APPLICATION OF GIS IN THE MAPPING OF SOIL FERTILITY DISTRIBUTION IN THE MEKONG DELTA

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ABSTRACT

Mekong Delta is one of the largest agricultural production areas in Vietnam. However, in recent years, the intensification of crops and the overexploitation of the land potential led to the soil degradation. Therefore, it is necessary to build soil fertility maps in order to have reasonable land use and exploitation measures. In addition, with the development of science and technology, especially GIS technology makes mapping easier. The study was conducted to determine the spatial distribution of soil fertility types and its constraints for agricultural cultivation. The study used the method of collecting information, converting soil classification map classified by WRB system into soil fertility map classified by FCC system; Identify obstacles based on soil fertility characteristics. Research results have identified Mekong Delta has 35 types of soil fertility: CCC, LLC, CCCf-, LLCf, OOOf, CCCs-, CCiC, ,LLiC, CCfC, CCiCf, LLfCs, CapCacC, LapLacC, SkeoSkS, SkeoRkR, Cs-Cs-Cs-, Ls-Ls-Cs-, CsCsCs, Ls-Ls-Cf s-, Ls-Ls-fCs-, CsCsCf s, LsLsCf s, LsLsfCs, Ca-pCa-Cc-, La-pLa-Cc-, Oa-pOa-Oc-, Ca-pCa-Cc-f, CapCacCf, Ca-ps-Ca-s-Cc-s-, La-ps-La-s-Cc-s-, Ca-psCa-sCc-s, Caps-Cacs-Cs-, CapsCacsCs, LapsLacsCs, CapsCacsCf s. Identified 11 types of constraints for agricultural cultivation, including Slightly acid (a-), Strongly acid (a), High P fixation and high Fe toxicity potential (i), Low available P (p), Strongly actual acid sulfate soils (c), Slightly actual acid sulfate soils (c-), Shallow potential acid sulfate soil (f) Deep potential acid sulfate soil (f-), Slight salinity (s-), Strongly salinity (s), Ability low supply mineral (k), Ability low nutrient retention (e), Low organic carbon content (o).

1. INTRODUCTION

The Mekong delta is one of the biggest agricultural cultivation regions in Vietnam. The intensive farming, rice cropping, unbalanced fertilization, less use of organic fertilizer led to the soil degradation (Guong, V.T. et al., 2010). In addition, constructing of dykes to prevent floods, using a lot of chemical fertilizers and pesticides which had made agricultural land, especially rice land was become harden and lose fertility (Guong, V.T. et al., 2016). The intensive cultivation that increased pressure on land led to degradation and pollution of soils (Minh, V.Q. and Tri, L.Q., 2016).

The Fertility Capability Soil Classification system (FCC) was developed more than 25 years ago to interpret soil taxonomy and soil tests in a quantitative manner that is relevant to growing plants (Buol et al., 1975; Sanchez et al., 1982). It is now widely used and included in the worldwide FAO soils database (FAO, 1995). Most of class limits were borrowed from Soil taxonomy (Soil Survey Staff, 1994) or the FAO/UNESCO soil classification system (FAO, 1974). Emphasis is placed on features that are easily detectable in the field, such as texture, color, depth of horizons, presence or absence of mottles, etc. Soil analytical laboratory data are only used to support the classification if available. The strength of this system is its ease of use, which allows the soil to be classified at several locations simply and quickly. To facilitate the easy transfer of information about soil properties and constraints, the system consisting of a series of individual letters to describe the soil. These properties signify fertility limitations with different interpretations, and represented by small letters (Minh, V.Q. and Tri, L.Q., 2016).

Nowadays, the technology sciences are sharp development, especially GIS technology which helps overlapping, composing, building maps to become easier. The study is based on the relationship between the WRB classification system (FAO, 2006) and the FCC system (Sanchez et al., 2003) with some modifications from Minh V.Q. (2007) and the power of GIS to map soil fertility for the Mekong Delta.

2. METHODOLOGY

2.1 Data collection

- Collect all data, secondary data which are relation with this study.

- Inheritance of the soil map classified according to WRB system (FAO, 2006) in Mekong delta in 2014 of the Department of Land Resources, College of Environment and Natural Resources, Can Tho University.

2.2 Fertility capability classification (FCC)

The Fertility Capability Classification (FCC) system from Sanchez et al. (2003), with some modifications from Minh V.Q. (2007) was used as reference system.

2.3 Determining the relationship between WRB system and FCC systems

- Determine the relationship between the diagnostic, diagnostic and diagnostic properties of the WRB system (FAO, 2006) with the structural characteristics of the FCC system (Sanchez et al., 2003; Minh V.Q., 2007).

- Develop the relationship between requirements and definitions of topsoil, subsoil and additional elements with diagnostic horizons, diagnostic materials, and diagnostic properties of the soil.

