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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

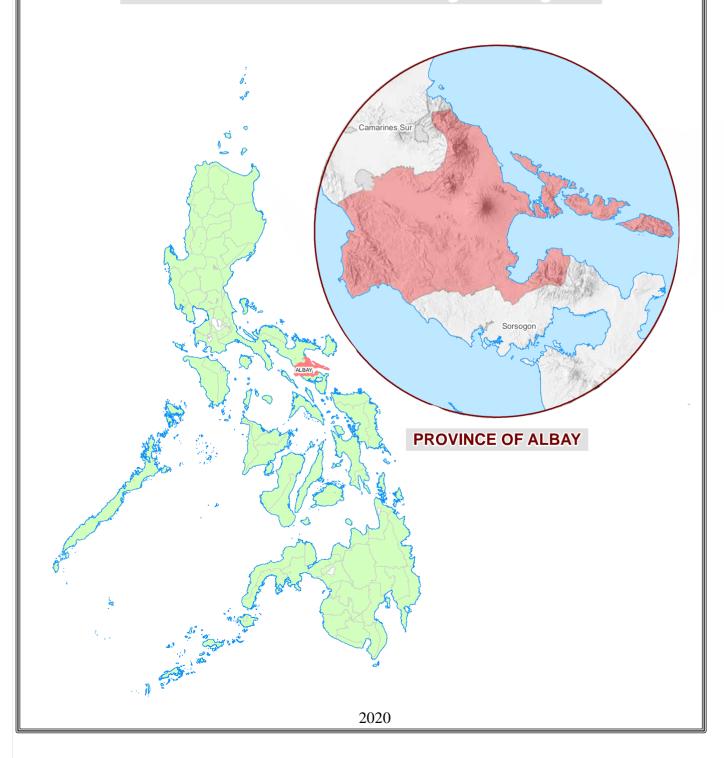


TABLE OF CONTENTS

	TABLE OF CONTENTS	
	RATIONALE	1
I	SOIL/LAND PHYSICAL CHARACTERISTICS	2
Α	General Description of Saline Affected Site	2
В	Land Management Unit (LMU)	2
С	Flooding	3
D	Elevation	4
Е	Agro-Climate	4
F	Land Use/Vegetation	5
II	CROP PRODUCTION ON SALINE AFFECTED AREAS	7
A	Key Informant Profile	7
В	Farm Production	7
С	Farm Input	8
D	Source of Irrigation	8
Е	Period of Salinity Occurrence and Practices to Address Salinity	9
III	SOIL CHEMICAL CHARACTERISTICS	10
A	Salinity Classification	10
В	Output Maps	14
Figure 1.1	Average Monthly Amount of Rainfall	4
Figure 1.2	Comparison of the Average Rainfall and Evapotranspiration	5
Figure 1.3	Paddy Rice	5
Figure 1.4	Auger Boring and Soil Sampling	6
Figure 2.1	Key Informant Interviews	7
Figure 2.2	Air Drying, Pulverizing and Packaging of Soil Samples	9
Table 1.1	Coastal Areas and Municipalities in Albay	2
Table 1.2	Land Management Units of Sampling Sites	3
Table 1.3	Land Use/Vegetation in Albay Sampling Sites.	6
Table 2.1	Rice Production in Coastal Municipalities of Albay	7
Table 2.2	Rice Seed Varieties	8
Table 2.3	Source of Irrigation for Paddy Rice	8
Table 3.1	Salinity Classification	10
Table 3.2	Electrical Conductivity (EC) of Soil Samples at Different Depths	11
Table 3.3	Coastal Land Area (in hectares) per Municipality at Different Degrees of Salinity (0-30 cm depth)	12
Table 3.4	Coastal Land Area (in hectares) per Municipality at Different Degrees of Salinity (30-60 cm depth)	12
Table 3.5	Coastal Land Area (in hectares) per Municipality at Different Degrees of Salinity (60-90 cm depth)	13
Table 3.6	Distribution of Coastal Land Area at Different Degrees of Salinity, Albay	13
	Province	
	SALINITY MAP (0-30cm) Province of Albay	15
	SALINITY MAP (30-60cm) Province of Albay	16
	SALINITY MAP (60-90cm) Province of Albay	17
	Working Group	
	Acknowledgements	
	References	
		•

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.

