AN INTERGRATED APPLICATION OF REMOTE SENSING AND GIS FOR STUDY FLUCTUATIONS OF LAND USE IN DIEM HO AND TRA LY ESTUARY AREAS, THAI BINH PROVINCE, VIETNAM.

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ABSTRACT

This study explores fluctuations of land use in Diem Ho estuary and Tra Ly estuary area from 1994 to 2013 using remotely sensed data, comparing and verifying with real observation result and some existing maps, especially land use map. The results show that the agricultural land sharply went down, almost 10 million m^2 from 1994 to 2001, and above 40 million m^2 from 2001 to 2013. There was a significant rise in the area of aquaculture, just below 10 million m^2 from 1994 to 2001 and around 22 million m^2 from 2001 to 2013. Salt marsh area reduced more than 400000 m^2 from 1994 to 2001, continue fell about 300000 m^2 to 2013 and distributed more and more scattered. Particularly, mangrove land grew above 10 million m^2 from 1994 to 2001, but dropped over 2 million m^2 from 2001 to 2013.

1. INTRODUCTION

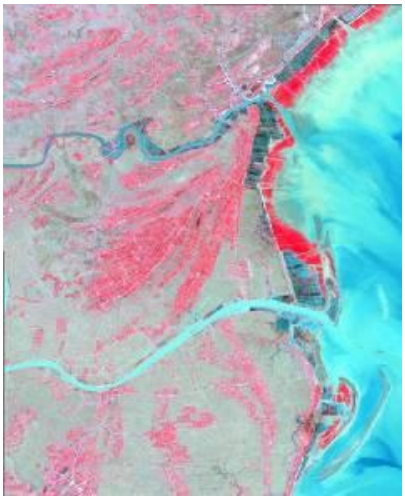
Tra Ly and Diem Ho estuary areas are in Thai Binh province, the center areas in the Red River Delta, with traditional agriculture and famous rice production. From the year 1994 to 2013, with the constantly rising of population, develop motivation of economical and social life, and changes in policy of the government leaded to changes in exploitation and utilization of soil resources.

Remote sensing and Geographic Information System (GIS) are effective tool for environmental subjects change research in general and land use change in particular. In addition to using Landsat images, the authors also used ASTER images which were provided by Japanese scientists and some related data.

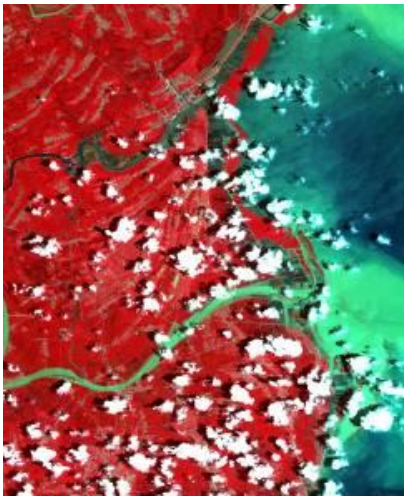
2. DATA AND METHODOLOGY

Data

The remotely sensed data sets used are Landsat ETM+ and Landsat 8 images acquired on 29th May 1994, 16th November 2001 and 27th December 2013, and an ASTER image acquired on 31st August 2002 was used to take sample and test the classification results. In addition, the authors also used some important data including topology map [5], land use map [4] and fieldwork data which was collected in different seasons in many years for training and validating the results.



(a)



(b)

Figure 1: Landsat RBG 4:3:2 acquired on 16/11/2001 (a) and ASTER RGB 3:2:1 acquired on 31/8/2002 (b) of study area.

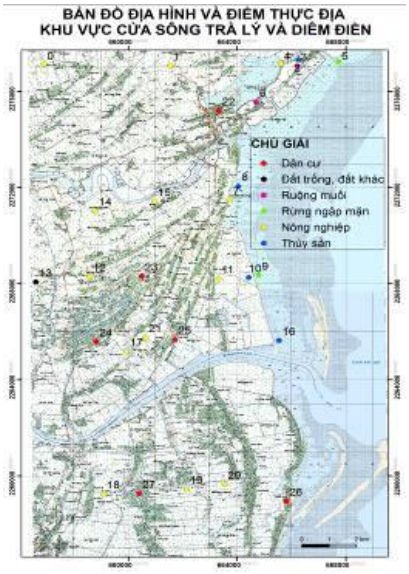


Figure 2: Topographic map and field trip data of study area.

