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Current Land Uses on Problem Soils in Hau Giang Province, Viet Nam

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Abstract:** In recent years, rice crop intensification in Hau Giang province, which has put a lot of pressure and led to a great change in soil resources and its distribution. The previous soil map of the province (2008) has changed and out of date. Then The research aims: to identify the diagnostic horizons, properties, materials and to update the soil map. The field data was collected as soils profile description from 175 profiles, and 51 profiles for soil analysis. Soil classification was followed WRB 2006. The results ư shown that two major soil groups were found, in which four diagnostic horizons (Mollic, Umbric, Plinthic, and Sulfuric); one diagnostic property (Gleyic); and one diagnostic material (Sulfidic) were identified, and 15 soil types were classified. The Gleysols soil group have 14 soil types (hamoGL, hamoGL(hu), monplGL), (moGL(ptip), moGL(ntip), moGL(dtip), (umGL(ptio), huGL(ptio), umpplGL(ntio), umGL(ntio), huGL(ntio), umGL(dtio), (mowsGL(ntip), umwsGL(ntio)) total area of 9,551.32 ha, accounting for 59.34%; while Anthrosols soil group have one soil type (RGah) area of 66.252,91 ha, accounting for 40.66%.
Soil name and soil map of Haugiang was updated according to WRB 2006 and can be used for further study and land use plan of province. Rice cultivation is dominated on most of Gleysols soil groups, while pineapple, sugarcane and fruit crops grow on the raised bed are mainly on Anthrosol soil group, where acid sulfate soil is dominated.
Keywords: Diagnostic horizons; Diagnostic materials; Diagnostic properties; Soil classification; WRB.

1. Introduction

Intensive farming in the Mekong Delta has been growing rapidly in recent years. Potential land exploitation is taking place very strongly. The intensive cropping process has greatly altered soil fertility characteristics, especially accelerated soil degradation processes that depleted the nutrient supply of crops (Vo Quang Minh et al., 2018a). Formerly established soil map of the region has been changed but have not been updated and no longer respond to the practical situation (Vo Quang Minh et al., 2018b). Especially in Hau Giang province, in particular, many land uses models have been developed that bring high profit for people (Thai Thanh Du et al, 2017). However, intensive cultivation does not pay attention to the conservation of soil resources, along with the changes in natural conditions, since soil fertility has been altered (Vo Quang Minh et al., 2018b). Otherwise, soil classification from WRB systems (FAO, 1998) has been changed and updated (FAO, 2006a), since the soil characterization and classification in the region need to be updated for further for land use planning.

2. Materials and Methods

Data collection: Collect all data and secondary data (soil map of Hau Giang province in 2008, and current land use map of Hau Giang Province in 2015, soil data analysis of Hau giang province from Land Resources Department, College of Natural Resources and Environment, Can Tho University.

Soil Survey: 174 soil profiles were described. Selection of sites for soil augering and soil profile descriptions, soil sampling for analysis based on the guidelines included Handbook for soil survey, classification, mapping and land Evaluation of Thai Bat et al., 2015 and Guidelines for soil profile description (FAO, 2006b).
Soil sampling: Sampling at 51 sites on the surface (Ap) and surface horizons of the actual depth of the soil horizon, to identify the main diagnostic horizons, properties, and material as described in (FAO, 1998) and (FAO, 2006a)
Soil Classification Method: Use FAO's World Reference Based System (WRB) to classify soil based on soil diagnostic horizons, properties and materials and the rules of the system (FAO, 1998), (FAO, 2006a).
Soil analysis: Soil samples were analysis for soil chemical a soil physics for major parameters in the lab of Department of Soil science, Can Tho University for soil diagnostics, properties and materials identification and classification
Soil mapping: Map of soil was updated from previous soil map based on the soil types classified, and contoured from previous soil map (2008), combined with land use status and field observation results.
GIS: Mapinfo software was used to create the soil map.

