

MONITORING OF AGRICULTURAL LAND USE CHANGE BY USING REMOTE SENSING AND GIS TECHNIQUES

(A case study of Tiengiang province in Mekong Delta area, South of Vietnam)

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1. Introduction

The study focuses on the integration of Remote Sensing with Geography Information System for monitoring the agricultural land use change and analysis. The agricultural land of the Tiengiang province, one of the most alluvial and dynamic soils in Mekong delta area, was chosen as a case study area. The available land use data, socio- economic and natural condition records were analysed and input into GIS database. The multi-sensor Landsat 1996, multi-temporal satellite images of Radarsat 1999-2000, aerial photos 1993 were analysed by using digital image and eye's interpretation to set up a map with 8 kinds of agricultural land used. Based on the map was established at 3 different point of times, overlay analysis and variable analysis by using GIS technique within 10 years 1990 – 2000 was showed the relationship between the socio-economic developments, natural environment and the policies of Government. This is the basic of science to update information about land using, at the same time can forecast a development direction.

2. Objectives

- * Using Aerial photographs 1993 to interpret and establish the agricultural land use map 1993
- * Using Landsat image 1996, 2000 to interpret a and establish the agricultural land use map 1996, 2000
- * Analyses and evaluation of agricultural land use change 1993, 1996, and 2000 by GIS technique and definition of agricultural land cover within the past 10 year (1990 – 2000)

3. Methodology

Applications of satellite image analysis techniques to establish the map of land use and evaluate the land cover change 1993-1996-2000 based on GIS.

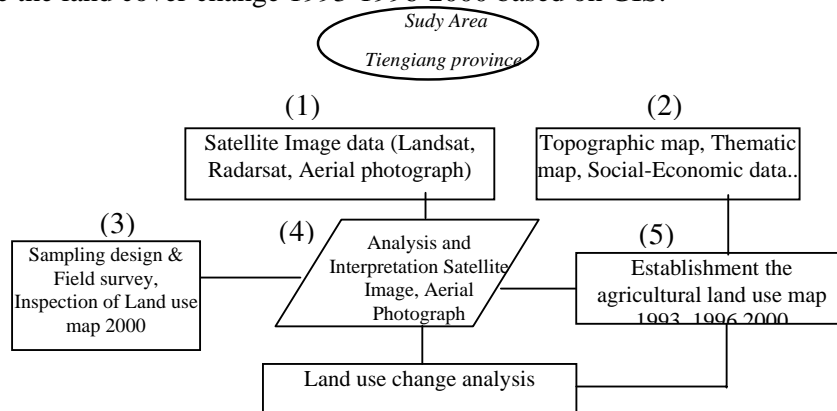


Figure 1. The general procedures in study area

3.1. Data collection

- Aerial photograph 01-1993, scale: 1/13.500 ;Satellite Image:The multi-sensor: Landsat TM (30m x 30m), 21/2/1996, the multi-sensor 2, 3, 4: Landsat TM Band: 2, 3, 4, (IFOV) 30x30m
- + Radar Image: Radarsat (12,5m x 12,5m), 3 date 04-04-1999, 02-08-1999, 17-01-2000, band C, HH, $\lambda = 5,6$ cm, 100 x 100 km
- The land map, projection Gauss, scale 1/25.000 (Source: The Cadastral center, 1995)
- The soil map 1998, scale 1/100.000 (Source: The Center for Research and Development of Mekong Delta)

