COMBINATION OF SUPERVISED CLASSIFICATION AND ECOLOGICAL MODELING IN LAND USE MAPPING

Pham Quang Vinh[1] and Nguyen Dinh Duong[2]

[1]Department of Cartography, Institute of Geography, VAST,

18 Hoang Quoc Viet Rd, Cau Giay, Hanoi, Vietnam.

Email: quangvinhgeo@yahoo.com

[2]Department of Environmental Information Study & Analysis, Institute of Geography, VAST,

18 Hoang Quoc Viet Rd, Cau Giay, Hanoi, Vietnam.

Email: gisideas2004@pmail.vnn.vn

ABSTRACT

The study area locates in Lam Dong province, Vietnam, which is multiform in land use types. Due to the fact that the classification in land use mapping using digital image processing method involves spectral reflection as the only input information, in many cases some objects of land use are too difficult to differentiate because of their spectral similarity, for instance, those between tea and coffee trees', Pinus merkusiana's *and* P. khasya's *and one-crop and open lands'. Using the ecological vegetation characters to verify outcomes of digital image processing appears to be necessary in such the cases. In integrating to re-classify output information, classification outputs attained from processing Landsat TM images using Maximum Likelihood approach were used as the basic data layer while ecological vegetation information i.e. DEM, slope, soil and bio-climate was regarded as conditional information layers, of which the integration was conducted using FORTRAN language in module MODELER of the image processing WinAsean 3.0. The exercise resulted in the successful differentiation between tea and coffee trees,* Pinus merkusiana's *and* P. khasya's*, one- crop paddy and open land, open* Dipterocarpacaea *forest and shrubs, two-crop wet paddy and grassy shrubs, vegetable field and shrubs, open land and milpa, etc.*

1. INTRODUCTION

Recently remote sensing technology has become one of the most effective method to incorporate data on land cover and land use [3]. In many cases, however, due to the close spectral reflection of objects in remote sensing data and the application of a single type of information in classifying these acquired objects, i. e. spectral reflection, the expected classification outcomes are not sometimes achieved, especially in classifying objects of land use. In the context, it is thought to integrate outputs from remote sensing based classification with information of the GIS (digital elevation model – DEM , slope and vegetation’s ecological characteristics) in an effort to maximize the accuracy of classification and the efficiency of remote sensing application. The nature of the exercise is to reclassify the obtained remote sensing based classification outcomes using integration of GIS data with classification images.

2. STUDY AREA

The case study for experiment is Lam Dong province, Vietnam, of which the coordinates are

From North $11^0$40' to $12^0$00' latitude, and

From East $108^0$00' to $108^0$44' longitude.

The area is characterized by mountains and waved basalt plateau with average elevation of 1,500 m. The type of land use in the area is multiform. Apart from broad leaved forests, there are monospecies pine forests and deciduous and semi-deciduous forests. Due to the fertile soil cover (basalt soil) along with the diversity in climatic conditions, the area is grown, except wet paddy, a wide range of industrial crops such as coffee, tea, mulberry tree, etc. thanks to the low temperature in and around Da Lat city, a number of temperate vegetables including cabbage, cauliflower, etc.

3. MATERIALS

In fulfil the exercise, following materials have been used, e.i:

- Satellite images: Landsat TM KJ 124-052 taken on 03/02/1998,
- UTM relief map, scaled 1/50.000, with isoline 20 m, which consists of 12 sheets:

C-49-1-A	C-49-1-D	D-49-133-A	D-49-133-D
C-49-1-B	C-49-2-A	D-49-133-B	D-49-134-A
C-49-1-C	C-49-2-C	D-49-133-C	D-49-134-C

- Pedology-geomorphology map, scaled 1/100.000.[2]
- Bio-climate map, scaled 1/100.000.[2]

Below are information of Landsat satellite image TM KJ 124-052 that was extracted for experiment:

- Co-ordinates of upper left corner: X= 495,002.89 m; Y= 1,357,570.38 m
- Co-ordinates of lower right corner: X= 557,472.89 m; Y= 1,288,569.38 m
- Image size: 2,750 x 2,300 pixel.

