AN INTEGRATION OF GIS AND AHP TECHNIQUES FOR LAND USE SUITABILITY ANALYSIS IN HOA VANG DISTRICT – DA NANG CITY, VIETNAM

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ABSTRACT

In recent years, FAO has emphasized assessment methods for sustainable land management in the field of land resources, which mainly focus on land assessment for the purpose of sustainable development. Therefore, land evaluation is to analyze and assess elements in the multi-criteria approach (MCA), provides decision-makers various importance level of each element. In addition, GIS technology is capable in spatial analysis, land database construction. Land assessment with GIS and AHP support is needed in order to improve the accuracy of the land potential assessment as a basis for the development of sustainable agricultural production, and improving the efficiency of land use.

Research approach towards evaluating multi-criteria combination of natural factors, socioeconomic, based on geographic information system GIS. Using fieldwork methods for soil characteristics, water and land use status. Assessment procedures applied multi-criteria land FAO (1976.1993) to evaluate land adapted for land use of agricultural land. Integration of GIS and AHP to evaluate and support a decision to use in each land unit.

1. INTRODUCTION

Efficient land use was widespread in the world, so the land assessment plays a very important role. Land evaluation provides important information as a basis for decision-making in the management of land use planning, especially in agriculture and rural development.

With 2/3 of the area is mountainous and midland regions Hoa Vang is considered potentially diverse land, unused land covers a large area, the majority of the population works in the agricultural sector. However, the efficiency of production is not commensurate with the potential to land. So the job of land managers is to assess land adaptability to find out the type of land use consistent with the ability to develop and bring high economic efficiency for farmers local.

This study aims to integrated of GIS and AHP techniques to assess the adaptability of land for crops for the development of sustainable agriculture Hoa Vang district, Da Nang city. From that proposed solutions to plant in suitable crops on each land units.

By using GIS data and AHP, the software of Expert Choice 11.0; MapInfo 11.0, ArcGIS 9.3 and Excel..., this study to mapping land units as a basis for assessing adaptive land use for agriculture, from that mapping the direction of agricultural land use efficiency in future.

2. RESEARCH METHODS

- *Data collection method:*

+ Spatial data are unisex map scale of 1: 25,000 as administrative maps, soil type, floor thickness, mechanical composition, slope, traffic, irrigation systems, map the current use land ...

+ Collect data attribute data mainly describe some elements of the unisexual map above, the statistics of natural conditions, socio-economic data on district ... development of agriculture - forestry districts and the ecological requirements of the type of use of agricultural land ..

- *Method of mapping:*

The number of single maps from paper maps were collected.

Husband puzzle map using GIS techniques: overlay the maps application to build the land unit map, the map adapts naturally - social and economic crops, navigation charts ..

- The software used in this study including data processing software Excel analysis software Expert Choice AHP is 11.0, GIS application software: MapInfo, ArcGIS ...

- *Methods of analysis, Modeling methodology, Methods of fieldwork, Method of experts*

