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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 BATAAN

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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.

BATAAN

I. SOIL/LAND PHYSICAL CHARACTERISTICS

A. General Description of Saline Affected Site

Bataan is located in the southern part of Region III between 14°24'30" to 14°57'30" north latitude and 120°14'45" to 120°36'30" east longitude. It is bordered by the provinces of Zambales and Pampanga on the north. The peninsula faces the West Philippine Sea on the west and Subic Bay on the north-west, and encloses Manila Bay on the east. A narrow coastline plain characterizes the eastern portion of the province, while the western coast features many ridges, cliffs and headlands.

There are ten (10) coastal municipalities in Bataan that are susceptible to soil salinity. Hence, the sites for sampling shown in Table 1.1.

Table 1.1. Coastal Areas and Municipalities in Bataan

No.	Municipality	No. of Barangay	No. of Sampling Sites	No. of Soil Samples Collected
1	Abucay	9	4	12
2	Bagac	14	4	12
3	Balanga	25	2	6
4	Hermosa	23	4	12
5	Limay	12	3	9
6	Morong	5	9	27
7	Orani	29	3	9
8	Orion	23	2	6
9	Pilar	19	6	18
10	Samal	14	5	15
	TOTAL	173	42	126

B. Land Management Unit (LMU)

Land Management Unit (LMU) 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. Each LMU has a distinct land characteristic and quality which denotes its limitations and potentials. It serves as basis in rating the suitability of crops planted in a given area.

The sampling sites in Bataan where the soil samples are collected are all under LMU 09- Broad Alluvial Plain. It is characterized as generally flat low relief. The soil is 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.

C. Flooding

Flooding is a seasonal, but recurring problem in the low lying areas of Bataan. This is brought about by tidal and river overflows during peak rain periods. About 86% of the farmer respondents experience flooding in their farms during rainy season. The depth of flood water ranges from 2-3 feet and last for 14 days maximum.

D. Elevation

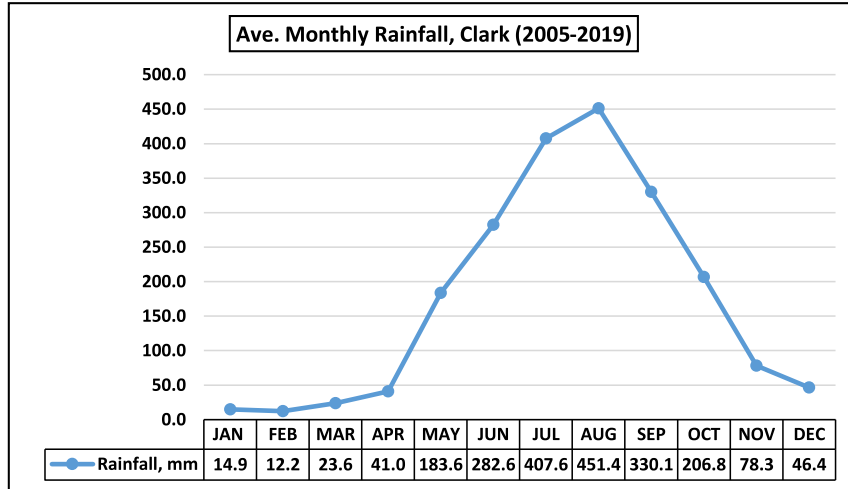
The elevation of a geographic location is the height above sea level (meters above sea level). Since the coastal areas are in the lowland pedo-ecological zone, soil sampling sites should be taken from elevations ranging from 0-5masl, 5-10masl, and 10-15masl. However, in the case of Bataan, soil sampling are taken only within the 0-5masl, where salinity occurs as observed by the Office of the Municipal Agriculturist.

E. Agro-Climate

The Province of Bataan has a Type I climate based on the Modified Corona's Classification of Climate. It is characterized with two pronounced seasons, dry from November to April, and wet during the rest of the year. Maximum rain period is from June to September.

