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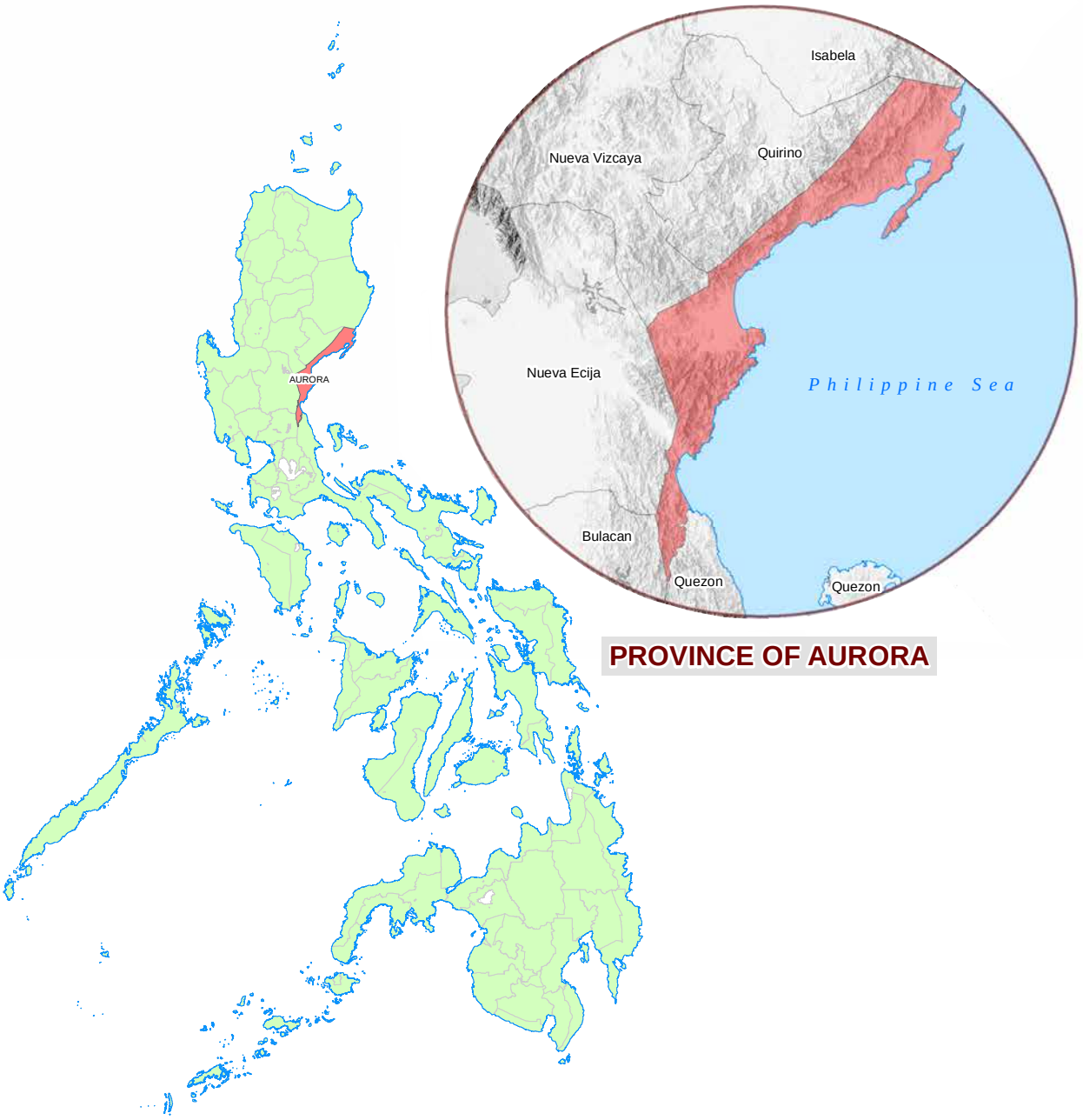
AGRICULTURAL LAND MANAGEMENT AND EVALUATION DIVISION

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



PROVINCE OF AURORA

2020

TABLE OF CONTENTS

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.

AURORA

I. SOIL/LAND PHYSICAL CHARACTERISTICS

A. General Description of Saline Affected Site

Aurora is a coastal province located in the eastern part of Central Luzon region, facing the Philippine Sea. It is bordered by the Northern Sierra Madre Natural Park of Isabela on the north, by the central range of the Sierra Madre, which contains the Casecnan Protected Landscape and Aurora Memorial National Park on the west, by the Umiray River on the south, and on the east by the Philippine Sea. Aurora is considered the gateway to the Pacific with coastline spanning 410 kilometers.

There are five (5) coastal municipalities susceptible to salinity; hence, the fifteen (15) soil sampling sites summarized in Table 1.1.