Methodology

Post-classification change detection method is used, means all images were rectified and classified individually before comparing them [7] (figure 4).

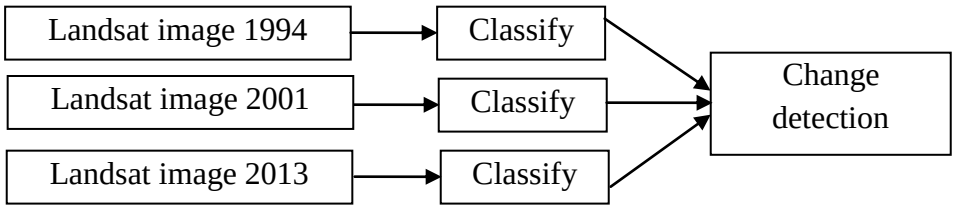


Figure 4: Analyzing processing

Land use maps are created by using Maximum Likelihood classification method, it assumes that the statistics for each class in each band are distributed and calculates the probability that a

given pixel belongs to a specific class. Each pixel is assigned to the highest probability class [1, 3, 4].

$$g_i(x) = \ln p(\omega_i) - \frac{1}{2}\ln|\Sigma_i| - \frac{1}{2}(x - m_i)^T \Sigma_i^{-1}(x - m_i)$$

Where:

i: class

x: n-dimensional data – where n is the number of bands

$p(\omega_i)$: probability that class ω_i occurs in the image and is assumed the same for all classes

$|\Sigma_i|$: determinant of the covariance matrix of the data in class ω_i

Σ_i^{-1}: its inverse matrix

m_i : mean vector

In case of land use classification in estuary area, the classes are fairly different, so using Maximum likelihood can limited the mixed between similar objects [2].

In this paper, the authors use ENVI software to analyzing remotely sensed images and ArcGIS to calculate changes in land use.

The method is shown in below flowchart (figure 5).