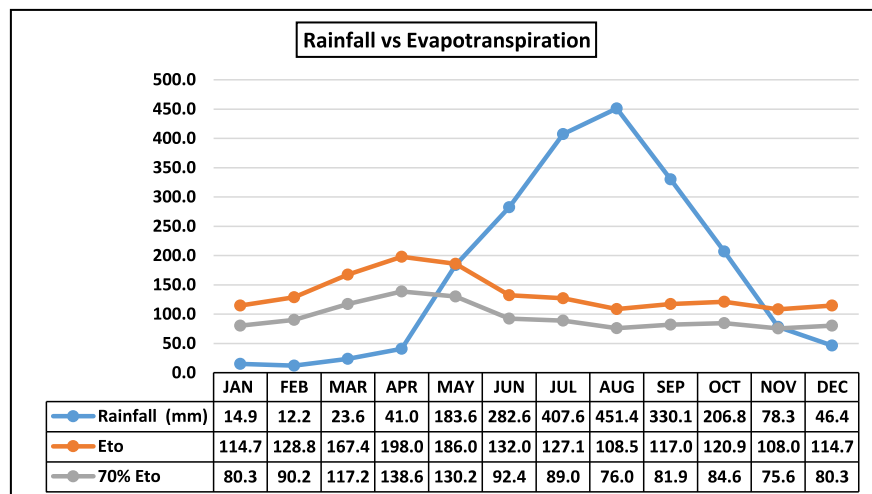
Since there are no available historical data of rainfall for Bataan, data from the nearest PAGASA station (Clark, Pampanga) is used. Figure 1.1 is the average monthly amount of rainfall that shows dry months in Bataan are November to April, while rainy months are from May to October.

Figure 1.1 Average Monthly Amount of Rainfall



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 1.2 comparison of rainfall and evapotranspiration in Bataan, 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 1.2 Comparison of the Average Rainfall and Evapotranspiration



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 provides primarily indicative information on the physical and socio-economic activities prevailing in the area.

The common land use/vegetation observed in the sampling sites is paddy rice, fishpond, mangrove/nipa, and patches of marshes (Table 1.2). Vegetables, root crops, and water melon are sometimes planted after non irrigated paddy rice. Some vegetation (i.e. mangrove, nipa, beard grass etc.) serve as indicators of salinity. Salinity reduces the kinds of crops that can be grown for economic purposes due to chemical reactions between salt water and soil clay particles.

Most of the farmers interviewed identified common indicators of salinity such as low yield, empty panicle, yellowish leaves, stunted growth, wilting, presence of white crust in soil surface, beard grass (Hapulid bobi), and Nipa.

Figure 1.3 Rice plant with empty panicles



Table 1.2 Land Use/Vegetation and Salinity Indicators in Bataan Sampling Sites.

MUNICIPALITY	Name of Brgys.	Land Use/Vegetation	Some Indicators of Salinity
Abucay	Capitagan Mabatang Calaylayan	Paddy Rice Irrigated, Non-Irrigated Paddy Rice, vegetables, sweet potato, fishpond	Mangrove, white crust, low yield, empty panicle, wilting, stunted growth
Bagac	Binuangan Old Saysayin	Paddy Rice Irrigated, Non-Irrigated Paddy Rice, vegetables, root crops	low yield, empty panicle, wilting, stunted growth, reddish/yellowish leaves
Balanga	Tuyo	Paddy Rice Irrigated, Non-Irrigated Paddy Rice, water melon, fishpond	Mangrove, low yield, empty panicle, wilting, stunted growth, reddish/yellowish leaves,
Hermosa	Mabuco Saba	Paddy Rice, Non- Irrigated Paddy Rice, vegetables, Fishpond	white crust, low yield, empty panicle, wilting, stunted growth, reddish/yellowish leaves, beard grass (Hapulid bobi)
Limay	Luz Kitang Alangan	Paddy Rice Irrigated, Non-Irrigated Paddy Rice, vegetables,	low yield, empty panicle, wilting, stunted growth, reddish/yellowish leaves
Morong	Nagbalayong Poblacion, Sabang	Paddy Rice Irrigated, Non-Irrigated Paddy Rice, vegetables	Mangrove/nipa, low yield, empty panicle, wilting, stunted growth, reddish /yellowish leaves, beard grass (Hapulid bobi), Nipa
Orani	Tapulao Kaparangan	Paddy Rice Irrigated, Non-Irrigated Paddy Rice, Fishpond	Mangrove, white crust, low yield, empty panicle, wilting, stunted growth, reddish/yellowish leaves, beard grass (Hapulid bobi)
Orion	Balot	Paddy Rice Irrigated, Non-Irrigated Paddy Rice, Fishpond	white crust, low yield, empty panicle, wilting, stunted growth, reddish/yellowish leaves
Pilar	Landing Bagumbayan Wakas, South, Munti, Bantan, Malapi, Maasim	Paddy Rice Irrigated, Non-Irrigated Paddy Rice, Fishpond. Mangrove	Mangrove/nipa, beard grass, low yield, empty panicle, wilting, stunted growth, reddish/yellowish leaves
Samal	San Juan, Lalawigan, Sapa	Paddy Rice Irrigated, Non-Irrigated Paddy Rice, vegetables, Fishpond	White crust, low yield, empty panicle, wilting, stunted growth, reddish/yellowish leaves, beard grass (Hapulid bobi)