Table 1.1. Coastal Areas and Municipalities in Aurora

No.	Municipality	No. of Barangay	No. of Sampling Sites	No. of Soil Samples Collected
1	Casiguran	24	5	15
2	Dilasag	11	3	9
3	Dinalungan	9	3	9
4	Dingalan	11	1	3
5	Dipaculao	25	3	9
	TOTAL	80	15	45

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 basis for integration of various resource information in suitability rating for different crops wherein each suitability class can be fitted with specific sets of management requirements and input. It is also the building block of the pedo-ecological zone, which represents a broader landscape grouping such as lowland, upland, hilllyland and highland.

Table 1.2 shows the land management units of the sampling sites per coastal municipality.

Table 1.2 Land Management Units of Sampling Sites

LMU	Description	Municipality
09 Broad Alluvial Plain	Generally flat low relief. The soil are very deep clay or heavy clay, moderately well drained to poorly drained, highly fertile and adaptable to wide range of crops dominated by paddy rice irrigated and non-irrigated.	Casiguran Dilasag Dinalungan Dingalan Dipaculao
02 Active tidal flats (Mangrove/Nipa)	Comprise the coastal, active tidal flat estuarine plain subject to constant tidal inundations. These are moderately deep to deep, very poorly drained, fine loamy to clayey textures saturated by saline water.	Casiguran

C. Flooding

The alluvial plain areas adjacent to Casiguran River, Aguang and other principal rivers and their tributaries are frequently affected by seasonal flooding because of its physiography.

Based on the key informant interviews, all of the farmers experience flooding during the months of September to December, when the amount of rainfall is maximum and leads to river overflow during peak rain periods. Severe flooding can be at a depth higher than 1.0 m with duration lasting for 3 days or more, and recedes in more than 24 hours.

D. Elevation

The elevation of a geographic location is the height above sea level (meters above sea level). Since the coastal areas are in the lowland pedo-ecological zone, soil sampling points are taken from elevations ranging from 0-5masl, 5-10masl and 10-15masl. However in some cases, soil sampling go beyond 15 masl depending on the suspected soil salinity in the area.

E. Agro-Climate

The Province of Aurora has a Type 4 climate. It is characterized by rainfall, more or less, evenly distributed throughout the year. The average monthly rainfall ranges from a minimum of 30-90mm to a maximum of 450-1,200mm as recorded over a 14-year period (2005-2019) by synoptic stations in Casiguran and Baler. The annual maximum daily rainfall is associated with typhoons because the coastal province faces the Pacific Ocean. This occurs over the months of October to December. Figure 1.1 and Figure 1.2 are the rainfall pattern from PAGASA synoptic stations in Baler and Casiguran, respectively. It can be observed that the maximum amount of rainfall is at the northern part of Aurora in Casiguran station during the months of November to December.

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.

Figure 1.1 Rainfall Pattern on the Southern Part of Aurora

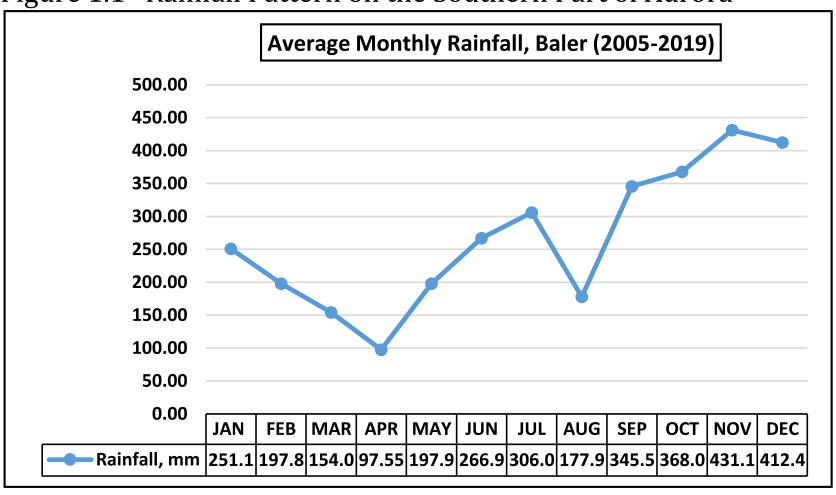
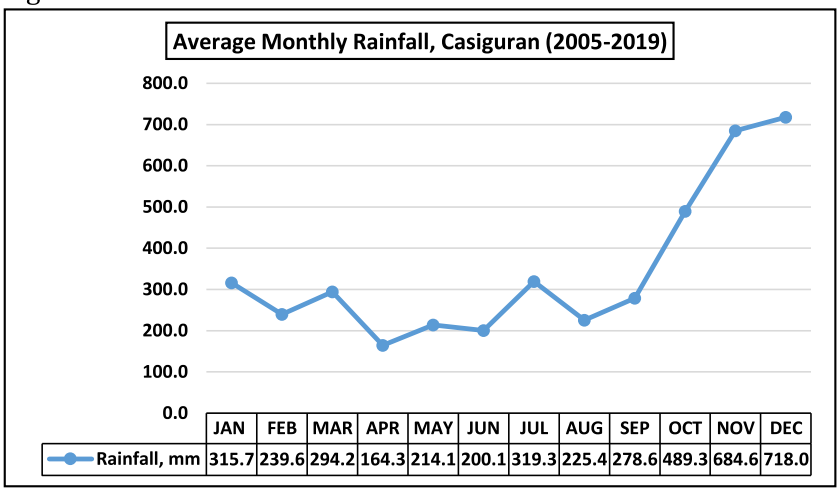