3.2. Integration of aerial photo and satellite image process

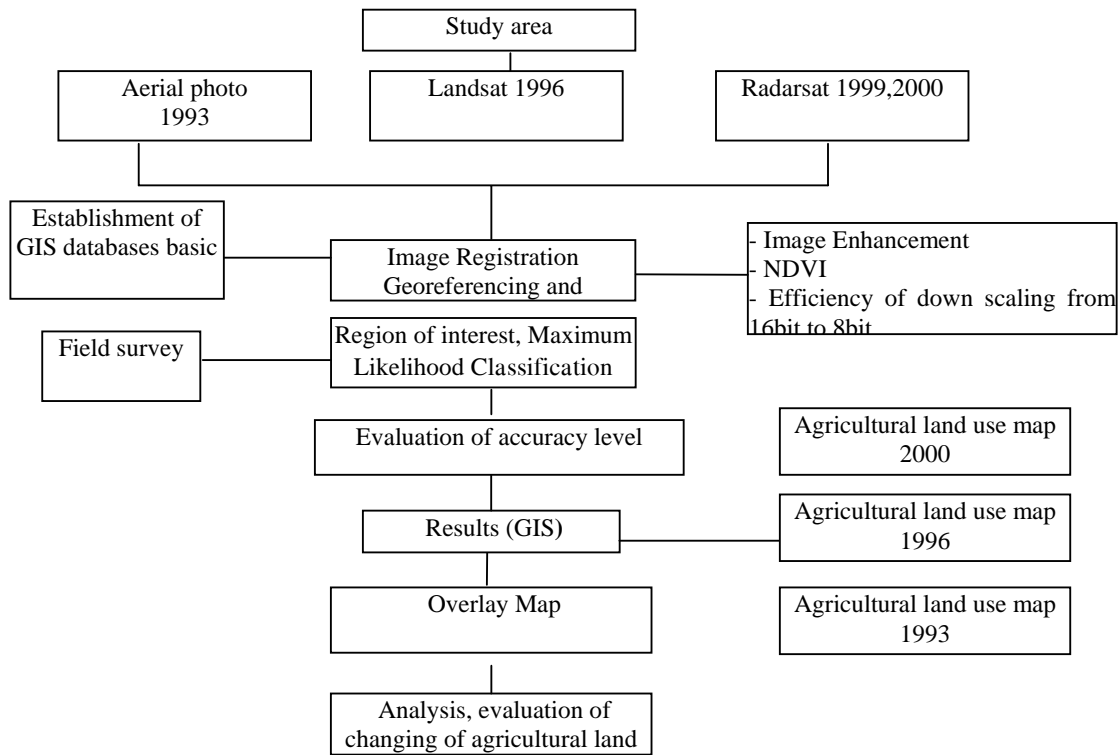


Figure 2. The process of integration and establishment of land cover map

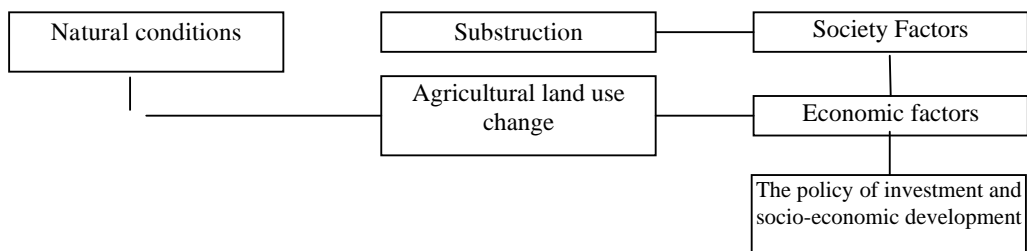


Figure 3. Layout of map overlay of agricultural land use 1993, 1996, and 2000

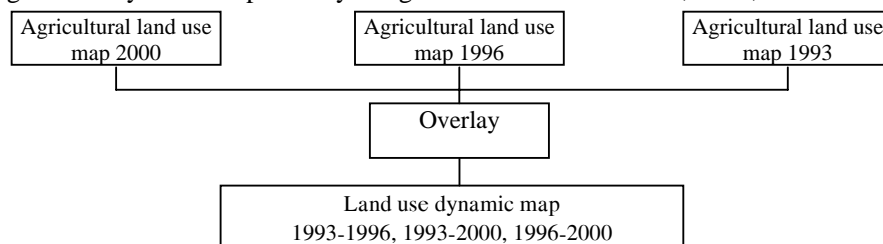


Figure 4: The factors effect to agricultural land use change

Table 1. Classification of the items of agricultural land use by using satellite image

