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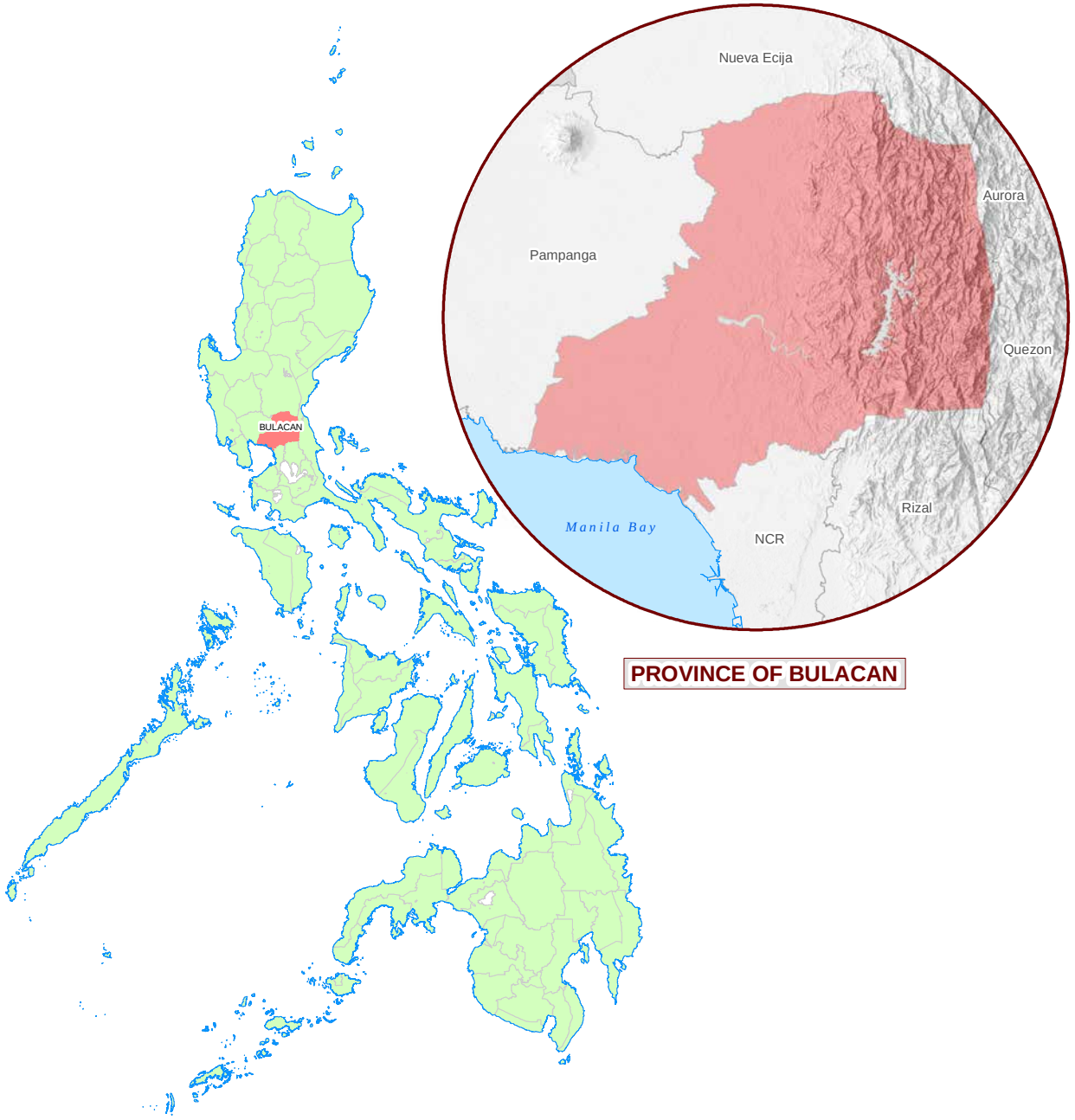
AGRICULTURAL LAND MANAGEMENT AND EVALUATION DIVISION

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



PROVINCE OF BULACAN

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 results to a total crop failure (BSWM, 1999). 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.

BULACAN

I. SOIL/LAND PHYSICAL CHARACTERISTICS

A. General Description of Saline Affected Site

Bulacan covers a total area of 2,796.10 square kilometres occupying the southeastern section of Central Luzon region. The province is bounded by Nueva Ecija on the north, Aurora (Dingalan) on the northeast, Quezon (General Nakar) on the east, Rizal (Rodriguez) on the southeast, Metro Manila on the south, Manila Bay on the southwest, and Pampanga on the west.

The largest river in Bulacan is the Angat River that passes through the towns of Norzagaray, Angat, Bustos, San Rafael, Baliwag, Plaridel, Pulilan, and Calumpit.

