly rainfall occurs during the period from March to May, so soil sampling was done in April until May.

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 socioeconomic 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 Agusan del Norte sampling sites are presented in Table 1.2. Some indicators of salinity per municipality are also indicated in this table.

Table 1.2 Land use/ vegetation in Agusan del Norte sampling sites.

Municipality	Land Use/ Vegetation	Some indications of salinity
BUTUAN	Nipa, Banana, Coconut, Nipa, Fish pond, Paddy Rice, Falcata, Grasses	Nipa, Sedges
BUENAVISTA	Paddy Rice, Nipa, Coconut	Nipa
NASIPIT	Nipa, Coconut, Paddy Rice, Falcata	Nipa
MAGALLANES	Coconut	
CABADBARAN	Coconut, Nipa, Cocon,Banana	Nipa
TUBAY	Coconut,Banana,Grasses, Vegetables, Falcata	
LAS NIEVES	Non-Irrigated Paddy Rice	
RTR	Non-Irrigated Paddy Rice	

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

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.

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

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 Agusan del Norte per degree of salinity. Based from this table, saline areas are generally higher at 60-90cm depth, but generally the coastal areas in Agusan del Norte is Slightly to Moderate Saline. Further and in-depth analysis is discussed on the suitability assessment.

Table 2.2 Distribution of Coastal Land Area at Different Degree of Salinity, Agusan del Norte

Salinity Class	Soil Depth					
	0-30cm		30-60cm		60- 90cm	
	hectares	%	hectares	%	hectares	%
Non salilne	179,677.6	98.0	178,724.6	97.5	176,635.4	96.3
Slightly Saline	3,084.0	1.7	3,687.6	2.0	5,190.2	2.8
Moderately Saline	585.4	0.3	923.8	0.5	1,475.5	0.8
Severely Saline	0.1	0.0	11.0	0.01	45.9	0.03
TOTAL	**183,347**	**100**	**183.347**	**100**	**183,347**	**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.

Rice Suitability Map of Agusan del Norte (page 13), shows that the Highly Suitable (S1) area for rice is 7.4% of the total coastal area, Moderately Suitable (S2) with varying limitations is 87.39% of the total coastal area, and the Marginally Suitable (S3) is 5.21% of the total coastal area. S3 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 2.3 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 3.4 shows that there is 33% decrease in yield on slightly saline irrigated paddy rice area, and 44% decrease in yield for moderately saline area. While for non-irrigated paddy rice, there is a 21% decrease in yield for slightly saline, 44% decrease in moderately saline, and 71 % decrease for severely saline areas. This shows that as the degree of salinity increases, decrease in yield also increases.

Table 2.3 Average Rice Yield by Degree of Salinity. Agusan del Norte, CY 2016-2017

Degree of Salinity	Average Yield Irrigated Paddy Rice	% decrease in Yield	Average Yield Non Irrigated Paddy Rice	% decrease in Yield
Non saline	3,332.5		2,707	
Slightly saline	2,229.5	33	2,131.5	21
Moderate saline	1,882.5	44	1,507	44
Severely saline			798.5	71

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

	Municipality	Non Saline	Slightly Saline	Moderately Saline	Severely Saline
1	BUENAVISTA	47,114.54	423.54	22.92	
2	BUTUAN CITY (Capital)	79,212.21	1,887.26	562.47	0.06
3	CITY OF CABADBARAN	21,022.21	421.79		
4	MAGALLANES	4,083.19	347.81		
5	NASIPIT	14,440.00			
6	TUBAY	13,805.42	3.58		
	Grand Total	**179,677.57**	**3,083.98**	**585.39**	**0.06**

