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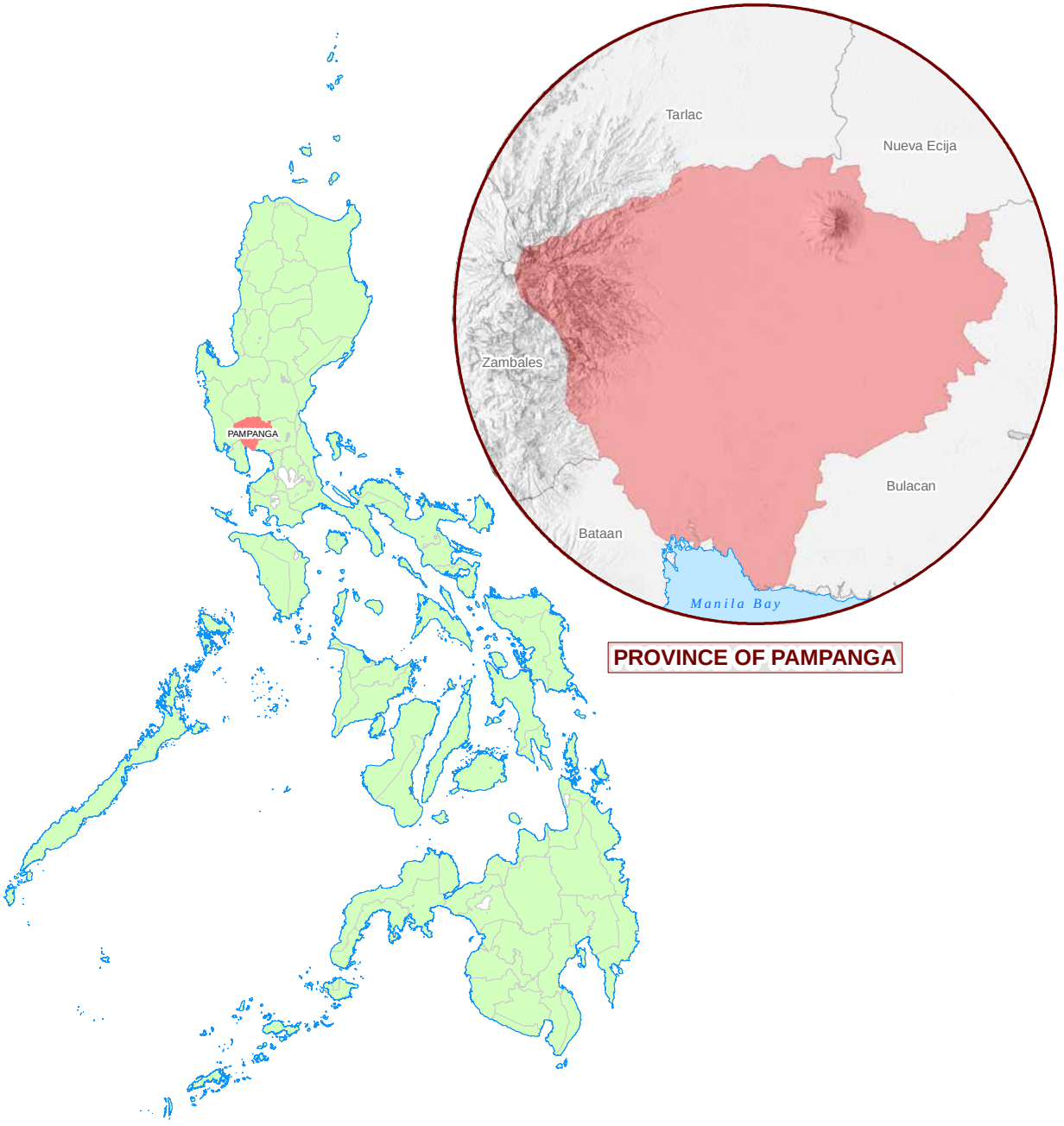
AGRICULTURAL LAND MANAGEMENT AND EVALUATION DIVISION

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



PROVINCE OF PAMPANGA

2020

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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.