Figure 1.2 Rainfall Pattern on the Northern Part of Aurora

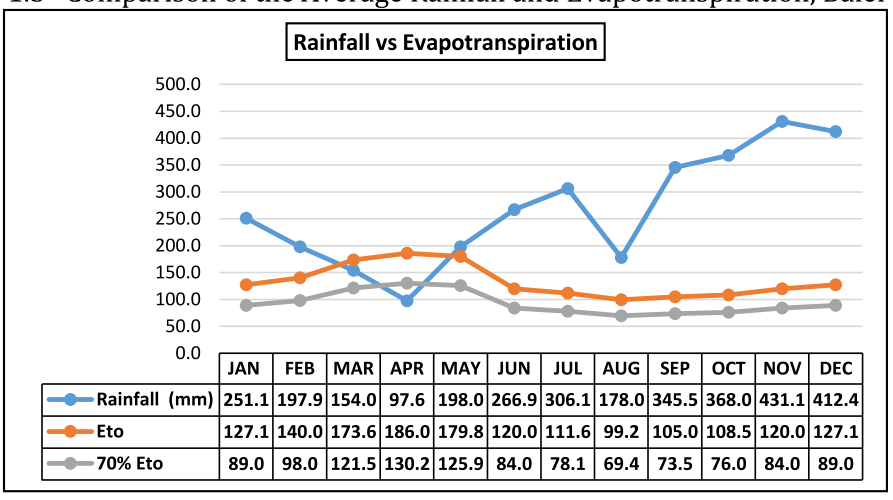


	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rainfall, mm	315.7	239.6	294.2	164.3	214.1	200.1	319.3	225.4	278.6	489.3	684.6	718.0

Evapotranspiration (Eto) is the sum of water transpired by the leaves of the crop and evaporation from the surrounding soil when water is not limited. Ideally, rainfall is considered to be sufficient if its amount is equal or higher than the potential evapotranspiration.

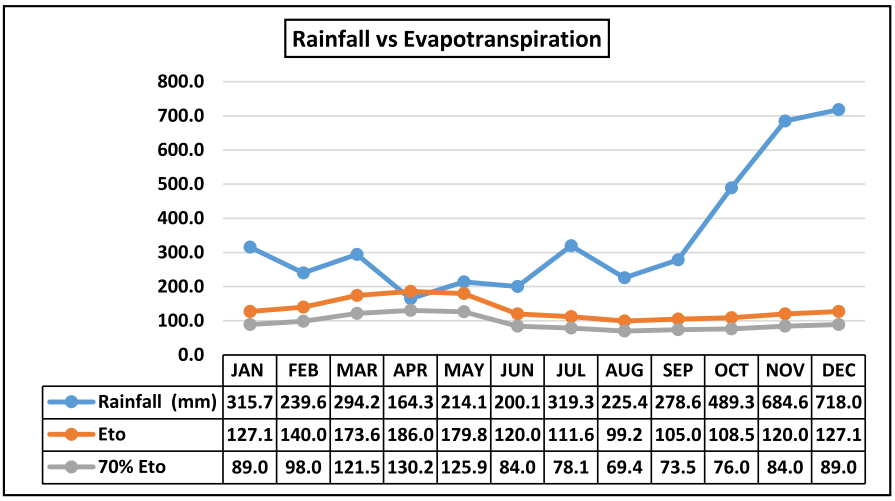
Figures 1.3 and 1.4 are the comparison of average rainfall and evapotranspiration in Aurora, from the 2 synoptic stations. Rainfall is higher than the potential evapotranspiration in the months of May to February. This means that soil moisture is sufficient to support crop cultivation, while for the month of April, there is a need for sufficient irrigation.

Figure 1.3 Comparison of the Average Rainfall and Evapotranspiration, Baler



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rainfall (mm)	251.1	197.9	154.0	97.6	198.0	266.9	306.1	178.0	345.5	368.0	431.1	412.4
Eto	127.1	140.0	173.6	186.0	179.8	120.0	111.6	99.2	105.0	108.5	120.0	127.1
70% Eto	89.0	98.0	121.5	130.2	125.9	84.0	78.1	69.4	73.5	76.0	84.0	89.0

Figure 1.4 Comparison of the Average Rainfall and Evapotranspiration, Casiguran



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rainfall (mm)	315.7	239.6	294.2	164.3	214.1	200.1	319.3	225.4	278.6	489.3	684.6	718.0
Eto	127.1	140.0	173.6	186.0	179.8	120.0	111.6	99.2	105.0	108.5	120.0	127.1
70% Eto	89.0	98.0	121.5	130.2	125.9	84.0	78.1	69.4	73.5	76.0	84.0	89.0

F. Land Use/Vegetation

Land use involves the management and modification of natural environment. It also has been defined as "the total 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 primarily indicative information 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 Aurora 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 Aurora Sampling Sites.