There are twelve (12) coastal municipalities susceptible to salinity, hence the thirty five (35) soil sampling sites are summarized as follows:

Table 1.1. Coastal Areas and Municipalities in Bulacan

No.	Municipality	No. of Barangay	No. of Sampling Sites	No. of Soil Samples Collected
1	Balagtas	9	3	9
2	Baliuag	27	1	3
3	Bocaue	19	4	12
4	Bulakan	14	3	9
5	Calumpit	29	5	15
6	Hagonoy	26	3	9
7	Malolos City	26	5	15
8	Marilao	16	1	3
9	Meycauayan City	26	1	3
10	Pandi	22	3	9
11	Paombong	14	5	15
12	Pulilan	19	1	3
	TOTAL	247	35	105

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.

There are seven (7) lowland LMUs considered within in the coverage area of 0-15 masl elevation as presented in Table 1.2.

Table 1.2 Land Management Units

LMU	Description	Municipality
01 Active tidal flats (Developed fishponds)	It comprises the low-lying areas along the coastal landscape. It is submerged or under water and often affected by high tide. This unit is formerly mangrove areas and former old tidal flat converted to fishponds formed from materials deposited by the rivers and ocean waters and occur on flat coastal areas	Paombong Hagonoy Malolos City
02 Active tidal flats (Mangrove/ Nipa)	This unit is basically similar with LMU 01 except for the covers, which are mangrove trees (bakawan and nipa) wherein this mangroves serve as buffer zone to protect the marine ecosystem from excessive siltation while shielding the land from tidal wave especially during the typhoon months. It also serves as the breeding place of some marine animals.	Paombong, Balagtas
09 Broad Alluvial Plain	The broad alluvial plain is generally an extensive continental plain whose width is no less than 500 meters and located on level to nearly level (0 to 3 percent slope) areas. It is formed through the deposition and accumulation of various materials such as gravels, sand, silt and clay from higher landscape brought about by the process of siltation by erosion and water.	Paombong Calumpit Malolos City Bulakan Bocaue Balagtas Baliuag Pandi
10 Former old tidal flat	The former old tidal flat occurs on the slightly elevated portion of the coastal landscape and has a level to nearly level topography (0-3 percent slope). It is developed from fluvio-marine deposits and affected by tidal flooding during high tide and saline intrusions during summer.	Paombong Hagonoy Malolos City Bocaue
13 Upper river terrace	These are elevated plain higher than the lower river terrace above the level of active flood plains. River terrace are bench-like landforms naturally curved by rivers along their winding course and it consists of a plain and accompanying escarpment of a more elevated land or the true valley wall which are seasonally flood prone areas.	Malolos City Bulakan
17 Infilled valleys	Upland alluvial plain surrounded by upland /highland or depression areas with less than 500 meters wide and slightly sloping areas sometimes referred to as enclosed valleys.	Meycauayan City
27 Lower piedmont plain	Nearly level to gently sloping, with slope ranging from 3 to 8 percent and located below the upper foot slope or piedmont.	Marilao Pandi

C. Flooding

Seasonal flooding occurrence was experienced by farmers with farms situated in naturally low lying areas in Bulacan. Floods are usually caused by surface runoff, dam and rivers overflow brought by heavy rainfall and high tides, and in some areas drainage facilities are heavily silted. These municipalities are Paombong, Hagonoy and Calumpit. Other farms experienced waterlogging particularly in Barangays Sta. Lucia and Panducot in Calumpit; Barangay Pinalagdan in Paombong; Barangay San Isidro in Hagonoy; and Barangay Bambang in Bocaue.

D. Elevation

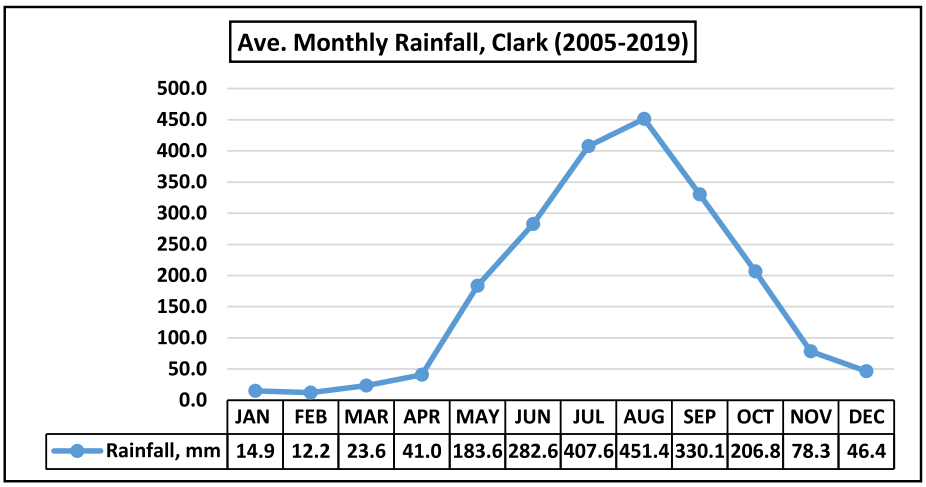
The elevation of a geographic location is the height above sea level (meters above sea level). Since the coastal areas are in the lowland pedo-ecological zone, soil sampling points are taken from the following elevations that ranges from 0-5masl, 5-10masl and 10-15masl. However in some cases, soil sampling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

E. Agro-Climate

Majority of the western portion of Bulacan are experiencing Type I climate, characterized by two pronounced seasons: dry during November to April, and wet for the rest of the year. While a small portion of the eastern side of the province are experiencing Type III climate, characterized by more or less even distribution of rainfall throughout the year.

