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FAO Suitability Analysis as a Tool in Identifying Constraints to Sugarcane Production in Negros Island, Philippines

Ryan T. Sarimong*

* College of Agriculture and Forestry
Capiz State University-Burias Campus, Mambusao, Capiz, Philippines

Abstract- The need to optimize land use has never been greater than at present, when rapid population growth and urban expansion are making areas available for agriculture a relatively scarce commodity.Locating specific sugarcane areas in Negros Island and their specific constraints are paramount to properly manage the current and future use of these arable lands. Thus, this research was designed to determine sugarcane production related constraints of selected soils in Negros Island and to recommend management strategies to address these constraints.Suitability analysis was done following the FAO suitability analysis scheme. Results of suitability analysis served as basis in identifying constraints of a particular soil type when used for sugarcane production.

Results revealed that all the 19 soil types used for sugarcane production in Negros Occidental were classified as marginally suitable according to the FAO scheme because of the existence of one severe limitation. The most common constraint found in sugarcane soils of Negros Occidental was wetness which depicts the possibility of flooding and drainage problem.Of the 10 soil types used for sugarcane production in Negros Oriental, only Siaton sandy loam was rated as moderately suitable because of the presence of only 2 slight limitations (wetness and climate) and 2 moderate limitations (soil fertility and physical properties). The remaining soil types were classified as marginally suitable with wetness and climate as the most dominating limitations.Furthermore, suitability map and constraint map were generated from the results of suitability analysis using FAO scheme. Recommended management strategies for each soil type were likewise suggested.

Index Terms*- suitability analysis, sugarcane production, FAO, constraints, soil types, soil series*

I. Introduction

The sugar industry has always been a major contributor to the Philippine economy. The report of the Sugar Regulatory Administration (SRA, 2015) indicated that in crop year 2013-2014, it contributed about 87 billion to the national output. In terms of trade balance and foreign reserves, it accounted for 111.76 million US dollars. As an industrial crop, it provides a significant source of livelihood through farming, processing and trading activities to 700,000 workers and 5 million dependents. Considering the production statistics, records from the Philippine Statistics Authority (PSA, 2014) showed that sugarcane production in 2014 went up by 4.18 percent which posted 2.90 percent higher gross earnings. This growth rate of sugar production has been achieved mainly through the expansion of cultivated areas.

Although the government has identified some 60,250 hectares as potential sugarcane plantation sites, this available resource could only supply the market for sugarcane products and by-products. Therefore, a strategy for developing the Philippine sugarcane industry should focus on increasing farm productivity. The country’s national average yield of 60 tons cane per hectare is still one of the lowest among sugar producing countries in Southeast Asia. There is also a need to address variations at the farm level since productivity varies enormously (Padilla-Fernandez and Nuthall, 2009).

Sugarcane production in Negros Island ranges from subsistence farming, i.e. the area is small enough just to sustain the need of the household, to large plantations owned by hacienderos. The production is likewise carried in almost all tillable areas and even fragile lands, which include the flat lowlands and the hilly and mountainous uplands. Massive land conversion from non-sugarcane to sugarcane is also evident especially in areas with rugged topography. The suitability of these areas for sugarcane production is therefore in question, as this will limit the productivity of the land for its intended purpose. Thus, the need to locate these specific sugarcane areas and their specific constraints are paramount to guide us to manage properly the current and future use of these arable lands.

In view of the vital contribution and role of the industry to the Philippine economy, the production of sugarcane must be given proper support by the government if it is to be made competitive. This can be attained by improving the technical efficiency of the sugarcane farmers, that is, their ability to achieve maximum output within their resources and current technology (Padilla-Fernandez and Nuthall, 2009). However at the outset, land resources used for sugarcane production should be assessed for suitability in order to optimize the use of available technology and inputs. Likewise, there is a pressing need for an appropriate land use system in response to the dwindling agricultural production against a towering population growth.Hence, this research was conceived.