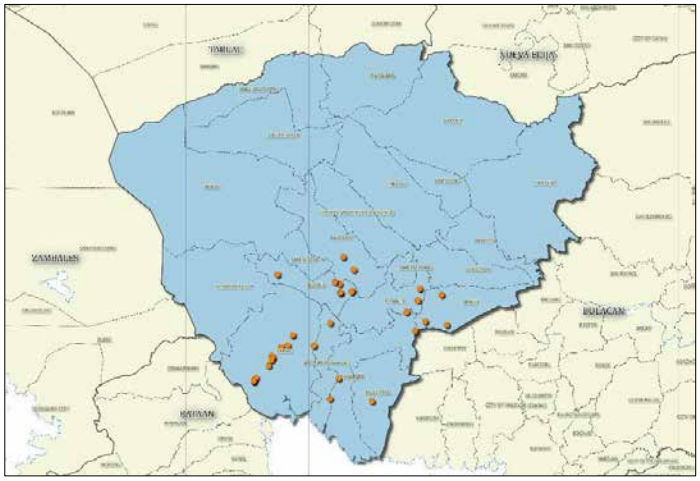
PAMPANGA

I. SOIL/LAND PHYSICAL CHARACTERISTICS

A. General Description of Saline Affected Site

Pampanga is located in the central part of Region III, lying on the northern shore of Manila Bay, approximately $15^0$04' North and $120^0$40' East. It is bounded on the north by Tarlac and Nueva Ecija, on the east by Bulacan, southwest by Bataan, and west by Zambales. Its terrain is relatively flat with only one distinct mountain, Mount Arayat, and the notable Pampanga River.

Figure 1.1. Map of Pampanga Province with Sampling Points



There are eight (8) coastal municipalities susceptible to salinity in the Province of Pampanga, hence the sites for sampling shown in Table 1.1.

Table 1.1. Coastal Areas and Municipalities in Pampanga

No.	MUNICIPALITY	No. of Barangays	No. of Sampling Sites	No. of Soil Samples Collected
1	Apalit	12	3	9
2	Bacolor	21	2	6
3	Guagua	31	7	19
4	Lubao	44	11	27
5	Macabebe	25	1	3
6	Masantol	26	1	1
7	Minalin	15	3	9
8	Sasmuan	12	3	3
	TOTAL	186	31	77

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, hilllyland and highland.

The sampling sites in Pampanga where the soil samples are collected are from the three LMUs, shown in Table 1.2 below.

Table 1.2 Land Management Units

Code	LMU	Description
01	Active tidal flats (Developed Fishponds)	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.
02	Active tidal flats (Mangrove/Nipa)	
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.

Figure 1.2 Developed Fishponds

Figure 1.3 Mangrove

Figure 1.4 Broad Alluvial Plain

C. Flooding

Flooding is a seasonal but recurring problem in Pampanga. This is brought about by river overflow during peak rain periods. Table 1.3 shows the area distribution of flooding by flooding class.

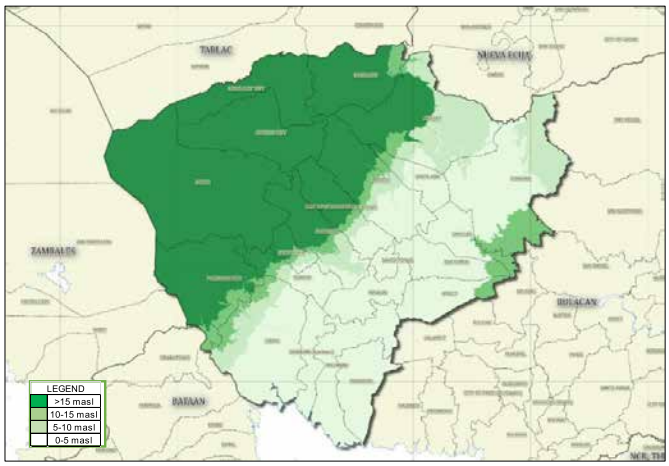
Table 1.3 Area Distribution of Flooding in Pampanga by Flooding Class

Flooding Class	Description	Area (hectares)
F0	No flooding	65,740
F1	Slight/ seasonal flooding	71,266
F2	Moderate seasonal flooding	41,242
F3	Severe flooding	39,820
	TOTAL	218,068

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. Figure 1.5 is the elevation classes in Pampanga.