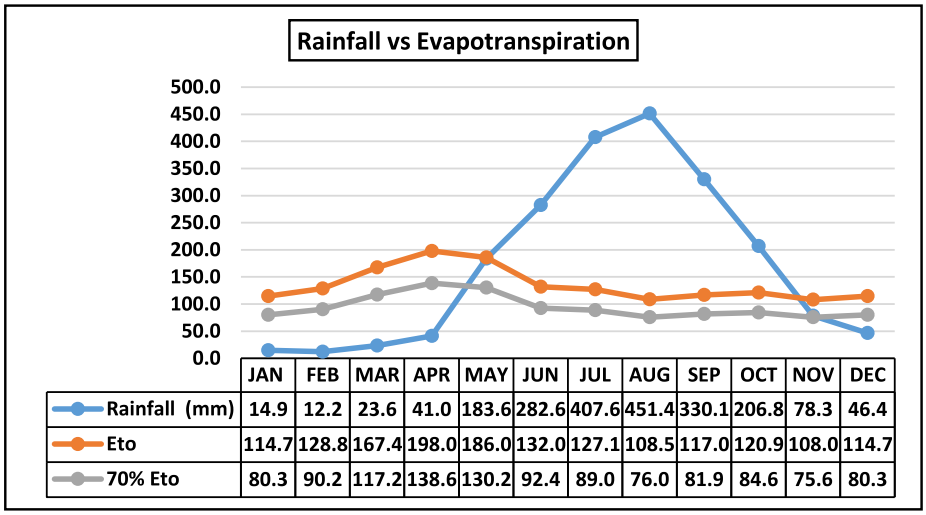
Since there are no available historical data of rainfall in Bulacan Province, this study used data from the nearest PAGASA station (Clark, Pampanga) as shown in Figure 1.1. The average monthly rainfall pattern shows that June to September have the highest amount of rainfall. Dry months are from November to April.

Figure 1.1 Average Monthly Rainfall Amount



	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

Figure 1.2 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

Evapotranspiration 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.

Figure 1.2 is the comparison of average rainfall and evapotranspiration. Rainfall is higher than the potential evapotranspiration (Eto) in the months of May to October. This means that soil moisture is sufficient to support crop cultivation, while for the months of November to April, sufficient irrigation is needed.

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 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 Bulacan 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 Bulacan Sampling Sites.

Municipality	Land Use/Vegetation	Some indicators of Salinity
Balagtas	Paddy rice irrigated	Aster weeds, mangrove/nipa
Bocaue	Paddy rice irrigated and non irrigated	Aster weeds
Bulakan	Paddy rice irrigated	Poor production, empty panicle, reddish/yellowish leaves
Calumpit	Paddy rice irrigated, fishpond	Poor production, white crust on soil surface, wilting, low yield, empty panicle, reddish leaves, stunted growth, water lily
Hagonoy	fishpond (prawn, bangus,tilapia)	Aster weeds, stunted growth
Malolos City	Paddy rice irrigated, fishpond	Poor production, beard grass, reddish/yellowish leaves
Marilao	Paddy rice non irrigated	
Meycauayan City	Paddy rice non irrigated, fishpond	
Pandi	Paddy rice irrigated, vegetables	Poor production
Paombong	Paddy rice irrigated, fishpond (prawn, bangus,tilapia)	Mangrove/nipa, poor production, beard grass, wilting, low yield, stunted growth, empty panicle, reddish leaves, "Inata"
Pulilan	Paddy rice irrigated, corn, vegetables	Poor production, white crust on soil surface, wilting, low yield, empty panicle, reddish leaves, stunted growth

Figure 1.3 Coordination meetings

II. CROP PRODUCTION ON SALINE AFFECTED AREAS

A. Key Informant Profile

Based on the 45 farmer respondents, the average age of farmers is 57, wherein the youngest and oldest is 38 and 78 years old, respectively. Their average years of farming experience is 38.

The ratio of female to male is 1:4, wherein 59% of the farmer respondents are owners of the farm. The average crop area for rice is 2.04 hectares.

Figure 2.1 Key Informant Interviews

B. Farm Production

The seasonal crops in Bulacan that contribute to agricultural productivity are rice (irrigated and non-irrigated), corn, turnips, squash, tomato and other vegetables in small plots.

Majority of the farmer respondents are engaged in rice-rice cropping pattern, while there are few who planted vegetables after rice usually on the second cropping or dry season. In areas affected by severe salinity, the cropping pattern is PRI - fallow or PRI – fishpond.