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

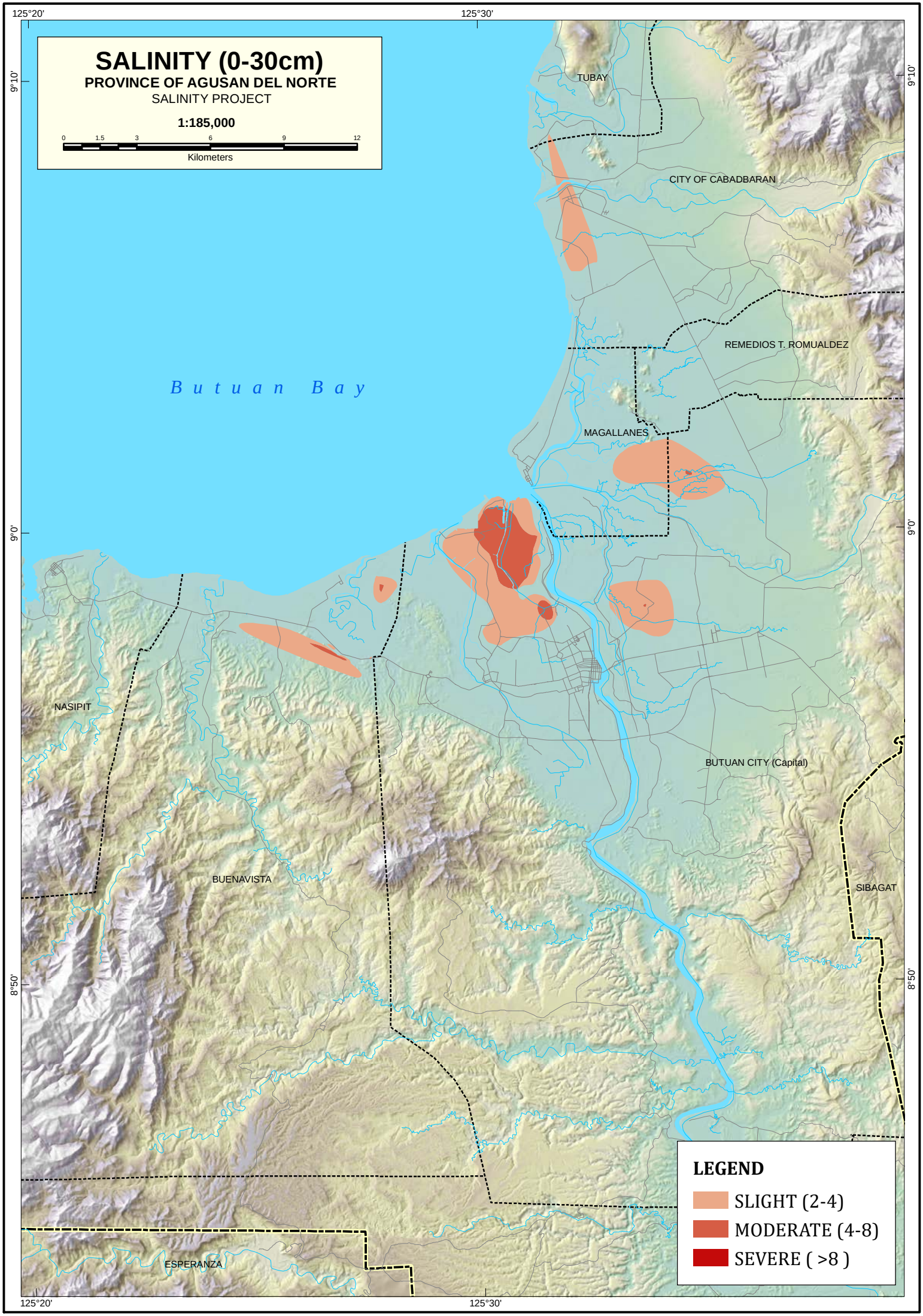
	Municipality	Non Saline	Slightly Saline	Moderately Saline	Severely Saline
1	BUENAVISTA	46,944.24	556.45	60.28	0.03
2	BUTUAN CITY (Capital)	78,163.39	2,624.15	863.54	10.92
3	CABADBARAN CITY	21,324.32	119.68		
4	MAGALLANES	4,043.99	387.01		
5	NASIPIT	14,440.00			
6	TUBAY	13,808.65	0.35		
	Grand Total	**178,724.59**	**3,687.64**	**923.82**	**10.96**