II. CROP PRODUCTION ON SALINE AFFECTED AREAS

A. Key Informant Profile

To assess socio-economic and farm productivity in saline affected areas, 40 representative farmers from the different sampling points were interviewed. Figure 2.1 shows that most of the farmer respondents are 61 to more than 70 years old (40%), while 17 % can be considered young (from 21-40 years old). The average farmer's age is 56 years old, with 26 average years of farming. Out of 40 farmer respondents, eight (8) are female and 32 are male. Only nine (9) are the owner of their farm, with an average farm size of 1.7 hectares.

Figure 2.1. Age of Farmer Respondents

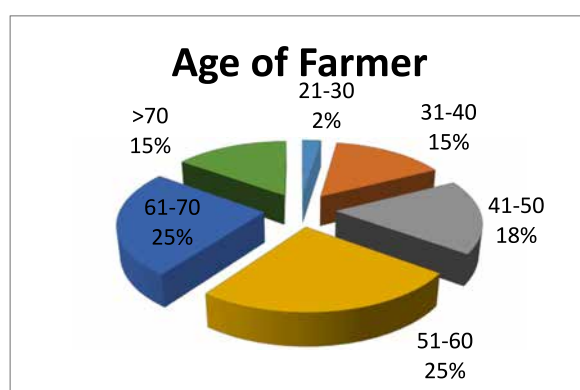


Figure 2.2 Key Informant Interview



B. Farm Production

The existing cropping pattern/system in Bataan sampling sites is Rice-Rice. Sometimes, farmers plant vegetables (sweet potato, okra, eggplant, mungbean, watermelon) during dry season, while for those without irrigation system and water logged areas let their farm fallow.

Rice production is generally lower during the dry season (November to April) as compared to the wet season. Table 2.1 shows the rice production in the coastal municipalities of Bataan.

Figure 2.3 Rice area affected by water logging and salinity



Table 2.1 Rice Production in Coastal Municipalities of Bataan

Coastal Municipalities	Average Crop Yield (kg/ha)*	
	Wet	Dry
1. Abucay	2,909.5	2,047.0
2. Bagac	2,680.2	1,177.6
3. Balanga	5,319.0	2,904.0
4. Hermosa	4,025.0	3,373.3
5. Limay	3,380.0	2,944.0
6. Morong	6,140.0	4,350.0
7. Orani	4,600.0	4,600.0
8. Orion	7,245.0	6,210.0
9. Pilar	4,849.2	3,277.5
10. Samal	3,657.0	2,852.0

* 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 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.

Commercial fertilizers such as T14, Urea and ammonium sulfate are commonly used by the farmers. Their rate of application ranges from 5 to 10 bags per hectare. Insecticides and pesticides are also used to control pest and diseases.

Table 2.2 Rice varieties and Fertilizers commonly used by Farmer Respondents

Rice Varieties	Fertilizers
1. NSIC RC 130 (Tubigan 3)	1. T14 (14-14-14)
2. NSIC RC 152 (Tubigan 10)	2. Urea (46-0-0)
3. NSIC RC 160 (Tubigan 14)	3. Ammonium Sulfate (21-0-0)
4. NSIC RC 216 (Tubigan17)	4. Muriate of Potash (0-0-62)
5. NSIC RC 218 SR (Mabango 3)	5. Ammonium Chloride 25%N
6. NSIC RC 222 (Tubigan 18)	
7. NSIC RC 238 (Tubigan 21)	
8. NSIC RC 298 (Tubigan 23)	
9. NSIC RC 300 (Tubigan 24)	
10. NSIC RC 352 (Tubigan 27)	

D. Source of Irrigation

Table 2.3 below shows that 45% of the farmer respondents uses pump on Shallow Tubewell (STW) to irrigate their farms, while others sourced their irrigation water from creeks (40%). Farmers either divert water from rivers/creeks or they pump it.