ALBAY

I. SOIL/LAND PHYSICAL CHARACTERISTICS

A. General Description of Saline Affected Area

Albay is a province situated in the Bicol Region occupying the southeastern peninsula of Luzon, bordered by Lagonoy Gulf on the northeast, Albay Gulf on the east, Poliqui Bay on the southeast, and Burias Pass on the southwest.

Albay has a total land area of 2,575.77 square kilometres which makes it the 53rd biggest province.

There are eigth (8) coastal municipalities in Albay that are susceptible to soil salinity, hence the sites for sampling shown in Table 1.1.

Table 1.1. Coastal Areas and Municipalities in Albay

		No. of	No. of Sampling	No. of Soil Samples
No.	Municipality	Barangay	Sites	Collected
1	Legazpi	70	2	6
2	Libon	47	1	3
3	Malilipot	18	4	12
4	Malinao	29	2	6
5	Manito	15	2	6
6	Pio Duran	33	1	3
7	Santo Domingo	23	1	3
8	Tiwi	25	2	6
	TOTAL	260	15	45

B. Land Management Unit (LMU)

Land Management Unit is a recurring pattern of land which possesses similar physical characteristics such as soil type associated with relatively uniform land use or vegetation cover and parent material. The land management unit 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 the building block of the pedo ecological zone, which represents a broader landscape grouping such as lowland, upland, hillyland and highland.

Table 1.2. Land Management Units of Sampling Sites

LMU	Description	Municipality	Barangay
04	Includes all the swampy depressions	Malinao	Baybay
Marshes	on the back plain, characterized by		
(Grassy	permanently water logged and		
type)	poorly drained areas.		
09	Generally flat low relief. The soil are	Libon	Bulusan
Broad	very deep clay or heavy clay,	Malilipot	San Isidro Ilawod,
Alluvial	moderately well drained to poorly		3 Poblacion, Sta.
Plain	drained, highly fertile and adaptable		Teresa, Binitayan
	to wide range of crops dominated by	Malinao	Jonop
	paddy rice irrigated and non-	Manito	Buyo, Buko
	irrigated.	Pio Duran	Marigondon
		Tiwi	Baybay, Bolo
16	Narrow and randomly occurring	Legazpi City	Bagacay,
Infilled/	patches of nearly level to gently		Banquerohan
Localized	sloping intervening valleys. The soils	Sto. Domingo	Buhatan
valleys	are deep and dominantly fine		
	textured with good drainage.		

Soil samples are collected in three (3) different Land Management Units: 04 Marshes (Grassy type), 09 Broad Alluvial Plain and 16 Infilled/localized Valleys. Table 1.2 shows the LMUs of the sampling sites per coastal municipality and barangay.

C. Flooding

Flooding happens on flat or low-lying areas when the soil is saturated by water or when the rate of rainfall exceeds the drainage capacity of the area and water remain on the surface for the certain period of time.

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

They also experienced "high tide flooding", wherein flooding occurs with high tides due to climate related sea level rise, land subsidence, and the loss of natural barriers.

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 and 5-10masl.

E. Agro-Climate

The climate in Albay is tropical and the weather is generally fair throughout the year with moderate rain showers during the second half of the year. A relatively warm and sunny season is experienced from March to June, and heavy rainfall is in December as shown in Figure 1.1. The average monthly amount of rainfall for Albay is from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) station in Legazpi City.

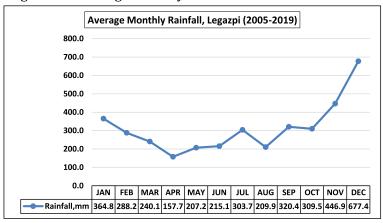


Figure 1.1 Average Monthly Amount of Rainfall

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 1.3 comparison of rainfall and evapotranspiration in Albay, the average rainfall is relatively higher than the potential evapotranspiration all throughout the year. This means that soil moisture is sufficient to support crop cultivation all year round.

