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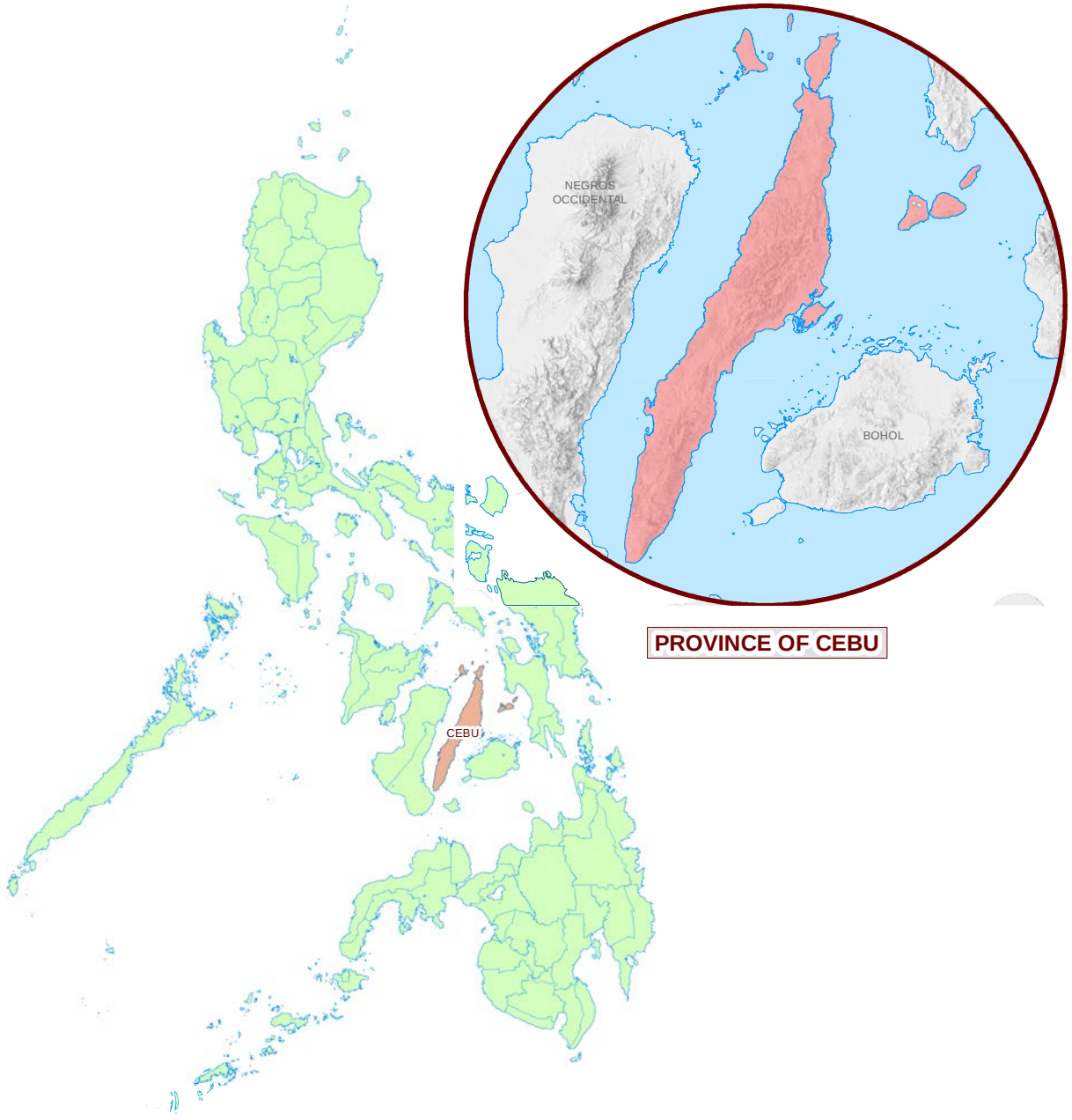
AGRICULTURAL LAND MANAGEMENT AND EVALUATION DIVISION

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



PROVINCE OF CEBU

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.

PROVINCE OF CEBU

I. SOIL/ LAND PHYSICAL CHARACTERISTICS

A. General Description of Saline Affected Site

The province of Cebu is located in the Central Visayas (Region VII) region, and consists of Cebu Island, as well as 167 smaller islands, which include Mactan, Bantayan, Malapascua, Olango and the Camotes Islands. It is approximately $10^0$19' North and $123^0$45' East. Cebu Island itself is long and narrow, stretching 196 kilometers from north to south and 32 kilometers across at its widest point. It has narrow coastlines, limestone plateaus and coastal plains. It also has rolling hills and rugged mountain ranges traversing the northern and southern lengths of the island.