15 objects were classified using the image processing WinAsean 4.0 and the supervised classification. Classification outcomes and the area of objects are presented in Table 1.

Based on above mentioned relief maps, elevation data was inputed. Then DEM modeling and a slope map of the study area were developed. All these maps were converted to raster form and adjusted to fit the co-ordinates of the image.

4 METHODOLOGY

It is known that objects of land use have a systematic relation to GIS data, particularly data on DEM, slope, soil conditions and bio-climate. The relation could be illustrated by the mathematic function:

$$DVSDD = F(a,b,...,n)$$

where: DVSDD is unit for object classification of land use;

F is function representing the relation of variables a,b,...,n;

a,b,...,n are variables describing constituents of DVSDD.

In the above function, F is either a logic function that is presented by a mathematic formula or a cognitive function that is presented by normal language [2]. In reality, the relation of land use objects with relief, soil and bio-climate conditions is more qualitative; therefore, it is not applicable to use mathematic formula to describe it. To do the job, cognitive function is the most relevant. Languages used in this function may include IF (CONDITION), CONTINUE, AND, THEN, ELSE... As such, the function could be generalized as follows:

A unit land use IF it satisfies conditions $a_i, b_i, ..., n_i$ THEN is called a $DVSDD_i$, ELSE it, when not satisfying, is not a $DVSDD_i$.

Where $a_i, b_i, ..., n_i$ are conditions satisfied by the unit land use i; and $DVSDD_i$ is the unit land use to define.

By doing so, information is integrated to identify land use objects for the map that need elaborating. Outcome gained from digital image processing using supervised classification principle is considered primary data while data obtained using GIS method is conditional information. The integration principle could be illustrated in the following matrix:

DVSDD	**Condition a**				**Condition b**				**....**				**Condition n**				**Result of integration**
	a_1	a_2	...	a_i	b_1	b_2	...	b_i					n_1	n_2	...	n_i	
$DVSDD_1$																	
$DVSDD_2$																	
...																	
...																	
$DVSDD_i$																	

Based on above mentioned analysis, along with the classification outcomes using digital image processing and data complied in GIS, it is possible to work out here the principle of information integration as shown in table below.

N^0	**Image classification types**	**Conditions satisfied, IF**				**Result of integration**
		Slope	**Elevation**	**Soil**	**Bio-climate**	
1	Paddy field	$< 3^0$ KTM	< 1500 m KTM	10 KTM	1,2,5,7,8 KTM	Two-crop paddy Grassland
2	Vegetable field	$< 3^0$ KTM	> 1000 m KTM	10 KTM	2,6,8,9 KTM	Vegetable field Close Forest
3	Industrial vegetation	$< 8^0$ $< 25^0$ KTM	< 1600 m < 1500 m KTM	2,6,8 10 KTM	1,5,7 3,4 KTM	Coffee + Tea Mulberry Tea
6	Poor Forest	KLQC KLQC KLQC	< 1000 m < 1000 m KTM	KLQC 7 KTM	5 3,4 KTM	Deciduous forest Dipterocarpacaea Poor Forest
7	Shrub	$< 15^0$ KLQC KLQC	> 1500 m < 1000 m KTM	KLQC 7 KTM	KLQC 3,4 KTM	Milpa Dipterocarpacaea Shrub

8	Pine	KLQC KLQC	< 1000 m > 1000 m	KLQC KLQC	KLQC KLQC	Pinus merkusiana's P. khasya's
10	Bare soil	$< 15^0$ $< 3^0$ $< 8^0$ KTM	> 1500 m < 1800 m < 1500 m KTM	KLQC 10 2,6,8 KTM	KLQC 1,2,5,6,7,8,9 3,4 KTM	Milpa one- crop paddy Sugar-cane Bare
13	Fired Forest	$< 8^0$ KTM	< 1500 m KTM	2,6,8 KTM	1,5,7 KTM	Coffee Milpa

Note: - KLQC: No relation.
- KTM: Not satisfied.