Table 2.1 shows the average rice yield for CY 2016-2017 per municipality, based on the key informant interview.

Table 2.1 Rice Production in Coastal Municipalities of Bulacan

Municipality	Average Rice Yield (kg/ha)			
	1st Cropping 2016	2nd Cropping 2016	1st Cropping 2017	2nd Cropping 2017
Balagtas	3,833	4,500	4,333	4,750
Bocaue	4,675	2,967	4,842.75	2,967
Bulakan	3,388	4,204	4,097	4,267
Calumpit		3,287	3,270	3,617
Hagonoy	3,000	3,400	4,000	2,800
Malolos City	4,175	3,588	5,400	3,675
Meycauayan City	3000		2200	
Paombong	2,630		2,557	
Pulilan	3,600		3,600	

*Based on the key informant interview, rice yield for CY 2016-2017

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 interview.

In terms of rice variety, majority of the farmers prefer NSIC Rc (Tubigan) series (112, 152, 160, 216, 218, 308) and inbred (400, 402) varieties because of its good eating quality. While other farmers used PSB Rc 20, SL8 and traditional variety “Wagwag".

Most commonly used insecticides are Brodan, Tribon, Cymbush, and Karate. Weedicides commonly used by farmer respondents are Machete, Nominee, Sofit, and 2-4D.

D. Source of Irrigation

Agricultural areas in Bulacan are provided with irrigation water supplied by the National Irrigation Administration (NIA) from Angat Dam. However, due to major rehabilitation in Pulilan, NIA temporarily stopped the operation, and affects majority of the rice farms in 2017. That is why most of the farmers resorted to pumping water from adjacent rivers.

Table 2.2 below shows that the majority of the farmer respondents (53%) pump water from nearby river and creeks. NIA assisted is 38% and rainfed is only 9%.

Table 2.2 Source of Irrigation for Paddy Rice

Source of Irrigation for Paddy Rice	%
National Irrigation Administration	38
Pumped from Rivers and creeks	53
Rainfed	9

E. Period of Salinity Occurrence and Practices to Address Salinity

Based on the farmer's interview, salinity occurs during the dry months of February to May. Some of them are willing to adopt to other suitable crop considering salinity, like watermelon, squash, okra, eggplant, chives and kangkong. According to them, these crops require less water and more income. While other farmers convert their farms into fishponds during wet season.

Most of the farmer-respondents' practices to address salinity are the following: 1) apply chicken dung after harvest as fertilizer, 2) adjust the planting schedule, 3) pump out stagnant water before land preparation, 4) observe river water before pumping for irrigation and 5) the Local Government of Bulacan installed check gates or "prensa" on strategic areas to control/minimize the entry of salt water on river systems.

Figure 2.2 Auger boring, soil sampling and characterization

Figure 2.3 Air drying, pulverizing and packaging of soil samples

III. SOIL CHEMICAL CHARACTERISTICS

Soil samples 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 below, based from 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 above. The Municipalities of Paombong, Hagonoy, Malolos, and Bocaue have severely saline soil @0-30cm depth. At 30-60cm and 60-90cm depths, Paombong, Hagonoy, and Malolos also have severely saline soil. These areas are hazardous to crop growth and only a few tolerant crops with shallow root system will yield satisfactorily.

Barangay Sto. Rosario in Paombong; San Isidro in Hagonoy; Barangays Sta Lucia and Panducot in Calumpit; Bambang,Bocaue; and San Juan, Balagtas show moderately saline soil at different depths. This means the soil is moderately hazardous to crop growth and will result to restricted yield on many crops. Generally, most of the soil samples are non saline.

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

Ref. No.	Barangay	Municipality	EC (mS/cm) @0-30cm	EC (mS/cm) @30-60cm	EC (mS/cm) @60-90cm
1	Sto. Rosario	Paombong	14.100	4.451	5.984
2	Pinalagdan	Paombong	0.943	1.059	1.364
3	Pinalagdan	Paombong	15.040	9.614	8.741
4	Kapitangan	Paombong	2.562	3.871	8.278
5	San Miguel	Hagonoy	12.440	8.203	9.629
6	San Isidro	Hagonoy	5.587	3.104	6.578
7	Iba-Ibayo	Hagonoy	1.315	1.217	1.227
8	San Miguel	Calumpit	3.152	1.726	1.581
9	Santa Lucia	Calumpit	5.756	3.448	3.009
10	Panducot	Calumpit	5.011	2.915	3.014
11	Iba O' Este	Calumpit	2.658	1.901	1.941
12	Mambog	Malolos	13.880	12.250	8.921
13	Balite	Malolos	2.500	2.690	2.109
14	Balayong	Malolos	0.648	0.337	0.245
15	Dakila	Malolos	0.476	0.305	0.272
16	Bambang	Bulakan	2.418	0.602	0.602
17	Bagumbayan	Bulakan	0.590	1.156	0.507
18	San Francisco	Bulakan	0.584	0.242	0.179
19	Igulot	Bocaue	0.829	0.528	0.170
20	Duhat	Bocaue	0.303	0.029	0.036
21	Tambubong	Bocaue	0.743	0.600	0.557
22	Bambang	Bocaue	10.460	7.651	6.518
23	Longos	Balagtas	2.716	1.039	0.877
24	San Juan	Balagtas	4.683	1.984	2.039
25	Pulong Gubat	Balagtas	0.360	0.164	0.201
26	Pinagbakahan	Malolos	0.884	0.733	0.441
27	Kapitangan	Paombong	0.484	0.343	0.264
28	Lawa (Caingin	Meycauyan	0.203	0.201	0.220
29	Calantipay	Baliuag	0.169	0.117	0.139
30	Taal	Pulilan	0.386	0.781	0.706
31	Pungo	Calumpit	0.806	0.829	0.496
32	Malibong Bata	Pandi	1.440	0.694	0.648
33	Malibong	Pandi	0.548	0.419	0.216
34	Sto. Niño	Pandi	0.361	0.507	0.509
35	Prenza II	Marilao	0.179	0.162	0.108