3. RESULT AND DISCUSSION

3.1. The process integration GIS and multi-criteria for assessment adaptation of land

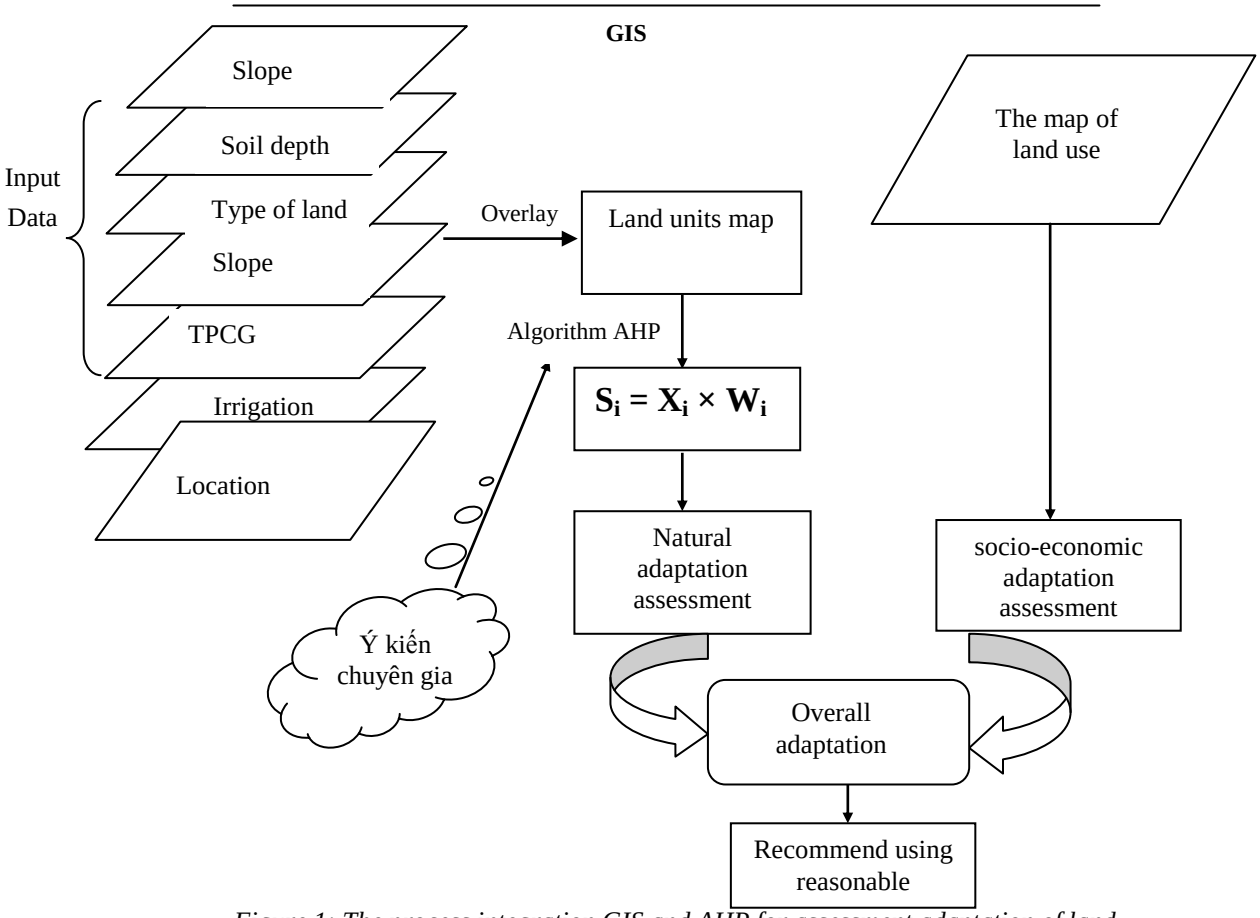


Figure 1: The process integration GIS and AHP for assessment adaptation of land

3.2. Building land unit map

3.2.1. Identify and decentralization indicators for land units map

Table 1: Decentralization Indicators land unit map Hoa Vang District

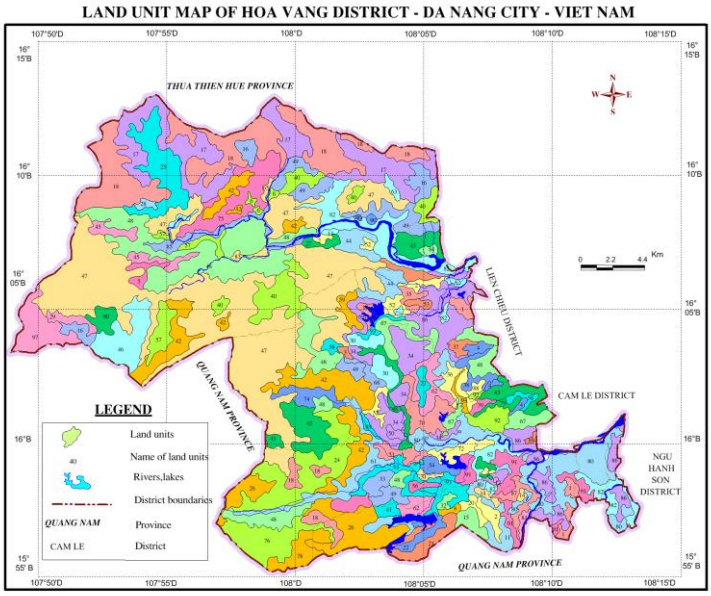
Indicators	Decentralisation	Legend	Indicators	Decentralisation	Legend
1. Type of land	1. Pg	G1	**3. Soil depth**	1. > 100 cm	D1
	2. Pf	G2		2. 75- 100 cm	D2
	3. Py	G3		3. 50 -75 cm	D3
	4. Pb	G4		4. 30- 50 cm	D4
	5. Pbc	G5		5. < 30cm	D5
	6. Fs	G6	**4. Mechanical Composition**	1. Sandy soil	C1
	7. Fq	G7		2. Mixed sand soil	C2
	8. Fp	G8		3. Light soil	C3
	9. Fa	G9		4. The average soil	C4
	10.C	G10		5. Heavy soil	C5
	11. D	G11		6. Gravels	C6
	12.Ha	G12	**5. Irrigation conditions**	1. Advantages	I1
	13. E	G13		2. Less advantages	I2
2. Slope	1. 0 -3^0	E1		3. Disadvantages	I3
	2. 3^0 - 8^0	E2	**6. Location**	1. Advantages	P1

	3. 8^0 - 15^0	E3		2. Less advantages	P2
	4. 15^0 - 20^0	E4		3. Disadvantages	P3
	5. 20^0 - 25^0	E5			
	6. Above 25^0	E6			

3.2.2. Results of mapping land units of Hoa Vang District

The natural land unit is formed on the basis of a different set of criteria for each natural elements from the input data, overlay layer as soil type maps, floor thickness, mechanical composition slope, irrigation regimes, location. Results 94 land units were isolated in Hoa Vang