Generally, the purpose of this study was to identify constraints to sugarcane production in Negros Island through FAO suitability analysis scheme. Specifically, the paper intended to: identify the soil types commonly used for sugarcane production in Negros Island; conduct suitability analysis of sugarcane soils in Negros Island using the FAO suitability analysis scheme; determine sugarcane production related constraints of each soil type; and provide recommendations on corrective measures to address the constraints identified for each soil type.

II. METHODOLOGY

A. Identification of Sugarcane Soils in the Study Area

The study area covered the Negros Island Region which is considered the Sugarcane Bowl of the Philippines. It is located in the Western part of Visayas.A review of publications related to sugarcane researches in Negros Island was done to identify the soils planted with sugarcane in the region. Javellana (2001) and Hombrebueno (1980) identified the major soil series used for sugarcane production in Negros Island. In Negros Occidental, the following soil series were found to be extensively used for sugarcane production:Bantay, Bolinao, Faraon, Guimbalaon, Isabela, La Castellana, Luisiana, San Manuel, Silay, and Umingan. For Negros Oriental, these soil series were used for long-term sugarcane production: Bolinao, Faraon, Isabela, La Castellana, Mandawe, San Manuel, and Siaton.

B. Gathering Data on Soil and Climatic Characteristics

Data on soil and climatic characteristics of the 12 soil series used for sugarcane production was obtained from available references. Simplified Keys to Soil Series of Negros Occidental and Negros Oriental published by PhilRice (2014), the Soil Survey Reports of Negros Occidental (Alicante et al., 1951) and Negros Oriental (Barrera and Jaug, 1960), and the work of Wiangsamut (2010) were used as references for most of the soil characteristics. Climatic characteristics of each soil series were obtained from www.en.climate-data.org. The data on mean annual rainfall and temperature was available for each municipality while the mean relative humidity was given per province. Having these information, an overlaying of Negros soil map (BSWM, 2013) and Municipal map (www.philgis.org) through ArcGIS 10.2 software was made to locate geographically the distribution of each soil series.

C. Defining and Matching the Soil and Climatic Requirements for Sugarcane Production

The criteria set by Sys, et al. (1993) on the soil and climatic requirements for sugarcane was used in determining the suitability of sugarcane to the previously identified 12 soil series. After the soil and climatic characteristics of the 12 soil series were obtained, they were then matched with the sugarcane requirements provided by Sys et al. (1993) to determine their suitability class. Matching was done using the FAO land evaluation system with the following interpretations of suitability classes:

Class S1 – soils without limitations or with 2 or 3 slight limitations.
Class S2 – soils with 2 or 3 slight limitations and no more than 2 moderate limitations.
Class S3 – soils with more than 2 moderate limitations and/or no more than 1 severe limitation that however does not exclude the use of the land.
Class N1 – soils with one severe limitation that excludes the use of the land or more than one severe limitation that can be corrected.
Class N2 – soils with severe or very severe limitations excluding the use of the land and that cannot be corrected.

D. Preparation of Sugarcane Suitability and Production Constraint Map

Sugarcane suitability map was prepared from the results of the suitability analysis. This was done to easily locate sites best suited for sugarcane growing and to aid in tracking down areas with production constraints.The constraints were then laid on a map to have a spatial view of the distribution of constraints across the island. Correspondingly, measures to address the constraints were recommended.

III. RESULTS AND DISCUSSION

Suitability Classification and Constraint Analysis of Soils in Negros Island for Sugarcane Production

Table Ipresents the suitability rating of selected soil types in Negros Island for sugarcane production. In the case of Negros Occidental, all the soil types subjected for suitability analysis were classified as marginally suitable (S3) which means that these soils have more than 2 moderate limitations and/or no more than 1 severe limitation that however does not exclude the use of the land for sugarcane production. Some of the identified severe limitations were: wetness for Bantay clay loam, Isabela clay, Isabela sandy loam, San Manuel fine sandy loam, San Manuel loam and Umingan clay loam; climate for Bolinao clay and Faraon sandy loam; soil physical properties for Faraon clay, Guimbalaon clay, Guimbalaon sandy loam, Guimbalaon loam and Guimbalaon loam gravelly; topography for Faraon clay steep phase and La Castellana clay loam; and soil fertility for Luisiana clay, Silay clay, Silay sandy loam and Silay loam.