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

	Municipality	Non Saline	Slightly Saline	Moderately Saline	Severely Saline
1	BUENAVISTA	46,164.44	1,239.60	156.75	0.21
2	BUTUAN CITY (Capital)	78,351.94	1,945.59	1,318.76	45.71
3	CABADBARAN CITY	20,674.81	769.19		
4	MAGALLANES	3,209.12	1,221.88		
5	NASIPIT	14,427.06	12.94		
6	TUBAY	13,808.00	1.00		
	Grand Total	**176,635.38**	**5,190.19**	**1,475.51**	**45.93**

Table 2.7 Legend for the Rice Suitability Map @ page 13
Coastal Rice Area - Province of Agusan del Norte

LEGEND						
SUITABILITY RATING	DESCRIPTION	LIMITING FACTORS			AREA	
		Moderate	Marginal	Severe	ha	%
S1	Highly Suitable				696	7.40
S2f	Moderately Suitable	f			455	4.84
S2fn		f,n			21	0.22
S2d		d			361	3.84
S2df		d,f			238	2.53
S2dfn		d,f,n			29	0.31
S2dx		d,x			1112	11.82
S2dxf		d,x,f			1576	16.76
S2dxfn		d,x,f,n			189	2.01
S2i		i			196	2.08
S2if		i,f			285	3.03
S2id		i,d			140	1.49
S2idf		i,d,f			233	2.48
S2idfn		i,d,f,n			25	0.27
S2idx		i,d,x			299	3.18
S2idxn		i,d,x,n			6	0.06
S2idxf		i,d,x,f			2557	27.19
S2idxfn		i,d,x,f,n			497	5.28
S3f	Marginally Suitable		f		90	0.96
S3f		n	f		3	0.03
S3n		d,f	n		8	0.09
S3f		d	f		79	0.84
S3f		d,n	f		5	0.05
S3fn		d	f,n		1	0.01
S3f		d,x	f		104	1.11
S3f		d,x,n	f		2	0.02
S3f		i	f		11	0.12
S3f		i,n	f		12	0.13
S3f		i,d	f		21	0.22
S3f		i,d,n	f		10	0.11
S3n		i,d,x,f	n		4	0.04
S3f		i,d,x	f		90	0.96
S3f		i,d,x,n	f		45	0.48
S3fn		i,d,x	f,n		4	0.04
				TOTAL	9404	100.00