]

Soil Salinity Maps at three different depths (0-30cm, 30-60cm, and 60-90cm) are delineated using the corresponding Electrical Conductivity (EC) readings, then interpolation is used to estimate the soil salinity at unsampled locations to create a continuous representation. Tables 3.3-3.5 interpret the land area in hectares per municipality at different degrees of salinity.

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
Balagtas	1,004.40	746.30	398.38		
Baliuag	4,502.99				
Bocaue	784.13	703.71	888.65	154.75	
Bulakan	749.22	5,507.17	981.06		
Bustos	1,662.83				
Calumpit	443.54	2,550.62	1,688.92		
Guiguinto	1,055.99	1,176.88			
Hagonoy	48.59	231.47	7,621.06	444.07	
Malolos City	1,455.91	2,720.68	2,638.01	273.25	
Marilao	756.20	851.90	155.53		
Meycauayan City	1,273.01	638.95	137.19		
Obando	319.74	1,301.76			
Pandi	2,045.13				
Paombong	22.11	88.65	3,869.40	551.16	
Plaridel	2,793.56	782.53			
Pulilan	3,963.37	303.44			
San Ildefonso	3,101.57				
San Miguel	5,451.62				
San Rafael	2,141.04				
Santa Maria	1,577.29	24.10			
TOTAL	**35,152.24**	**17,628.18**	**18,378.21**	**1,423.23**	

Table 3.3 shows the land area (in hectares) affected by salinity for 0-30cm depth. Severely saline is 1,423.23 hectares, mostly in Paombong and Hagonoy. Moderately saline is 18,378.21 hectares, mostly in Hagonoy, Paombong and Malolos City. These areas are moderately to highly hazardous to crop growth, and only a few tolerant crops can yield satisfactorily.

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
Balagtas	1,952.33	193.21	3.53		
Baliuag	4,502.99				
Bocaue	1,364.13	647.97	519.15		
Bulakan	4,535.18	2,486.61	215.66		
Bustos	1,662.83				
Calumpit	1,191.83	3,490.73	0.54		
Guiguinto	2,063.74	169.14			
Hagonoy	103.00	5,033.39	3,185.12	23.67	
Malolos City	2,167.67	4,206.90	531.05	182.24	
Marilao	1,253.09	504.16	6.38		
Meycauayan	1,400.68	648.47			
Obando	1,145.54	475.96			
Pandi	2,045.13				
Paombong	36.65	3,850.68	627.47	16.54	
Plaridel	3,576.09				
Pulilan	4,266.82				
San Ildefonso	3,101.57				
San Miguel	5,451.62				
San Rafael	2,141.04				
Santa Maria	1,601.39				
TOTAL	**45,563.30**	**21,707.22**	**5,088.90**	**222.44**	

On Table 3.4 at 30-60cm depth, the coastal land area affected by salinity is lower compared to Table 3.3 coastal land area at 0-30cm depth. Severely saline area is 222.44 hectares, mostly in Malolos City. Moderately saline is 5,088.90 hectares, mostly in Hagonoy. These areas are moderately hazardous to crop growth.

Table 3.5 shows the coastal land area at 60-90 cm depth, and it is higher (11,378.02 hectares) for moderately saline soil, but the lowest (179.74 hectares) land area for severely saline soil.

Table 3.6 summarizes the total coastal land area of the Province of Bulacan per degree of salinity. The notable result is that at soil depth 0-30cm, 25.32% of the coastal land area is moderately affected by salinity. The same with that of the 60-90cm depth, wherein 15.67% of the coastal land area is also moderately saline. Generally, majority of the soil samples are non saline.