Items	Class	Unit	Samples
Rice - Vegetable	1	05	10
Vegetable	2	13	10
Orchard, garden, home garden	3	17	10
Industrial plant	4	19	10
Coconut tree	5	20	5
Forestry (mangrove, etc.)	6	33	5
Urban	7	53	5
Land use for other purpose	8	50	10

4. Results and discussion

4.1. Integration results of Landsat TM and Radarsat

Multi-sensor Landsat TM 1996 had been integrated based on FCC band 2, 3, and 4. The key samplings had been integrated with eight kinds of objects in Table 1 and had been checked during site survey period combination to the aerial photo and land use map 1995, 1999.

Supervised classification Landsat 1996 method had been used to identify objects such as rice-vegetable, garden, home garden and coconut were high efficiency (80%), other objects such as vegetable only, industrial plants were average (70%-78%) and the left objects were very low efficiency shows in (Fig 5). Evaluation of the accurate classification Landsat 1996 on every object and be calculated by Kappa constant, the accurate level 83.89%.

$$\text{Equation Kappa } \chi = (d-q)/(N-q)$$

$$\chi = (278-54)/(321-54) = 83.89\%$$

The integration result of Radar image (4/4/1999, 2/8/1999, and 17/01/2000) based on reflected intensity variation in height and over flood, the density and structure of the objects that was changed in eight bits formation. Based on the different times of photos collection (April, August and January) recognizes variation in over flood level as well as the growing up of vegetable and non-vegetable.

The classification result of Radar combination of three different times by two supervised classification methods and based on the determination of pixel valuables on samples, selection of eight kinds of objects for eight classification layers (Fig 6)

Evaluation of the accurate classification on Radar combination of three different times for each classification layer object and is calculated by Kappa constant. The results show that the Radar combination (4/4/1999, 2/8/1999, 17/01/2000) after classification, the accurate level 70,8%.

$$\chi = (136-22)/(183-22) = 70,8\%$$

4.2. Integration aerial photo 1993

- Aerial photo 01/1993 scale 1/13.500 Tien Giang Province including in 397 photos with the overlay scale 1/13.500. Land cover map 1993 had been established based on gray level, formation, and distribution of particles space structure (sand, silt).

- The integration process had been done by eye's integration method to recognize objects and delineate an area.

4.3. Evaluation – Analyze of Agricultural land use change 1993-1996-2000

Overlay method had been used to evaluate land use change through three stages: 1993-1996, 1993-2000, 1996-2000 with eight kinds of object is combined in matrix (8x8) shows in Table 2

1. 1993

Land use for growing up rice, rice-vegetable occupied 50% of the total area, whereas, total area for cultivated vegetable only, garden, industrial plants and coconut were around 2.38%, 25.11%, 2.48% and 5.17%, respectively. Urban area and land use for other purposes occupied around 4.852.8 ha and 11.586.87 ha in comparison with total Province area 219.639.6000 ha. (Fig 7)

2. 1996

Total area for growing up rice and rice-vegetable reduced down 46.64%, whereas, land use for growing up vegetable only, garden, industrial plants and coconut increased up 9.53%, 27.07%, 4.30% and 4.44%, respectively. In case of urban area, it increased around 0.24% whereas land use for other purpose reduced 3.83%. (Fig 8)

3. 2000

Total area for growing up rice and rice-vegetable were around 48.48 % increasing 1.84% whereas land use for growing vegetable only, garden, industrial plant, coconut, and forestry were

around 3.17%, 32.54%, 3.63% and 3.13%, respectively. Urban area and land use for other purpose occupied around 0.25% and 2.62% (Fig 9)

Land use change in each stage 1993, 1996 and 2000 have been varied:

Stage 1993-1996:

Figure 10 and *Table 3* show that total area for growing up rice and rice-vegetable reduced -13,95% in comparison with 1993, total area for growing vegetable increased (7,15%) this is because in 1996, had forecasted big over flood so the farmers tended to grow up vegetable with short harvested period. Total land use for growing industrial plants such as sugar can, pineapple, etc., had increased. The forestry area had reduced because of destroying the Melaleuca and Eucalyptus forestry. The wasteland had been reclaimed and grown sugar can, pineapple and vegetable because of that land use for other purpose (wasteland, etc.) was also reduced. Go Cong is an salty area so the agricultural land in this area was usually changed because of saltwater often come inside land because of that total area for growing up rice, rice-vegetable and vegetable always change.

Total area for growing up perennial plants, garden and home garden had increased (1,96%) mainly place in island, dyke, ridge and silt around resident area and along highway. In the beginning the perennial plants grown on residents, islands and dykes zone, gradually, it moved to land use for growing coconut and rice because these kinds of plants gave very low efficiency. In 1996 total urban area was (0,24%) increased (0,02%) in comparison with 1993 it depend on three mainly factors: 1990-1995, GDP per person increased 2,05%/year, the urban population increased 3,11% (1990 – 2000), urban area, housing developed from 12,7% (1990) to 16% (1996).

Stage 1996-2000.

Figure 11 and *Table 4* show land use change 1996-2000, there is no big increasing in land use for growing rice and rice-vegetable. This is the natural development direction. Land use for growing vegetable decreased 66,69% in comparison with 1996, partly because land had been used for growing rice again, partly because land had been changed to grow Melaleuca (Tan Phuoc), the left one had been used to grow perennial plants and garden.

Land use for growing industrial plants and coconut tends decreasing 45,2% in comparison with 1996 that is because these kinds of plant brought very low economic efficiency. Therefore, both types of land use had been changed to grow orchard plant and Melaleuca. Land use for other purposes has also reduced down 31,39% in comparison with 1996, it can be explained that the wasteland had been reclaimed to grow Melaleuca and rice. In 2000, total urban area was 5.433.3 ha increased 3.2% in comparison with 1996

Stage 1993-2000

Figure 12 shows the general in stage 1993-2000 and *Table 5* shows Land cover change. In comparison between two stages 1993-1996 and 1996-2000, there are many similar points in land use change as well as land use for growing perennial plant, garden, home garden and resident area, it had increased in different time. Tendency of land use change in stage 1993-2000 and 1993-1996 was similar. Total area for growing rice, rice-vegetable, coconut, forestry and other purposes had decreased, contrary, land use for growing vegetable, industrial plants, perennial plants, garden and resident area had increased. In consideration of macroscopic angle, this is changing tendency following the agricultural economic direction of Tien Giang Province and Mekong delta.

The urban population increasing made urban area also increasing 11.96% from 1993 to 2000; total area for cultivated rice, rice-vegetable had been utilized and reclaimed for urban development. For increasing of agricultural area, the deserted land and wasteland had been improved (Dong Thap Muoi zone) to serve for growing rice, rice-vegetable, industrial plant (sugar can, pineapple, etc) forestry (Melaleuca, Eucalyptus, etc) so the land use for other purposes had decreased 50.25% within past ten year. But contrary, land use for cultivated

forestry and industrial plant had increased. However, in stage 1990 – 1995 the yield of rice had increased and exported average over 93 000 tons/year and over 260 000 tons/year in stage 1995-1998. But the economic efficiency was not so high in comparison with other types of plants. So, partly area for growing rice-vegetable had been changed to grow orchard plants and vegetables, therefore total area for growing rice decreased 8,79% in stage 1993-2000. Between 1996-2000, the tendency of agricultural land cover had been varied unusual. *Figure 11* shows the comparison of the structure of land use in Tien Giang province 1993-1996-2000

In sum, the factors effect of land use in Tien Giang province were the impact of economic market (the price of goods, investment policy and consumption of agricultural production), weather conditions (flood and tide). Both of factors would be varied not only cultivated area but also the plant structure

5. Conclusions

-Based on the application of GIS and RS technique to evaluate the agricultural land use change Tien Giang province 1990 – 2000.