It is also shown in Table I that out of the 10 soil types in Negros Oriental which were considered for suitability analysis, only Siaton sandy loam was classified as moderately suitable (S2). This soil has 2 slight limitations (wetness and climate) and 2 moderate limitations (soil fertility and physical properties). The rest were rated as marginally suitable (S3) due to their severe limitation like wetness (Isabela clay, San Manuel fine sandy loam, San Manuel loam), soil physical properties (Bolinao clay, Faraon clay), topography (Faraon clay steep phase), and climate (La Castellan clay, La Castellana clay loam steep phase, Mandawe clay).

The summary of constraints for sugarcane production of some soil types in Negros Island is presented in Table II. Likewise, a suitability map of sugarcane production in Negros Island is illustrated in Figure 1 and the spatial distribution of constraints is mapped in Figure 2. To address these constraints, recommended management strategies / corrective measures for each soil type are listed in Table III.

Table I: Suitability rating for sugarcane production of some soil types in Negros Island

Soil Types (Negros Occidental)	**Suitability Rating**	**Soil Types (Negros Oriental)**	**Suitability Rating**
Bantay clay loam	S3wstfc	Bolinao clay	S3stwfc
Bolinao clay	S3cstwf	Faraon clay	S3stwfc
Faraon clay	S3stwc	Faraon clay steep phase	S3tswfc
Faraon clay steep phase	S3tswfc	Isabela clay	S3wsfc
Faraon sandy loam	S3cstw	La Castellana clay	S3cstfw
Guimbalaon clay	S3stfwc	La Castellana clay loam steep phase	S3ctsfw
Guimbalaon loam	S3stfc	Mandawe clay	S3cwsf
Guimbalaon loam gravelly	S3stfc	San Manuel fine sandy loam	S3wsfc
Guimbalaon sandy loam	S3stfwc	San Manuel loam	S3wcf
Isabela clay	S3wsfc	Siaton sandy loam	S2fswc
Isabela sandy loam	S3wsfc		
La Castellana clay loam	S3tsfwc		
Luisiana clay	S3ftwc		
San Manuel fine sandy loam	S3wsfc		
San Manuel loam	S3wfc		
Silay clay	S3fswc		
Silay loam	S3fwc		
Silay sandy loam	S3fswc		
Umingan clay loam	S3wfsc		

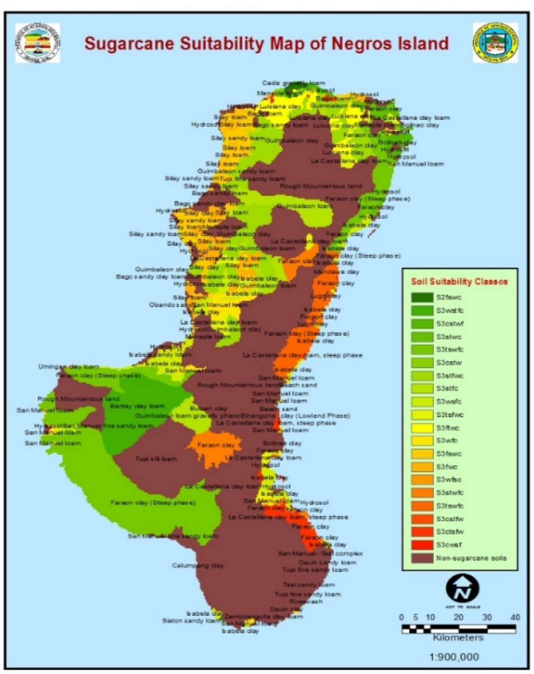
Limitations:*c-climatic, t-topographic, w-wetness, f-soil fertility not readily to be corrected, s-soil physical properties*

Table II: Summary of constraints of each soil type when used for sugarcane production

Soil Types	**Constraints**				
	Topography	Wetness	Soil physical properties	Fertility characteristics	Climatic characteristics
Bantay clay loam	Gently sloping to undulating, moderate erosion	Excessive external drainage	Shallow soil limit	Slightly acidic, low K	
Bolinao clay	Rolling topography, erosion risk	Moderately permeable	Presence of stones, hard workability, shallow rooting depth	Slightly acidic, low K	Insufficient rainfall may require irrigation