2.4 Geographic information system

- The FCC map was built based on coordinate reference system: EPSG:32648, WGS84/ UTM zone 48N.

- Using MapInfo software to compose, present and publish FCC map.

- Using ArcGIS software to overlay the FCC map with the administrative map of the Mekong Delta to determine the spatial distribution as well as the area of various types of soil fertility in each province.

3. RESULTS AND DISCUSSION

3.1 The base of the conversion from the soil map (WRB system) to the soil fertility map (FCC system)

In the FCC system which was supplemented by Minh. V.Q. (2007) that identify relationship between diagnostic horizons, diagnostic properties and diagnostic materials in rice cultivation land with some characteristics and constraint factors term in the FCC system. This will serve as a basis for the use of the Soil Map with diagnostic horizons, diagnostic properties and diagnostic materials for transformation into the soil fertility map in Mekong delta province. The basis for conversion is presented in Table 1 and Table 2.

Table 1: The relationship between Major Soil Groups (WRB system) and characteristics and constraint factors (FCC system) in Mekong Delta.

No.	Major Soil Groups	FCC system					
		Modifers			Soiltexture		
		0-20	20-50	50-100	0-20	20-50	50-100
1	Albeluvisols	-	-	-	C	C	C
2	Alisols	-	-	-	C	C	C
3	Arenosols	k, e and o	k	-	S	S	S
4	Fluvisols	-	-	-	L	L	C
5	Gleysols	-	-	-	C	C	C
6	Histosols	-	-	-	O	O	O
7	Leptosols	k, e and o	k	-	S	R	R
8	Luvisols	-	-	-	C	C	C
9	Plimthosols	-	i	-	C	C	C
10	Solonchaks	s	s	s	C	C	C

Notes: ***C**: Soil Texture is Clay* ***L**: Soil Texture is Loam* ***S**: Soil Texture is Sandy*
***R**: Rock* ***O**: Organic* ***k**: Ability low supply mineral*
***e**: Ability low nutrient retention* ***o**: Low organic carbon*

Table 2: The relationship between diagnostic horizons, diagnostic properties and diagnostic materials (WRB system) and characteristics and constraint factors (FCC system) in Mekong Delta.

No.	WRB system			FCC system		
	Diagnostic Horizons	Diagnostic Properties	Diagnostic Materials	Modifers		
				0-20	20-50	50-100
1	Thionic	EpiOrthiThionic	-	a and p	c	-
2	Thionic	EndoOrthiThionic	-	a- and p	-	c-
3	Thionic	EpiProtoThionic	Sulfidic	-	f	-
4	Thionic	EndoProtoThionic	Sulfidic	-	-	f-
5	Salic	-	-	s	s	s
6	-	HypoSalic	-	s-	s-	s-
7	-	EndoSalic	-	-	-	s
8	-	Sodic	-	s	s	s
9	Plinthic	-	-	-	i	-
10	-	Rhodic	-	-	i	-

Notes: ***a**: Slightly acid* ***a**: Strongly acid*
***i**: High P fixation* ***p**: Possible lack of P*
***s**: Slightly salinity* ***s**: Strongly salinity*
***c**: Strongly actual acid sulfate soils* ***c**: Moderately actual acid sulfate soils*
***f**: Shallow potential acid sulfate soil* ***f**: Deep potential acid sulfate soil*
***k**: Ability low supply mineral* ***e**: Ability low nutrient retention*
***o**: Low organic carbon*

3.2 The soil fertility map in Mekong delta based on the conversion from soil map

Based on the relationship between Major Soil Groups, diagnostic horizons, diagnostic properties and diagnostic materials (WRB system) and characteristics and constraint factors (FCC system) and Soil Map of Mekong Delta in 2014. The research was identified 35 types of soil fertility in Mekong Delta, including: CCC, LLC, CCCf-, LLCf-, OOOf-, CCCs-, CCiC,

,LLiC, CCfC, CCiCf-, *LLfCs*, CapCacC, LapLacC, SkeoSkS, SkeoRkR, Cs-Cs-Cs-, Ls-Ls-Cs-, CsCsCs, Ls-Ls-Cf-s-, Ls-Ls-fCs-, CsCsCf-s, LsLsCf-s, LsLsfCs, Ca-pCa-Cc-, La-pLa-Cc-, Oa-pOa-Oc-, Ca-pCa-Cc-f-, CapCacCf-, Ca-ps-Ca-s-Cc-s-, La-ps-La-s-Cc-s-, Ca-psCa-sCc-s, Caps-Cacs-Cs-, CapsCacsCs, LapsLacsCs, CapsCacsCf-s. Therein, the biggest area is the CCC soil fertility (790,734.0 ha, accounting for 20,21%) and the smallest area is the Oa-pOa-Oc- soil fertility (2,484,8 ha, accounting for 0,06%). Specifically, the types of soil fertility and their distribution are presented in Table 3 and Figure 1. Besides that, the research was identified 11 types of constraints for agricultural cultivation, including Slightly acid (a-), Strongly acid (a), High P fixation and high Fe toxicity potential (i), Low available P (p), Strongly actual acid sulfate soils (c), Slightly actual acid sulfate soils (c-), Shallow potential acid sulfate soil (f) Deep potential acid sulfate soil (f-), Slight salinity (s-), Strongly salinity (s), Ability low supply mineral (k), Ability low nutrient retention (e), Low organic carbon content (o).

