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Major Soil Series of Capiz, Philippines and their Suitable Crops

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ABSTRACT

Evaluation and assessment of soil variabilities to determine crop suitability, constraints and best management practices to enhance crop productivity of the major soil series in Capiz were conducted from March to July 2016. A random collection of composite soil samples were taken from three depths (0-20, 20-40, and 40-60 cm) on the shoulder, back slope, and foot slope. Composite soil samples were air dried, pulverized, and were passed through a 2 mm mesh sieve and were analyzed in the laboratory. Results of laboratory analysis were used in matching land qualities and crop requirements following the 1975 FAO framework. Results show that Alimodian, Bantog, Faraon, Luisiana, San Manuel, and Sapian soil series were currently not suitable (N1) for corn due to soil acidity problem (pH<5). However, Alimodian, Bantog, Faraon and Sapian series were marginally suitable (S3) to banana, sugarcane, sweet potato and upland rice. Luisiana and San Manuel series were only marginally suitable to cassava but currently not suitable to other crops and permanently not suitable (N2) to irrigated and lowland rice. Other soil constraints identified to limit production of crops include drainage, coarse fragments, soil depth, topography, and rainfall. Regular conduct of soil survey and analysis is recommended to monitor fertility status and degree of variabilities in the field for proper land use.

Keywords — Crop suitability, soil series, Geographical Information System (GIS), Philippines

INTRODUCTION

Soils form and continually change, at different rates along different pathways (Schaetzl & Anderson, 2005). Along with change,certain variabilities in its chemical and physical characteristics show. Thus,suitability may have changed,and this may have to be evaluated. Knowledge of variability of soil properties is very indispensable as this can affect crop yield. It is there fore essential to study variability trends of soils to highlight its potentials and enhance its management and productivity (Gbadegesin et al. 2011).

According to Paz-Gonzalez, Vieira, and Castro (2000), changes in physical properties of soil within or among agricultural fields is natural because of the impact of soil-forming factors. However, some variabilities are brought about by tillage and other management practices. Also, much variability can occur as a result of land use and management.

Bureau of Soils (1962) grouped the soils of Capiz, Philippines into: (a) soils of the plains and valleys; (b) soils of the hills and mountains; (c) and miscellaneous types. *Alimodian, Luisiana, Sapian*, and *Faraon* soil series were classified as soils of the hills and mountains that developed on consolidated materials, while *San*

Manuel and *Bantog* were grouped as soils of the plains and valleys or soils of the lowlands (Carating, Galanta, & Bacatio, 2014). The latter consist of recent alluvial fans and flood plains. The plains and valleys are principally devoted to the cultivation of lowland rice while the upland and rolling areas are suited to crop diversification, grazing, and fruit raising. The sea shores except those covered by swamps and marshes are best for growing of coconuts.

In Capiz, crops like rice, corn, sugarcane, cassava, banana and sweet potato are abundantly grown as they are considered major crops of the province. As observed in the field, it is a common practice for farmers, especially the marginal ones, to plant crops they desire to their small areas regardless of the type of soil and landscape position. They till and cultivate lands even with steeper slopes and plant almost the same crops continuously. Soil becomes susceptible in erosion resulting to alteration of its physical and chemical condition.

OBJECTIVES OF THE STUDY

The study intended to evaluate the characteristics of the different soil series in the Province of Capiz. Specifically, it aimed to (1) determine its suitability to different crops; (2) identify constraints and create management strategies to improve soil condition; and (3) map crop suitability using geographical information system (GIS) to facilitate easier identification of areas suitable to plant specific crops.