SALINITY (0-30cm)
PROVINCE OF AGUSAN DEL NORTE
SALINITY PROJECT
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Kilometers
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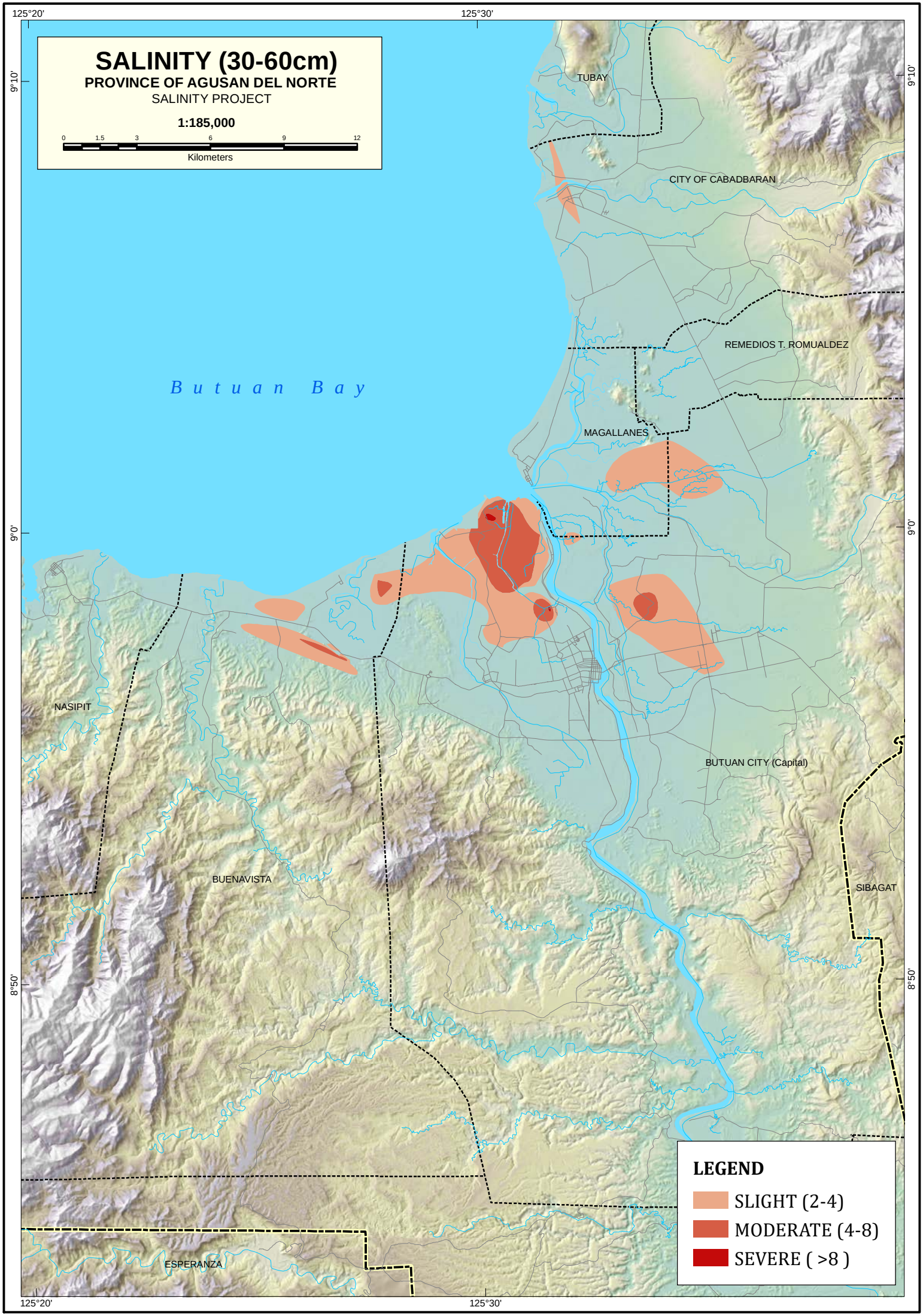
125°30'
9°10'
9°0'
8°50'
TUBAY
CITY OF CABADBARAN
REMEDIOS T. ROMUALDEZ
MAGALLANES
Butuan Bay
NASIPIT
BUTUAN CITY (Capital)
BUENAVISTA