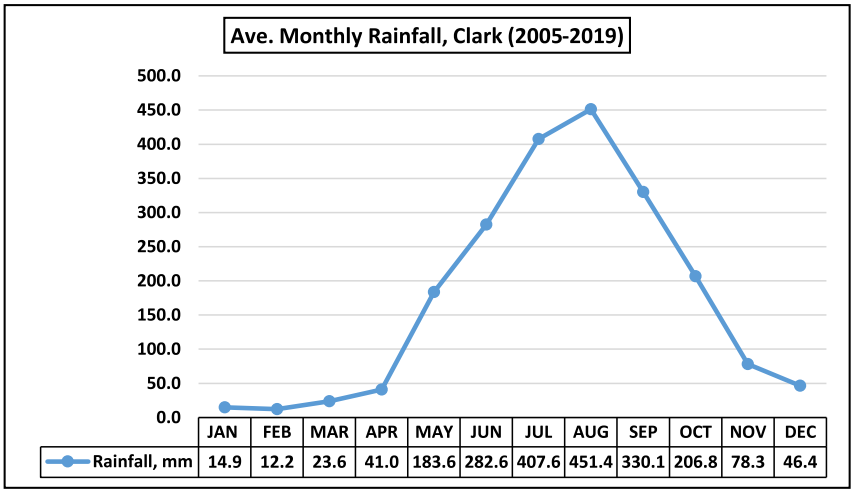
Figure 1.5 Elevation Classes – Pampanga



E. Agro-Climate

Based on the Modified Corona's Classification of Climate, Pampanga is in Type I Climate, characterized by two pronounced seasons, dry from November to April, and wet during the rest of the year. Maximum rain period is from June to September. Figure 1.6 shows the average monthly amount of rainfall from the PAGASA station in Clark International Airport.

Figure 1.6. Average Monthly Amount of Rainfall

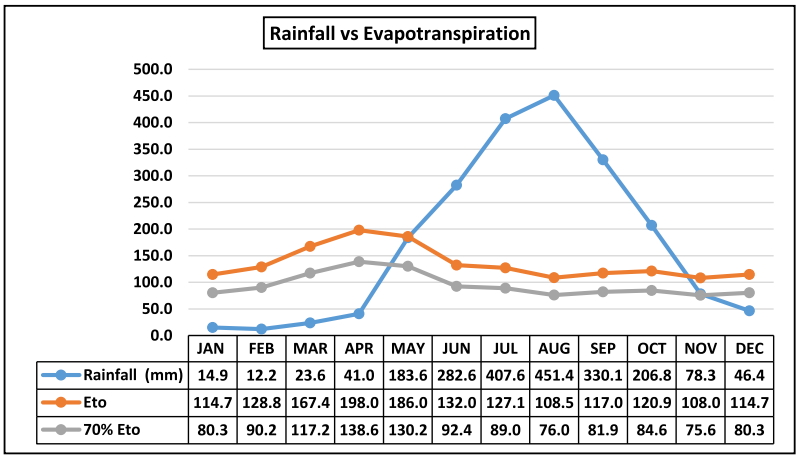


	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rainfall, mm	14.9	12.2	23.6	41.0	183.6	282.6	407.6	451.4	330.1	206.8	78.3	46.4

There are reported cases of saltwater intrusion in communities at the mouth of Pampanga River, which have been steadily occurring during high tides in summer according to the Bureau of Fisheries and Aquatic Resources (BFAR) in Central Luzon.

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. In Figure 1.7 comparison of rainfall and evapotranspiration in Pampanga, the average rainfall is relatively higher than the potential evapotranspiration from May to October. This means that soil moisture is sufficient to support crop cultivation. However, for the months of November to April, there is a need for supplemental irrigation.

Figure 1.7 Comparison of the Average Rainfall and Evapotranspiration



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rainfall (mm)	14.9	12.2	23.6	41.0	183.6	282.6	407.6	451.4	330.1	206.8	78.3	46.4
Eto	114.7	128.8	167.4	198.0	186.0	132.0	127.1	108.5	117.0	120.9	108.0	114.7
70% Eto	80.3	90.2	117.2	138.6	130.2	92.4	89.0	76.0	81.9	84.6	75.6	80.3

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 Pampanga sampling sites are presented in Table 1.4. Some indicators of salinity per municipality are also indicated in this table.

Table 1.4 Land use/vegetation in Pampanga sampling sites.

Municipality	Land Use/Vegetation	Some indicators of Salinity
Apalit	Paddy rice, fishpond	White crust on soil surface
Bacolor	Paddy rice	
Guagua	Paddy rice, mungbean, eggplant, tomato, green pepper, fishpond	Nipa, wilting, empty panicle, yellowish leaves, low yield
Lubao	Paddy Rice, Non-Irrigated Paddy Rice, Mungbean, Fishpond	A white crust forms over bare ground, low yield, wilting, beard grass (Hapulid bobi), Nipa
Macabebe	Paddy Rice	
Masantol	Fishpond	Mangrove, Nipa
Minalin	Paddy rice, fishpond	Crop death
Sasmuan	Fishpond	Mangrove, Nipa, fish kill

Figure 1.8 Paddy rice, mungbean, white crust on soil surface and mangroves

II. CROP PRODUCTION ON SALINE AFFECTED AREAS

A. Key Informant Profile

Based on the 29 farmer respondents, 48% of them are 51-60 years old, while the youngest are 21-30 years old at 7%. Twenty- five percent (25%) of the farmer respondents have a farming experience of 31-40 years, while 18% are less experienced (1-10 years).