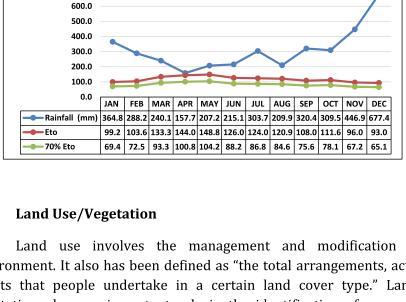


Figure 1.2 Comparison of the Average Rainfall and Evapotranspiration

Rainfall vs Evapotranspiration

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



Figure 1.3 Paddy Rice

Table 1.3 Land Use/Vegetation in Albay Sampling Sites.

Municipality	Land Use/Vegetation	Some indicators of Salinity
1. Legazpi City	Irrigated and non	Mangrove/nipa, aster weeds, beard grass
	irrigated paddy rice	
2. Libon	Non irrigated paddy rice	Mangrove/nipa
3. Malilipot	Irrigated and non irrigated paddy rice	Mangrove/nipa, aster weeds, beard grass, poor yield/productivity, sedges, wilting, empty panicle
4. Malinao	Non irrigated paddy rice	Mangrove/nipa, aster weeds, poor yield/productivity, sedges, stunted growth
5. Manito	Irrigated and non irrigated paddy rice	Mangrove/nipa
6. Pio Duran	Non irrigated paddy rice	Mangrove/nipa, beard grass, sedges, empty panicle, stunted growth
7. Santo Domingo	Non irrigated paddy rice	Mangrove/nipa, aster weeds, beard grass, poor yield/productivity, sedges, empty panicle
8. Tiwi	Irrigated paddy rice	Mangrove/nipa, aster weeds, sedges

Figure 1.4 Auger Boring & Soil Sampling



II. CROP PRODUCTION ON SALINE AFFECTED AREAS

A. Key Informant Profile

Based on the 22 farmer respondents with 4:7 female-male ratio, the average age of farmers is 58. The eldest and youngest is 83 and 33 years old. Most of the farmer respondents are the owners of their farm (59%), the rest are tenants (41%). The average farm size is 1.7 hectares per farmer and their average farming experience is 26 years.

B. Farm Production

The four major crops in Albay that contribute to agricultural productivity are coconut, rice, sugar and abaca. Table 2.1 shows the average rice yield from CY 2015-2017 per municipality, based on the key informant interviews.

Table 2.1 Rice Production in Coastal Municipalities of Albay

	Average Rice Yield , kg/ha*					
Coastal	20	15	20	16	20	17
Municipalities	1 st Cropping	2 nd Cropping	1st Cropping	2nd Cropping	1st Cropping	2nd Cropping
1. Legazpi	1,283	983	1,233	933	1,317	1,567
2. Libon	3,750	1,750	3,750	1,750	3,750	1,750
3. Malilipot	2,190	1,895	2,055	1,795	2,135	1,690
4. Malinao	1,650	1,650	1,390	1,450	1,620	900
5. Manito	3,667	4,667	3,400	3,983	3,133	3,583
6. Pio Duran					2,000	2,000
7. Sto Domingo	1,500	1,500	1,000	1,000	1,000	1,000
8. Tiwi	2,325	1,575	1,950	1,700	1,850	875

^{*}Based on the key informant interview, rice yield for CY 2015-2017



Figure 2.1 Key Informant Interviews

C. Farm Input

The study is limited to the coastal communities of the province, therefore, the information on farm inputs are mainly based on the key informant interviews. Farmer respondents usually use commercially available rice seed varieties as shown in Table 2.2.

Table 2.2 Rice Seed Varieties

Seed Variety	Description
NSIC Rc222	Long maturing rice variety
NSIC Rc118	Early maturing & drought tolerant
PSB Rc10	Early maturing & drought tolerant
NSIC Rc216	Variety for all seasons
NSIC 314H	Hybrid seeds

For fertilizers, they use inorganic fertilizers like urea (46-0-0), complete (14-14-14), ammonium phosphate (16-20-0) and magnum. They also use chemical herbicides 2,4-D, and insecticides like cymbus, furadan, and karate.