Figure 2: Land unit map of Hoa Vang District - Da Nang city - Viet Nam



b. Results of selected categories of land use assessment

Hoa Vang natural conditions, land is relatively favorable. Through investigation showed that the type of land use commonly follows: LUT 1: 2 harvests of rice: spring and summer-autumn rice; LUT 2: rice – others food cops: spring and summer-autumn rice, sweet potato, maize, vegetable, peanuts…; LUT 3: specialized cultivation annual crops: vegetables, soybean, peanut, sweet potato, maize, tobacco, Cassava, sugarcane…; LUT4: specialized cultivation perennial crops: Fruit trees; Plantation forests (eucalyptus, acacia auriculiformis)…

By analyzing the above criteria and actual survey we chose the type used mainly in arable land in the territory of studies to evaluate such as paddy cultivation with 2-crop rice; upland crops (annual crops); perennials.

c. Requirements of the land use type of land use

Table 2: Classification criteria of the type of land use

Type of land use	Elements	Appropriate classification			
		S1	S2	S3	N
2-crop rice	Type of land (G)	Pb, Pbc, Pg, Rk	Pf, D, X, S, M, Py, Fl, Cg, Fl, D	C, Fs, Fq, Fp	Sandy soil
	Soil depth (D)	> 50cm	30-50cm	< 30cm	-
	Mechanical composition (C)	Heavy soil, The average soil	Light soil	Mixed sand soil	Sandy soil
	Slope (S)	$0\text{-}3^0$	3^0 - 8^0	8^0 - 15^0	> 15^0
	Irrigation (I)	Advantages	Less advantages	Disadvantages	-
	Location	Advantages	Less	Disadvantages	-