There are fourteen (14) coastal municipalities susceptible to salinity, hence the sites for sampling shown in Table 1.1.

Table 1.1. Coastal Areas and Municipalities in Cebu

No.	MUNICIPALITY	No. of Barangays	No. of Sampling Sites	No. of Soil Samples
1	Argao	45	4	12
2	Asturias	27	1	3
3	Alcantara	9	1	3
4	Aloguinsan	15	1	3
5	Balamban	28	3	9
6	Barili	42	1	3
7	Carcar City	15	4	12
8	Danao City	42	1	3
9	Minglanilla	19	2	6
10	Moalboal	15	1	3
11	Pinamungajan	26	1	3
12	Sibonga	25	2	6
13	Talisay City	22	1	3
14	Toledo City	38	3	9
	TOTAL	**368**	**26**	**78**

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.

For this project, all the sampling sites are characterized as broad alluvial plain or LMU 09. It is 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 1.1 LMU 09 Broad Alluvial Plain

C. Flooding

About 85% of the total land area of Cebu is not affected by seasonal flooding because of high physiography which occupies the central area of the province. Affected by seasonal flooding are some alluvial and river terraces caused by river bank overflow. Mountains watershed with poor vegetation contributes to flash flood on lower areas especially during heavy rainfall in the months of June to December. Table 1.2 shows the flooding hazard classification in the province of Cebu based on Land Mapping Unit (LMU).

Table 1.2 Classification of Flooding Hazard in Cebu

Flooding Class	Description	LMU	Municipality
F0	No flooding observed	22- limestone/karst plains, lower terraces 23- limestone/karst plains, upper terraces 36- lower foot slopes (karstic limestone hills)	Asturias, Aloguinsan, Sibonga, Barili, Minglanilla
F1	Slight seasonal flooding due to accumulation of water runoff from higher areas with an approximate depth of 25cm. for a duration of 4 to 8 hrs. during rainy days.	09- broad alluvial plains	Asturias Balamban
F2	Moderate seasonal flooding due to creek or river bank overflow, local flash floods and accumulation of rain water to depth of 25 to 150 cm. for a duration of 1 to 2 days.	12- lower river terraces 09- broad alluvial plains	Toledo City
F3	Almost flooded throughout the year. It includes water logged areas like marshes, swamps and fishponds.	01- active tidal flats (fishpond/salt bed) 02- active tidal flats (mangrove/ nipa)	Pinamungajan, Moalboal, Danao City, Talisay, Carcar, Argao, Toledo

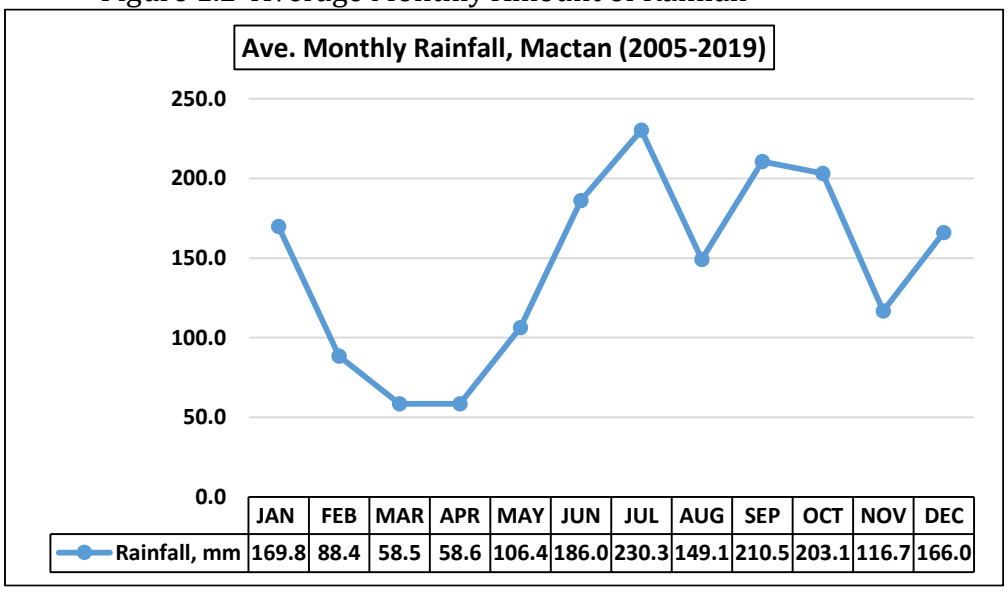
D. Elevation

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.