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

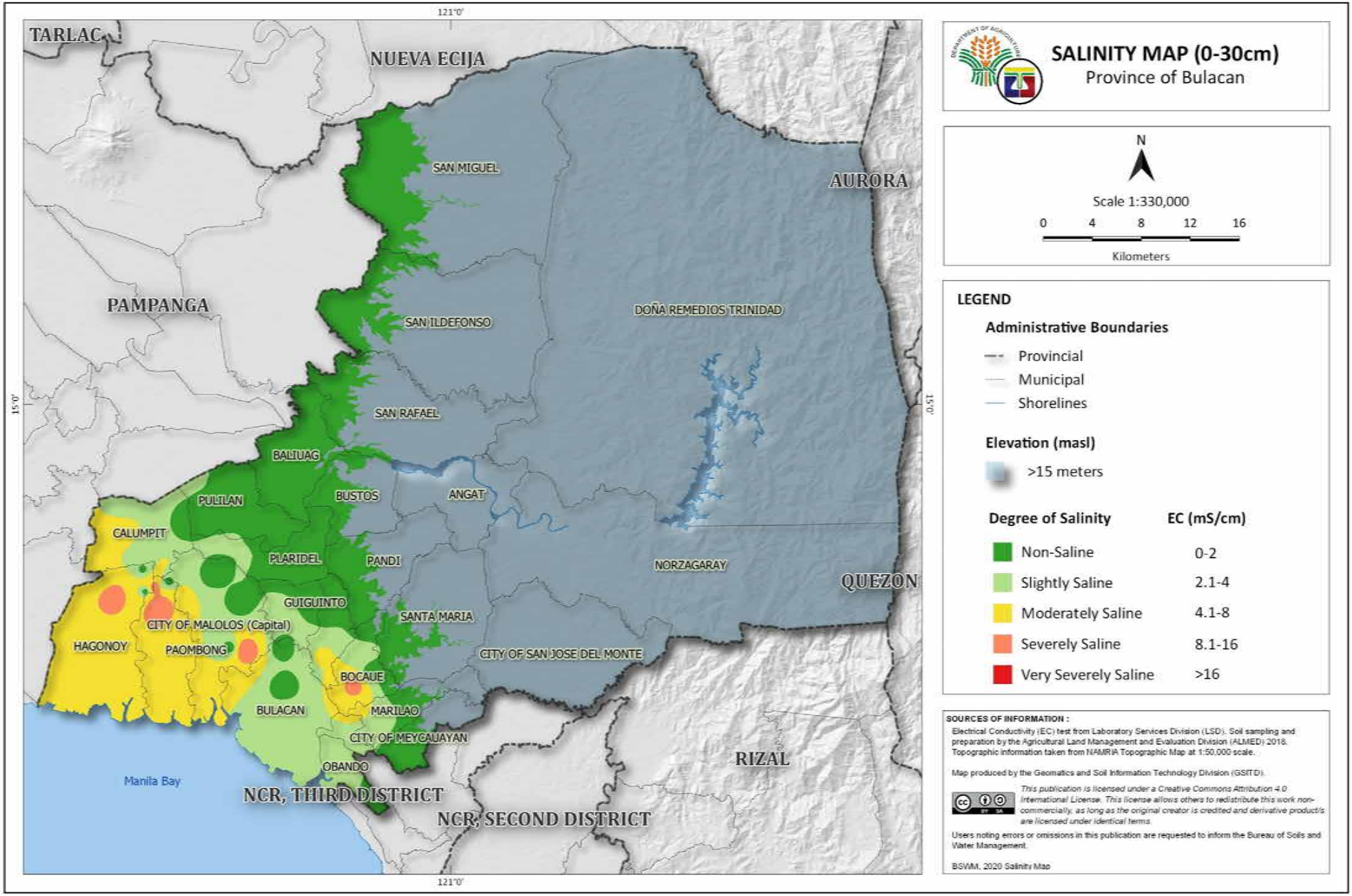
Coastal Municipality	Non Saline	Slightly Saline	Moderately Saline	Severely Saline	Very Severely Saline
Balagtas	1,974.38	174.69			
Baliuag	4,502.99				
Bocaue	1,411.83	806.13	313.29		
Bulakan	5,964.02	1,251.09	22.34		
Bustos	1,662.83				
Calumpit	1,131.15	3,506.72	45.22		
Guiguinto	2,222.21	10.67			
Hagonoy	78.04	416.67	7,743.03	107.44	
Malolos City	2,338.02	4,168.51	544.56	36.77	
Marilao	1,516.08	247.55			
Meycauayan	1,751.51	297.63			
Obando	1,621.50				
Pandi	2,045.13				
Paombong	23.18	1,763.04	2,709.58	35.53	
Plaridel	3,576.09				
Pulilan	4,266.82				
San Ildefonso	3,101.57				
San Miguel	5,451.62				
San Rafael	2,141.04				
Santa Maria	1,601.39				
TOTAL	**48,381.39**	**12,642.71**	**11,378.02**	**179.74**	