			advantages		
Upland crops	Type of land (G)	Pc, Pbc, Pg, Py, Pf,	X, Fs, Fp,	Fa, Fq, B, C, Ha , Fs	Remaining
	Soil depth (D)	Light soil, The average soil	Mixed sand soil, Heavy soil	Sandy soil, Heavy clay	-
	Mechanical composition (C)	$0\text{-}3^0$	3^0 - 8^0	8^0 - 15^0	> 15^0
	Slope (S)	> 70cm	50-70cm	30 - 50cm	< 30cm
	Irrigation (I)	Advantages	Less advantages	Disadvantages	-
	Location	Advantages	Less advantages	Disadvantages	-
Perennials	Type of land (G)	P, D, Fp	Fs, Ha	Fa, Fq, B, C	Remaining
	Soil depth (D)	Trên 100cm	70-100cm	50- 70cm	< 50cm
	Mechanical composition (C)	Heavy soil	Light soil, The average soil	Mixed sand soil, Clay	Sandy soil
	Slope (S)	$0\text{-}3^0$	3^0 - 8^0	8^0 - 15^0	> 15^0
	Irrigation (I)	Advantages	Less advantages	Disadvantages	-
	Location	Advantages	Less advantages	Disadvantages	-

3.3. Integrating AHP and GIS methods to assess soil adaptability Hoa Vang district - Da Nang City - Viet Nam

3.3.1. Assessment and classification of natural adaptation

a. Step 1: Identify key elements of land use (W_i)

Analysis of the relative importance of these criteria, using multi- criteria analysis with AHP support system, analyzing the priority weights according to Saaty 9 level. The elements of land units are rated according to the land use requirements of each type of land use. Priority levels were compared in pairs and, depending on the characteristics of each type of land use, real conditions of local priorities that different.

Table 3: Indicators of Saaty paired comparison factors

STT	Characteristics comparing the pair of factors	Evaluation marks
1	Equally important	1
2	Less important	3
3	Medium important	5
4	Important	7
5	Very important	9
6	Area between the degree on	2,4,6,8

Based on the target table comparison Saaty's pairwise and summary of opinions at the importance of each criterion from the experts, conducted in order to determine the criteria weights W_i. With three systems of land use proposed, based on the conduct of evaluation and use AHP algorithm, we calculate the weight vector W_i (weighting factor of i) with decision support software Expert Choice Version 11. results calculated weight vector as follows:

Table 4: The results of indicator weights W_i Experchoi 11.0 software

Weights W_i / Indicator	2-crop rice	Annual crops	Perennials
1. Type of land (G)	0.185	0.313	0.243
2. Soil depth (D)	0.067	0.133	0.312
3. Mechanical Composition (C)	0.111	0.174	0.089
4. Slope (Sl)	0.26	0.098	0.139
5. Irrigration (I)	0.334	0.243	0.175
6. Location	0.043	0.039	0.044

Consistency Ratio – CR of 2- crop rice: CR = 0.00874, CR of Annual crops = 0.00338, CR of Perennials = 0.02; Consistency Ratio of land use to satisfy the condition is CR <10%.

b. Step 2: Identify adaptation X_i index for each component

Table 5: Adaptation Xi index for each component

STT	Rating adaptation	Points X_i
1	+ Very adaptable (S1)	9
2	+ Adaptable (S2):	7
3	+ Less adaptable (S3)	5
4	+ Inopportune (N):	1

Based on the database and the actual conditions Hoa Vang district, two factors are irrigation regimes and locations that are classified as follows: Advantages (9 points), less favorable and unfavorable (1 point).

c.Step 3: Calculate the appropriate S_i index for each land unit, grading value S_i to establish sustainable adaptive map as follows:

$$S_i = \sum_{i=1}^{n} W_i * X_i$$

Scale adaptive calculation are ranked to determine the appropriate level for the following rate: Inopportune (N): $S_i < 4$; Less adaptable (S3): S_i từ 4 đến 5; Adaptable (S2): S_i từ 6 đến 8; Very adaptable (S1): $S_i >= 8$