Faraon clay	Rolling topography, moderate erosion	Slow permeability	Many rock outcrops, hard workability, shallow rooting depth	High pH may cause Fe and Zn deficiency	
Faraon clay steep phase	Hilly, severe erosion	Slow permeability	Many rock outcrops, hard workability, shallow rooting depth	High pH may cause Fe and Zn deficiency	
Faraon sandy loam	Rolling to hilly topography, erosion risk	Slow permeability	Many rock outcrops, shallow rooting depth	Slightly alkaline	Insufficient rainfall may require irrigation
Guimbalaon clay	Rolling to hilly topography, severe erosion	Impeded drainage	Presence of rock outcrops, hard tillage, presence of hardpan, shallow rooting depth	Slightly acidic, low P and K	
Guimbalaon loam	Rolling to hilly topography, severe erosion	Low water retention	Presence of rock outcrops, shallow rooting depth	Slightly acidic, poor nutrient retention, low base saturation, low P and K	
Guimbalaon loam gravelly	Rolling to hilly topography, severe erosion	Low water retention	Many rock outcrops and pebbles, hard workability, shallow rooting depth	Slightly acidic, poor nutrient retention, low base saturation, low P and K	
Guimbalaon sandy loam	Rolling to hilly topography, severe erosion	Low water retention, rapid permeability	Presence of rock outcrops, shallow rooting depth	Slightly acidic, poor nutrient retention, leaching of bases, low P and K	
Isabela clay		Seasonally flooded, poor drainage	Hard workability, severe topsoil shrinking and swelling	High P fixation	
Isabela sandy loam		Seasonally flooded, poor drainage	Hard workability, severe topsoil shrinking and swelling	High P fixation	
La Castellana clay	Rolling topography, severe erosion	Excessive drainage, low moisture	Presence of boulder outcrops, hardly tilled, shallow rooting depth	N and P deficiency, acidic	Insufficient rainfall may require irrigation
La Castellana clay loam	Rolling to hilly topography, severe erosion	Excessive drainage, low moisture	Many boulder outcrops, hard tillage, shallow soil depth	Acidic, low inherent fertility	
La Castellana clay loam steep phase	Hilly topography, severe erosion	Excessive drainage, low moisture	Many boulder outcrops, hard tillage, shallow soil depth	Acidic, low inherent fertility	Insufficient rainfall may require irrigation
Luisiana clay	Rolling topography, risk of run-off			Very acidic, low K and other bases, low nutrient retention	
Mandawe clay		Frequent flooding, poor drainage	Few stones, moderate workability	Slightly alkaline, low K	Insufficient rainfall may require irrigation
San Manuel fine sandy loam		Excessively wet and annual flooding for short periods and	Rapid permeability	Low organic matter	

	excessive drought during dry season			
San Manuel loam	Excessively wet and annual flooding for short periods and excessive drought during dry season		Low organic matter	Insufficient rainfall may require irrigation
Siaton sandy loam		Moderate permeability	Slightly acidic, moderate organic matter	
Silay clay	Poor drainage, impeded percolation due to the presence of "bakias"	Difficulty in tillage	Acidic, low inherent fertility	
Silay loam	Poor drainage, impeded percolation due to the presence of "bakias"		Acidic, low inherent fertility	
Silay sandy loam	Poor drainage, impeded percolation due to the presence of "bakias"		Acidic, low inherent fertility	
Umingan clay loam	Excessive downward movement of water, hence tends to be droughty, seasonal flooding especially after heavy rains	Rock outcrops abundant at 0.6 m	Slightly acidic, relatively low fertility	