MATERIALS AND METHODS

This study was conducted in the province of Capiz, Philippines from March to July, 2016. Capiz (Figure 1) is one of the six provinces of Western Visayas Region and is located on the Island of Panay with a total land area of 10,196 hectares or 101.96 square kilometers. It is situated at the heart of the Philippine Archipelago at 11°09'to 11° 40'north latitude and 122°11'to 123°05' east longitude and is shaped like an open palm. The province is bounded by the Sibuyan Sea on the north, on the south and south east by Iloilo Province, on the south west by the Province of Antique, and on the west and northwest by the Province of Aklan. The topography varies from rolling lands and hills to mountain peaks and ranges that stretch from the northern portion towards the south bordering Iloilo province.

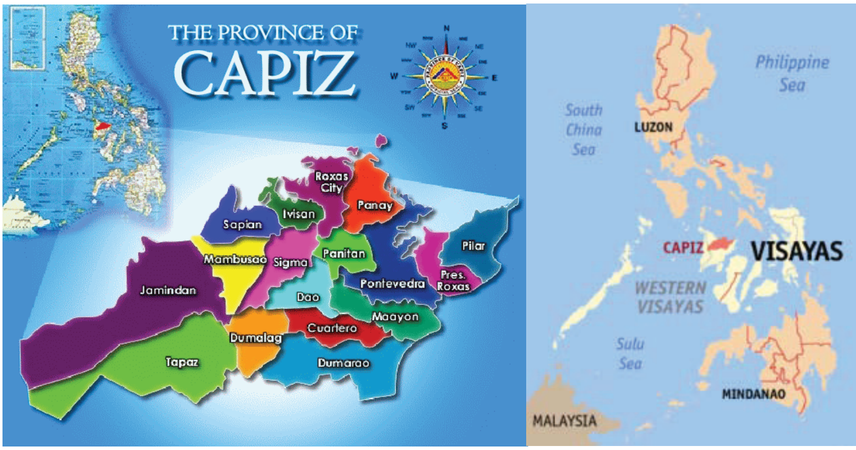

Figure 1. Map of the province of Capiz, Philippines.

Sampling and sample preparation

Before sampling was done, a soil map was prepared to serve as a guide in the field (Figure 2). After identifying the areas where the different soil series are found, soil samples were taken randomly from different slope positions of the major soil series grouped into soils of the hills and mountains, soils of the uplands and soils of the lowlands. A fabricated soil auger was designed to gather soil samples from 0-20, 20-40, and 40-60 cm depths and sub-samples were collected from 20 auger borings. These sub-samples were mixed together, and at least one kilogram was taken to serve as the composite sample. Collected composite samples were air-dried,pulverized and were passed through a 2 mm sieve, and were packed with proper labels before submitting to the laboratory for chemical and physical analysis.

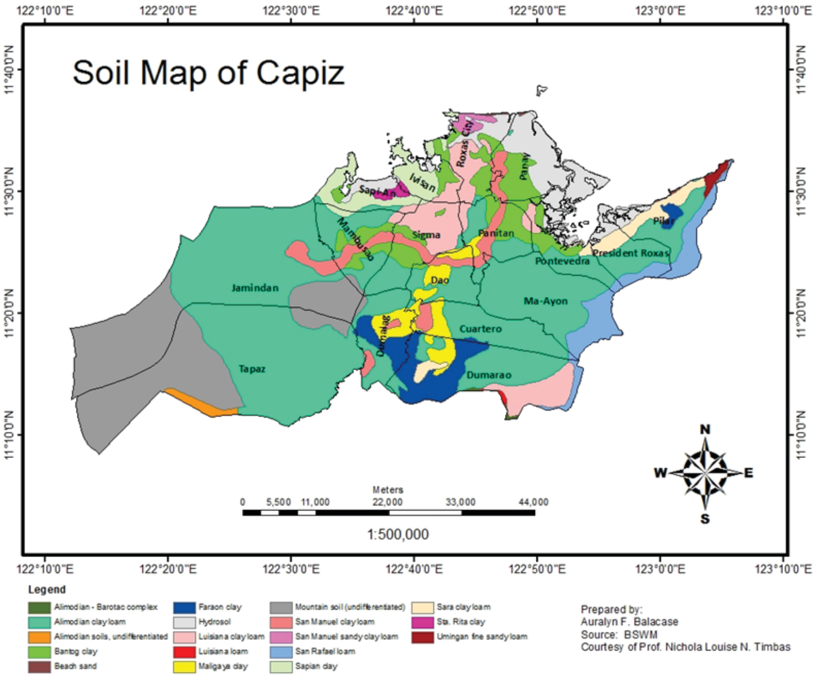

Figure 2. Soil map of Capiz, Philippines.