D. Source of Irrigation

Table 2.3 Source of Irrigation for Paddy Rice

Source of Irrigation for Paddy Rice	%
National Irrigation Administration	18
Rainfed	82
Creeks	44
Springs	17

Based on the 22 farmer respondents, only 18% of them have irrigation system assisted by NIA, and most of them are rainfed (82%). But, 61% of the rainfed areas are given supplemental irrigation from nearby creeks and springs during times when rainfall fails to provide sufficient moisture for normal plant growth, and in order to improve and stabilize their yields.

E. Period of Salinity Occurrence and Practices to Address Salinity

Majority of the farmer respondents (82%) said that salinity affects their rice farms during the months of July-August, and December- February. But, they do not consider to adopt other suitable crops considering salinity because according to them, they have no idea what to plant and it's a waste of time and money. Some of them plant vegetables aside from rice, for their daily consumption.

Most of the farmer-respondents' practices to address salinity are the following: 1) replanting to replace the seedlings, 2) applying chemical fertilizer to the soil, and 3) flushing saline water with fresh water and draining irrigation canals.



Figure 2.2 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°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 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)

Tuble 5.1 buill	ity classification (Top basea, race	
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 Tiwi and Legazpi have very severely saline soil. These areas have very high hazard for crop growth and only a few tolerant forage can grow satisfactorily. At 60-90cm depth Tiwi, Santo Domingo and Pio Duran the soil is

severely saline. These areas are also hazard for crop growth, although only very few plants have root system that can reach this depth. Moderately saline soils are in some areas in Malinao, Malilipot, Santo Domingo, Manito and Pio Duran. These are moderately hazard for crop growth that will result to restricted yield of many crops. Most of the soil samples are slightly saline to non saline.

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

Auger Ref	Sitio	Barangay	Municipality	EC (mS/cm) @0-30cm	EC (mS/cm) @30-60cm	EC (mS/cm) @60-90cm
SS1	Balinad	Baybay	Tiwi	18.1	16.7	13.91
SS2	Purok 7	Bolo	Tiwi	3.908	2.294	2.024
SS3	Purok 1	Baybay	Malinao	5.592	4.055	4.752
SS4	Purok 8	Jonop	Malinao	4.108	2.212	1.851
SS5	Purok 3	San Isidro Ilawod	Malilipot	1.140	2.935	3.332
SS6		3 Poblacion	Malilipot	4.719	2.336	1.593
SS7	Purok 1	Sta. Teresa	Malilipot	0.222	0.114	0.212
SS8		Binitayan	Malilipot	1.145	0.718	1.133
SS9	Purok 1	Buhatan	Sto. Domingo	4.097	4.281	11.82
SS10	Purok 1	Buyo	Manito	0.746	1.008	5.296
SS11		Buko	Manito	0.502	0.327	0.278
SS12	Purok 4	Marigondon	Pio Duran	6.452	6.969	10.04
SS13	Calambay	Bulusan	Libon	1.270	0.735	0.699
SS14	Purok 2	Bagacay	Legazpi City	29.96	25.93	22.90
SS15	Danlagan	Banquerohan	Legazpi City	10.35	14.33	22.41

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 shows the land area (in hectares) affected by salinity for 0-30cm depth. Very severely saline is 758.44 hectares, mostly in Legazpi City. Severely saline is 2,069.73 hectares, also mostly in Legazpi City. Moderately saline is 7,765.73 hectares, mostly in Malinao, Oas, and Pio Duran. These areas have moderate to very high hazard to crop growth and only a few tolerant crops yield satisfactorily.