Municipality	Land Use/Vegetation	Some indicators of Salinity
Casiguran	Irrigated and non-irrigated paddy rice, coconut, forest	mangrove/nipa, white crust in soil surface, poor yield/productivity, wilting, empty panicle, reddish/yellowish leaves & stunted growth
Dilasag	Irrigated and non-irrigated paddy rice, forest, pasture	reddish/yellowish leaves & stunted growth
Dinalungan	Irrigated and non-irrigated paddy rice, forest	mangrove/nipa, white crust in soil surface, poor yield/productivity, wilting, empty panicle, reddish/yellowish leaves & stunted growth
Dingalan	Irrigated and non-irrigated paddy rice, pasture	white crust in soil surface, empty panicle & reddish/yellowish leaves
Dipaculao	Irrigated and non-irrigated paddy rice, pasture	white crust in soil surface, empty panicle, reddish/yellowish leaves & stunted growth

II. CROP PRODUCTION ON SALINE AFFECTED AREAS

A. Key Informant Profile

Based on the 15 farmer respondents, the average age of farmers is 53 years old, the youngest and oldest is 31and 76 years old, respectively. The average years of farming experience is 27 years old.

All fifteen (15) farmer respondents (4 female and 11 male) are the owner of their farm, with an average farm size of 1.28 hectares.

Figure 2.1 Key Informant Interview

Figure 2.1 Key Informant Interview

B. Farm Production

The seasonal crops in Aurora that contribute to agricultural productivity are rice (irrigated and non-irrigated) and corn while the annual/perennial crop is coconut. Table 2.1 shows the average rice yield for CY 2017 per municipality, based from the key informant interviews.

Table 2.1 Rice Production in Coastal Municipalities of Aurora

Coastal Municipality	Average Rice Yield , kg/ha*	
	1st Cropping	2nd Cropping
1. Casiguran	4,475	3,775
2. Dilasag	3,450	1,700
3. Dinalungan	3,750	3,100
4. Dingalan	2,000	1,500
5. Dipaculao	4,033	3,783

*Based on the key informant interview, rice yield for CY 2017

C. Farm Input

The study is limited to the coastal communities of the province, therefore, the information on farm inputs are mainly based on the key informant interviews.

Farmer respondents usually use commercially available rice seed varieties including hybrid rice. They have not planted the saline–tolerant varieties like Salinas, because, according to them, these varieties are not readily available in the market.

For fertilizers, they use urea (46-0-0), complete (14-14-14), and ammonium phosphate (16-20-0). They also use chemical herbicides molluscicides.

D. Source of Irrigation

Table 2.2 shows that the majority of the farmer respondents have irrigation systems assisted by the National Irrigation Administration (NIA) (68%); others have shallow tubewell (13%); communal irrigation system is 7%; rainfed is 6%; and others are pumping irrigation water from the creeks (6%).

Table 2.2 Source of Irrigation for Paddy Rice

Source of Irrigation for Paddy Rice	%
National Irrigation Administration	68
Communal Irrigation	7
Shallow tubewell	13
Rivers and creeks	6
Rainfed	6

E. Period of Salinity Occurrence and Practices to Address Salinity

During the months of September to December, flooding is experienced in the province and, according to the farmer respondents, salinity occurs during these months. Majority of the farmer respondents are not willing to adopt to other suitable crop considering salinity because they still want to plant rice in their farm.

Most of the farmer respondents' practices to address salinity are applying fertilizer to increase crop productivity and putting drainage/canal passage to eliminate salt water during heavy rains.

Figure 2.2 Auger Boring and Soil Sampling

Figure 2.3 Soil Sampling and Data Gathering

Figure 2.4 Air Drying of Soil Samples

III. SOIL CHEMICAL CHARACTERISTICS

Soil are brought to the BSWM Laboratory Services Division for the soil salinity/alkalinity test which includes pH (1:1) at 25^{0}C, Electrical Conductivity (EC) at 25^{0}C, Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Sum of Cations, Carbonate (CO_3), Bicarbonate (HCO_3), Chloride (Cl), Sulfate (SO_4), Sum of Anions, and Sodium Adsorption Ratio (SAR).

The EC test results are classified according to its salinity class and then used to map salinity in the coastal area. Other laboratory test results are gathered as input to the Saline-Affected Areas Database Information System (SADIS v1.1). This spatial database can be used as reference for future research studies on salinity.

A. Salinity Classification

The laboratory results for salinity testing, specifically the EC readings, are classified using Table 3.1, based on the BSWM/FAO Salinity Project in 1999. This salinity classification is rice-based and applicable to Philippine setting.