Table 3: The types of soil fertility and their distribution in Mekong Delta.

No.	FCC	An Giang	Bạc Liêu	Bến Tre	Cà Mau	Cần Thơ	Đồng Tháp	Hậu Giang	Kiên Giang	Long An	Sóc Trăng	Tiền Giang	Trà Vinh	Vĩnh Long	Tổng
1	CCC	170.197,5	25.285,1	5.691,1	8.366,6	52.335,0	59.532,5	92.101,2	117.477,5	48.418,4	153.765,9	6.084,6	19.329,7	32.148,8	790.734,0
2	LLC	65.021,2		23.526,2		9.452,3	53.101,6	5.256,5	1.748,6	1.745,8	7.208,5	13.417,4	24.480,2	14.354,7	219.313,1
3	CCCf-	42.639,1				35.791,1	68.993,2	4.998,1	16.368,3	71.102,8		9.111,8	1.840,4	17.204,4	268.049,1
4	LLCf-					22.317,0		2.976,8	1.820,9	7.877,5				18.220,4	53.212,6
5	OOOf-	553,2			19.209,4			41,5	10.231,3						30.035,3
6	CCCs-		83.968,6	19.418,8	164.320,6				88.051,2	1.325,7	28.932,1	25.542,1	12.538,6		424.097,5
7	CCiC	5.254,9		25.204,3			104.674,8		4.953,0	142.454,3		35.045,7	13.692,8	41.228,5	372.508,3
8	LLiC			18.258,1			18.056,9			41.995,2		77.472,3	26.852,7	7.254,9	189.890,0
9	CCfC									2.935,6		9.505,5			12.441,1
10	CCiCf-													3.707,2	3.707,2
11	LLfCs			5.517,0						7,7		11.557,6			17.082,2
12	CapCacC	10.416,2	774,3			9.794,3	15.534,0	18.674,6	57.645,5	3.451,0	12.296,5	3.683,7	729,7	6.853,1	139.852,9
13	LapLacC	1.148,5						6.849,0	9.033,1	10.846,6	5.638,7				33.515,9
14	SkeoSkS	7.575,0	595,0	8.978,3						211,6	8.549,7	7.312,1	20.755,7	2.685,1	56.662,5
15	SkeoRkR	10.707,5							5.120,0						15.827,5
16	Cs-Cs-Cs-		37.491,9	50.824,3	15.440,5			5.247,2	8.517,2	6.226,6	3.279,9	5.762,7	8.705,1		141.495,3
17	Ls-Ls-Cs-										6.383,4		26.722,6		33.106,0
18	CsCsCs		42.267,7	34.337,8	39.230,3				17.900,6	40.891,9	94.446,5	13.346,3	27.839,2		310.260,2
19	Ls-Ls-Cf-s-			4.253,5	6.252,6				15.016,0				3.819,2		29.341,3
20	Ls-Ls-fCs-		802,8					8.679,7	13.236,8						22.719,3
21	CsCsCf-s		13.285,2		3.942,7				621,1						17.849,0
22	LsLsCf-s			2.791,4	28.929,7				697,2		900,0		6.786,5		40.104,7
23	LsLsfCs		10.024,8	8.305,9	142.211,4				17.783,9				8.443,4		186.769,3
24	Ca-pCa-Cc-	5.211,5	32.498,1		10.801,6	911,7		4.206,5	39.095,0	2.072,6					94.796,9
25	La-pLa-Cc-	7.948,9					1.864,9	8.304,4		7.477,9	4.498,3				30.094,5
26	Oa-pOa-Oc-								2.484,8						2.484,8
27	Ca-pCa-Cc-f-								9.130,0						9.130,0
28	CapCacCf-	10.805,8			71.253,4	9.920,5			48.894,8	55.332,3	1.136,7	16.701,6			214.045,0
29	Ca-ps-Ca-s-Cc-s-		398,7						3.347,5				9.453,1		13.199,3
30	La-ps-La-s-Cc-s-									2.902,2					2.902,2
31	Ca-psCa-sCc-s				5.949,5				14.731,1						20.680,6
32	Caps-Cacs-Cs-		15.375,9					4.634,6	30.140,1		308,6				50.459,2
33	CapsCacsCs								26.989,4				4.484,2		31.473,6
34	LapsLacsCs			883,5					6.908,0						7.791,5
35	CapsCacsCf-s				26.496,7										26.496,7