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

	Non	Slightly	Moderately	Severely	Very
Coastal Municipality	Saline	Saline	Saline	Saline	Severely
					Saline
1. Bacacay	158.93	921.15	142.73		
2. City of Ligao			594.95		
3. City of Tabaco	24.89	581.75	260.43		
4. Daraga				18.45	3.30
5. Legazpi City			302.22	1,456.79	654.11
6. Libon	4,833.90	164.09	836.21		
7. Malilipot	272.93	197.46	23.08		
8. Malinao			2,462.60	46.17	
9. Manito	551.74	22.65	14.03	79.09	
10. Oas	1.14		1,073.97		
11. Pio Duran			1,146.72		
12. Polangui	484.34				
13. Santo Domingo			282.07		
14. Tiwi		12.46	626.71	469.22	101.04
TOTAL	6,327.88	1,899.56	7,765.73	2,069.73	758.44

Table 3.4 Coastal Land Area (in hectares) per Municipality at Different Degrees

of Salinity (30-60 cm depth)

The state of the s	Non	Slightly	Moderately	Severely	Very
Coastal Municipality	Saline	Saline	Saline	Saline	Severely
					Saline
1. Bacacay	314.57	773.26	134.99		
2. City of Ligao			594.95		
3. City of Tabaco		867.08			
4. Daraga				18.45	3.30
5. Legazpi City		360.82	33.44	1,357.82	661.05
6. Libon	4,833.90	184.46	815.84		
7. Malilipot	332.07	161.40			
8. Malinao		1,368.24	1,140.53		
9. Manito	574.49	13.90	79.13		
10. Oas	1.14		1,073.97		
11. Pio Duran			1,146.72		
12. Polangui	484.34				
13. Santo Domingo		198.63	83.44		
14. Tiwi		144.09	553.06	473.76	38.52
TOTAL	6,540.50	4,071.87	5,656.08	1,850.03	702.87

On Table 3.4 at 30-60cm depth, the land area affected by salinity is a little lower than the 0-30cm depth. Very severely saline is 702.87 hectares, mostly Legazpi City. Severely saline is 1,850.03 hectares, also mostly Legazpi City. Moderately saline is 5,656.08 hectares, mostly Malinao, Oas, and Pio Duran.

Table 3.5 shows the largest area affected by salinity. Very severely saline is almost the same with the first 2 depths, 757.76 hectares. While for the severely saline and moderately saline soil, area increased to 4,734.12 hectares, and 4,284.10 hectares respectively.

Table 3.5 Coastal Land Area (in hectares) per Municipality at Different Degrees of

Salinity (60-90 cm depth)

Samily (60-90 cm dep	Non	Slightly	Moderately	Severely	Very
Coastal Municipality	Saline	Saline	Saline	Saline	Severely
					Saline
1. Bacacay	159.75	534.16	365.15	163.74	
2. City of Ligao				594.95	
3. City of Tabaco		867.08			
4. Daraga				18.45	3.30
5. Legazpi City			77.79	1,580.87	754.46
6. Libon	4,833.90	166.78	833.53		
7. Malilipot	396.49	96.97			
8. Malinao	12.17	1,156.14	1,340.46		
9. Manito	49.46	48.96	485.02	84.07	
10. Oas	1.14		465.76	608.21	
11. Pio Duran				1,146.72	
12. Polangui	484.34				
13. Santo Domingo			173.12	108.95	
14. Tiwi		238.02	543.26	428.15	
TOTAL	5,937.25	3,108.11	4,284.10	4,734.12	757.76