Table 3.1 Salinity Classification (Crop-based, Rice)

Electrical Conductivity *(mS/cm)*	Soil Salinity Class	Hazard for Crop Growth	Plant Response
0 - 2	Non Saline	Very low	Negligible
2.1 - 4	Slightly Saline	Low	Restricted yield of sensitive crops
4.1 - 8	Moderately Saline	Moderate	Restricted yield of many crops
8.1 - 16	Severely Saline	High	Only a few tolerant crops yield satisfactorily
>16	Very Severely Saline	Very high	Only a few tolerant forage grow satisfactorily

Table 3.2 shows the laboratory EC test results of soil samples per municipality. Each EC readings are further classified using Table 3.1. The Municipalities of Dipaculao and Casiguran have severely saline soil at a certain depth (60-90cm) and barangay (Lipit and Esteves). These areas have high hazard for crop growth and only a few tolerant crops and with shallow root system will yield satisfactorily.

Some areas in Dilasag and Casiguran also show moderately saline soil at a certain depth, which means there is a moderate hazard for crop growth that will result to restricted yield of many crops. Most of the soil samples are non saline.

Table 3.2 Electrical Conductivity (EC) of Soil Samples at Different Depths

Auger Ref.	Barangay	Municipality	EC (mS/cm) @0-30cm	EC (mS/cm) @30-60cm	EC (mS/cm) @60-90cm
AuAB1	Ibona	Dingalan	0.7850	0.4230	0.4900
AuAB2	Borlongan	Dipaculao	1.4610	1.9030	1.6000
AuAB3	Lipit	Dipaculao	0.3300	0.2210	12.2700
AuAB4	Lipit	Dipaculao	0.3470	0.2580	0.4310
AuAB5	Diniog	Dilasag	0.3110	0.2820	0.3380
AuAB6	Diniog	Dilasag	3.3190	2.1520	3.5680
AuAB7	Diniog	Dilasag	1.3410	2.5600	7.6830
AuAB8	Lual	Casiguran	0.6430	0.5340	5.3600
AuAB9	Esteves	Casiguran	7.1900	7.7580	9.3960
AuAB10	Dibacong	Casiguran	0.3240	0.2000	3.9580
AuAB11	Tinib	Casiguran	0.9750	2.2090	6.5970
AuAB12	Dibet	Casiguran	3.2310	2.5360	0.2778
AuAB13	Dibaraybay	Dinalungan	0.4889	0.4303	0.3223
AuAB14	Mapalad	Dinalungan	0.0613	0.0391	0.0561
AuAB15	Nipoo	Dinalungan	2.0770	1.6620	0.7460

The soil salinity maps at three different depths (0-30cm, 30-60cm, and 60-90cm) are delineated using the corresponding coordinates of the sampling sites and the EC readings. These maps interpret the land area (in hectares) per municipality at different degrees of salinity, as shown in Tables 3.3 – 3.5.

The Soil Salinity Map of Aurora at 0-30cm, and Table 3.3 show that the Municipality of Casiguran specifically Barangay Esteves has 1,451.85 hectares moderately saline soil.

For Table 3.4 at 30-60cm depth, Casiguran still show a moderately saline soil at 1,440.11 hectares.

Table 3.3 Coastal Land Area (in hectares) per Municipality at Different Degrees of Salinity (0-30 cm depth)

Coastal Municipality	Non Saline	Slightly Saline	Moderately Saline	Severely Saline	Very Severely Saline
1. Baler	4,617.81				
2. Casiguran	5,672.56	642.70	1,451.85		
3. Dilasag	4,718.57	455.25			
4. Dinalungan	2,271.72	130.73			
5. Dingalan	2,498.65				
6. Dipaculao	4,906.57				
7. Maria Aurora	942.82				
8. San Luis	2,232.01				
TOTAL	**27,860.73**	**1,228.68**	**1,451.85**		

Table 3.4 Coastal Land Area (in hectares) per Municipality at Different Degrees of Salinity (30-60 cm depth)

Coastal Municipality	Non Saline	Slightly Saline	Moderately Saline	Severely Saline	Very Severely Saline
1. Baler	4,617.81				
2. Casiguran	5,625.11	701.89	1,440.11		
3. Dilasag	4,130.67	1,043.15			
4. Dinalungan	2,331.99	70.46			
5. Dingalan	2,498.65				
6. Dipaculao	4,906.57				
7. Maria Aurora	942.82				
8. San Luis	2,232.01				
TOTAL	**27,285.64**	**1,815.50**	**1,440.11**		

Table 3.5 Coastal Land Area (in hectares) per Municipality at Different Degrees of Salinity (60-90 cm depth)

Coastal Municipality	Non Saline	Slightly Saline	Moderately Saline	Severely Saline	Very Severely Saline
1. Baler	387.02		4,230.80		
2. Casiguran	1,565.87	341.52	5,526.10	333.62	
3. Dilasag	1,601.89	260.81	3,311.12		
4. Dinalungan	2,263.91	138.54			
5. Dingalan	2,498.65				
6. Dipaculao	1,504.97	149.64	2,939.18	312.79	
7. Maria Aurora			942.82		
8. San Luis	1,315.08		916.93		
TOTAL	**11,137.39**	**890.51**	**17,866.96**	**646.40**	

For Table 3.5 at 60-90cm depth, there are severely saline soils in Barangay Esteves, Casiguran (333.62 hectares) and Lipit, Dipaculao (312.79 hectares). Moderately saline soils are in Baler, Casiguran, Dilasag, Dipaculao, Maria Aurora and San Luis with a total land area equal to 17,866.96 hectares. It may be observed that although there are no sampling sites in Baler, Maria Aurora and San Luis, some areas of these municipalities are still identified as moderately saline because on the process of map delineation through interpolation, the sampling points in Dipaculao extended its predicted values to these 3 nearby municipalities.