3. Results

Based on the results of soil survey (175 sites for soil profile description) in 7 districts (Chau Thanh A, Phung Hiep, Long My, Vi Thuy, Vi Thanh, Nga Bay and Long My Town) and 51 soil profiles for soil profile description and soil sampling for soil analysis. The soil map of Hau Giang was updated.
Soil chemical properties of some profiles and major diagnostic horizons, properties and material for soil classification are shown in below tables:

Table 1: Analysis of soil samples at some sampling sites

Code	pH_{H2O} 1:2,5	EC 1:2,5, mS/cm	CEC meq/100g	K exch, meq/100g	Na exch, meq/100g	Ca exch, meq/100g	Mg exch, meq/100g	% Base
HG 95	4.16	0.199	17.20	0.372	0.126	5.16	5.82	66.73
HG 99	3.79	0.558	13.90	0.324	0.086	3.63	2.64	48.06
HG 91	4.88	0.199	15.86	0.206	0.257	7.67	4.83	81.73
HG 108	3.67	1.700	15.41	0.411	0.189	5.83	4.11	68.40
HG 110	3.55	0.338	17.34	0.517	0.060	1.06	3.42	29.16
HG 112	3.76	0.374	14.70	0.185	0.062	1.74	2.19	28.41
HG 135	4.12	1.040	16.24	0.837	0.922	1.80	5.42	55.29
HG 153	3.11	0.725	14.84	0.568	0.144	0.28	4.75	38.69

According to the table, most of the soils in Hau Giang province have low pH, due acid sulfate with thionic horizon and the occurrent of Jarosite mottles, with high Fe and Al. Soils in Hau Giang have how ECe, meaning that soils are low salinity. Based saturation at some profile is less than 50%.

Table 2: Diagnostic, Diagnostic, and Diagnostic Elements by Landforms

No	Soil code	Diagnostic horizons	Diagnostic properties	Diagnostic material	Area (ha)	%
1	hamoGL	Mollic	Gleyic		49.313,83	30,26
2	hamoGL(hu)	Mollic	Gleyic		6.777,06	4,16
3	monplGL	Mollic, Plinthic	Gleyic		1.264,69	0,78
4	moGL(ptip)	Mollic	Gleyic	Sulfidic	821,66	0,50
5	mowsGL(ntip)	Mollic	Gleyic	Sulfidic	4.946,98	3,04
6	moGL(ntip)	Mollic	Gleyic	Sulfidic	4.640,34	2,85
7	moGL(dtip)	Mollic	Gleyic	Sulfidic	2.241,35	1,38
8	umGL(ptio)	Umbric, Sulfuric	Gleyic		251,76	0,15
9	huGL(ptio)	Sulfuric	Gleyic		8.556,19	5,25
10	umwsGL(ntio)	Umbric, Sulfuric	Gleyic		2.071,05	1,27
11	umpplGL(ntio)	Umbric, Sulfuric, Plinthic	Gleyic		152,64	0,09

12	umGL(ntio)	Umbric, Sulfuric	Gleyic		9.216,82	5,66
13	huGL(ntio)	Sulfuric	Gleyic		6.368,98	3,91
14	umGL(dtio)	Umbric, Sulfuric	Gleyic		86,63	0,05
15	ATgl		Gleyic		66.252,91	40,66

3.1. Diagnostic horizon, diagnostic properties and diagnostic materials

3.1.1. Diagnostic horizons

Based on the results of the survey, the description and analysis of the area showed that there are 4 major diagnostic horizons in the province, according to WRB (2006) definition:

- Mollic horizon: The thickness of the soil horizon at survey sites ranged from 20 to 60 cm, dark colour (Chroma ≤ 3), with the base saturation of 55.29 - 81.73% and the organic content High muscle (3.48 - 8.31%).
- Umbric horizon: The thickness of the soil horizon at survey sites ranged from 20 to 60 cm, dark colour (Chroma ≤ 3), saturated base ranged from 28.41 to 48.06% organic (3.53 - 8.24%).