N⁰	**Image classification types**	**Conditions satisfied, IF**		**Result of integration**
		Settlement map	**Slope**	
11	Settlement	Inside Outside	$< 15^0$ KTM	Urban Bare

5. RESULTS AND DISCUSSION

By using two above methods (remote sensing based classification and integration of remote sensing based classification and data in GIS) the exercise resulted in 23 objects to be classified. The area calculated is different between the two methods. To clarify the difference, we conducted calculations of area and percentage of land use object using WinAsean 4.0 software. The findings are presented in table below.

Table 1. Area and percentage percentage of land use by classification

N⁰	Class	Total Pixel	Area (ha)	Percen tage
1	Cloud	146964	13227	3,52
2	Cloud shade	57297	5157	1,37
3	Water	12777	1150	0,31
4	Medium forest	485583	43702	11,63
5	Two-crop paddy	20134	1812	0,48
6	Vegetable field	15343	1381	0,37
7	Fired Forest	228051	20525	5,46
8	Industrial vegetation	143397	12906	3,43
9	Close forest	662712	59644	15,87
10	Poor forest	464141	41773	11,11
11	Pine forest	930266	83724	22,28
12	Shrub	228049	20524	5,46
13	Grassland	20733	1866	0,50
14	Bare soil	724223	65180	17,34
15	Settlement	36228	3261	0,87

Table 2. Area and percentage percentage of land use by integration

N⁰	Class	Total Pixel	Area (ha)	Perce n-tage
1	Cloud	146964	13227	3,52
2	Cloud shade	57297	5157	1,37
3	Water	12777	1150	0,31
4	Medium forest	485583	43702	11,63
5	Two-crop paddy	6063	546	0,15
6	One-crop paddy	82742	7447	1,98
7	Vegetable field	4130	372	0,10
8	Milpa	233936	21054	5,60
9	Coffee + Tea	47266	4254	1,13
10	Mulberry	2071	186	0,05
11	Tea	94060	8465	2,25
12	Coffee	23315	2098	0,56
13	Sugar-cane	29631	2667	0,71
14	Close forest	673925	60653	16,14
15	Poor forest	430931	38784	10,32
16	Dipterocarpac-aea	14398	1296	0,34
17	Deciduous forest	19578	1762	0,47
18	P.merkusiana's	138057	12425	3,31
19	P. khasya's	792209	71299	18,97
20	Shrub	221261	19913	5,30
21	Grassland	34804	3132	0,83
22	Bare soil	613002	55170	14,68
23	Urban	11898	1071	0,28

Calculations show that the area of moderate forest, water, cloud and cloud shade, which are seen to be exactly classification using remote sensing data and therefore they are not applicable in the re-classification process, stays the same. The other objects that are applicable in the reclassification process appear to differ in area. That also means chosen criteria for information integration are relevant to the reality, in the other words, these cretiria all involve the calculation. There are a number of new objects to appear after the reclassification and, at the same time, some objects do not exist as they are divided into others, for example, *industrial crop land* is divided into coffee and tea, mulberry, and tea; or *pine* is divided into *Pinus merkusiana* and *P. khasya*; etc. As afore analysed, because *two-crop paddy* includes grassland, after the reclassification, the area of two rice crop lands reduces by an amount that is equal the increasing amount of grassland. Similarly, *vegetable field* decreases at an increase of close forest. The calculated area and percentage of objects differs from one classification method to the other while the total area remains the same, that is, the area is shifted from one type to another.