SIBAGAT
ESPERANZA
LEGEND
SLIGHT (2-4)
MODERATE (4-8)
SEVERE (>8)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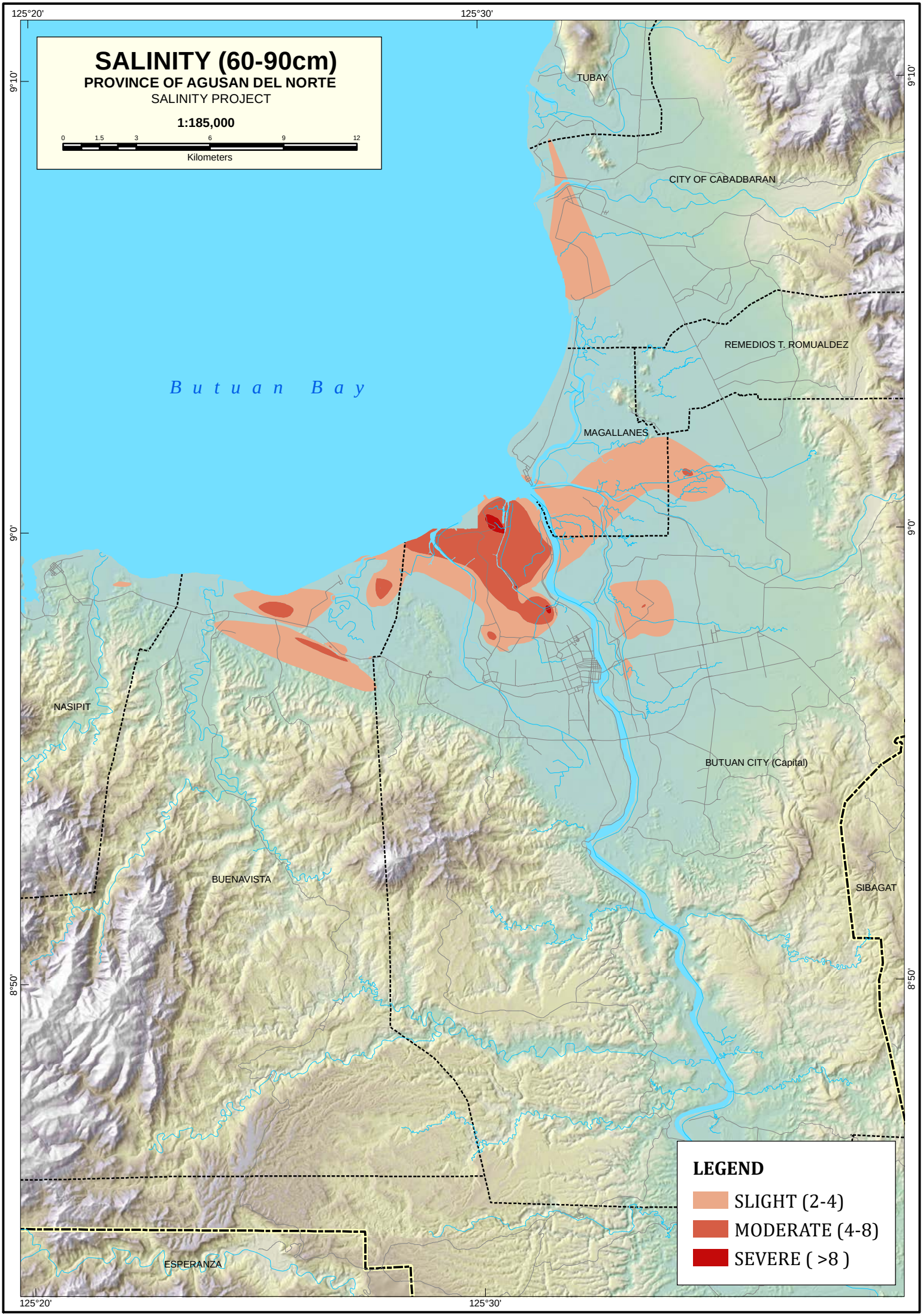
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SALINITY PROJECT
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LEGEND
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SEVERE (>8)