Analysis of Data

Descriptive analysis was used to analyze data of the study. Chemical characteristics and land qualities were used to describe *Alimodian,Bantog, Faraon,Luisiana,San Manuel,andSapian* soil series.

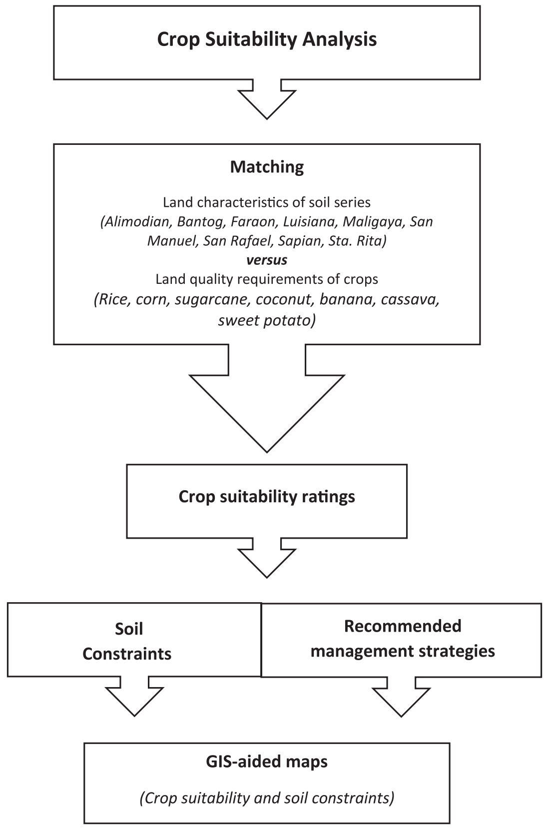

Figure 3. The conceptual framework of the study.

RESULTS AND DISCUSSION

Results of the matching of chemical characteristics (Appendix Table 1) with land qualities and climatic features of the different soil series (Appendix Table 2) are presented in Table 1. Results in the table show the suitability ratings of the different soil series to the crops and the corresponding limitations. Based on results, corn is the most affected by physical and chemical variabilities of the soil. Corn, based on the result of matching, is currently not suitable (N1) to grow in all soil series studied which did not conform to the findings of PhilRice

(2013).The factor that limits to growing corn on the different soils is soil pH. Based on report in 2013 (PhilRice), corn was moderately suitable to *Alimodian*, marginally suitable to *Bantog, Faraon* and *Sapian* series and highly suitable to *San Manuel* soil series. However, the same result was recorded for *Luisiana* in which corn was also currently not suitable. These changes after three years might be due to natural calamities like the typhoon Yolanda that struck the province three years ago causing floods, landslides and severe erosion, especially in the denuded highlands. Likewise, the cultural and management practices of the farmers such as mono-cropping and continuous tillage, may have worsened the soil condition and led to the degradation of these soils.

Table 1. Land quality and climatic characteristics of the different soil series in Capiz.