E. Agro-Climate

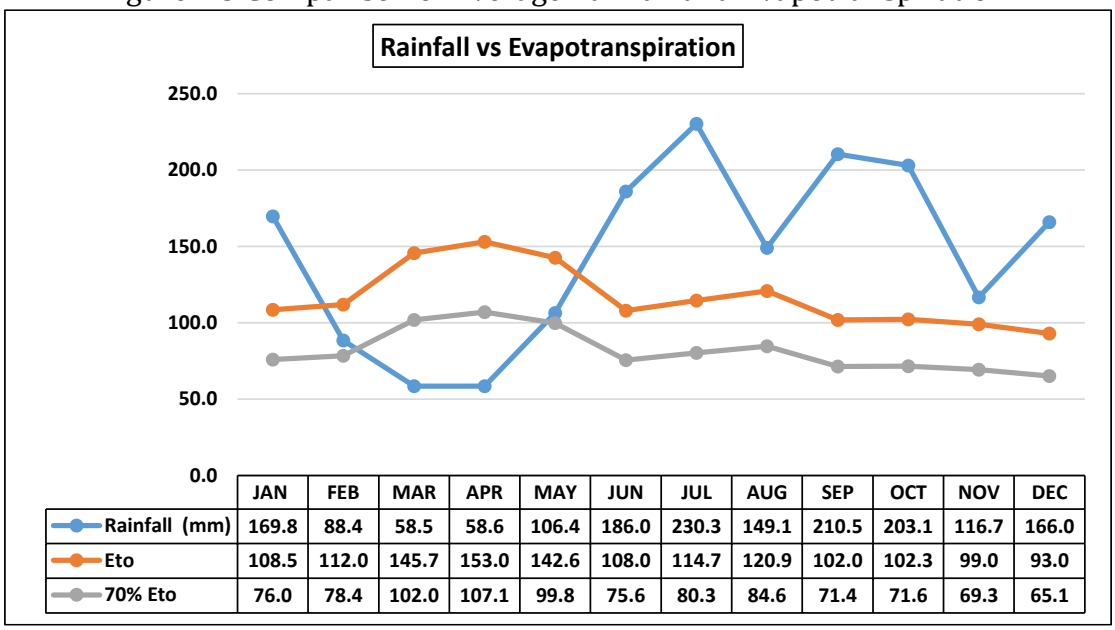
Based on the Modified Corona's Classification of Climate, the identified coastal municipalities of Cebu are under Type III Climate. The seasons are not very pronounced, relatively dry from November to May and wet for the rest of the year. Figure 1.2 shows the average monthly amount of rainfall from the PAGASA station in Mactan, Cebu.

Figure 1.2 Average Monthly Amount of Rainfall



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rainfall, mm	169.8	88.4	58.5	58.6	106.4	186.0	230.3	149.1	210.5	203.1	116.7	166.0

Figure 1.3 Comparison of Average Rainfall and Evapotranspiration



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rainfall (mm)	169.8	88.4	58.5	58.6	106.4	186.0	230.3	149.1	210.5	203.1	116.7	166.0
Eto	108.5	112.0	145.7	153.0	142.6	108.0	114.7	120.9	102.0	102.3	99.0	93.0
70% Eto	76.0	78.4	102.0	107.1	99.8	75.6	80.3	84.6	71.4	71.6	69.3	65.1

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 1.3 comparison of rainfall and evapotranspiration in Cebu, the average rainfall is relatively higher than the potential evapotranspiration from June to January. This means that soil moisture is sufficient to support crop cultivation. However, for the months of February to May, there is a need for supplemental irrigation.

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 Cebu sampling sites are presented in Table 1.3. Some indicators of salinity per municipality are also indicated in this table.

Figure 1.4 White Crust on Soil Surface at Barangay Guinsay, Danao City

Table 1.3 Land use/vegetation in Cebu sampling sites.

Municipality	Land Use/Vegetation	Some indicators of Salinity
Argao	Paddy rice	
Asturias	Paddy rice	
Alcantara	Paddy rice	Mangrove/ nipa, sedges, empty panicle, stunted growth
Aloguinsan	Paddy rice	
Balamban	Paddy rice	Reddish, yellowish leaves
Barili	Paddy rice	Wilting, reddish/yellowish leaves, stunted growth, death of palay
Carcar City	Paddy rice	Mangrove/ nipa, reddish/yellowish leaves, stunted growth. Kagang (crabs)
Danao City	Rainfed rice	White crust in soil surface, stunted growth, water lily
Minglanilla	Paddy rice	
Moalboal	Paddy rice, fish pond	Mangrove/ nipa, reddish/yellowish leaves, death of palay
Pinamungajan	Rainfed rice	Wilting, reddish/yellowish leaves, stunted growth, shells
Sibonga	Paddy rice	Stunted growth
Talisay	Paddy rice	
Toledo City	Paddy rice	Mangrove/ nipa, empty panicle, reddish/yellowish leaves, stunted growth

Figure 1.5 Presence of Water Lilies and Shells @ Danao City and Pinamungajan

II. CROP PRODUCTION ON SALINE AFFECTED AREAS

A. Key Informant Profile

Based on the 24 farmer respondents with 1:2 female-male ratio, the average age of farmers is 61. The eldest and youngest is 82 and 44 years old. Half the number of the farmer respondents are owners of their farms, and the other half are tenants. The average farm size is 1.3 hectares per farmer and their average farming experience is 31 years.