Figure 1: Mollic horizon

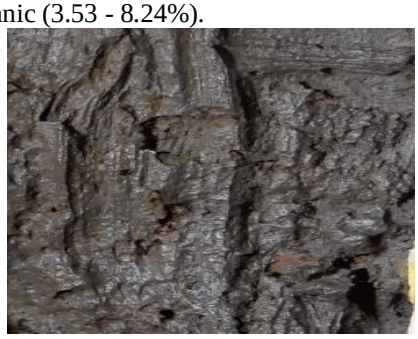

Figure 2: Umbric horizon

- Plinthic horizon: The survey results show that the Plinthic horizon in Hau Giang province has a depth of 35-80 cm and ends at 70-150 cm depth
- Thionic horizon: the results of the soil survey showing that the actual acid sulfate soil (the Munsell colour of mottle is from 2.5Y 8/6-8/8 occurred at a depth of 40-150 cm and end at 100-200 cm. Besides, sulfidic soil material is also identified.

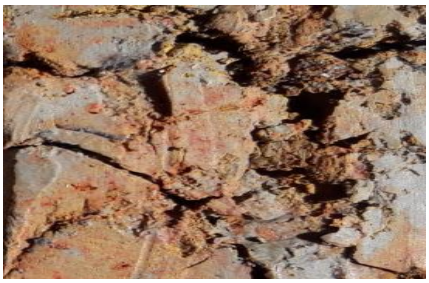

Figure 3: Plinthic horizon

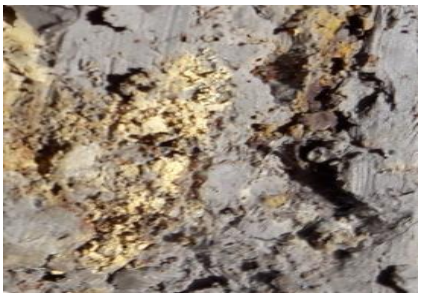

Figure 4: Thionic horizon

3.1.2. Diagnostic properties

According to the classification system WRB 2006, there is one Gleyic diagnostic property identified and used for classifying major soil groups in Hau Giang province. The Gleyic property often occurs at a depth of 40-150 cm.

3.1.3. Diagnostic materials

Depending on the field testing and soil analysis for material diagnostics horizon identification, only sulfidic diagnostic identified and the material often occurs at a depth from 30 to 150 cm.


Figure 5: Gleyic property


Figure 6: Sulfidic material

3.2. Major soil groups and soil types in the province

As the above-identified diagnostic horizon, properties, and material, Hau Giang Province has two major soil groups including Gleysols and Anthrosols, which are shown in Table 3 and Figure 7. There are only two major soil groups as Gleysols and Anthrosol, in which Gleysols soil group occupied the largest area (96.709,98 ha, or 50.34%), while Anthrosols soil group is occupied 66.252,91 ha (40.00%)

The Gleysols group in Hau Giang province consists of 14 soil types with a total area of 96,709.98 hectares, accounting for 59.34% of the province's area. In particular, Hapli-Mollic-Gleysols occupied the largest area, 49,313.8 ha (30.26%); while Umbri-Bathi-Orthi Thionic-Gleysols occupied the smallest area (86,63ha or 0.05%).

The Anthrosols soil group occupied 66.252.91 hectares, accounting for 40.66% of the province and has only one soil type (Gleyic–Anthrosols).