Parameters	Alimodian	Bantog	Faraon	Luisiana	San Manuel	Sapian
Topography (t)*						
Slope (%)	Rolling to mountainous	Level to slightly undulating	Rolling to hilly	Rolling to mountainous	Level to slightly undulating	Rolling to mountainous
Wetness (w)*						
Flooding	none	None to flooding	none	None	Seasonal	none
Drainage	Good	Somewhat poor	good	Good	Good	Good to excessive
Soil Physical Characteristics (s)*						
Texture	clay loam	clay	clay	clay loam	clay loam	clay
Structure	granulated	blocky	Blocky	Granulated	granulated	Blocky
Course fragment	Occasional	none	Common to many	None	None	Gravel and stones; rock outcrops
Effective rooting depth (cm)	Moderate (0.6 m)	Deep (> 1m)	Shallow (0.3 m)	Very deep (> 2m)	Deep (> 1 m)	Deep (0.7 m)
Fertility Characteristics (f)*						
CEC	High	high	High	Moderate	High	Low
Base saturation (%)	Moderate to high	high	High	Low	High	low
pH	4.5 – 6.5 (acid)	6.5 – 8.0 (slightly acid to alkaline)	6.5 – 8.0 (slightly acid to basic)	4.5 – 5.5 (acid)	6.5 – 7.5 (slightly acid to neutral	4.0 – 4.5 (acid)
Organic matter (%)	Low to moderate	Moderate to high	Moderate to high	Low	moderate	low
P (ppm)	Low to moderate	Moderate to high	Low to moderate	Low	Moderate	Deficient

K (ppm)	Low to moderate	Low to moderate	Moderate	Low	Moderate	Deficient
Climatic Characteristics (c)**						
Annual rainfall (mm)	2, 457	2, 033	2, 543	2, 400	2, 460	2, 423
Mean annual temperature (C)	27.43	27.55	27.4	27.5	27.48	27.6
Relative Humidity (%)	80	80	80	80	80	80

Other crops like banana, sugarcane, sweet potato, and upland rice were found to be marginally suitable (S3) to *Alimodian, Bantog, Faraon*, and *Sapian* soil series. Soil constraints were found to be topography (slope), fertility (pH), climate (rainfall), wetness (drainage), and soil characteristics (stoniness and soil depth (Table 1). On the other hand, these crops were currently not suitable (N1) in *Luisiana* and *San Manuel* soil series. Again, limiting factor for their suitability is pH. Cassava was also found marginally suitable (S3) for *Alimodian*, *Bantog*, *Luisiana*, and *San Manuel* but permanently not suitable (N2) to *Faraon*and *Sapian*. Among the soil series, *Luisiana* and *San Manuel* both were currently not suitable (N1) and permanently not suitable (N2) for growing high-value crops in the province. *Alimodian, Bantog, Faraon*, and *Sapian* were marginally suitable (S3) to selected crops. Some of these findings also did not conform to the findings of PhilRice (2013).

Alimodian series was rated currently not suitable (N1) for corn primarily because of soil pH (Appendix Table 1). On the other hand, this series was rated permanently not suitable (N2) for irrigated rice due to its rolling to hilly and mountainous topography (Appendix Table 2). These suitability ratings were generated using the landscape and soil requirements for corn (Sys et al., 1993). To resolve and correct the problem on acidity, it is recommended to lime the soil a month before planting to give time for lime material to react with other cations in the soil. Another practice to improve soil condition is to add adequate fertilizer to supply the nutrients required for the growth and development of crops.

Table 2. Land quality requirements of major crops in Capiz.