In term of image, the image of objects is fairly homogeneous and not so *mixed* as that of remote sensing based exercise. Newly appeared objects such as one rice crop land, sugar cane land, woodland, etc. are easily identified. However, the only image of one rice crop land looks natural and relevant to reality (stretching along valleys and rivers) while the boundary of sugar cane land and woodland is not natural depending on borders among land use types and among bio-climate units. This again proves that the accuracy of compiled GIS data is significantly decisive to the information integration process for reclassifying land use objects. Outcomes of the reclassification show the matching of classified residential areas with reality, i.e. apart from concentrated residential areas that are exactly identified, scattered residential points tend to locate along traffic roads or river valleys.

The above mentioned outcomes are only preliminary as initial experiment of the methodology, therefore, there exist limits, particularly in GIS data.

- The accuracy of used GIS data has not been evaluated (the accuracy of pedology-geomorphology map, bio- climate map, relief map, etc.).
- Classification units of bio-climate map and pedology-geomorphology map are not relevant to specifications concerning ecological features of plant types. For example, while the specifically required rainfall of deciduous forest and semi-deciduous forest ranges in 600-1,200 mm/year and 1200-1800 mm/year, the classification units applied for bio-climate 1,500-2,000, 2,000-2,500 and over 2500 mm/year. This causes some difficulty to apply and affect the accuracy of information integration for classification.

The effective application of this method requires further studies on the relationship between land use objects and GIS data. It is said successful finding of this relationship is significantly crucial and decisive in application of the method. To improve the accuracy of the integration outcomes, it is necessary to compile GIS data in the way they match ecological features of various crop types and other natural vegetations.

8. REFERENCES

1. Projet EU, STD3 CT94-0310. *"Constitution et utilisation d'un base de donnĐes gĐographique pour une meilleure gestion des terres et de l' environnement. Application aux Hautes - terres du Vietnam."* Hanoi, 1999.

2. Lillesand T.M. & Kiefer R.W. (1994). *Remote sensing and Image interpretation* (3rd Edn). New York: John Wiley & Sons Inc. 750pp.

3. Rapper J.F and Levington R. 1995. *Development of a geomorphological spatial model using object-oriented design.* International journal of Geographical Information system. No 4, 1995. pp 359-383.