Figure 2.1 Key Informant Interview

B. Farm Production

Table 2.1 Rice Production in Coastal Municipalities of Pampanga

	Coastal Municipality	Total Land Area (hectares)	Rice Area (hectares)	Ave. Yield Irrigated Paddy Rice (kg/ha)
1	Lubao	15,577	5,563.80	
2	Sasmuan	9,180		
3	Guagua	4,867	1,582	5,930
4	Bacolor	7,170		
5	Minalin	4,827	155	4,200
6	Apalit	6,147	3,318.02	4,540
7	Macabebe	10,516		
8	Masantol	4,825		
	TOTAL	63,109		

The seasonal crops in Pampanga that contribute to agricultural productivity are paddy rice (irrigated and non-irrigated), eggplant, sweet potato, tomato, and mungo. The annual/ perennial crops are sugarcane and cassava.

C. Farm Input

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

Farmers usually use any commercially available seed variety of rice. They have not planted the saline–tolerant varieties like Salinas, because, according to them, these varieties are not readily available in the market.

They usually use urea and complete (14-14-14) fertilizer.

D. Source of Irrigation

Table 2.2 Source of Irrigation for Paddy Rice in the Coastal Municipalities

Source of Irrigation for Paddy Rice	%
National Irrigation Administration	4.5
Rainfed	13.6
Deepwell	13.6
Open Source Pump	31.8
Shallow Tubewell	36.4

Based on the 29 farmer respondents, 36.4% of the farmer respondents' source of irrigation for paddy rice is the shallow tubewell, followed by the open source pump at 31.8%. Nearby rivers and creeks where they pump irrigation water tend to overflow during heavy rains. These rivers are mostly connected to Pampanga River and Manila Bay.

E. Period of Salinity Occurrence and Practices to Address Salinity

During dry months of November to April, surface accumulation of salts increases in saline affected areas. While during rainy months, salts start to leach into lower depths. However, there are cases where salt water from Manila Bay flow over to Pampanga River and its tributaries which are the main sources of their irrigation.

Most of the farmer respondents' practice is to manage one cropping of rice during the rainy season to address soil salinity. They sometimes plant mungo as a second crop or let their farm fallow. Another practice is the rice-fish system. It is an integrated rice field/pond complex where fish are grown concurrently or alternately with rice. Rice-fish system allows the production of fish and other aquatic animals from the same rice field area generally without causing reductions in rice yields.

The rice-fish system is acknowledged by the International Rice Research Institute (IRRI) as a management practice to address flooding and salinity in rice fields. However, there are some considerations in this practice. First, water control is crucial and rice fields cannot be allowed to dry up while fish stocks are present. Second, stocked fish may escape if fields flood. Flood control can be difficult in rainfed rice systems. Third, areas of rice fields deepened for fish culture may result in less rice growing area. Lastly, having fish present may help dissuade farmers from using pesticides. Pesticides have the potential for poisoning fish and some types can be absorbed by the fish and then ingested by humans.

Figure 2.2 Auger Boring and Soil Sampling

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 of this project are classified using Table 3.2 below, based on the BSWM/FAO Saliniy 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 Electrical Conductivity (EC) of Soil Samples at Different Depths