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

Salinity Class	Soil Depth (cm)					
	0-30		30-60		60-90	
	hectares	%	hectares	%	hectares	%
Non saline	35,152.24	48.43	45,563.30	62.77	48,381.39	66.66
Slightly saline	17,628.18	24.29	21,707.22	29.91	12,642.71	17.42
Moderately saline	18,378.21	25.32	5,088.90	7.01	11,378.02	15.67
Severely saline	1,423.23	1.96	222.44	0.31	179.74	0.25
Very Severely saline						
TOTAL	**72,581.86**	**100**	**72,581.86**	**100**	**72,581.86**	**100**

B. Output Maps

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



SALINITY MAP (0-30cm)

Province of Bulacan

N

Scale 1:330,000

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

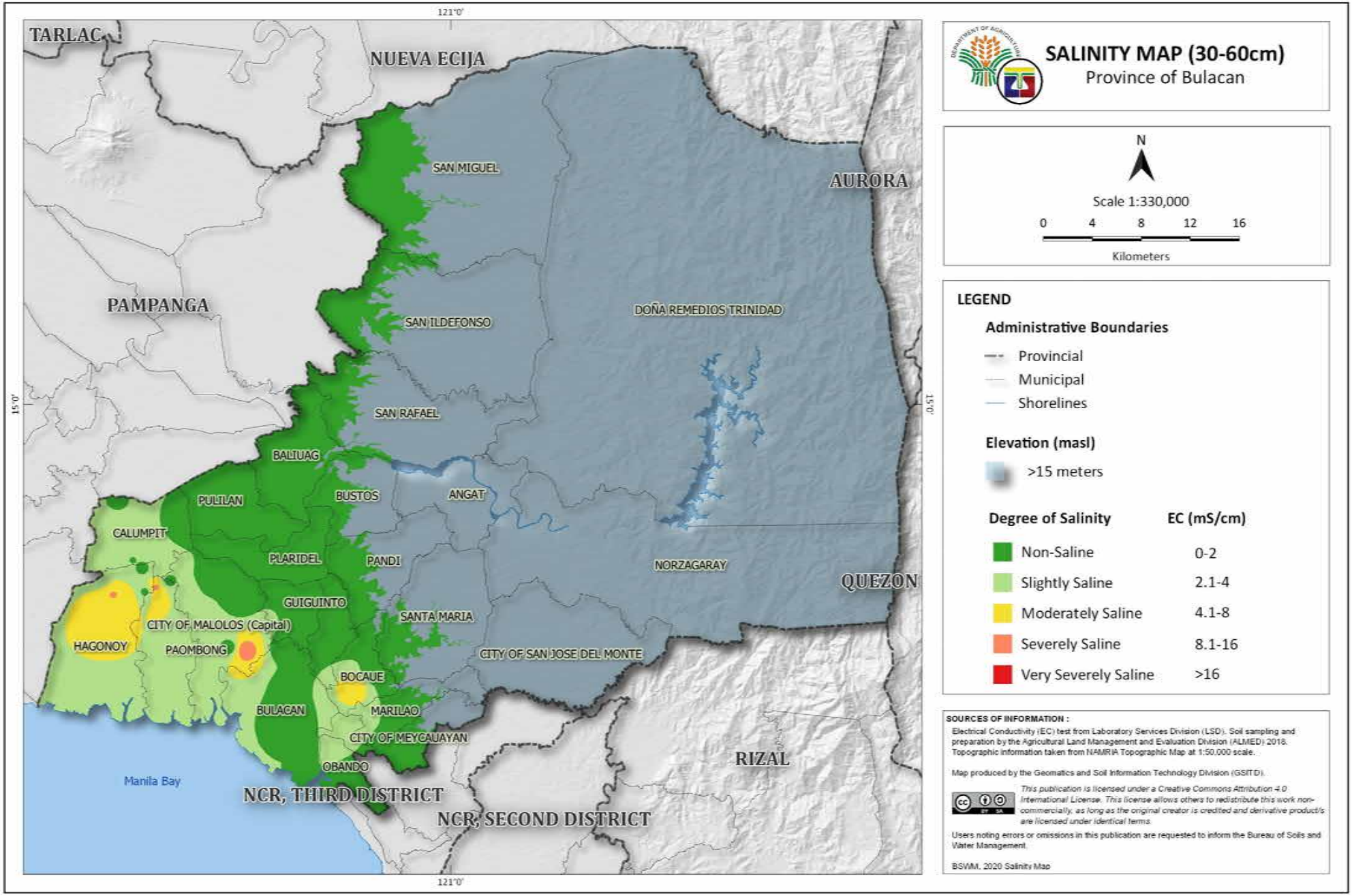
SOURCES OF INFORMATION :