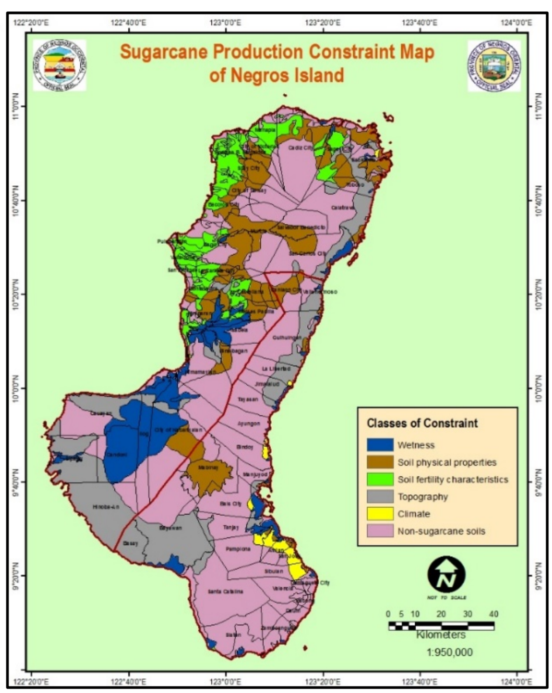


Figure 1: Suitability map

Figure 2: Constraint map

Table III: Recommended management strategies / corrective measures for each soil type when used for sugarcane production

Soil Types	Soil Management Recommendations / Corrective Measures
Bantay clay loam	Lime application, adequate fertilization, contour farming, maybe used for diversified cropping
Bolinao clay	Contour farming, proper fertilization, organic matter addition, timing of planting, adequate irrigation system, use of limestone outcrops for bunding, maybe used for diversified farming
Faraon clay	Contour farming, shallow cultivation, timing of planting and plowing, application of less-acidic fertilizers, construction of bunds from limestone outcrops, maybe used for diversified farming
Faraon claysteep phase	Contour farming, shallow cultivation and minimum tillage, application of less-acidic fertilizers, construction of bunds from limestone outcrops, maybe used for diversified farming
Faraon sandy loam	Contour farming, shallow cultivation , application of less-acidic fertilizers, construction of bunds from limestone outcrops, adequate irrigation facilities, maybe used for diversified farming
Guimbalaon clay	Contour farming, erosion prevention and water control practices, OM incorporation, proper fertilization, liming, use of outcrops for bunding, subsoiling to break hardpan, maybe used for diversified farming
Guimbalaon loam	Contour farming, erosion prevention and water control practices, OM incorporation, proper fertilization, liming, use of outcrops for bunding, maybe used for diversified farming
Guimbalaon loam gravelly	Contour farming, erosion prevention and water control practices, OM incorporation, proper fertilization, liming, use of outcrops for bunding, maybe used for diversified farming
Guimbalaon sandy loam	Contour farming, erosion prevention and water control practices, OM incorporation, proper fertilization, liming, use of outcrops for bunding, maybe used for diversified farming
Isabela clay	N and P fertilization, build drainage canals, construct furrows and ridges, cultivate at optimum moisture content, maybe used for diversified farming
Isabela sandy loam	N and P fertilization, build drainage canals, construct furrows and ridges, cultivate ate optimum moisture content, maybe used for diversified farming
La Castellana clay	N and P fertilization, lime application, contour farming, adequate irrigation, use of rock outcrops to construct bunds, maybe used for diversified farming
La Castellana clay loam	N and P fertilization, lime application, contour farming, adequate irrigation, use of rock outcrops to construct bunds, maybe used for diversified farming
La Castellana clay loam steep phase	N and P fertilization, lime application, contour farming, shallow cultivation and minimum tillage, adequate irrigation, use of rock outcrops to construct bunds, maybe used for diversified farming
Luisiana clay	Contour farming, adequate fertilization, liming, OM incorporation, maybe used for diversified farming
Mandawe clay	Proper fertilization, adequate irrigation, build drainage canals, construct furrows and ridges, cultivate at optimum moisture content, maybe used for diversified farming
San Manuel fine sandy loam	Adequate drainage, irrigation and flood control systems, broad furrows and ridges, regular addition of organic matter, proper fertilization, timing of cultivation and planting, maybe used for diversified farming
San Manuel loam	Adequate drainage, irrigation and flood control systems, adequate supplemental irrigation, broad furrows and ridges, regular addition of organic matter, proper fertilization, timing of cultivation and planting, maybe used for diversified farming
Siaton sandy loam	Proper fertilization, organic matter addition, liming, supplemental irrigation, maybe used for diversified farming
Silay clay	Adequate fertilization, OM incorporation, liming, deep plowing, build adequate