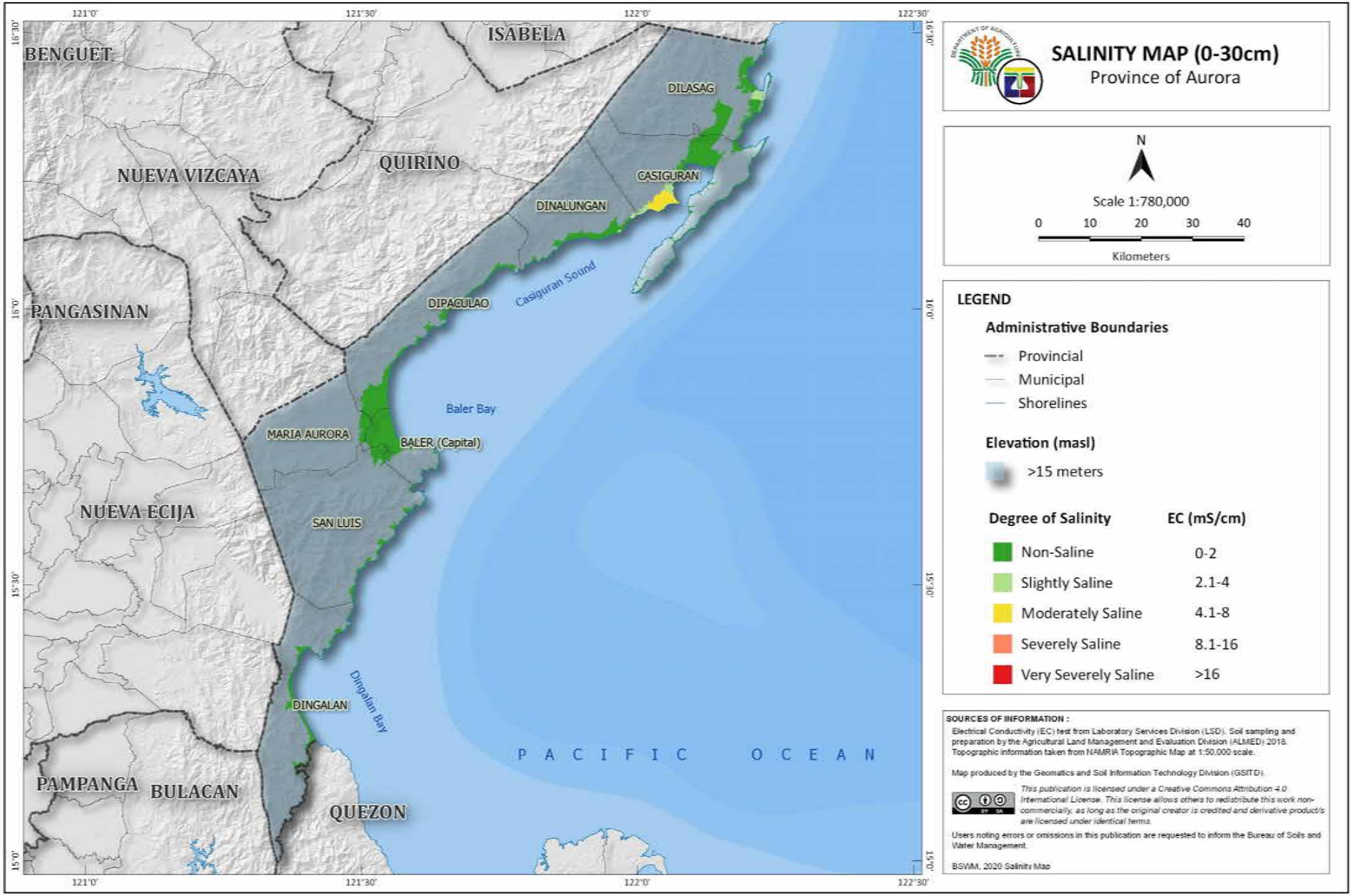
Table 3.6 Distribution of Coastal Land Area at Different Degrees of Salinity, Aurora Province

Salinity Class	Soil Depth (cm)					
	0-30		30-60		60-90	
	hectares	%	hectares	%	hectares	%
Non saline	27,860.73	91.2	27,285.64	89.34	11,137.39	36.5
Slightly saline	1,228.68	4.0	1,815.50	5.94	890.51	2.9
Moderately saline	1,451.85	4.8	1,440.11	4.72	17,866.96	58.5
Severely saline					646.40	2.1
Very Severely saline						
TOTAL	**30,541.26**	**100**	**30,541.26**	**100**	**30,541.26**	**100**

Table 3.6 summarizes the total coastal land area of Aurora per degree of salinity and the notable result is that at soil depth 60-90cm, 58.5% of the coastal land area is moderately affected by salinity and 2.1% is severely saline. Although only very few plants have root system that can reach this depth, there are chances that during dry months, salts will accumulate at the surface of the soil and thus, can be moderately to highly hazardous to crop growth.