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 Bulacan

N

Scale 1:330,000

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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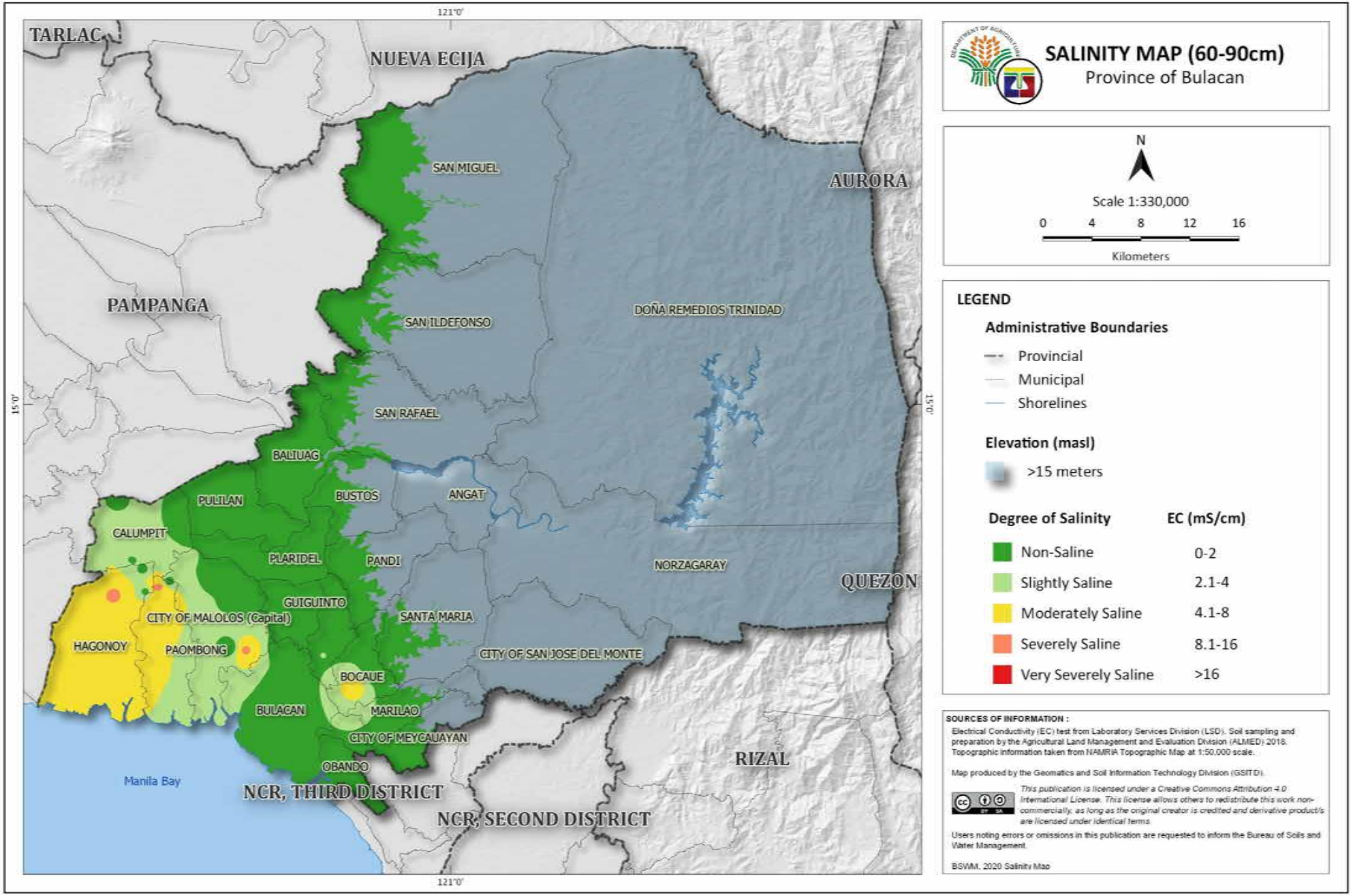
BSWM, 2020 Salinity Map



SALINITY MAP (60-90cm)

Province of Bulacan

N

Scale 1:330,000

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 :

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BSWM, 2020 Salinity Map

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References

1. The Soil Survey Manual Technical Publication No. 2, ISSN 1908- 9600, BSWM December 2008.
2. BSWM/FAO Salinity Project, 1999.
3. Rad, H.E., et al. The Effects of Salinity at Different Growth Stages on Rice Yield.
4. https://serc.carleton.edu/microbelife/research_methods/environ_sampling/pH_EC.html Water and Soil Characterization - pH and Electrical Conductivity
5. https://search.informit.com.au/documentSummary;dn=280216550175956;res=IELHSS Use of Saline Water for Weed Control in Seashore Paspalum ('Paspalum vginatum')
6. http://waterquality.montana.edu/energy/cbm/background/soil-prop.html#SalProp Effects of Salinity on Plant Growth
7. http://www.fao.org/docrep/x5871e/x5871e04.htm Saline Soils and their Management.
8. http://www.greenpeace.org/seasia/ 2007
9. www.cagayano.tripod.com
10. https://albay.gov.ph
11. https://aurora.gov.ph/about
12. https://en.wikipedia.org/wiki/Aurora_(province)
13. https://en.wikipedia.org/wiki/Albay
14. https://en.wikipedia.org/wiki/Sorsogon
15. http://www.knowledgebank.irri.org/training/fact-sheets/crop-establishment/item/rice-fish-systems-fact-sheet
17. Land Resources Evaluation Project, BSWM