	drainage canals, maybe used for diversified farming
Silay loam	Adequate fertilization, OM incorporation, liming, deep plowing, build adequate drainage canals, maybe used for diversified farming
Silay sandy loam	Adequate fertilization, OM incorporation, liming, deep plowing, build adequate drainage canals, maybe used for diversified farming
Umingan clay loam	Construction of adequate irrigation and flood control system, application of fertilizer and organic matter, liming, clearing of large gravels and rocks, maybe used for diversified farming

IV. CONCLUSIONS

In conclusion, a greater proportion of soil types in Negros Occidental is used for sugarcane farming implying the great dependence of the province's economy on the sugar industry. In Negros Oriental, sugarcane growing is limited only to some soil types reflecting that the province may have other priority crops beside sugarcane. As a tool,FAO scheme can be effectively used in conducting suitability analysis of soils grown to sugarcane and consequently in determining production related constraints of each soil type.Results of FAO suitability analysis can serve as basis in generating suitability map and constraint map.

REFERENCES

[1] Alicante, M. M., Rosell, D. Z., Barrera, A., Jaug, J. O. and L. Engle. 1951. Soil Survey of Negros Occidental Province, Philippines. Soil Report 14. Department of Agriculture and Natural Resources. Bureau of Printing, Manila. 119 pp.
[2] Barrera, A. and J. Jaug. 1960. Soil Survey of Negros Oriental Province, Philippines. Soil Report 26. Bureau of Soils, Department of Agriculture and Natural Resources. Bureau of Printing, Manila. 97 pp.
[3] BSWM. 2013. Soil Series Map of the Philippines. Updating the Harmonized World Soil Database (HWSD): Correlation of Philippine Soils into FAO's World Reference Base for Soil Resources (WRB).
[4] Hombrebueno, E. M. 1980. A parametric approach to productivity evaluation of soils for sugarcane production. Ph. D. Dissertation, UPLB, College, Laguna.
[5] http://www.sra.gov.ph. Retrieved on October 10, 2015.
[6] Javellana, A. M. J. 2001. The productivity rating of major sugarcane soils in Negros Occidental, Philippines. Unpublished M. S. Thesis, University of the Philippines Los Banos, Laguna.
[7] Padilla-Fernandez, M. D. and P. L. Nuthall. 2009. Technical efficiency in the production of sugarcane in Central Negros area, Philippines: an application of data envelopment analysis. J. ISSAAS Vol. 15 No. 1: 77-90.
[8] Philippine Political Map. Retrieved from www.philgis.org.
[9] PhilRice. 2014. Simplified Keys to Soil Series of Negros Occidental. Soil Series Guidebook ISBN 978-971-9081-90-6. Philippine Rice Research Institute. 65 p.
[10] PhilRice. 2014. Simplified Keys to Soil Series of Negros Oriental. Soil Series Guidebook ISBN 978-971-9081-91-3. Philippine Rice Research Institute. 57 p.
[11] PSA. 2014. Performance of Philippine Agriculture January to December 2014. Philippine Statistics Authority. Retrieved from https://psa.gov.ph on August 7, 2015.
[12] Sys, C., Van Ranst, E., Debaveye, J. and F. Beernaert. 1993. Land Evaluation. Part III – Crop Requirements. Agricultural Publications – N^0 7, General Administration for Development Cooperation, Brussels, Belgium.
[13] Wiangsamut, B. 2010. Compiled Laboratory Exercises in Soil 260 (Environment and Land Use). Study Area: Negros Occidental. SAED, UPLB.
[14] www.en.climate-data.org/location. Climate data of different municipalities in Negros Occidental and Negros Oriental, Philippines.

AUTHOR

First Author / Correspondence Author – Ryan T. Sarimong, Faculty of Soil Science and Agronomy, Capiz StateUniversity-Burias Campus, Mambusao, Capiz, Philippines. Email address: ryansoiler4@yahoo.com

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