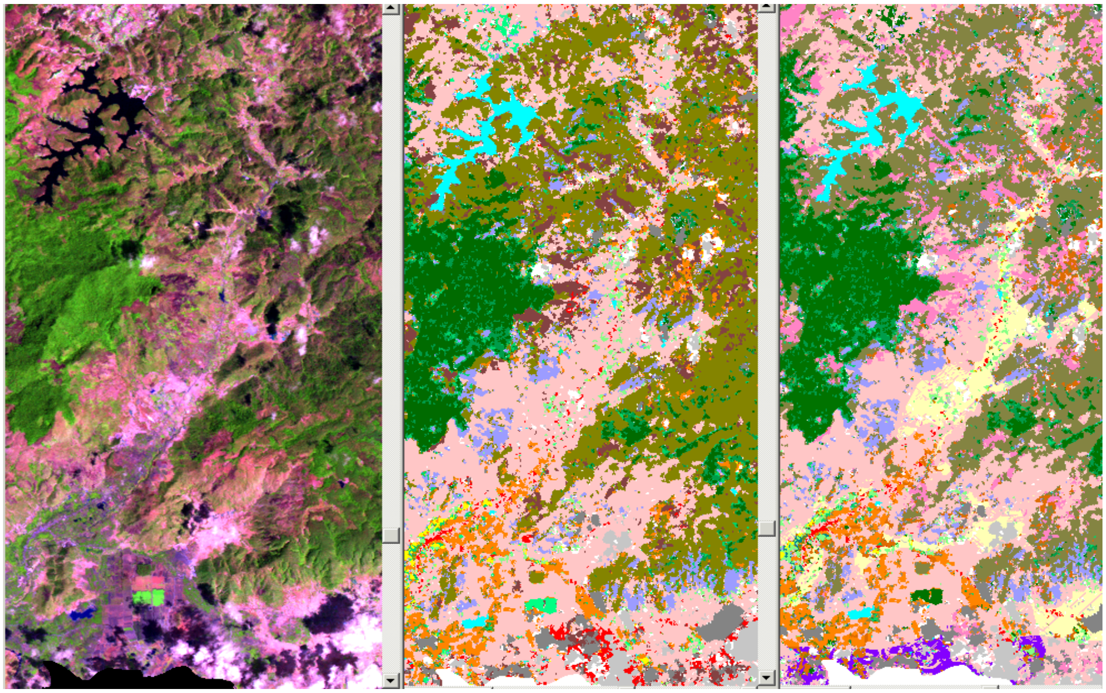

Figure 1. Original image (left), Result of classification RS (middle) and Result of integration (right)

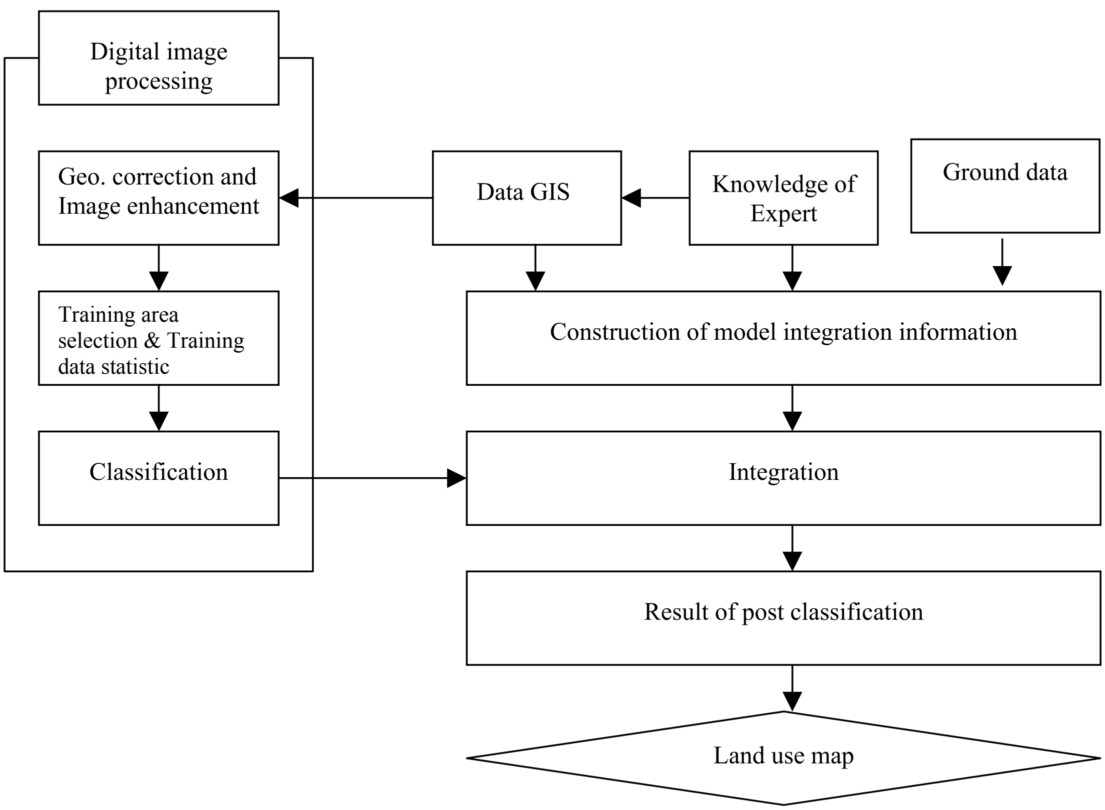

Figure 2. Flow of current land use by combining of digital image processing and GIS analysis