Table 6: Results of classifying natural adaptive 3 types of land use

Grade	**S1**		**S2**		**S3**		**N**	
Type of land use	Area (ha)	Rate %	Area (ha)	Rate %	Area (ha)	Rate %	Area (ha)	Rate %
2-crop rice	16048.4	17.9	6743.6	9.2	12327.7	16.8	38336.3	52.2
Upland crops	12939.3	16.4	12035.7	15.3	26108,4	35.5	24.051,8	32.7
Perennials	15524.6	21.1	5030.3	6.8	18355.1	24.9	33792.3	46.1

3.3.2. Assessment and classification of adaptive socio-economic factors

In 11 categories of land use on the current use of the land as forest production, soil protection forest, special use forest land, aquaculture land, residential land use land, unused land, the land of rivers and streams and water surface can not be arranged in agricultural production should not judge the subject, just use the rice land, land for annual crops, perennial crop land, the land of no use as indicators adapted to assess the socio-economic. Area soils are not rated about 70.582ha.

Table 7: Level of adaptive factors social – economic

Type of land use	**Current use of land**	**The level of adaptation**			
		S1	**S2**	**S3**	**N**
2-crop rice	Paddy land	✓			These lands are not rated
	Annual crop land		✓		
	Perennial crop land			✓	
Upland crops	Paddy land		✓		
	Annual crop land	✓			
	Perennial crop land			✓	
Perennials	Paddy land			✓	
	Annual crop land		✓		
	Perennial crop land	✓			

Table 8: Results of classification of adaptive socio-economic 3 types of land use

Grade TN	**S1**		**S2**		**S3**		**N**	
Type of land use	Area (ha)	Rate %	Area (ha)	Rate %	Area (ha)	Rate %	Area (ha)	Rate %
2-crop rice	4224.1	5.8	1531.9	2.1	1139.4	1.6	66542.6	90.6
Upland crops	1663.3	2.3	4224.1	5.8	1282.1	1.7	66268.5	90.2
Perennials	1282.1	1.7	1663.3	2.3	4224.1	5.8	66268.5	90.2

3.3.3. Partition the overall adaptation to natural conditions and socio-economic

To partition the overall adaptation to natural conditions and socio-economic, we overlay two layers: natural adaptation and socio-economic adaptation. Coding evaluation for each level of adapted as follows: Inopportune (N): encoded is 0; Less adaptable (S3): encoded is 1; Adaptable (S2): encoded is 2; Very adaptable (S1): encoded is 3

$$Si_{total} = Si_{natural} * Si_{social\text{-}economic}$$

Domain of common adaptation indicators is used to classify the evaluation maps land adaptability. Scale adaptation calculation ranked to determine the appropriate level for the following rate: Inopportune (N): $S_{i\ total}$ from 0 to 3; Less adaptable (S3): $S_{i\ total}$ from 4 to 5; Adaptable (S2): $S_{i\ total}$ from 6 to 7; Very adaptable (S1): $S_{i\ total}$ from 8 to 9

Table 9: Results of the overall classification of adaptation natural conditions and socio-economic

Grade TN	**S1**		**S2**		**S3**		**N**	
Type of land use	Area (ha)	Rate %	Area (ha)	Rate %	Area (ha)	Rate %	Area (ha)	Rate %
2-crop rice	3694.9	5.03	1446.6	2.0	114.8	0.2	68199.7	92.8
Upland crops	1080.9	1.5	649.7	0.9	609.7	0.8	70565.1	96.1
Perennials	816.2	1.1	1653.5	2.3	220.4	0.3	70766..3	96.3

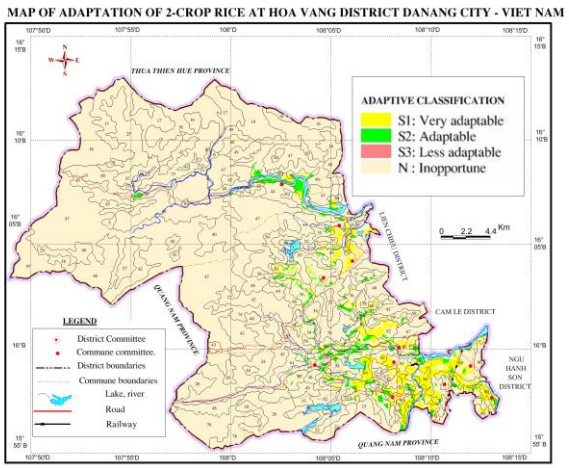


Figure 3: Map of adaptation of 2-crop rice at Hoa Vang district – Danang City - Viet Nam