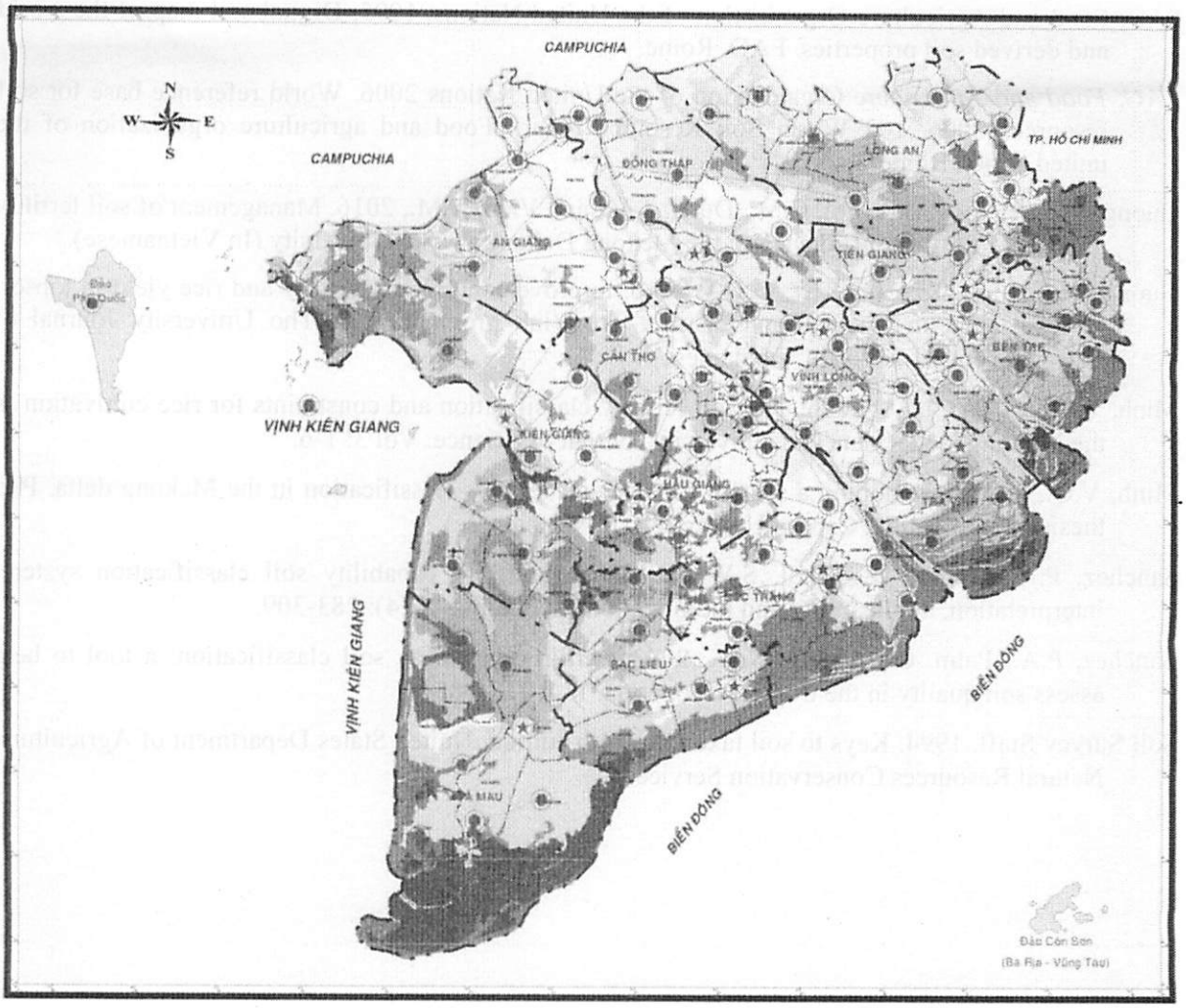

Figure 1: The soil fertility map in Mekong Delta

4. CONCLUSION

From the results of the conversion of the soil map classified by WRB (FAO, 2006) to the soil fertility map which was assessed the overall of fertility potential of agricultural cultivation in Mekong River Delta follow FCC system with 35 types of soil fertility.

Thanks to the strong support of the GIS tool, the research has been built the soil fertility map based on soil maps for Mekong Delta. Thereby, the potential and distribution of soil fertility types in the Mekong Delta are assessed.

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