B. Output Maps

The following are the output maps of the project: the Soil Salinity Maps of the Province of Aurora at 0-30cm depth; 30-60cm depth; and 60-90cm depth.



SALINITY MAP (0-30cm)

Province of Aurora

N

Scale 1:780,000

0 10 20 30 40

Kilometers

LEGEND

Administrative Boundaries

- Provincial
- Municipal
- Shorelines

Elevation (masl)

- >15 meters

Degree of Salinity	EC (mS/cm)
Non-Saline	0-2
Slightly Saline	2.1-4
Moderately Saline	4.1-8
Severely Saline	8.1-16
Very Severely Saline	>16

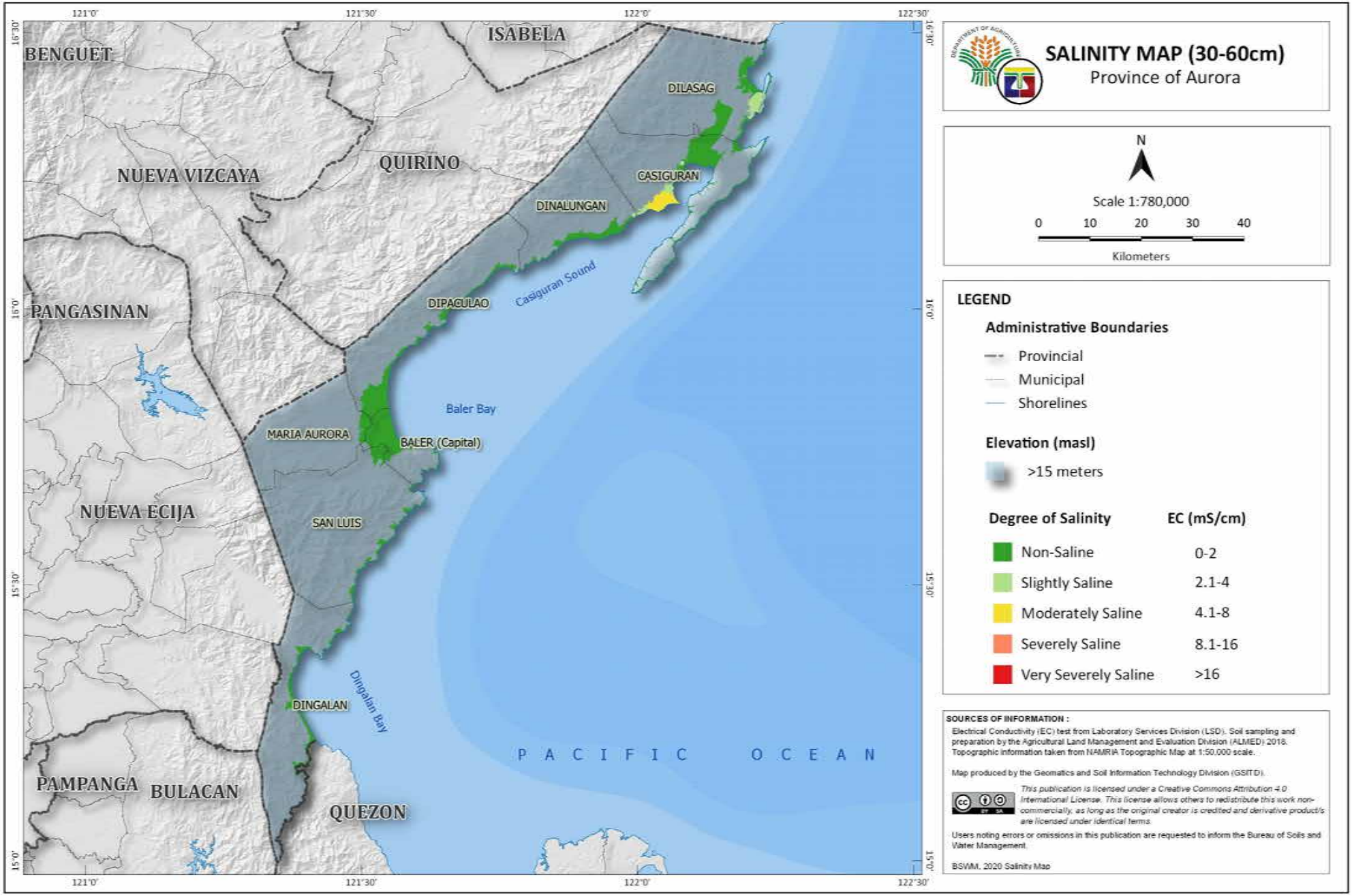
SOURCES OF INFORMATION :

Electrical Conductivity (EC) test from Laboratory Services Division (LSD). Soil sampling and preparation by the Agricultural Land Management and Evaluation Division (ALMED) 2018. Topographic information taken from NAMRIA Topographic Map at 1:50,000 scale.