No.	Barangay	Municipality	EC (mS/cm) @0-30cm	EC (mS/cm) @30-60cm	EC (mS/cm) @60-90cm
PL1	Sta. Cruz	Lubao	6.956	4.659	3.572
PL2	Sta. Cruz	Lubao	8.706	3.8	2.846
PL3	Calangain	Lubao	2.862	0.874	0.582
PL4	Balantacan	Lubao	1.037	0.261	0.38
PL5	Balantacan	Lubao	14.11	11.15	7.565
PL6	Remedios	Lubao	5.006	1.713	1.461
PL7	San Rafael Baruya	Lubao	6.14	4.267	5.284
PL8	Baruya	Lubao	12.17	3.812	1.776
PL9	Prado Sioco	Lubao	30.59	30.59	30.59
PL10	Calangain	Lubao	16.93	16.93	16.93
PL11	Sta. Catalina	Lubao	19.69	19.69	19.69
PS12	San Pedro	Sasmuan	27.1	27.1	27.1
PS13	Malusac	Sasmuan	32.35	32.35	32.35
PS14	Sebitanan	Sasmuan	27.3	27.3	27.3
PG15	San Agustin, Betis	Guagua	2.846	7.565	1.786
PG16	San Agustin, Betis	Guagua	11.28	11.28	11.28
PG17	Sta. Ines, Betis	Guagua	7.512	4.267	2.772
PG18	Sta. Ines, Betis	Guagua	4.213	3.312	2.497
PG19	San Juan Nepomuceno	Guagua	6.186	3.638	2.888
PG20	San Juan Nepomuceno	Guagua	1.732	1.066	2.725
PG21	Pulong Masle	Guagua	0.792	0.247	0.222
PB22	San Vicente	Bacolor	2.831	1.985	2.33
PB23	San Antonio	Bacolor	2.03	2.003	1.854
PMi24	Lourdes	Minalin	2.649	1.304	1.153
PMi25	San Isidro	Minalin	3.108	2.611	2.478
PMi26	Sta. Maria	Minalin	2.665	2.221	2.171
PA27	Sampaloc	Apalit	4.827	2.919	3.045
PA28	Colgante	Apalit	1.374	0.779	0.599
PA29	Capalangan	Apalit	0.652	0.288	0.266
PMc30	Kadwang Tete	Macabebe	4.077	2.054	2.218
PMs31	San Pedro	Masantol	14.61	14.61	14.61

Note: refer to Table 3.1 Salinity Classification

Table 3.2 shows the laboratory EC test results of soil samples per coastal municipality. Each EC readings are further classified using Table 3.1. The municipalities of Lubao and Sasmuan have very severely saline soil. These areas, which are fishponds and rice-fish farms, are very hazardous for crop growth. Other municipalities with fishponds and have severely saline soils are Guagua and Masantol. These areas have high hazard for crop growth and only a few tolerant crops with shallow root system will yield satisfactorily. Some areas in Lubao, Guagua, Apalit and Macabebe show moderately saline soil, which is moderately hazardous for crop growth that will result to restricted yield of many crops. Most of the soil samples are non saline to slightly saline.

Soil Salinity Maps are produced at three different depths (0-30 cm, 30-60 cm and 60-90 cm). These maps interpret the land area per municipality at different degree of salinity, as shown in Tables 3.3 – 3.5.

Based on Table 3.3, the greatest area with severely saline soil is Lubao (6,201.6 hectares), followed by Masantol (5,179.98 hectares) for 0-30cm depth.

Based on Tables 3.4 – 3.5, the same municipalities have the greatest area for severely saline soil. These areas should be given attention by planners because other areas, specially rice areas, may be affected during flooding.

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

Coastal Municipality	Non Saline	Slightly Saline	Moderately Saline	Severely Saline	Very Severely Saline
1. Apalit	1,550.55	3,909.37	302.73		
2. Bacolor	912.89	2,139.88	665.08		
3. Guagua	622.93	784.76	1,046.18	613.30	136.26
4. Lubao	109.20	1,632.44	3,783.08	6,201.60	4,754.43
5. Macabebe		248.67	1,279.04	3,768.78	3,734.48
6. Masantol			1.98	5,179.98	1,583.29
7. Minalin		2,185.26	931.85	1,575.51	513.05
8. Sasmuan				456.93	3,554.94
TOTAL	**3,195.58**	**10,900.37**	**8,009.92**	**17,796.11**	**14,276.45**

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

Coastal Municipality	Non Saline	Slightly Saline	Moderately Saline	Severely Saline	Very Severely Saline
1. Apalit	4,715.06	1,047.58			
2. Bacolor	1,612.96	2,016.26	88.63		
3. Guagua	883.49	738.20	785.72	629.51	166.52
4. Lubao	1,472.83	1,709.87	3,536.14	7,015.14	2,746.78
5. Macabebe	58.89	450.85	1,301.82	3,568.02	3,651.38
6. Masantol			62.29	5,231.69	1,471.27
7. Minalin	298.42	2,213.37	843.28	1,391.26	459.34
8. Sasmuan				544.74	3,467.13
TOTAL	**9,041.66**	**8,176.13**	**6,617.87**	**18,380.37**	**11,962.42**

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

Coastal Municipality	Non Saline	Slightly Saline	Moderately Saline	Severely Saline	Very Severely Saline
1. Apalit	4,595.69	1,166.95			
2. Bacolor	1,560.88	2,116.08	40.89		
3. Guagua	598.91	1,066.63	836.57	569.21	132.12
4. Lubao	1,922.50	1,069.58	4,108.64	6,823.23	2,556.80
5. Macabebe	70.27	445.09	1,284.77	3,588.44	3,642.40
6. Masantol			60.02	5,234.12	1,471.11
7. Minalin	367.54	2,252.36	825.43	1,339.28	421.07
8. Sasmuan				547.39	3,464.48
TOTAL	**9,115.78**	**8,116.69**	**7,156.33**	**18,101.67**	**11,687.97**