Figure 2.1 Key Informant Interview in Poblacion, Argao

B. Farm Production

The temporary/seasonal crops in the Province of Cebu that contribute to agricultural productivity are corn, rice, root crops and vegetables. While the perennial/permanent crops are coconut, banana and mango.

Table 2.1 shows the average rice yield from CY 2017-2018 per municipality, based on the key informant interviews.

Table 2.1 Rice Production in Coastal Municipalities of Cebu Province

	Coastal Municipality	Total Land Area (hectares)	Rice Area (hectares)	Ave. Yield Irrigated Paddy Rice (MT/ha)
1	Argao	19,150	222.18	4
2	Asturias	19,045	232	2.25
3	Alcantara	3,520	26	3
4	Aloguinsan	6,192		
5	Balamban	33,356	147	2.5
6	Barili	12,221	78	3.8
7	Carcar City	11,678	226	3
8	Danao City	10,730	8	2
9	Minglanilla	6,560	22	3.2
10	Moalboal	12,486	40	4
11	Pinamungajan	10,916	190.693	3
12	Sibonga	13,345	29	3.5
13	Talisay City	3,987	36	3.9
14	Toledo City	21,628	428.52	3.52
	TOTAL	**184,814**		

C. Farm Input

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

Farmers usually use commercially available seed variety of rice like Rc18, Rc 126, and hybrid seeds in the market. The municipalities of Moalboal and Carcar have started planting saline-tolerant varieties like Salinas, but its efficiency is still to be evaluated.

Urea (46-0-0) and complete (14-14-14) fertilizers are usually used by farmers, while the chemical pesticides they use are Lannate and Karate insecticides.

D. Source of Irrigation

Irrigation was an indispensable means for producing agricultural crops in Central Visayas. The common irrigation systems used by most farms in Cebu were the communal system of irrigation. Lands planted with temporary crops like rice

and corn benefited most on the irrigation facilities of the province. The other irrigation systems are from springs and water falls.

Table 2.2 below summarizes the sources of irrigation for paddy rice based on the farmer respondents. Most of the farmers 70.8% are assisted by the National Irrigation Administration (NIA), while 12.5% are rainfed. Other source of irrigation (16.7%) are from springs and falls.

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

Source of Irrigation for Paddy Rice	%
National Irrigation Administration	70.8
Rainfed	12.5
Spring/ Falls	16.7

E. Period of Salinity Occurrence and Practices to Address Salinity

Only a few of the farmer respondents (37.5%) said that salinity affects their rice farms, others are not sure because for them inadequate supply of irrigation water is the main problem. 21% of the farmer respondents consider adopting to other crops to increase their productivity, while others still want to plant rice.

Most of the farmer-respondents' practices to address salinity are the following: 1) plant Salinas variety of rice, 2) follow the rice-corn-mungo cropping pattern, 3) apply fertilizer, 4) plant at the start of the rainy season, and 5) use "tabay" or water well made of hollow blocks to stock irrigation water.

Figure 2.2 Auger Boring in Barangay Sta. Ana, Barili

Figure 2.3 Soil Sampling in Barangay Tajao, Pinamungajan

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 25^0C, Electrical Conductivity (EC) at 25^0C, 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 and 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 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 in Cebu Province per municipality. Each EC readings are further classified using Table 3.1 above. Barangay Tuyom, Carcar City at 30-60cm depth have severely saline soil. This area is high hazard for crop growth and only a few tolerant crops yield