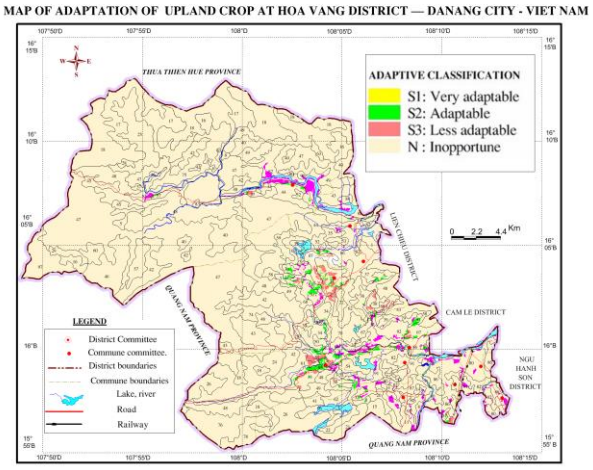


Figure 4: Map of adaptation of Upland crop at Hoa Vang district – Danang City - Viet Nam

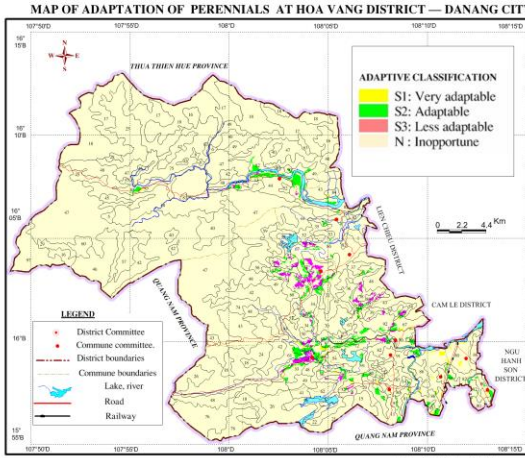


Figure 4: Map of adaptation of Perennials at Hoa Vang district – Da Nang City - Viet Nam

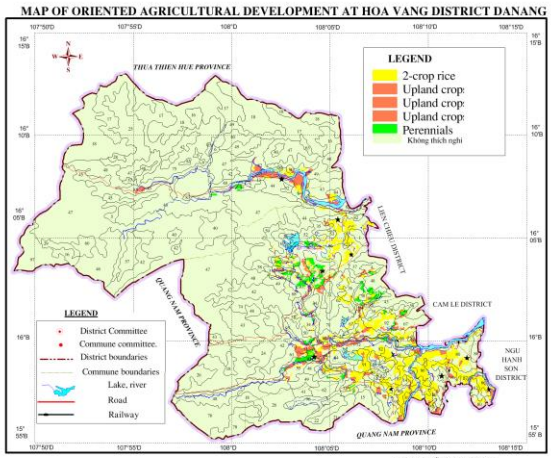


Figure 5: Map of oriented agricultural development at Hoa Vang District, - Da Nang city - Viet Nam

4. CONCLUSIONS

From this study, land for agricultural production generally decreased, except land used for growing vegetables and flowers. So productivity growth is one of the key solutions to increase the value added of the sector.

Continue to build and expand intensive vegetable growing areas, cultivated edible mushroom in Hoa Tien, Hoa Phong, Hoa Khuong...; growing areas of flowers and ornamental plants in Hoa Phước, Hoa Chau, Hoa Lien... to meet the best needs of the urban population.

Planning and production layout to suit the gardens, forest gardens, fruit growing areas …, on the basis of selectivity and yield of crops of high economic value consistent with the climate and soil of the region.

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