RICE SUITABILITY MAP

(Coastal Rice Area)

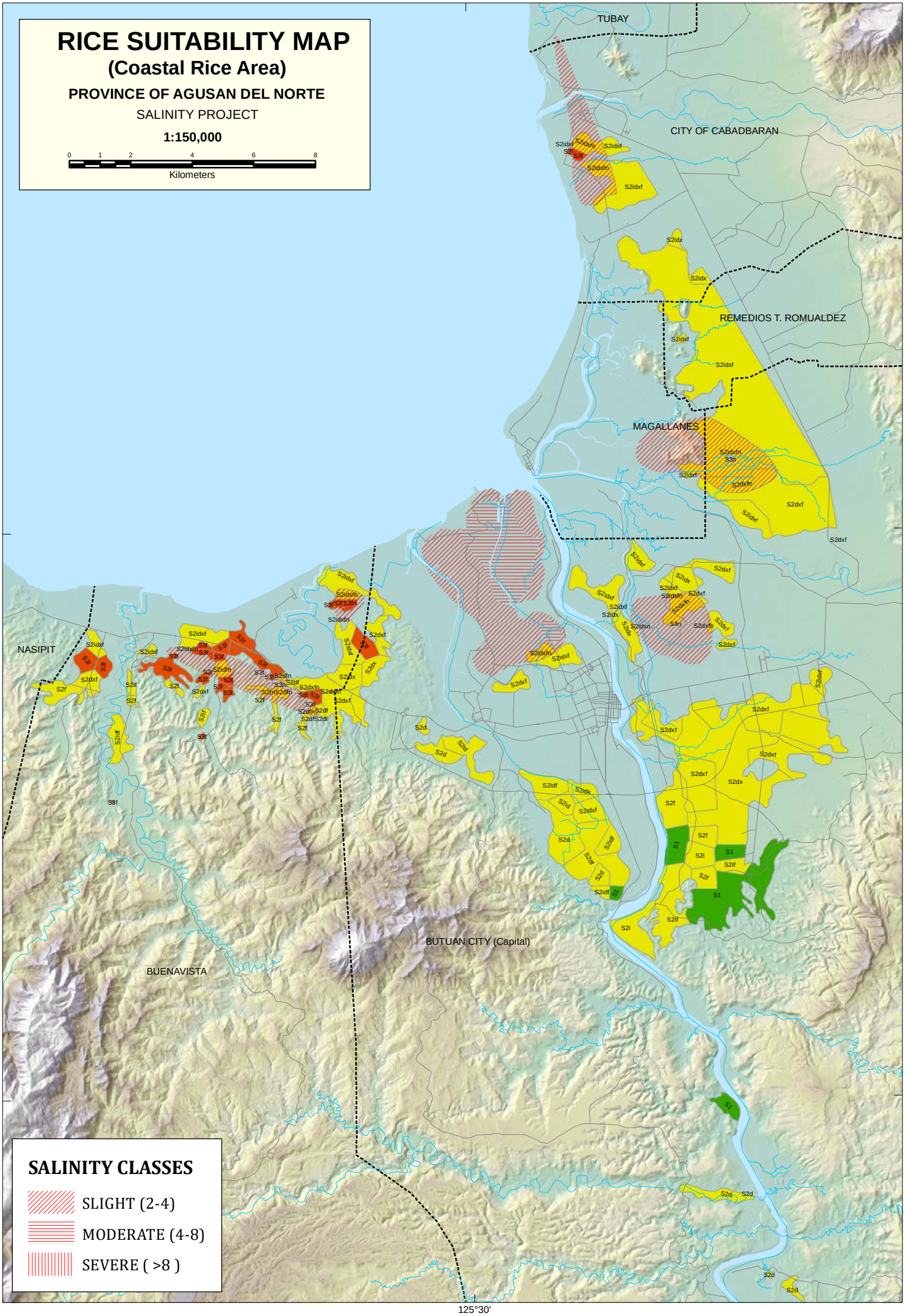
PROVINCE OF AGUSAN DEL NORTE

SALINITY PROJECT

1:150,000

0 1 2 4 6 8

Kilometers



SALINITY CLASSES

- SLIGHT (2-4)
- MODERATE (4-8)
- SEVERE (>8)

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

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Auger Boring and Soil Sampling

Key Informant Interview

Field Validation of SAFDZ Maps

Index of Salinity: White crust on Soil Surface