Table 2.3 Source of Irrigation for Paddy Rice

Source of Irrigation for Paddy Rice	%
Rainfed	15
Shallow Tubewell	45
Creeks	40

Figure 2.4 Shallow Tubewell



E. Period of Salinity Occurrence and Practices to Address Salinity

During the rainy months of June to September, flooding is experienced in the province of Bataan. Salt water from Manila Bay back flows over rivers and its tributaries during heavy rains and flash floods enter into their farms. These nearby rivers and creeks are also the main source of their irrigation water.

Most of the farmer respondents' practices to address salinity are planting vegetables as a second crop or let their farm fallow, converting farm into fishpond, putting check valve/gate to prevent the entry of salt water to their farms especially during high tide and flooding, and avoiding over extraction and pumping of salt water.

Figure 2.5 Culvert that serves as check gate to control entry of irrigation water/ salt water



III. SOIL CHEMICAL CHARACTERISTICS

Soil samples collected were brought to the BSWM Laboratory Services Division for the soil salinity/alkalinity test which includes pH (1:1) at 25°C, Electrical Conductivity (EC) at 25°C, Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Sum of Cations, Carbonate (CO₃), Bicarbonate (HCO₃), Chloride (Cl), Sulfate(SO₄), 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 Electrical Conductivity (EC) of Soil Samples at Different Depths, Bataan

Auger Ref	Barangay	Municipality	EC (mS/cm) @0-30cm	EC (mS/cm) @30-60cm	EC (mS/cm) @60-90cm
1	Nagbalayong	Morong	0.78	0.511	2.92
2	Nagbalayong	Morong	0.325	1.227	11.39
3	Nagbalayong	Morong	2.211	6.328	3.664
4	Nagbalayong	Morong	0.166	0.179	0.109
5	Poblacion	Morong	0.34	0.124	0.307
6	Poblacion	Morong	0.146	0.201	0.152
7	Poblacion	Morong	0.305	0.175	0.168
8	Sabang/Poblacion	Morong	0.741	0.891	3.044
9	Sabang	Morong	0.808	3.96	13.88
10	Binuangan	Bagac	0.208	1.224	0.492
11	Binuangan/Old Saysayin	Bagac	0.327	0.142	0.195
12	Saysayin	Bagac	0.827	0.478	0.828
13	Saysayin	Bagac	0.362	0.256	0.953
14	Landing/Bagumbayan	Pilar	10.95	5.577	4.217
15	Landing	Pilar	0.401	0.383	0.23
16	Wakas South/Munti	Pilar	0.915	0.362	0.17
17	Wakas South	Pilar	0.981	0.471	1.099
18	Bantan Malapi/Maasim	Pilar	0.4725	0.585	0.471
19	Bantan Malapi	Pilar	0.23	0.183	0.153
20	Luz/Kitang	Limay	0.848	2.958	12.56
21	Alangan	Limay	0.334	0.157	0.144
22	Alangan	Limay	0.99	0.861	6.46
23	Balut	Orion	1.314	0.659	13.01
24	Balut	Orion	0.387	0.33	0.584
25	Tuyo	Balanga City	7.442	0.379	1.759
26	Tuyo	Balanga City	0.705	3.826	12.41
27	Capitagan	Abucay	0.5744	0.395	1.028
28	Mabatang	Abucay	1.123	2.884	4.924
29	Mabatang	Abucay	2.385	4.212	9.817
30	Calaylayan	Abucay	1.671	2.416	3.287
31	San Juan	Samal	0.658	0.431	0.29
32	San Juan	Samal	0.439	0.314	0.393
33	Lalawigan	Samal	0.27	0.323	0.136
34	Sapa	Samal	0.428	0.839	0.866
35	Sapa	Samal	0.5	0.284	0.694
36	Tapulao	Orani	0.945	0.707	0.355
37	Tapulao	Orani	0.844	0.999	7.927
38	Kaparangan	Orani	1.362	0.419	0.53
39	Mabuco	Hermosa	0.989	0.508	2.092
40	Mabuco	Hermosa	0.91	0.472	0.511
41	Saba	Hermosa	0.618	0.518	0.378
42	Saba	Hermosa	4.955	1.898	1.893

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 Morong, Limay, Orion, Balanga, and Abucay have severely saline soil at 60-90cm depth. These areas have high hazard for crop growth and only a few tolerant crops with shallow root system will yield satisfactorily. Also, one barangay in Pilar at 0-30cm depth has the same severely saline soil.