-These techniques brought efficiency about time as well as the basic of science in evaluation of natural resources, especially, surface resources.

Fig 5: Supervised classification map Landsat 1996

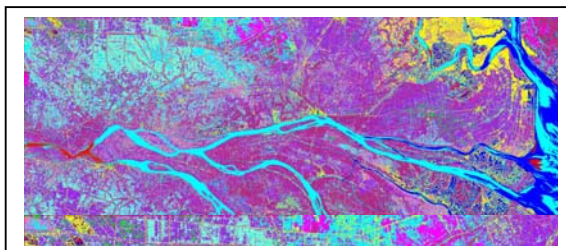


Fig 6: Unsupervised classification map Radar (4.4.1999, 2.8.1999, 17.01.2000)

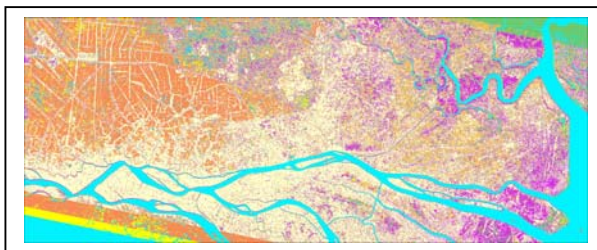


Fig 7: Agricultural land use map 1993

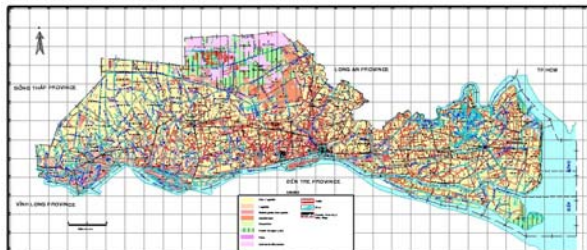


Fig 8: Agricultural land use map 1996



Figure 10: Land use dynamic map 1993-1996

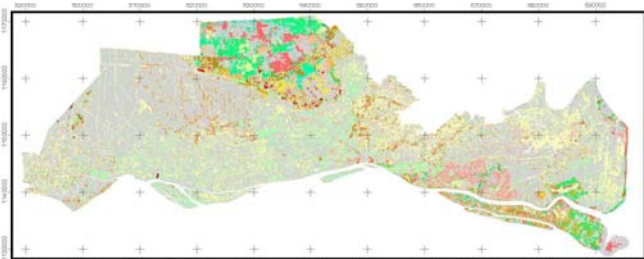


Fig 9: Agricultural land use map 2000



Fig 11: Land use dynamic map 1996-2000

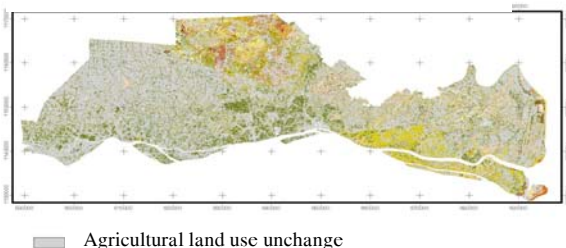


Figure 12: Land use dynamic map 1993-2000

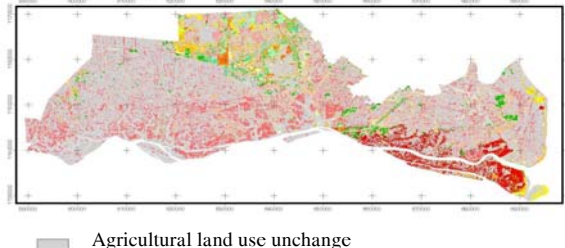


Table 2 : Percent of agricultural land used area in 1993/1996/2000

Units	Total area in 2000	%	Total area in 1996		Total area in 1993		Total area in 96-93	Total area in 2000-93	Total area in 2000-96
05	1064783700	48.48	1024473600	46.64	1167424200	53.15	-142950600	-102640500	40310100
13	69721200	3.17	209321100	9.53	52330500	2.38	156990600	17390700	-139599900
17	714636000	32.54	594608400	27.07	551582100	25.11	43026300	163053900	120027600
19	79652700	3.63	94495500	4.30	54420300	2.48	40075200	25232400	-14842800
20	68715900	3.13	97465500	4.44	113581800	5.17	-16116300	-44865900	-28749600
33	135809100	6.18	86750100	3.95	136335600	6.21	-49585500	-526500	49059000
53	5433300	0.25	5264100	0.24	4852800	0.22	411300	580500	169200
50	57644100	2.62	84017700	3.83	115868700	5.28	-31851000	-58224600	-26373600
Total (ha)	2196396000	100	2196396000	100	2196396000	100			

Table 3: The agricultural land used change in 1993/1996

1996/1993	05	13	17	19	20	33	53	50	Total area (ha)
05	762232500	118822500	237430800	5466600	37512000	1325700	115200	4518900	1167424200
13	25407900	9524700	12044700	3297600	247500	1462500	0	345600	52330500
17	184176900	56736000	281253600	9617400	13856400	3112200	1154700	1674900	551582100