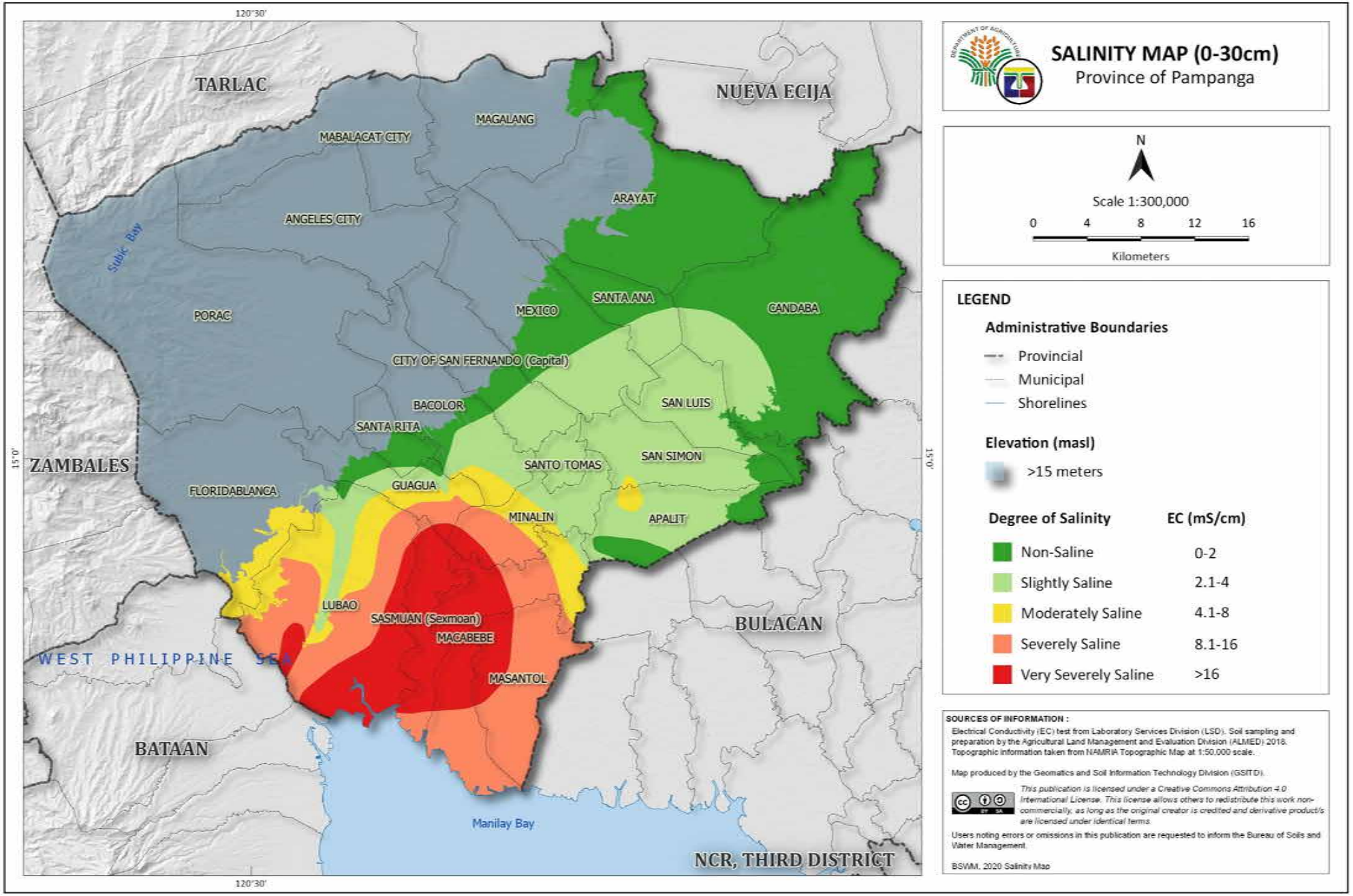
Table 3.6 Distribution of Coastal Land Area at Different Degree of Salinity, Pampanga