satisfactorily. Municipalities with moderately saline soil at various depths are Carcar City, Alcantara, Argao and Sibonga. These areas is moderately hazardous to crop growth, and have restricted yield to many crops. Most of the soil samples are non saline to slightly 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
CeAs1	Owak	Asturias	1.255	0.562	0.427
CeBa2	Cantuod	Balamban	0.417	0.527	0.589
CeBa3	Nangka	Balamban	2.278	1.318	0.965
CeBa4	Buanoy	Balamban	0.647	0.761	0.692
CeDa5	Looc	Danao City	2.095	2.144	3.055
CeTo6	Mainggit (Sto. Niño)	Toledo City	0.429	0.666	0.511
CeTo7	Matab-ang	Toledo City	0.324	0.51	0.323
CeTo8	Talavera	Toledo City	1.215	0.562	0.351
CePi9	Tajao	Pinamungajan	0.847	0.618	2.174
CeAlo10	Poblacion	Aloguinsan	0.794	0.365	0.529
CeCar11	Ocaña	Carcar City	1.52	0.805	0.582
CeCar12	Bolinawan	Carcar City	4.705	2.809	5.42
CeCar13	Poblacion II	Carcar City	4.427	2.629	1.236
CeCar14	Tuyom	Carcar City	1.065	8.792	0.923
CeMo15	Tunga	Moalboal	1.01	0.894	1.076
CeAl16	Polo	Alcantara	4.519	4.621	6.703
CeBar17	Sta Ana	Barili	0.569	0.334	0.261
CeAr18	Bogo	Argao	1.013	1.391	0.42
CeAr19	Tulic	Argao	1.393	0.554	0.545
CeAr20	Poblacion	Argao	4.382	2.494	1.812
CeAr21	Langtad	Argao	0.594	0.33	0.319
CeSi22	Bagacay	Sibonga	1.019	1.01	0.581
CeSi23	Bahay	Sibonga	3.327	4.32	3.922
CeMin24	Calajo-an	Minglanilla	1.425	0.871	0.765
CeMin25	Tungkil	Minglanilla	2.933	1.475	1.068
CeTa26	Pooc	Talisay City	1.916	0.738	0.537

Soil Salinity Maps for 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 per municipality at different degrees of salinity, as shown in Tables 3.3 – 3.5.

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. Alcantara		263.01	61.32		
2. Aloguisan	508.12				
3. Argao	888.72	78.42	8.95		
4. Asturias	1,408.98				
5. Badian		644.46			
6. Balamban	2,383.58				
7. Barili	638.98				
8. Carmen	612.73				
9. Cebu City	1,479.17	517.72			
10. City of Carcar	682.11	769.32	483.32		
11. City of Naga	234.25	443.27			
12. Compostela	675.08				
13. Consolacion	1,009.75				
14. Danao City	412.54	989.43			
15. Dumanjug	172.57	285.82			
16. Liloan	1,674.53				
17. Mandaue City	1,801.14				
18. Minglanilla	471.69	235.16			
19. Moalboal	281.35	1,508.37			
20. Pinamungahan	2,143.26				
21. Ronda		350.63			
22. San Fernando		406.05			
23. Sibonga	224.17	512.60			
24. Talisay City		1,150.58			
25. Toledo City	2,849.55				
TOTAL	**20,552.27**	**8,154.86**	**553.60**		

Table 3.3 shows the land area in hectares affected by salinity for 0-30cm depth. Moderately saline is 553.60 hectares, mostly from the City of Carcar. The municipalities of Alcantara and Agao are also moderately saline at 61.32 and 8.95 hectares, respectively. These areas are moderately hazardous to crop growth that will result to restricted yield to many crops.

In Table 3.4 at 30-60cm depth, the land area affected by salinity is higher than at 0-30cm depth. Severely saline is 203.91 hectares, solely from the City of Carcar. These areas are highly hazardous to crop growth, and only a few tolerant crops can yield satisfactorily. Moderately saline area is 1,064.82 hectares, mostly from the City of Carcar (734.61 ha.), San Fernando, and Sibonga.

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. Alcantara	8.17	247.86	68.30		
2. Aloguisan	508.12				
3. Argao	961.94	14.16			
4. Asturias	1,408.98				
5. Badian	18.13	626.33			
6. Balamban	2,383.58				
7. Barili	638.98				
8. Carmen	612.73				
9. Cebu City	1,996.89				
10. City of Carcar	238.68	757.55	734.61	203.91	
11. City of Naga	538.44	139.08			
12. Compostela	675.08				
13. Consolacion	1,009.75				
14. Danao City	461.81	940.17			
15. Dumanjug	432.84	25.55			
16. Liloan	1,674.53				
17. Mandaue City	1,801.14				
18. Minglanilla	706.84				
19. Moalboal	385.17	1,404.55			
20. Pinamungahan	2,143.26				
21. Ronda		350.63			
22. San Fernando		250.34	155.72		
23. Sibonga	278.48	352.09	106.20		
24. Talisay City	1,150.58				
25. Toledo City	2,849.55				
TOTAL	**22,883.68**	**5,108.31**	**1,064.82**	**203.91**	

In Table 3.5 Moderately saline area is 1,168.86 hectares, mostly from the municipality of Moalboal (663.87 ha.). Other municipalities with moderately saline soil are Alcantara, City of Carcar and Ronda. These areas are moderately hazardous to crop growth that will result to restricted yield to many crops, although only very few plants have root system that can reach 60-90 cm depth.