Moderately saline soils are also observed in different depths in these municipalities. These are moderately hazardous for crop growth that can result to restricted yield of many crops. Majority of the soil samples are non saline.

The Soil Salinity Maps of the Province of Bataan for three different depths (0-30cm, 30-60cm, and 60-90cm) are the output maps 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. On Table 3.3 moderately saline soil is only 115.30 hectares, while the severely saline soil is 4.77 hectares in Pilar.

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. Abucay	1,380.81	223.18			
2. Bagac	948.36				
3. Balanga	4.02	1,627.70	71.88		
4. Dinalupihan	2,623.34				
5. Hermosa	3,256.33	512.72	3.22		
6. Limay	510.08				
7. Mariveles	1,244.09				
8. Morong	1,576.30	3.75			
9. Orani	1,765.38				
10. Orion	1,848.43	4.53			
11. Pilar	554.09	1,151.97	40.20	4.77	
12. Samal	1,479.81				
TOTAL	17,191.04	3,523.85	115.30	4.77	

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. Abucay	718.87	876.04	9.07		
2. Bagac	948.36				
3. Balanga	1,651.38	52.21			
4. Dinalupihan	2,623.34				
5. Hermosa	3,772.26				
6. Limay	303.43	206.65			
7. Mariveles	1,244.09				
8. Morong	1,295.55	269.20	15.31		
9. Orani	1,765.38				
10. Orion	1,852.96				
11. Pilar	1,688.84	55.41	6.79		
12. Samal	1,479.26	0.55			
TOTAL	19,343.72	1,460.07	31.17		

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. Abucay	40.50	484.18	1,056.08	23.23	
2. Bagac	808.80	139.56			
3. Balanga	0.09	764.17	925.68	13.65	
4. Dinalupihan	2,623.34				
5. Hermosa	3,764.84	7.43			
6. Limay	3.96	23.82	219.74	262.56	
7. Mariveles	86.02	614.50	543.57		
8. Morong	383.57	492.35	636.89	67.24	
9. Orani	1,034.26	685.17	45.94		
10. Orion	228.43	630.32	969.54	24.67	
11. Pilar	692.18	1,043.78	15.08		
12. Samal	1,085.55	394.21	0.05		
TOTAL	10,751.54	5,279.49	4,412.59	391.34	

On Table 3.4 moderately saline soil is 31.17 hectares, while on Table 3.5, salinity is at 60-90cm depth, wherein the sum of severely saline soil is 391.34 hectares. These are in the municipalities of Abucay, Balanga, Limay, Morong and Orion. The greatest area with severely saline soil is in Limay (262.56 hectares).

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

Salinity Class	Soil Depth					
	0-30cm		30-60cm		60-90cm	
	hectares	%	hectares	%	hectares	%
Non saline	17,191.04	82.51	19,343.73	92.84	10,751.55	51.60
Slightly saline	3,523.85	16.91	1,460.07	7.01	5,279.49	25.34
Moderately saline	115.30	0.553	31.17	0.15	4,412.59	21.18
Severely saline	4.77	0.023			391.34	1.88
Very Severely saline						
TOTAL	20,834.96	100	20,834.97	100	20,834.97	100

Table 3.6 summarizes the total coastal land area of Bataan per degree of salinity and the notable result is that at soil depth 60-90cm, 21.18% of the coastal land area is moderately affected by salinity and only 1.88% 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 that can result to restricted yield of many crops. In summary, majority of the soil samples are non saline.