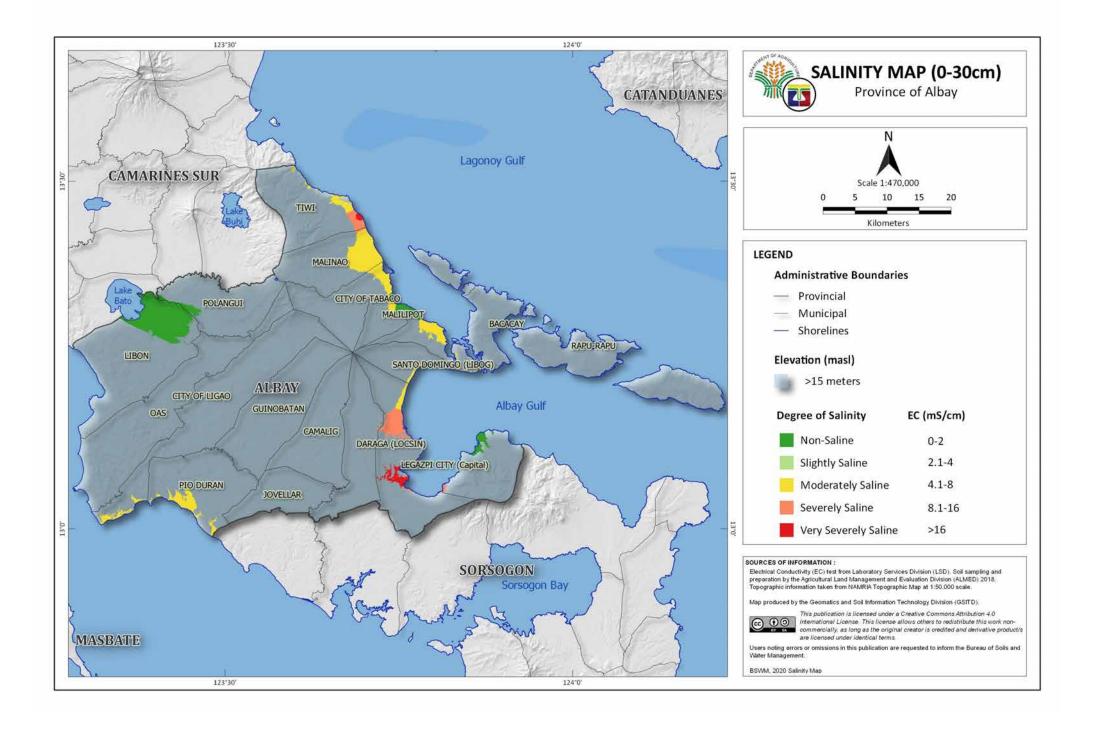
Table 3.6 Distribution of Coastal Land Area at Different Degrees of Salinity, Albay Province

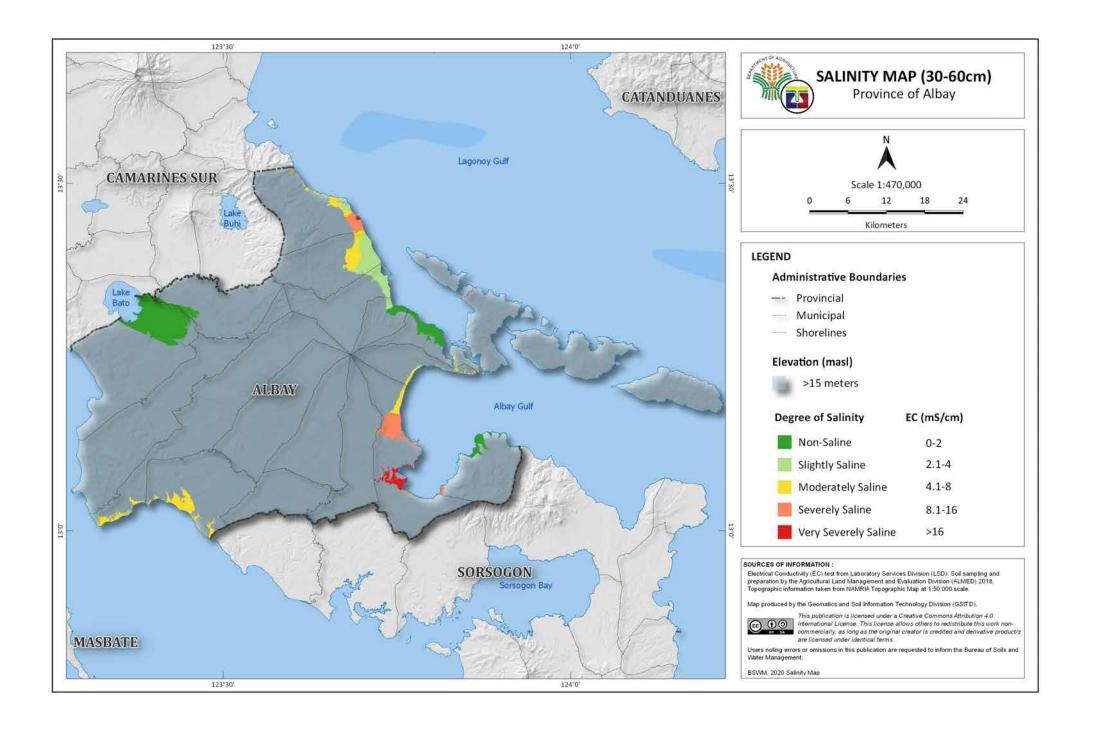
Salinity Class	Soil Depth (cm)					
	0-30		30-60		60-90	
	hectares	%	hectares	%	hectares	%
Non saline	6,327.88	33.62	6,540.50	34.75	5,937.25	31.55
Slightly saline	1,899.56	10.09	4,071.87	21.63	3,108.11	16.51
Moderately saline	7,765.73	41.26	5,656.08	30.05	4,284.10	22.76
Severely saline	2,069.73	11.00	1,850.03	9.83	4,734.12	25.15
Very Severely saline	758.44	4.03	702.87	3.73	757.76	4.03