Table 3: Area of Soil types by WRB system 2006

	Symbol	**Soil type (WRB 2006)**	**Area (ha)**	**%**
I	**GL**	**Gleysols**	**96.709,98**	**59,34**
1	hamoGL	Haplic Mollic Gleysols	49.313,83	30,26
2	hamoGL(hu)	Haplic Mollic Gleysols (Humic)	6.777,06	4,16
3	monplGL	Mollic EndoPlinthic Gleysols	1.264,69	0,78
4	moGL(ptip)	Mollic Gleysols (EpiProto Thionic)	821,66	0,50
5	mowsGL(ntip)	Mollic HypoSalic Gleysols (EndoProto Thionic)	4.946,98	3,04
6	moGL(ntip)	Mollic Gleysols (EndoProto Thionic)	4.640,34	2,85
7	moGL(dtip)	Mollic Gleysols (BathiProto Thionic)	2.241,35	1,38
8	umGL(ptio)	Umbric Gleysols (EndoOrthi Thionic)	251,76	0,15
9	huGL(ptio)	Gleysols (EpiOrthi Thionic, Humic)	8.556,19	5,25
10	umwsGL(ntio)	Umbric HypoSalic Gleysols (EndoOrthi Thionic)	2.071,05	1,27
11	umpplGL(ntio)	Umbric EpiPlinthic Gleysols (EndoOrthi Thionic)	152,64	0,09
12	umGL(ntio)	Umbric Gleysols (EndoOrthi Thionic)	9.216,82	5,66
13	huGL(ntio)	Gleysols (EndoOrthi Thionic, Humic)	6.368,98	3,91
14	umGL(dtio)	Umbric Gleysols (BathyOrthiThionic)	86,63	0,05
II	**AT**	**Anthrosols**	**66.252,91**	**40,66**
1	ATgl	Gleyic Anthrosols	66.252,91	40,66

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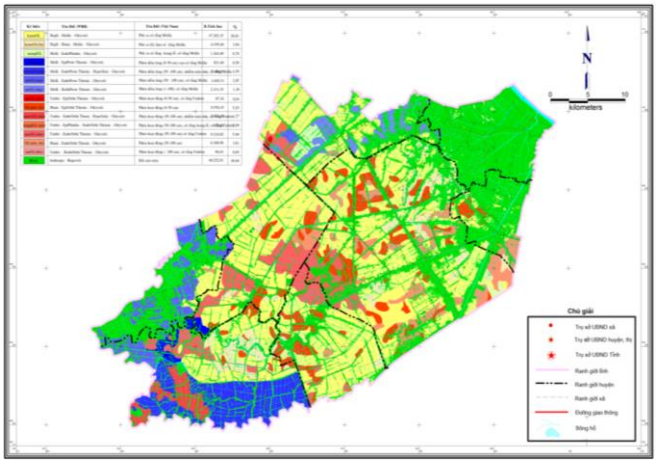

Figure 7: Soil map of Hau Giang province, by WRB system

3.3. Current Land use on soil types in the province

Most of the soils in the province are alluvial soil, then crops can grow well on these soils, but at some soil types, the occurrence of sulfidic material can release toxicity if oxidized, causing soil with low pH, high Al^{3+} and Fe^{2+}, the damage to root crops. These soils have OrthiThionic properties, which have low pH, high toxicity, that is the result of oxidation of sulfidic material of above soils. On these soil types, rice can grow well in case of soil under the reduced condition, and fresh irrigation water, which can leach toxicity to the canals, and soils get high pH and low toxicity. Otherwise, If freshwater supplied, upland crops can grow well on these soil.

On Anthrosol soil group, Orchard and Upland crops occupied the largest area, (35,246 and 6,030 ha respectively), while there is no rice on these soil group, due to most of the soil is acidic, the occurrent of sulfidic material, low pH, high toxicity. While Pineapple and Sugarcane can tolerate soils with low pH and high toxicity, and soils need to make a raised bed for leaching of toxicity. The rest of the areas are urban land.