Salinity Class	Soil Depth (cm)					
	0-30		30-60		60-90	
	hectares	%	hectares	%	hectares	%
Non saline	3,195.58	5.9	9,041.66	16.7	9,115.78	16.8
Slightly saline	10,900.37	20.1	8,176.13	15.1	8,116.69	15.0
Moderately saline	8,009.92	14.8	6,617.87	12.2	7,156.33	13.2
Severely saline	17,796.11	32.8	18,380.37	33.9	18,101.67	33.4
Very Severely saline	14,276.45	26.4	11,962.42	22.1	11,687.97	21.6
TOTAL	**54,178.44**	**100**	**54,178.44**	**100**	**54,178.44**	**100**

Table 3.6 summarizes the total coastal land area of Pampanga per degree of salinity. It can be observed that around 30% of the coastal area in Pampanga is severely saline (almost 18,000hectares), while 26.4% (more than 14,000 hectares) are very severely saline.

B. Output Maps

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



SALINITY MAP (0-30cm)

Province of Pampanga

N

Scale 1:300,000

0 4 8 12 16

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

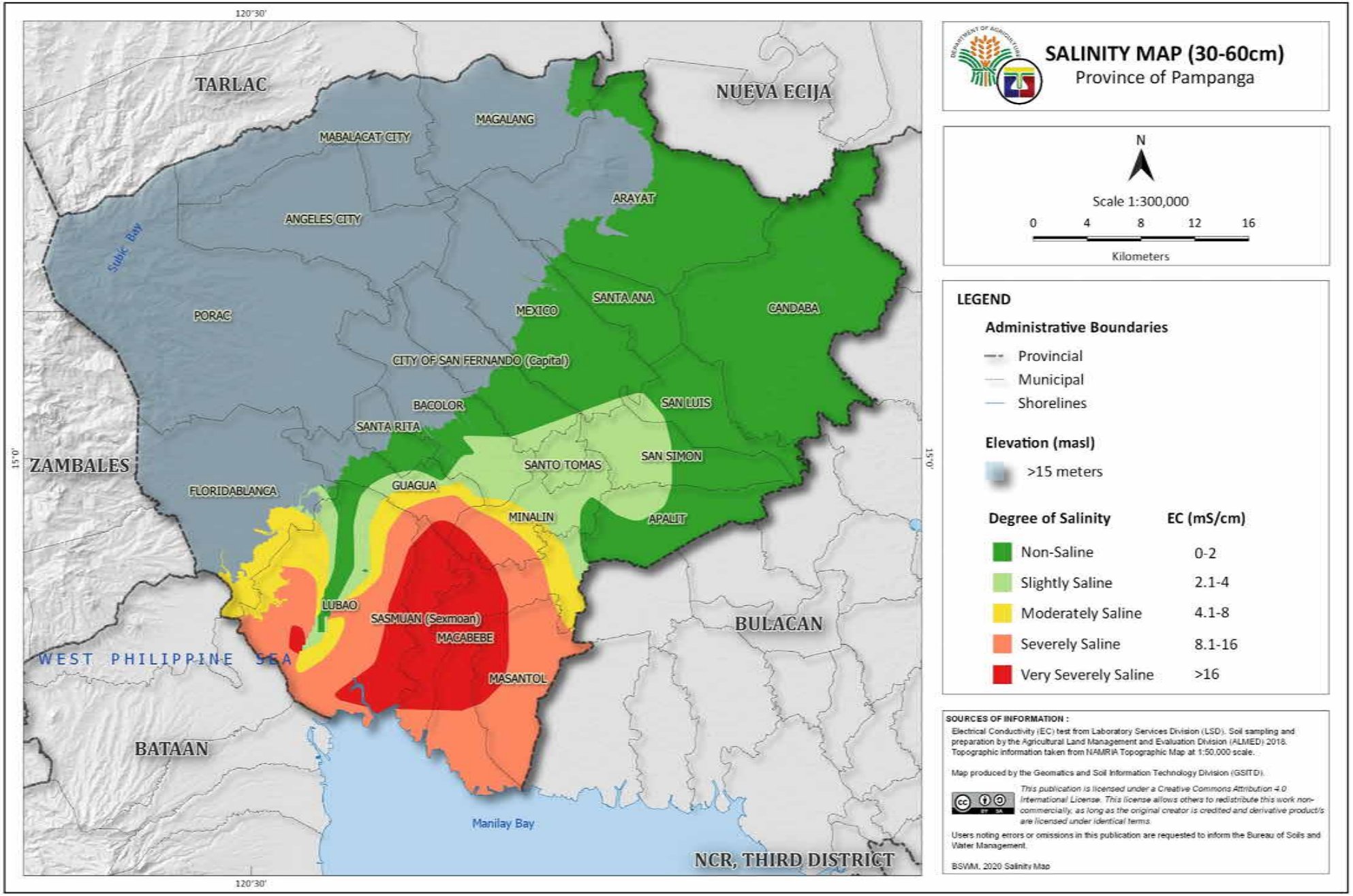
SOURCES OF INFORMATION :