CROPS	Degree of Limitation	Topography (t)	Wetness (w)		Soil (s)			Fertility (f)	
		Slope	Drainage	Flooding	Texture	Soil Depth (cm)	Coarse Fragments	Soil pH	%OC
Banana	0	0-8	Well-drained	None	SiCs, SiCL, CL, SiL	>100	0-3	6.4-5.8	>2.4
	1	8-16	Good	Slight	SC, L	100-75	3-15	5.8-5.6	2.4-1.5
	2	16-30	Moderate	Moderate	SCL	75-50	15-35	5.6-5.2	1.5-0.8
	3	30-50	Poor		SL, LfS, LS	50-25	35-55	5.2-4.5	<0.8
	4	>50	Very Poor	Severe	Cm, SiCm, fS, S, cS	<25	>55	<4.5	-
Cassava	0	0-4	Good	None	L, SCL	>125	0-3	6.0-5.5	>1.5
	1	4-8		-	SiC, Co, CL, SiCL, SC	125-100	3-15	5.5-5.2	1.5-0.8
	2	8-16	Moderate	-	LcS, LS, fS	100-75	15-35	5.2-4.8	-
	3	16-30	Imperfect	-	S, cS	75-50	35-50	4.8-4.5	-
	4	30-50	Poor but drainable	-	Cm, SiCm	<50	>55	<4.5	-
Coconut	0	0-4	Good	None	SiC, SiCL, CL, SiL, SC	>100	0-3	6.3-5.6	>1.5
	1	4-8	Moderate	-	L, SCL, SL, LfS, LS	100-75	3-15	5.6-5.2	1.5-0.8
	2	8-16	Imp. Fluctuate groundwater	-	LcS, fS	75-50	15-35	5.2-4.8	<0.8
	3	16-30	Imperfect, almost high groundwater	-	S, cS	5.-25	35-55	4.8-4.5	-
	4	30-50	Poor, drainable	-	Cm, SiCm	<25	>55	<4.5	-
Corn	0	0-4	Good	None	SiC, SiCL, Si, SiL, Cl	>100	0-3	6.6-6.2	>2
	1	4-8	Moderate	-	SC, L, SCL	100-75	3-15	6.2-5.8	2.0-12
	2	8-16	Imperfect	Slight	SL, LFS, LS	75-50	15-35	5.8-5.5	1.2-0.8
	3	16-30	Poor and aeric	Moderate	fS, S, LcS	50-20	35-55	5.5-5.2	<0.8
	4	30-50	Poor but drainable		Cm, SiCm, cS	<20	>55	<5.2	-

Sugar-cane	0	0-2	Good	None	SiC, Co, SiL, CL, Si, SiCL	>125	0-3	6.5-6	>2.5
	1	2-4	Moderate		SC, L, SCL	125-80	3-15	6.0-5.5	2.5-1.5
	2	4-8	Imperfect		LS, LfS	80-50	15-35	5.5-5.0	1.5-1.0
	3	8-16	Poor and aeric	Slight	LcS, fS, LS	50-25	35-55	5.0-4.5	<1.0
	4	>16	Poor but drainable	Moderate	Cm, SiCm, S, cS	<25	>55	<4.5	-
Sweet Potato	0	0-4	Good	None	SiC, Co, SiCL, Si	>100	0-3	6.6-6.0	>3
	1	4-8	Moderate	-	Sl, L, SCL, SC	100-75	3-15	6.0-5.2	3-2
	2	8-16	Imperfect	-	LS, LfS	75-50	15-35	5.2-4.8	2-1
	3	16-30	Poor and aeric	Slight	LcS, fS, S	50-20	35-55	4.8-4.5	<1
	4	30-50	Poor but drainable	Moderate	Cm, SiC	<20	>55	<4.5	-
Ir-rigated rice	0	0	Imperfect	F0, F11, F12	SiCs, Co, SiCL, CL, Si	>90	0	6.5-6	>2
	1	<1	Moderate	F21, F23, F31, F32	SiCs, Co, SiCL, CL, Si	90-75	<3	6.0-5.5	2.0-12
	2	1-2	Poor	F13, F	SiL, SC, L, SCL	75-50	3-15	5.5-5.0	1.2-0.8
	3	2-4	Very poor		SL, LfS, LS, LcS, fS	50-20	15-35	5.0-4.5	<0.8
	4	>4	-		S, cS	<20	>35	<4.5	-
Rainfed Upland Rice	0	0-2	Good	None	SiCs, Co, SiCL, Cl, Si, SiL	>120	<3	6.5-6	>2
	1	2-4	Moderate	-	SC, L	120-90	3-15	6.0-5.5	2-1.5
	3	8-16	Poor and aeric	F12-13	fS	50-20	35-55-	5.0-4.5	<0.8
	4	16-25	Poor but drainable	>F13	-	<20	>55	<4.5	-

Source: Sys, et al., 1993

Bantog series obtained both currently not suitable (N1) for coconut and corn with wetness and soil pH as limiting factors, respectively. This series is classified as a lowland soil (Carating et al., 2014) and has external soil drainage. Just like *Alimodian, Bantog* series also has a pH below 5.0.