Table 4: Current land uses on different soil types in Hau Giang province

No.	Type of soils	Upland crop	Rice	Aquaculture	Forest	Others	River	Total
1	**hamoGL**	40,788.66	4,293.85	1.65	2,087.64		110.39	**47,282.19**
2	**hamoGL(hu)**	73.54	4,983.97	1,153.45	248.67			**6,459.63**
3	**monplGL**	990.45	6.17		267.56			**1,264.18**
4	**moGL(ptip)**	797.35	1.71	21.70			0.89	**821.65**
5	**mowsGL(ntip)**	7,435.81	36.48	7.96				**7,480.25**
6	**moGL(ntip)**	412.74	4,212.93	7.33			7.33	**4,640.33**
7	**moGL(dtip)**	2,196.22	41.52	3.58				**2,241.32**
8	**umGL(ptio)**	67.36						**67.36**
9	**GL(ptio, hu)**	7,210.49	732.89	28.19	584.60			**8,556.17**
10	**umwsGL(ntio)**	16.04	2,052.41	2.59				**2,071.04**
11	**umpplGL(ntio)**		150.26	2.39				**152.65**
12	**umGL(ntio)**	183.30	8,830.92	20.35	182.21			**9,216.78**
13	**GL(ntio, hu)**	3,947.06	1,314.59	4.53	1,102.78			**6,368.96**
14	**umGL(dtio)**		86.63					**86.63**
15	**ATgl**	17,546.67	35,246.25	3,062.04		6,218.03	4,178.31	**66,251.30**
Total								162,960.44

On Gleysol soil group, soils have Gleyic property, it means most of the soils under reduced conditions, higher soil pH, high toxicity, at sometimes of the year, soil can be oxidized to form the soil mottle. Especially, sulfidic soil material is oxidized to release toxicity then the soil has low pH. However, the wet season, rice can grow well on these soils (83,750 ha). However, upland crops such as sugarcane, corn, can growth on these soils if small raised bed created to kept soi dried.

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Figure 8: Sugarcane on acid sulfate soil raised bed

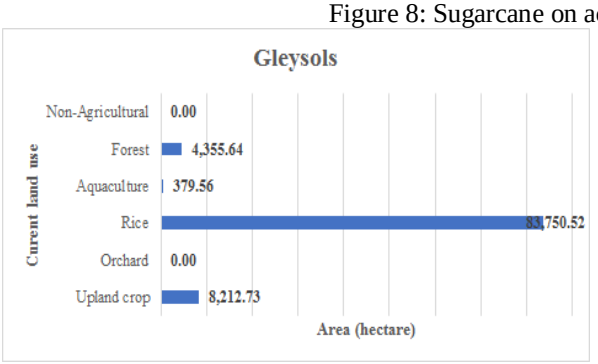

Figure 9: Current land uses on Gleysols soil group

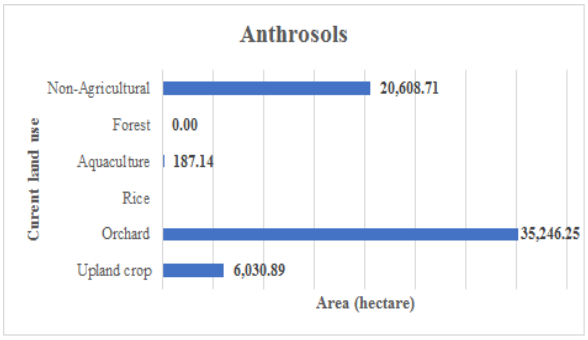

Figure 10: Current land uses on Anthrosols soil group

4. Conclusion

The soil map of the Hau Giang province has been updated based on the previous soil map. Two major soil groups identified from WRB system (Gleysols and Anthrosols). Four diagnostic horizons (Mollic, Umbric, Plinthic and Sulfuric), one diagnostic material (Sulfidic) and one diagnostic property (Gleyic) were identified. Within two major soil groups, 15 soil types have been identified: the Gleysols group of 14 soil types (hamoGL, hamoGL (hu), monplGL), moGL (ptip), moGL (ntip), moGL (dtip), umGL huGL, umGL (ntio), huGL (ntio), umGL (dtio), mowsGL (ntip), umwsGL (ntio)) with a total area of 96,709.98 hectares accounting for 59, 34% and Anthrosols with one soil type (ATgl), occupied 66,252.91 ha, accounting for 40.66% or 66%.

Rice cultivation is dominated on Gleysols while Orchard and Upland crops with the raised bed are mainly on Anthrosols soils where acid sulfate soils are dominated.

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A Brief Author Biography

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