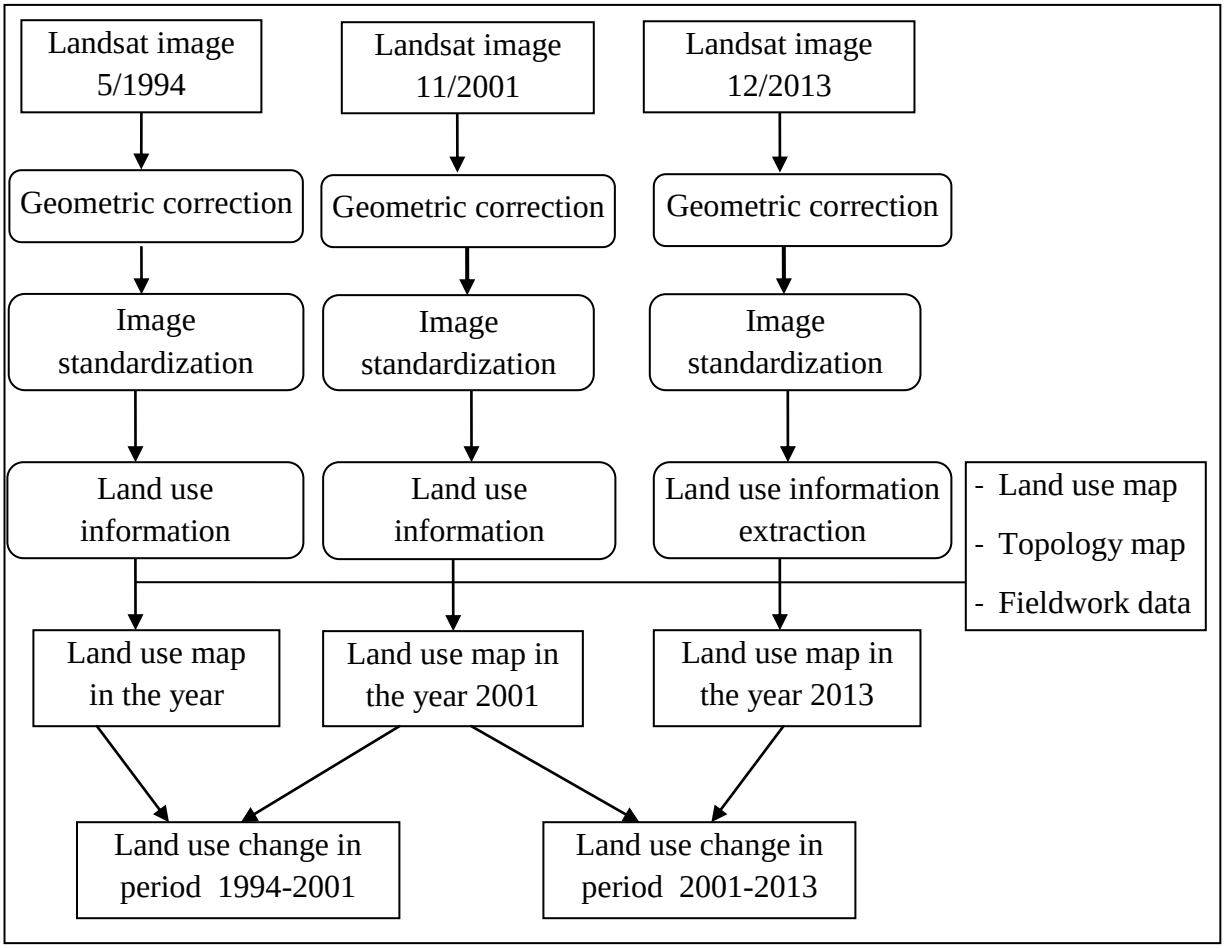


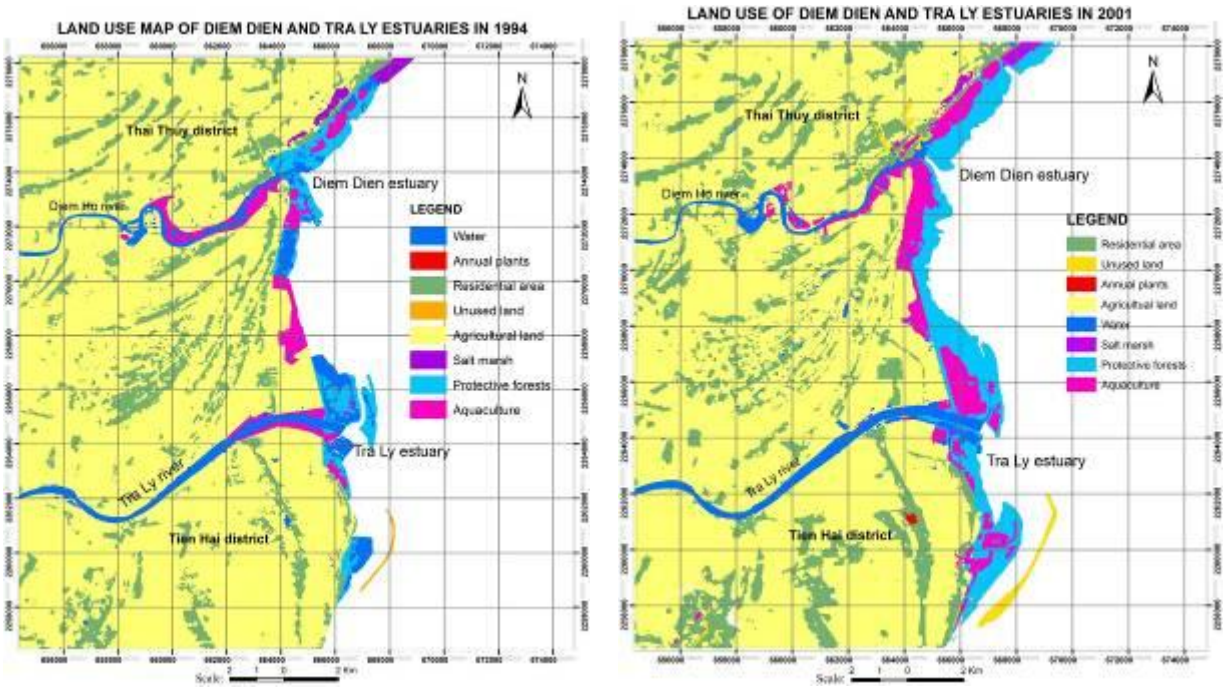
Figure 5: Flowchart of methodology

According to the characteristic of the study area and regulation of land use map, the authors divided into 8 objects: residential area (KDC), annual plants (CHN), agricultural land (DNN), salt marsh (RM), protective forest (RPH), aquaculture (NTTS), water (NM) and unused land (DK).