Faraon series was currently not suitable for corn and irrigated rice. The limiting factors for these crops are soil pH and topography, respectively. Cassava is permanently not suitable to this series because of rock outcrops. Soil depth required for cassava to be highly suitable is between 100 cm to 125 cm (Sys, Van Ranst, Debaveye, & Beernaert, 1993). Faraon has a soil depth of 30 cm only. This is due to the presence of stones ranging from common to many (PhilRice, 2013).

Luisiana and San Manuel were both currently not suitable (N1) to banana, coconut, corn, sugarcane, sweet potato, and rainfed upland rice. The common limiting factor for both soil series is soil pH (Appendix Table 1). According to Sys et al. (1993), for these soil series to be highly suitable to these crops, the pH should range from 5.2 to 6.3 (coconut); 5.6 to 6.4 (banana); 5.5 to 6.5 (rainfed upland rice); 5.2 to 6.6 (sweet potato); and 5.5 to 6.5 (sugarcane). On the other hand, for irrigated rice, these series failed to meet the pH requirement because their pH is below 5.0.

Lastly, *Sapian* series is also currently not suitable (N1) for corn due to pH. *Sapian* series is classified as soil of the hills and mountains (Carating et al., 2014) which is characterized by low fertility (PhilRice, 2013). On the other hand, this soil series is permanently not suitable to cassava and irrigated rice due to fertility problem (pH) and topography.

Table 4 summarizes the identified soil constraints and their corresponding recommended cultural and management strategies that will serve as a guide to farmers and researchers. It can be noticed that pH was consistently the common limitation of the different major soil series followed by topography. Other factors such as rainfall, drainage and course fragments also limit production. The problem on soil acidity can be corrected by liming while other factors like drainage can be minimized by the installation of drainage canals and flood control system. In the case of course fragments, manual removal of rocks and stones is recommended. Rocks can be piled to serve as barrier, especially in areas with high slopes. The slope can be addressed by terracing, minimum tillage and intensive soil conservation practices such as cover cropping. Other recommended practices for the replenishment of depleted nutrients are the incorporation of organic matter and adequate fertilization. Mulching can also be practiced to avoid a surface run-off.

Figure 4 shows the generated crop suitability maps using geographical information system (GIS) to give a clearer view of the specific locations in the field where the major crops can be planted.

Table 3. The summary of crop suitability ratings of the different soil series in Capiz.

Crop	**Soil Series**					
	Alimodian	**Bantog**	**Faraon**	**Luisiana**	**San Manuel**	**Sapian**
Banana	S3tf	S3f	S3sf	N1f	N1f	S3tsf
Cassava	S3sf	S3wsf	N2s	S3f	S3f	N2s
Coconut	S3f	N1w	S3ts	N1f	N1f	S3tsf
Corn	N1f	N1f	N1f	N1f	N1f	N1f
Sugarcane	S3f	S3f	S3sf	N1f	N1f	S3f
Sweet Potato	S3cf	S3wf	S3sf	N1f	N1f	S3tsf
Irrigated Rice	N2t	S3f	N1t	N2tf	N2f	N2ts
Rainfed Upland Rice	S3tcf	S3cf	S3csf	N1f	N1f	S3tsf

Suitability rating:
S1 Highly suitable
S2 Moderately suitable
S3 Marginally suitable
N1 Currently not suitable
N2 Permanently not suitable

Limitations:
t topography
w drainage, flooding
s texture, coarse fragments, soil depth
f pH, OM
c rainfall, temperature, relative humidity