B. Output Maps

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



SALINITY MAP (0-30cm) Province of Bataan



Scale 1:280,000

0 4 8 12 16
Kilometers

LEGEND

Administrative Boundaries

- Provincial
- Municipal
- Shorelines

Elevation (masl)

- >15 meters

Degree of Salinity

Non-Saline	0-2
Slightly Saline	2.1-4
Moderately Saline	4.1-8
Severely Saline	8.1-16
Very Severely Saline	>16

EC (mS/cm)

SOURCES OF INFORMATION :

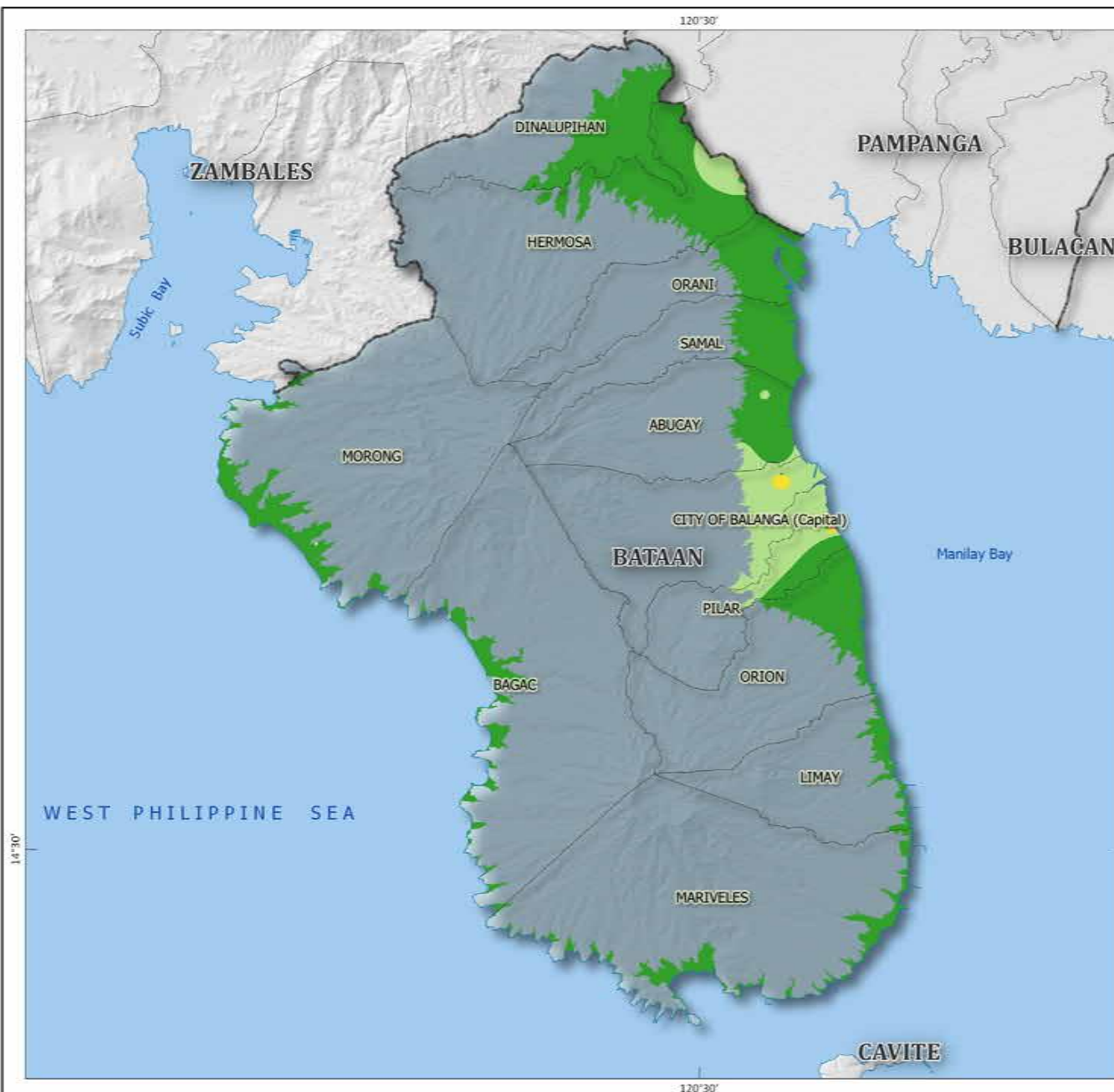
Electrical Conductivity (EC) test from Laboratory Services Division (LSD). Soil sampling and preparation by the Agricultural Land Management and Evaluation Division (ALMED) 2018. Topographic information taken from NAMRIA Topographic Map at 1:50,000 scale.