19	6292800	2673000	4206600	31202100	151200	8655300	0	1239300	54420300
20	27514800	16017300	25113600	25200	43992900	6300	0	911700	113581800
33	10585800	3558600	19572300	25946100	1444500	46736100	0	28492200	136335600
53	136800	69300	404100	0	248400	0	3994200	0	4852800
50	8126100	1919700	14582700	18940500	12600	25452000	0	46835100	115868700
Total (ha)	1024473600	209321100	594608400	94495500	97465500	86750100	5264100	84017700	2196396000

Table 4: The agricultural land used change in 2000/1996

2000/1996	05	13	17	19	20	33	53	50	Total area (ha)
05	685816200	24979500	274562100	7187400	15735600	11432700	80100	4095000	1024473600
13	102812400	7683300	78788700	3523500	11370600	3590100	29700	1328400	209321100
17	193465800	16557300	335678400	9602100	13478400	20287800	468900	3993300	594608400
19	11837700	7611300	4976100	37200600	395100	25440300	3600	7095600	94495500
20	56197800	1092600	12064500	0	0	262800	50400	196200	97465500
33	5958900	6256800	4169700	14272200	27482400	42073200	19800	13943700	86750100
53	8100	900	207000	0	0	0	4772700	0	5264100
50	8686800	5539500	4189500	7866900	253800	32722200	8100	26991900	84017700
Total (ha)	1064783700	69721200	714636000	79652700	68715900	135809100	5433300	57644100	2196396000

Table 5: The agricultural land used change in 2000/1993

2000/1993	05	13	17	19	20	33	53	50	Total area (ha)
05	685816200	24979500	274562100	7187400	15735600	11432700	80100	4095000	1167424200
13	102812400	7683300	78788700	3523500	11370600	3590100	29700	1328400	52330500
17	193465800	16557300	335678400	9602100	13478400	20287800	468900	3993300	551582100
19	11837700	7611300	4976100	37200600	395100	25440300	3600	7095600	54420300
20	56197800	1092600	12064500	0	0	262800	50400	196200	113581800
33	5958900	6256800	4169700	14272200	27482400	42073200	19800	13943700	136335600
53	8100	900	207000	0	0	0	4772700	0	4852800
50	8686800	5539500	4189500	7866900	253800	32722200	8100	26991900	115868700
Total (ha)	1064783700	69721200	714636000	79652700	68715900	135809100	5433300	57644100	2196396000

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