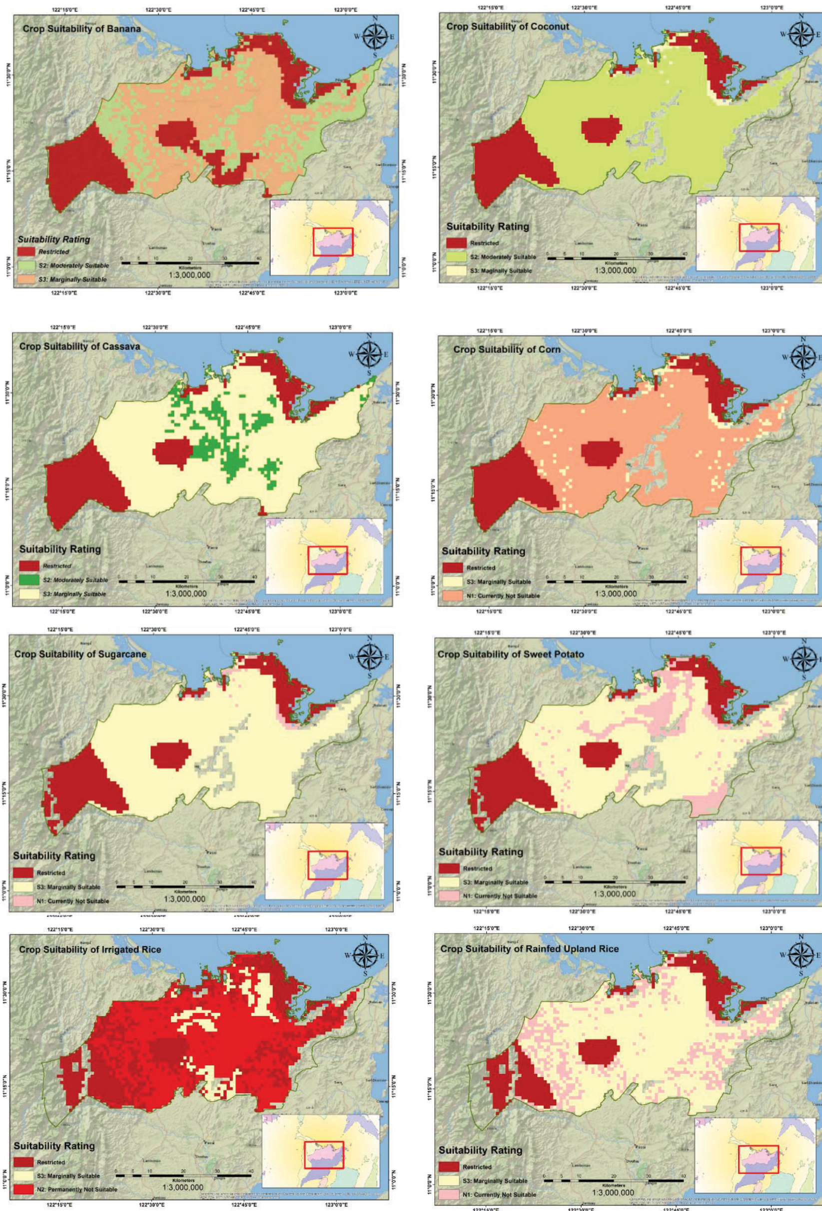

Figure 4. Crop suitability map of the different major soils in Capiz

Table 4. Limitations of crop production and recommended management strategies for the different soil series.