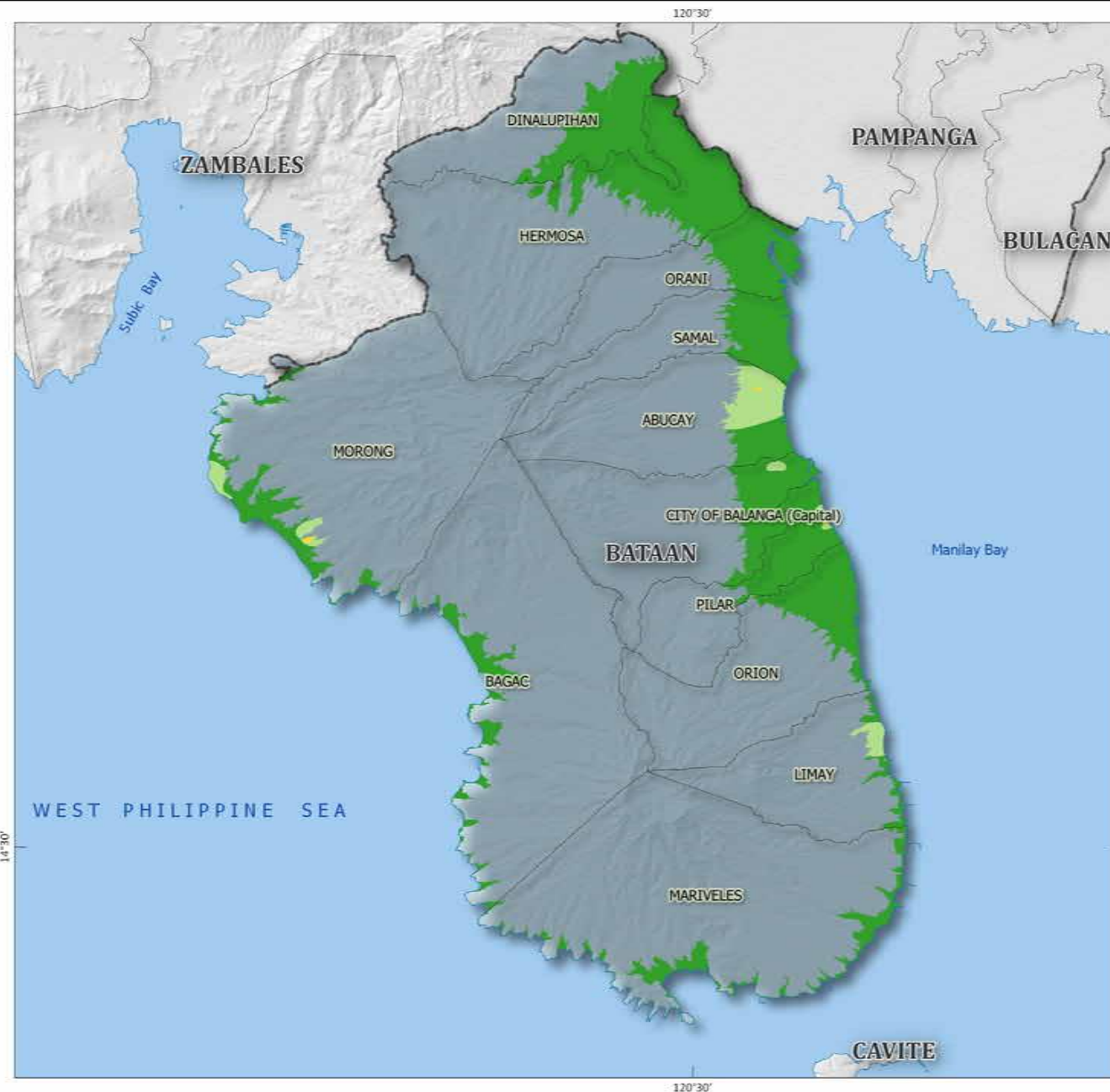
Map produced by the Geomatics and Soil Information Technology Division (GSITD).

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BSWM, 2020 Salinity Map

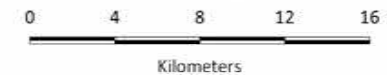




SALINITY MAP (30-60cm) Province of Bataan



Scale 1:280,000



LEGEND

Administrative Boundaries

- Provincial
- Municipal
- Shorelines

Elevation (masl)

- >15 meters

Degree of Salinity

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).