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 Pampanga

N

Scale 1:300,000

0 4 8 12 16

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
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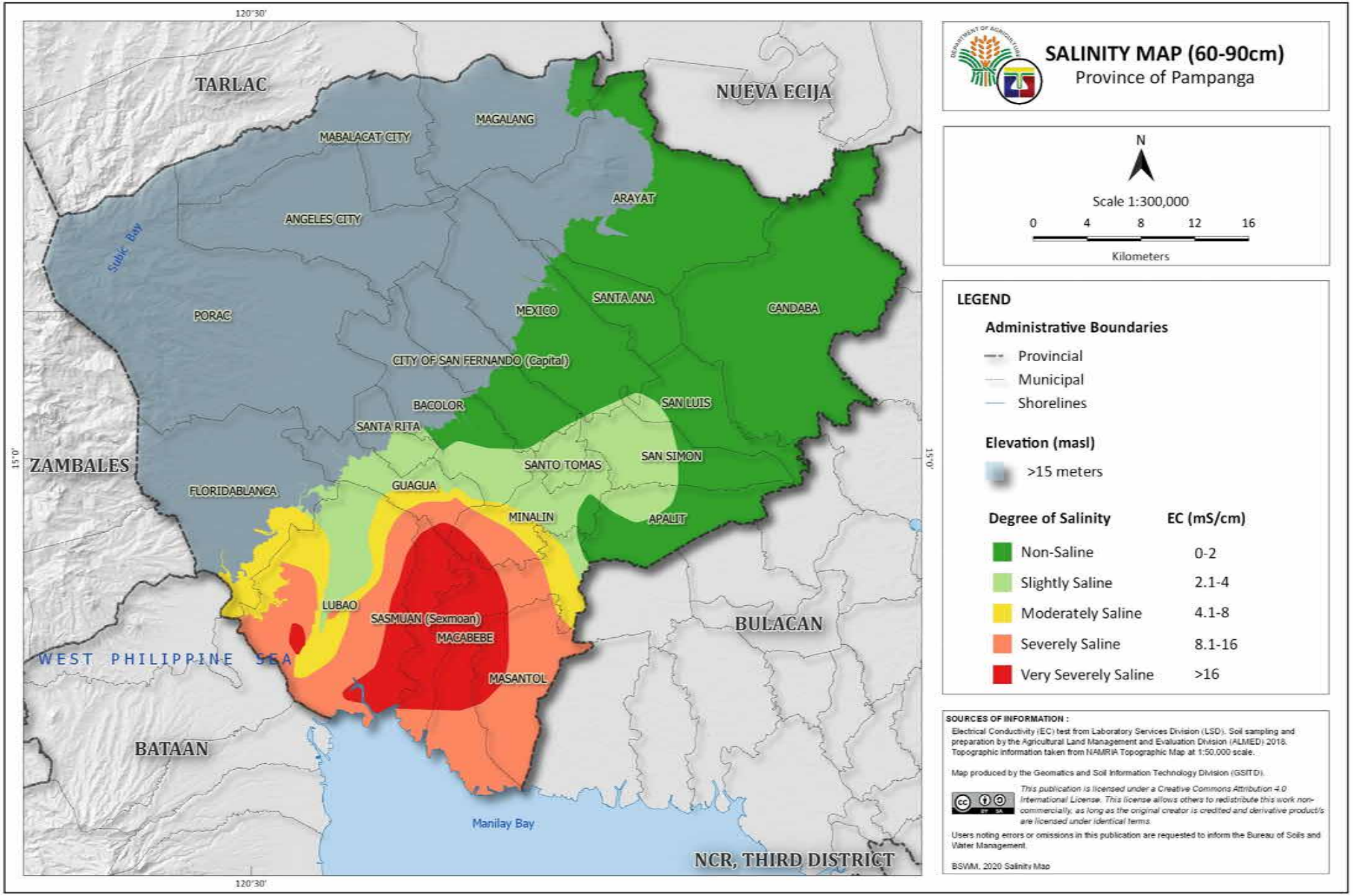

SALINITY MAP (60-90cm)

Province of Pampanga

N

Scale 1:300,000

0 4 8 12 16

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
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BSWM, 2020 Salinity Map

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