Soil series	Marginally Suitable	Currently not Suitable	Limitations	Recommendations
Alimodian	Banana, coconut, cassava, sugarcane, sweet potato, upland rice	Corn	Topography, pH, rainfall	Terracing, liming, adequate fertilization, organic matter incorporation, mulching, deep plowing, intensive soil conservation practices.
Bantog	Banana, cassava, sugarcane, sweet potato, irrigated rice, upland rice	Coconut, corn	pH, drainage, rainfall	Liming, installation of drainage canals and flood control system, proper maintenance of dikes, mulching, application of organic materials.
Faraon	Banana, coconut, sugarcane, sweet potato, upland rice	Corn, irrigated rice.	Topography, pH, drainage, course fragments	Terracing, liming, installation of drainage canals, manual removal of rocks and stones, shallow cultivation.
Luisiana	Cassava	Banana, coconut, corn, sugarcane, sweet potato, upland rice	pH, topography, low fertility	Liming, terracing, contour farming, strip cropping, cover cropping, adequate fertility, incorporation of OM
San Manuel	Cassava	Coconut, corn, sugarcane, sweet potato, upland rice	pH	Liming and adequate fertilization, incorporation of OM
Sapian	Banana, coconut, sugarcane, sweet potato, upland rice	Corn	Topography, pH, course fragments	Terracing, liming, manual removal of rocks and stones, mulching, OM incorporation

Results of the study reveal that the soil series (*Alimodian, Bantog, Faraon, Luisiana, San Manuel*, and *Sapian*) in the province of Capiz were generally marginally suitable (S3), currently not suitable (N1), and permanently not suitable for banana, cassava, coconut, corn, sugarcane, sweet potato, irrigated rice, and rainfed upland rice.

Alimodian soil series is marginally (S3) suitable to banana, cassava, coconut, sugarcane, sweet potato, and rainfed upland rice. Soil constraints identified include topography (slope) and pH for banana, soil depth and pH for cassava, pH for coconut and sugarcane, rainfall and pH for sweet potato and rainfed upland rice. It was also found out that Alimodian series is currently not suitable for corn due to pH (<5) and that this series is permanently not suitable for irrigated rice due to slope. Alimodian is classified as soils of the uplands with rolling to hilly to mountainous topography.

Bantog, just like alimodian soil series, is also marginally suitable for banana, cassava, sugarcane, sweet potato, irrigated and rainfed upland rice, but currently not suitable for coconut and corn. Limiting factors to growing this crops include pH for all the crops, drainage for cassava and sweet potato, and rainfall for rainfed upland rice. Cocorn and coconut are both not suitable to this series because of drainage and fertility problem (pH). Bantog is characterized by poor drainage.

Faraon, is marginally suitable (S3) for banana, coconut, sugarcane, sweet potato, and rainfed upland rice. Similarly, pH is the most common limiting factor and coarse fragments of rock outcrops. *Faraon* is also currently not suitable (N1) for corn and irrigated rice and permanently not suitable for cassava. Soil depth is the constraint found to growing cassava on this soil while pH and slope for corn and irrigated rice, respectively.

Faraon, just like *Alimodian* soil series, is classified as soils of the uplands with rolling to hilly to mountainous topography.

CONCLUSION

The different soil series in the Province of Capiz showed varied physical and chemical characteristics based on laboratory results. These variations occur because these soils developed and formed from different parent materials and managed by farmers. Factors such as topography, fertility, wetness, soil characteristics such as stoniness and soil depth, and climatic characteristics of these soils, also contributed to the suitability of these soils to different crops. The different major crops in the Province that were considered also showed different requirements for their growth and development.

Soil constraints identified can be corrected by the application of lime to neutralize acidity; terracing for high slopes to minimize erosion; deep plowing to enhance soil depth; and installing proper and adequate water system to supply water to higher areas. Other recommended strategies include adequate fertilization, incorporation of organic matter, installation of drainage canals and flood control systems, mulching, manual removal of rocks and stones and deep plowing.

GIS-aided crop suitability maps were generated to serve as guide in the field for easier identification of locations for planting crops.

Since these soils are continuously used by farmers in growing different crops, it is wise to conduct regular soil survey and analysis to monitor fertility status and degree of variabilities in the field for proper land use. Farmers should also be oriented with new technologies to improve soil productivity and crop yield.

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