3. RESULT AND DISCUSSION

Result

Land use map for 3 years are showed in figure 6 and figure 7. They are the research results of ourselves.



(a) (b)

Figure 6: Land use map of study area in 1994 (a) and 2001 (b)

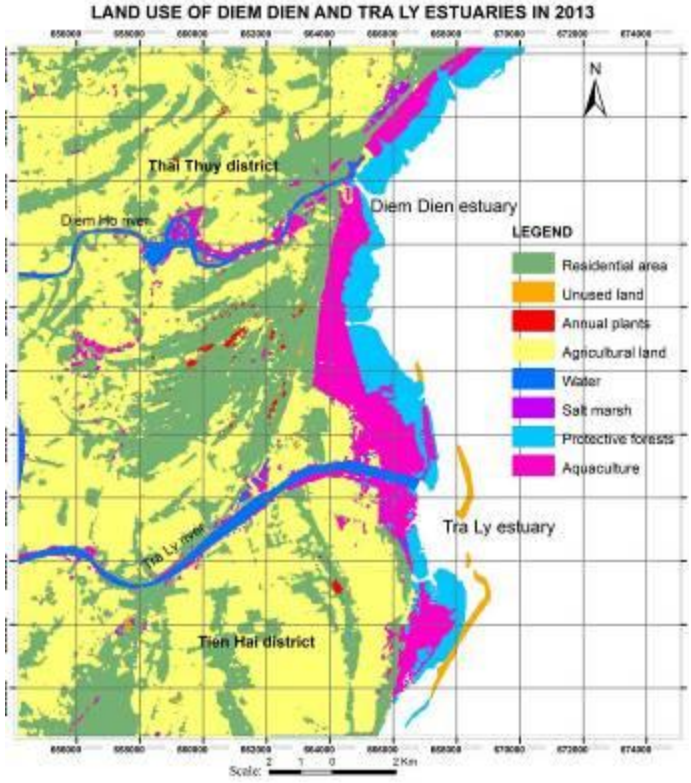


Figure 7: Land use map of study area in the year 2013

The percentage of land use objects are calculated after mapping land use map showed in figure 8:

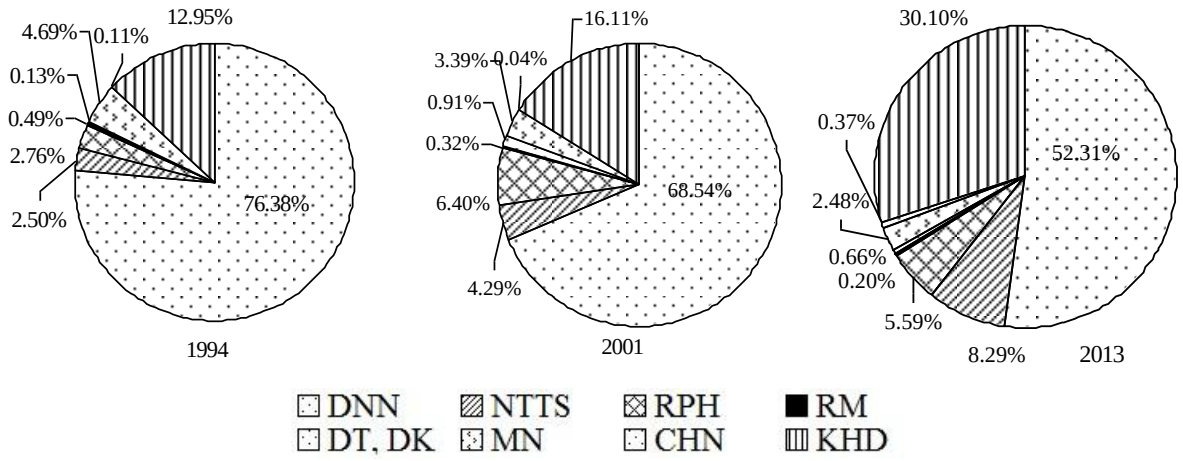
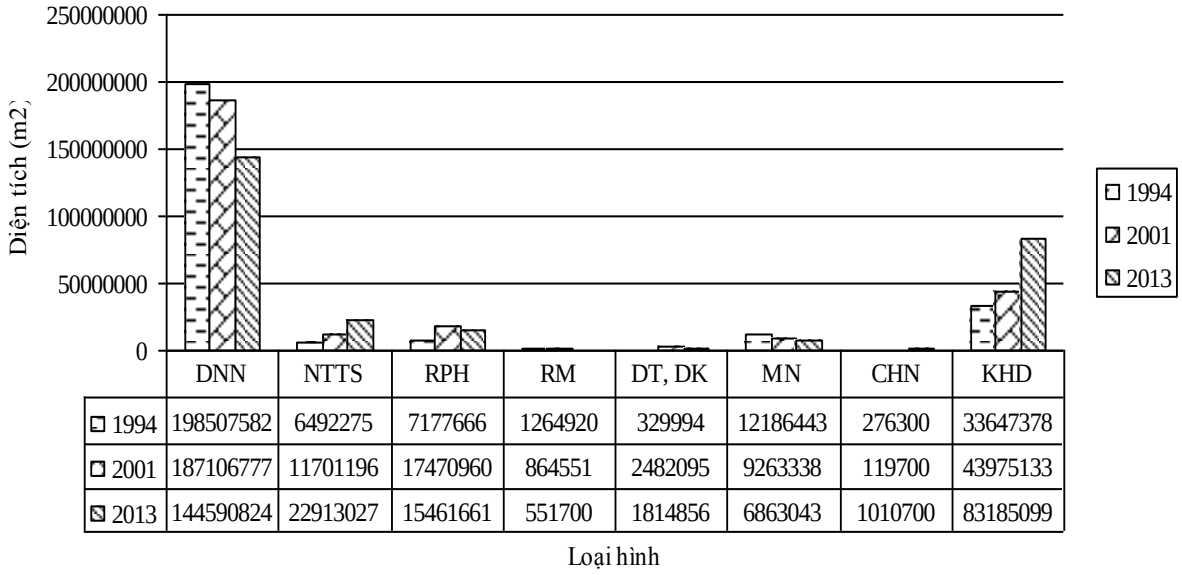


Figure 8: Percentage of land use objects in study area

The area of land use objects are showed below (figure 9):



	DNN	NTTS	RPH	RM	DT, DK	MN	CHN	KHD
1994	198507582	6492275	7177666	1264920	329994	12186443	276300	33647378
2001	187106777	11701196	17470960	864551	2482095	9263338	119700	43975133
2013	144590824	22913027	15461661	551700	1814856	6863043	1010700	83185099

Figure 9: The area of land use objects in study area

Discussion

The results show that the agricultural land sharply went down, almost 10 million m^2 from 1994 to 2001, and above 40 million m^2 from 2001 to 2013. These areas turned to residential area: in the period from 1994 to 2001, the residential area rise more than 10 million m^2 and continuously rise around 40 million m^2 to 2013.