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BSWM, 2020 Salinity Map



SALINITY MAP (60-90cm) Province of Bataan



Scale 1:280,000

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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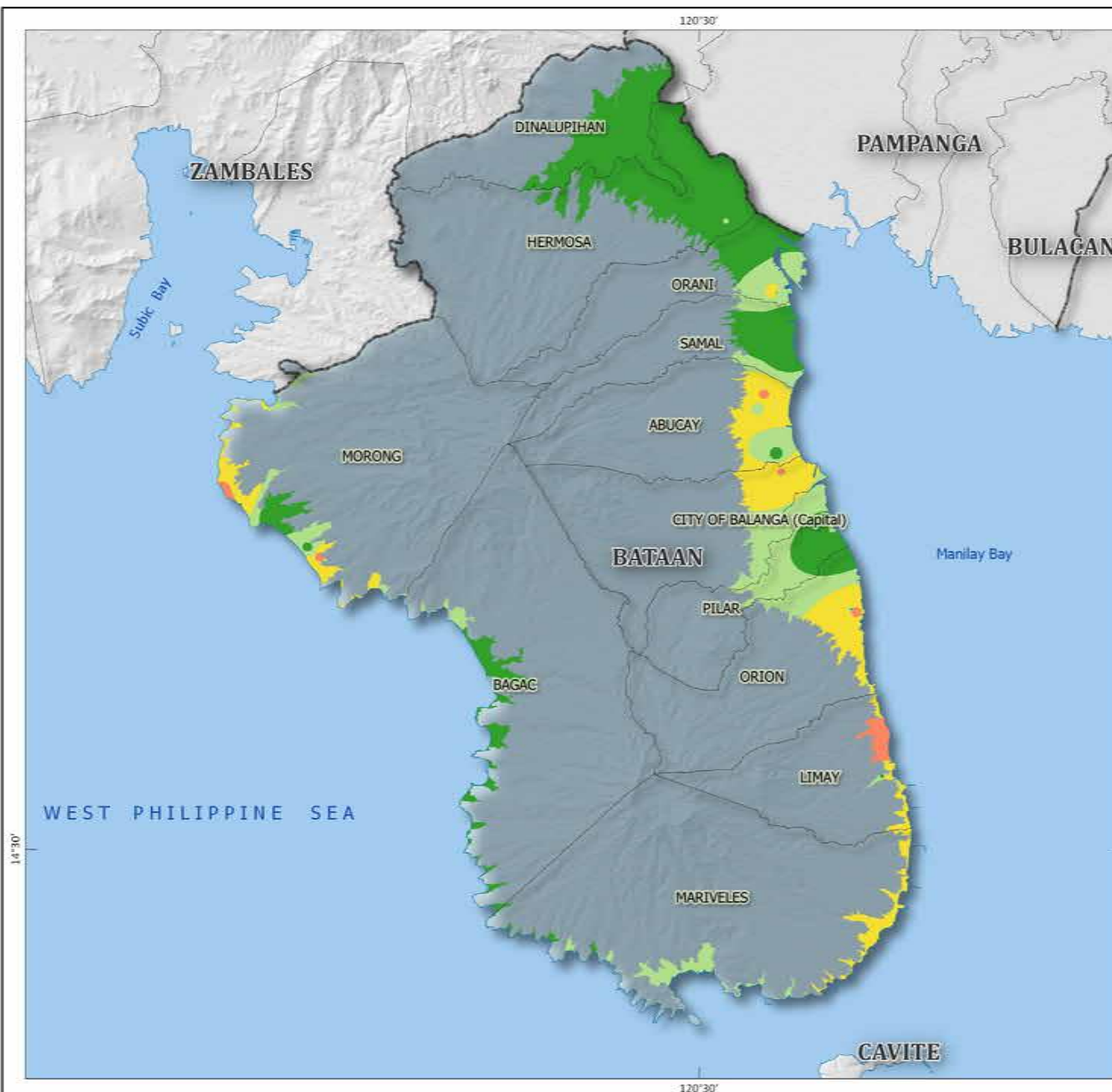
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BSWM, 2020 Salinity Map





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Acknowledgements

We would like to thank the following personnel who gave us direction and encouragement during the study management and implementations: Ms. Angel C. Enriquez, former Director of BSWM; Mr. Elmer B. Borre, former Division Chief of ALMED; Dr. Dante Margate; and Rafhonzel B. De Lara.

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