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. Alcantara		16.99	307.34		
2. Aloguisan	508.12				
3. Argao	976.10				
4. Asturias	1,408.98				
5. Badian		644.46			
6. Balamban	2,383.58				
7. Barili	638.98				
8. Carmen	30.42	582.31			
9. Cebu City	1,996.89				
10. City of Carcar	1,577.20	240.09	117.45		
11. City of Naga	677.52				
12. Compostela	115.22	559.86			
13. Consolacion	1,009.75				
14. Danao City		1,401.98			
15. Dumanjug	144.14	314.25			
16. Liloan	1,674.53				
17. Mandaue City	1,801.14				
18. Minglanilla	706.84				
19. Moalboal	85.65	1,040.20	663.87		
20. Pinamungahan	1,147.52	995.74			
21. Ronda		270.44	80.19		
22. San Fernando	406.05				
23. Sibonga	313.66	423.11			
24. Talisay City	1,150.58				
25. Toledo City	2,495.68	353.87			
TOTAL	**21,248.56**	**6,843.31**	**1,168.86**		

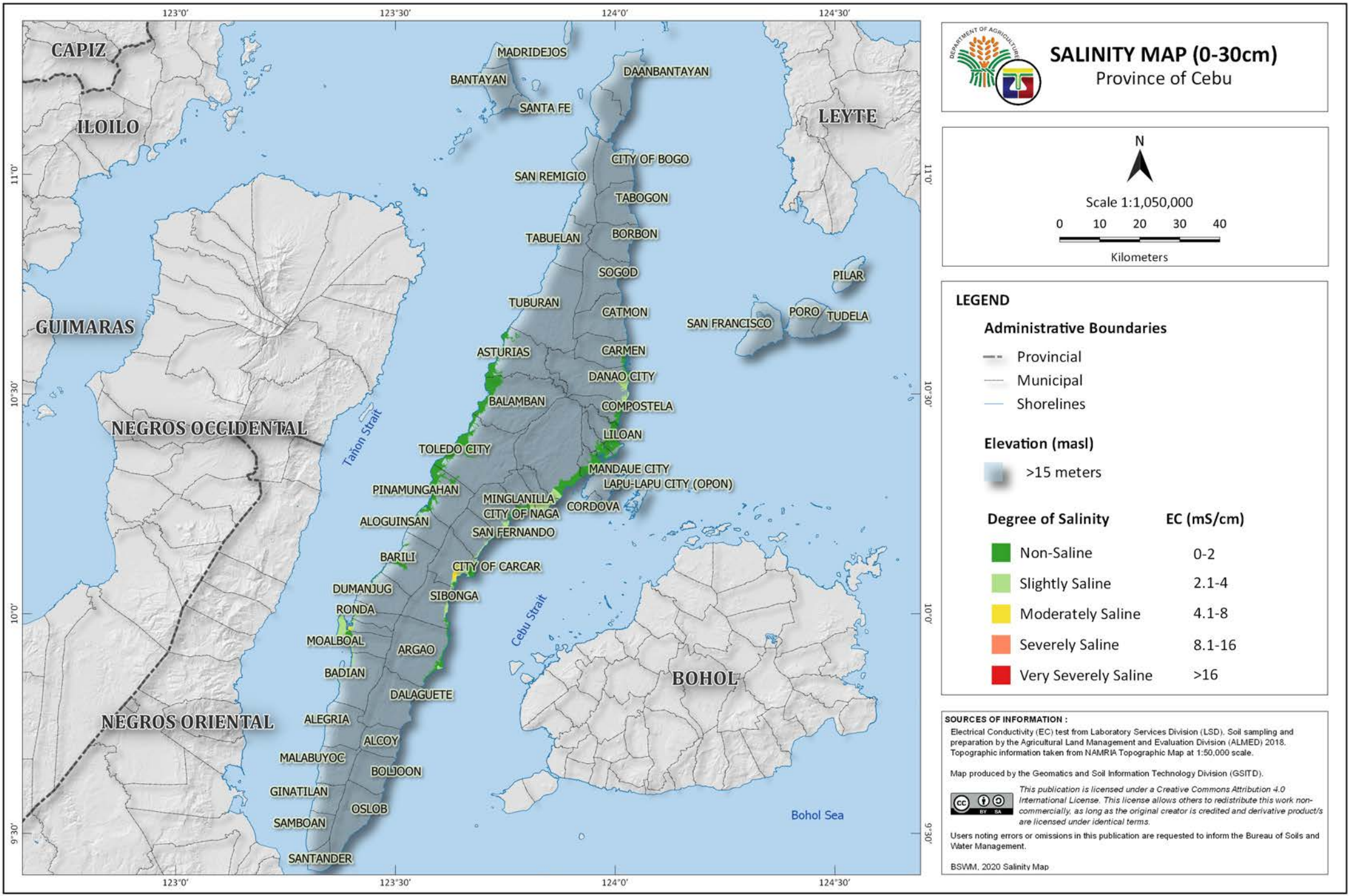
Table 3.6 Distribution of Coastal Land Area at Different Degree of Salinity