There was a significant rise in the area of aquaculture, just below 10 million m^2 from 1994 to 2001 and around 22 million m^2 from 2001 to 2013.

Salt marsh area reduced more than 400000 m^2, equivalent 30% from 1994 to 2001, continue decreased about 300000 m^2 to 2013 and distributed more and more scattered.

Particularly, mangrove land grew above 10 million m^2 from 1994 to 2001, but dropped over 2 million m^2 from 2001 to 2013 due to changing to aquaculture or mangrove land – aquaculture combined.

Table 1: Change area of land use matrix from 1994 to 2001 (Unit: m^2)

1994-2001	KDC	DT, DK	CHN	DNN	NM	RM	RPH	NTTS
KDC	22022881	568513	0	10697424	136920	31500	66299	53153
DT,DK	900	126000	0	19742	148	0	288620	111
CHN	77785	0	66600	131915	0	0	0	0
DNN	21299362	475348	0	173868726	1170169	10278	141552	818720
NM	58837	85192	0	605422	6481776	244	1395358	3509928
RM	30600	1812	0	252000	2969	795497	28254	107678
RPH	392219	144205	0	93929	244442	1422	3253304	2942898
NTTS	77176	1850	0	1495891	911004	0	396680	3609609

Table 2: Change area of land use matrix from 2001 to 2013 (Unit: m^2)

2001 -2013	KDC	DT,DK	CHN	DNN	NM	RM	RPH	NTTS
KDC	37921688	2700	126509	5640416	62774	4500	1620	213460
DT,DK	1063707	60001	0	217741	3177	0	50313	18195
CHN	43650	0	73800	2250	0	0	0	0
DNN	41624780	318486	807691	137150380	497674	238702	85471	6388008
NM	914797	14513	0	383347	5882167	1597	86655	1962370
RM	87241	0	1800	23400	0	306000	62709	385200
RPH	144815	0	0	156331	57897	0	10749846	4528238
NTTS	925389	1800	0	6445289	283459	0	548179	9359415

The causes of land use change in this study area are:

- Residential area increased due to the housing demand and construction of rural infrastructure.

- Salt marsh area reduced because its economic efficiency was low, as well as lack of investment.

- Mangrove land increased by the government investment policy and effective help from some non-government organizations (NGO), particularly in the period 1990-2010.

- Aquaculture area was expanded because of high economic efficiency, low initial investment, and suitable natural condition.

- In the near future, aquaculture are (mainly crab, edible seaweed, shrimp, oyster) will continue to expand, and salt marsh area will decrease.

REFERENCES

[1] Truong Xuan Luan et al. 2005. "*Geographical Information Systems in Geology*". Textbook of Hanoi university of Mining and Geology.

[2] Vu Anh Tuan. 2004. *"Study the land cover change and its effects to the soil erosion of the Tra Khuc watershed by applying remote sensing and GIS methodology*". Doctoral dissertation, Hanoi University of Science, Vietnam National University.

[3] J.J Settle & S.A. Briggs, 2007, *Fast maximum likelihood classification of remotely-sensed imagery*. International Journal of Remote Sensing

[4] Richards, J.A., 1999, *Remote Sensing Digital Image Analysis*. Springer-Verlag, Berlin, p240.

[5] Land use map of Tien Hai district, Thai Binh province, scale: 1: 10.000. Song Chau informatics and geodetic technology Co.Ltd.

[6] Topographic map: F48-82-C-c, F48-94-A-a; scale: 1:25.000. Vietnam General Department of Land Administration, 2002.

[7] Jensen J.R., Ruthchey K., Koch M.S., Sunil Narumalani. *Inland wetland change detection in the Everglades Water Conservation area 2A using a time series of normalized remotely sensed data*. Photogrammetric engineering and remote sensing ISSN 0099-1112.