Map produced by the Geomatics and Soil Information Technology Division (GSITD).

Users noting errors or omissions in this publication are requested to inform the Bureau of Soils and Water Management.

BSWM, 2020 Salinity Map



SALINITY MAP (30-60cm)

Province of Aurora

N

Scale 1:780,000

0 10 20 30 40

Kilometers

LEGEND

Administrative Boundaries

- Provincial
- Municipal
- Shorelines

Elevation (masl)

- >15 meters

Degree of Salinity	EC (mS/cm)
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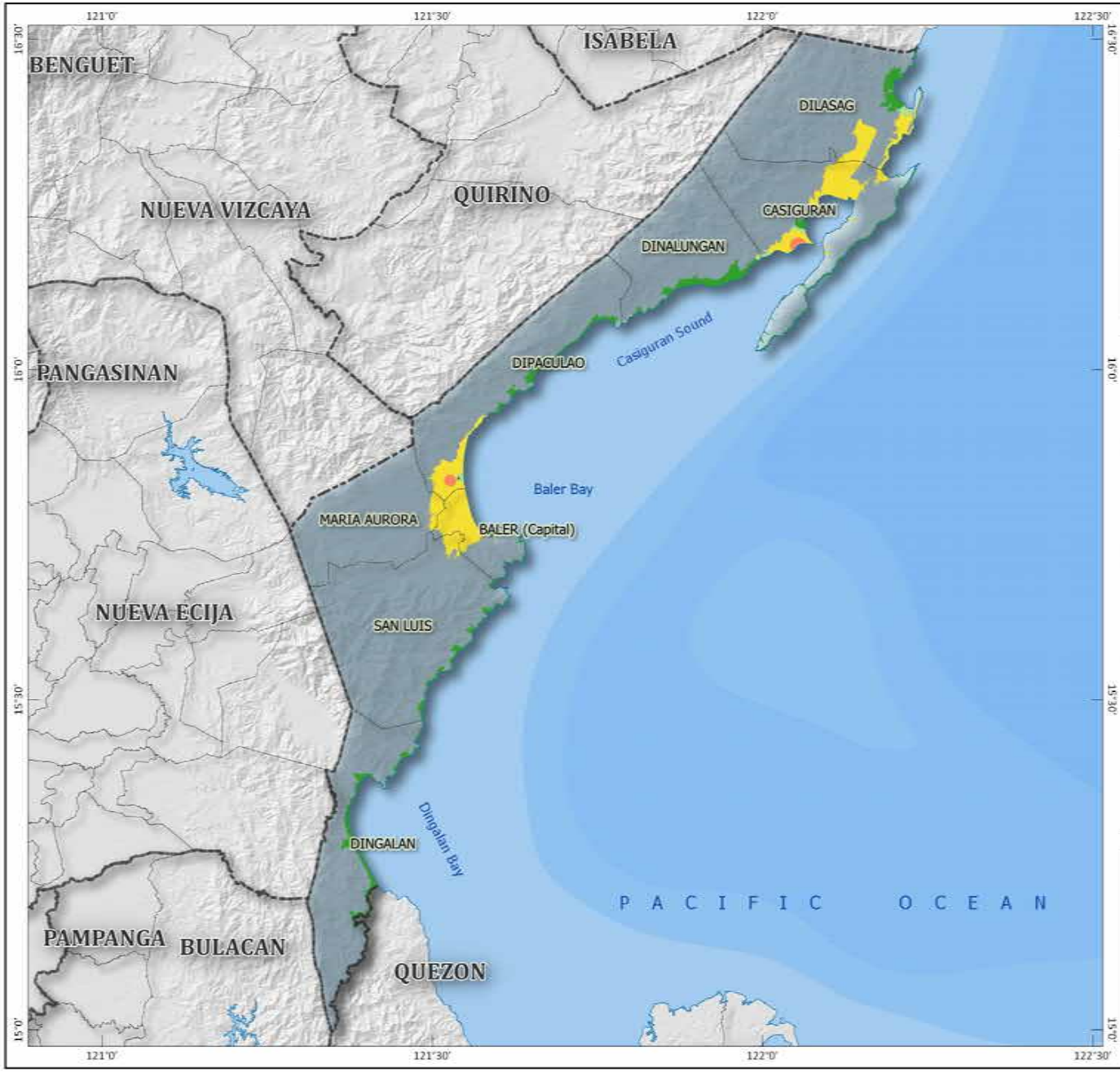

SALINITY MAP (60-90cm)

Province of Aurora

N

Scale 1:780,000

0 10 20 30 40

Kilometers

LEGEND

Administrative Boundaries

- Provincial
- Municipal
- Shorelines

Elevation (masl)

- >15 meters

Degree of Salinity	EC (mS/cm)
Non-Saline	0-2
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Map produced by the Geomatics and Soil Information Technology Division (GSITD).

BSWM, 2020 Salinity Map

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