SALINITY CLASS	SOIL DEPTH					
	0-30 cm		30-60 cm		60-90 cm	
	hectares	%	hectares	%	hectares	%
Non Saline	20,552.27	70.24	22,883.68	78.21	21,248.56	72.62
Slightly Saline	8,154.86	27.87	5,108.31	17.46	6,843.31	23.39
Moderately Saline	553.60	1.89	1,064.82	3.64	1,168.86	3.99
Severely Saline			203.91	0.70		
Very Severely Saline						
TOTAL	**29,260.72**	**100**	**29,260.72**	**100**	**29,260.72**	**100**

Table 3.6 summarizes the total coastal land area of Cebu per degree of salinity. Severely saline soil is only 0.70% of the total coastal land area of Cebu, and can only be found at 30-60cm depth. Moderately saline area is highest at 60-90cm depth (3.99%), and at 30-60cm depth (3.64%). Generally, most of the coastal area in Cebu are non saline to slightly saline.

B. Output Maps

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



SALINITY MAP (0-30cm)

Province of Cebu

N

Scale 1:1,050,000

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

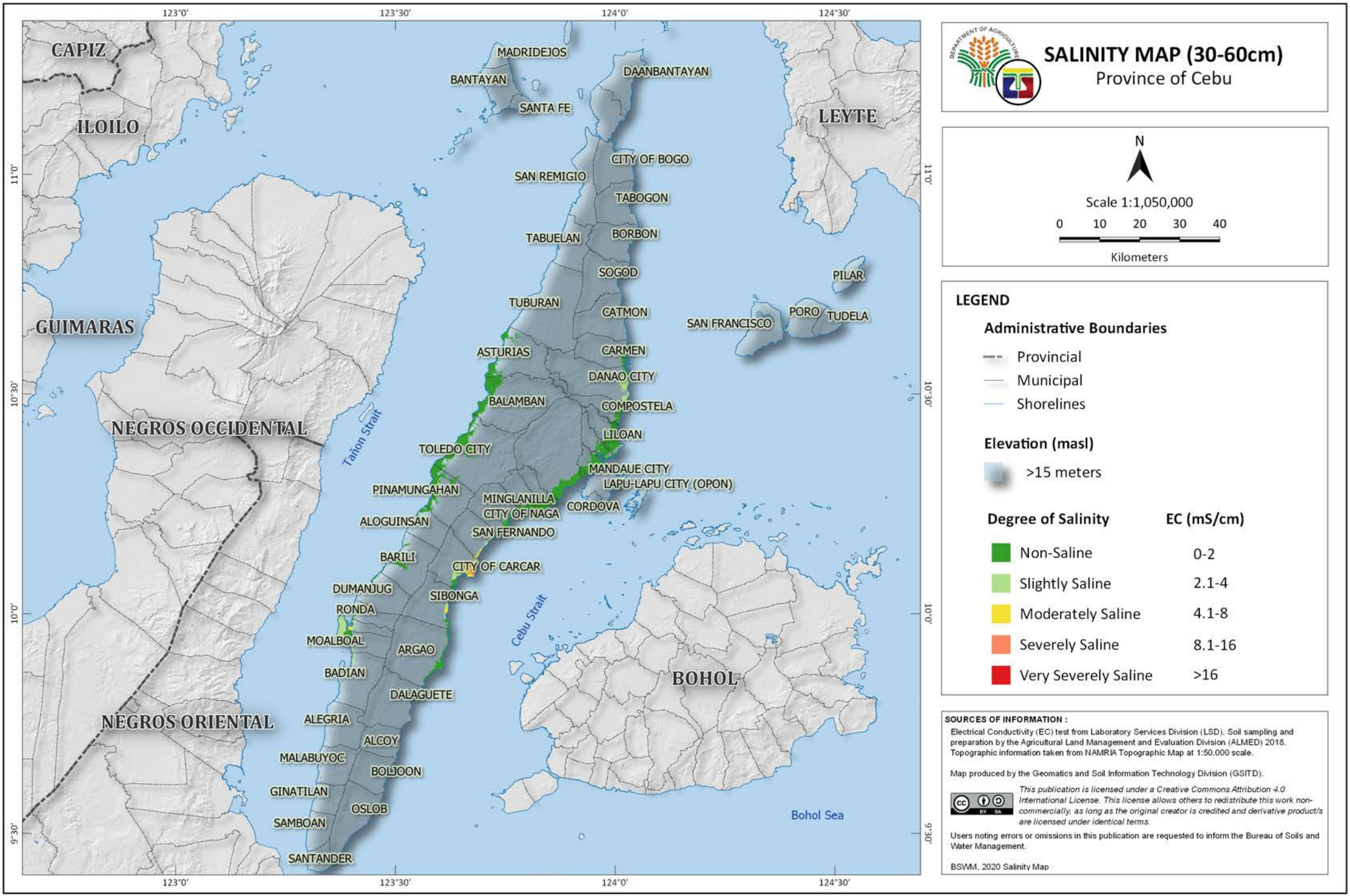
SOURCES OF INFORMATION :