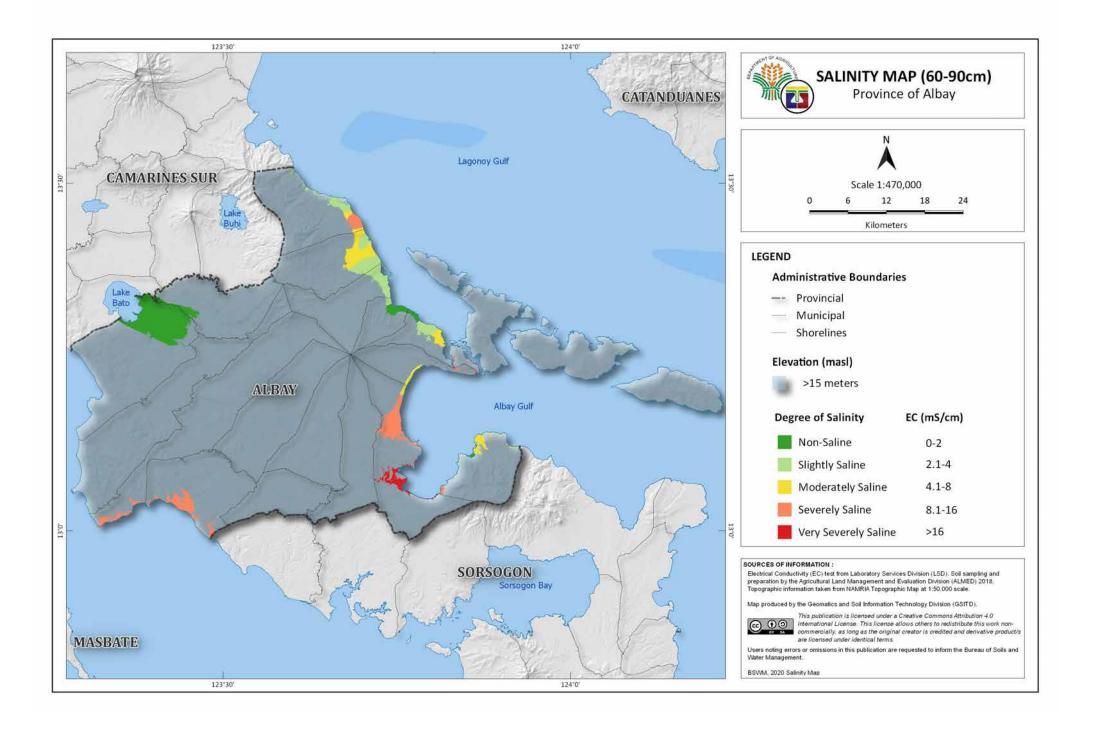
Table 3.6 summarizes the total coastal land area of Albay per degree of salinity. Notable observation is at 60-90cm depth wherein 25.15% of the coastal land area is severely saline.

B. Output Maps

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









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