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 Cebu

N

Scale 1:1,050,000

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 :

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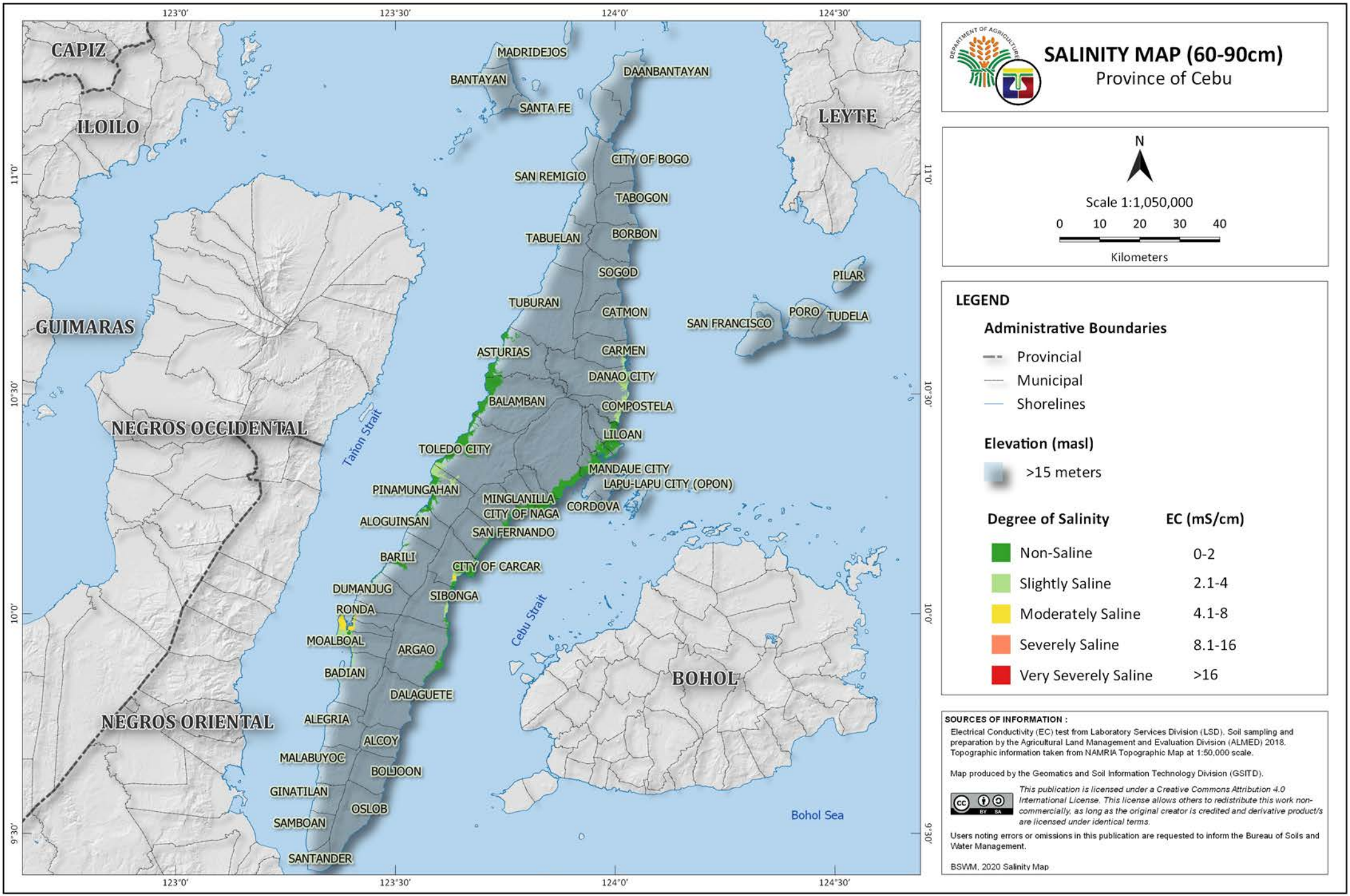
BSWM, 2020 Salinity Map



SALINITY MAP (60-90cm)

Province of Cebu

N

Scale 1:1,050,000

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 :

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BSWM, 2020 Salinity Map

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