LAND USE CHANGE DETECTION USING REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM (GIS) IN GUA MUSANG DISTRICT, KELANTAN, MALAYSIA

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KAMARUZAMAN, J. & SENTHAVY, S. 2003. Land use change detection using remote sensing and geographical information system (GIS) in Gua Musang district, Kelantan, Malaysia. A study integrating remote sensing and geographical information system (GIS) was carried out in northern part of Gua Musang district, Kelantan, Malaysia to map and determine the land use change as a result of development pressure in the area. Two sets of Landsat Thematic Mapper (TM), dated May 1990 and July 1997, at a scale of 1:150 000 were acquired. Land use classes were interpreted from these images and the resultant maps were checked in the field to determine ground truth and mapping accuracy. The land use map data were then transferred directly into the computer via ACR/INFO and ARC-VIEW softwares. The land use data were digitised in ARC/INFO and overlaid and analysed in ARC-VIEW. Ground verification showed that the total overall map accuracy was 86.54%. The results showed that shrub increased by 181.14% from 1990 to 1997 and newly cleared area, rubber and oil palm increased by 91.37, 45.19 and 44.72% respectively. On the other hand, other land use classes such as mixed horticulture, diversified crops, urban and paddy increased by 38.82, 11.95, 10.30 and 4.70% respectively. However, the extent of undisturbed and disturbed forest reduced by 8.10 and 27.70% respectively during the same period. Shrubs showed an increasing trend of land use while forest areas decreased in area compared with other land use classes. Rapid land use change took place in the northern part of Gua Musang district where nearly 36% of the changes were associated with shrub, oil palm and rubber land use conversions.

Key words: Land use classes - ground verification

KAMARUZAMAN, J. & SENTHAVY, S. 2003. Mengesan perubahan guna tanah menggunakan penderiaan jauh dan sistem maklumat geografi (GIS) di daerah Gua Musang, Kelantan, Malaysia. Kajian integrasi penderiaan jauh dan sistem maklumat geografi (GIS) ini dijalankan di bahagian utara daerah Gua Musang, Kelantan, Malaysia untuk pemetaan dan mengenal pasti perubahan guna tanah akibat tekanan pembangunan di kawasan tersebut. Data Landsat TM bertarikh Mei 1990 dan Julai 1997 berskala 1:150 000 diperoleh. Kelas guna tanah diinterpretasi dan peta yang dihasilkan disemak di lapangan untuk tujuan ketepatan pemetaan. Data peta guna tanah dipindahkan ke dalam komputer secara langsung menggunakan perisian ACR/INFO dan ARC-VIEW. Data guna tanah didigitalkan mengguna ARC/INFO

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lalu dilapisi dan dianalisis dalam ARC-VIEW. Semakan di lapangan menunjukkan ketepatan keseluruhan peta mencapai 86.54%. Keputusan menunjukkan bahawa kawasan lalang/semak meningkat sebanyak 181.14% dari tahun 1990 ke tahun 1997 sementara kawasan yang baru diterangkan, getah dan kelapa sawit masing-masing bertambah sebanyak 91.37, 45.19 dan 44.72%. Guna tanah yang lain seperti hortikultur campuran, tanaman pelbagai, kawasan bandar dan padi masing-masing bertambah sebanyak 38.82, 11.95, 10.30 dan 4.70%. Bagaimanapun kawasan hutan yang tidak diganggu dan diganggu masing-masing berkurangan sebanyak 8.10 dan 27.70% dalam tempoh masa yang sama. Kawasan semak meningkat secara ketara manakala kawasan berhutan menurun berbanding kelas guna tanah yang lain. Perubahan guna tanah yang pantas berlaku di utara daerah Gua Musang dan sebanyak 36% perubahan itu merangkumi semak, kelapa sawit dan kawasan getah.

Introduction

The total land area of Peninsular Malaysia is approximately 13.2 million ha, of which 5.97 million ha or 45.3% is forested. Growing population cause scarcity of forested land and widespread changes in land use. To ensure that future generations can enjoy the benefits of forest resources, more efficient management of these resources is needed. Land use planners, managers, policy makers and researchers alike need to understand and detect the complexity of changes and their factors involved.

Change detection is useful for determining and evaluating differences in a variety of surface phenomenon over time. Change detection studies recognise the abiotic and biotic components of spectral and temporal changes that occur within ecosystem (Mouat *et al.* 1993). It is important that such changes be inventoried accurately so that the physical and human processes at work can be more fully understood (Jensen 1996). Therefore, it is not surprising that significant effort has gone into the development of change detection methods using remotely sensed data (Jensen 1996).

Remote sensing techniques have proven useful for gathering information about natural resources on large-scale basis, such as for the whole country. The Malaysian Ministry of Agriculture has been using aerial photo interpretation for land use mapping in Peninsular Malaysia. With increasing availability of high resolution satellite imagery, and as the capabilities to handle land information within the country are modernised, it is opportune to explore the potential of remote sensing and geographical information system (GIS) to gather and update information on natural resources.

GIS has become an important tool for analysing and transferring spatial data information from the surface of the earth to paper (Burrough 1986). The spatial information data from remote sensing can be analysed using sophisticated GIS hardware and software computer systems. This provides faster and more efficient acquisition of such information to users.

The objective of this study was to assess the usefulness of integrating remotely sensed data (Landsat TM) with GIS for detection of land use change. The specific objectives were to quantify and map the land use change in the northern part of Gua Musang district, Kelantan, Peninsular Malaysia between 1990 and 1997.

Materials and methods

Study site

The state of Kelantan, with an area of about 14 922 km^2, is situated in north-east Peninsular Malaysia. It consists of 10 districts and the total population is about 1 288 362. Gua Musang is one of the districts and it is located in the south of Kelantan (Figure 1). The total area of Gua Musang is 8104 km^2 (810 400 ha) with a population of about 143 258 (Anonymous 1997). Initially, it was decided that the study site cover the whole of Gua Musang; unfortunately satellite data was unavailable at the time of study. Instead, the study site only covered the northern part of Gua Musang (3170 km^2) within latitudes 4° 55' and 5° 25'N and longitudes 101° 25' and 102° 30' E. The land use/cover mainly composed of forest, oil palm, rubber, cleared land, mixed horticulture, homestead garden and villages. Gua Musang was chosen as a study area due to rapid conversion of agricultural land occurring in the region.

Climate

Gua Musang has a hot, humid tropical climate. Temperature and rainfall are generally high throughout the year. The mean annual temperature varies from 25° to 28 °C and mean annual rainfall exceeds 2000 mm.

Imagery

The primary data used in this study were Landsat TM dated 6 May 1990 and 20 July 1997 (path/row: 127/56) acquired in CD-ROM format from the Malaysian Centre for Remote Sensing (MACRES), Kuala Lumpur. The images were geometrically and radiometrically corrected by MACRES.

Ancillary data

Additional data were obtained from Department of Agriculture and Department of Forestry, Kelantan. The ancillary data used were:

(1) topographic map,
(2) land use map 1990 scale 1:150 000 derived from aerial photo,
(3) land use map 1997 ammonia printed scale 1: 50 000 derived from aerial photo, and
(4) development map of Gua Musang district.

Hardware and software

The hardware used for this study was a microcomputer PC and its accessories including digitiser (Calcomp 9000), plotter (HP DesignJet 750C plus) and printer (Canon BJC-2000SP). The GIS software used was ARC/INFO version 3.4.2 and ARC-VIEW version 3.1. For image processing, ILWIS software was used. A hand-held global positioning system, Geo Explorer II, was used for positioning of ground truth.

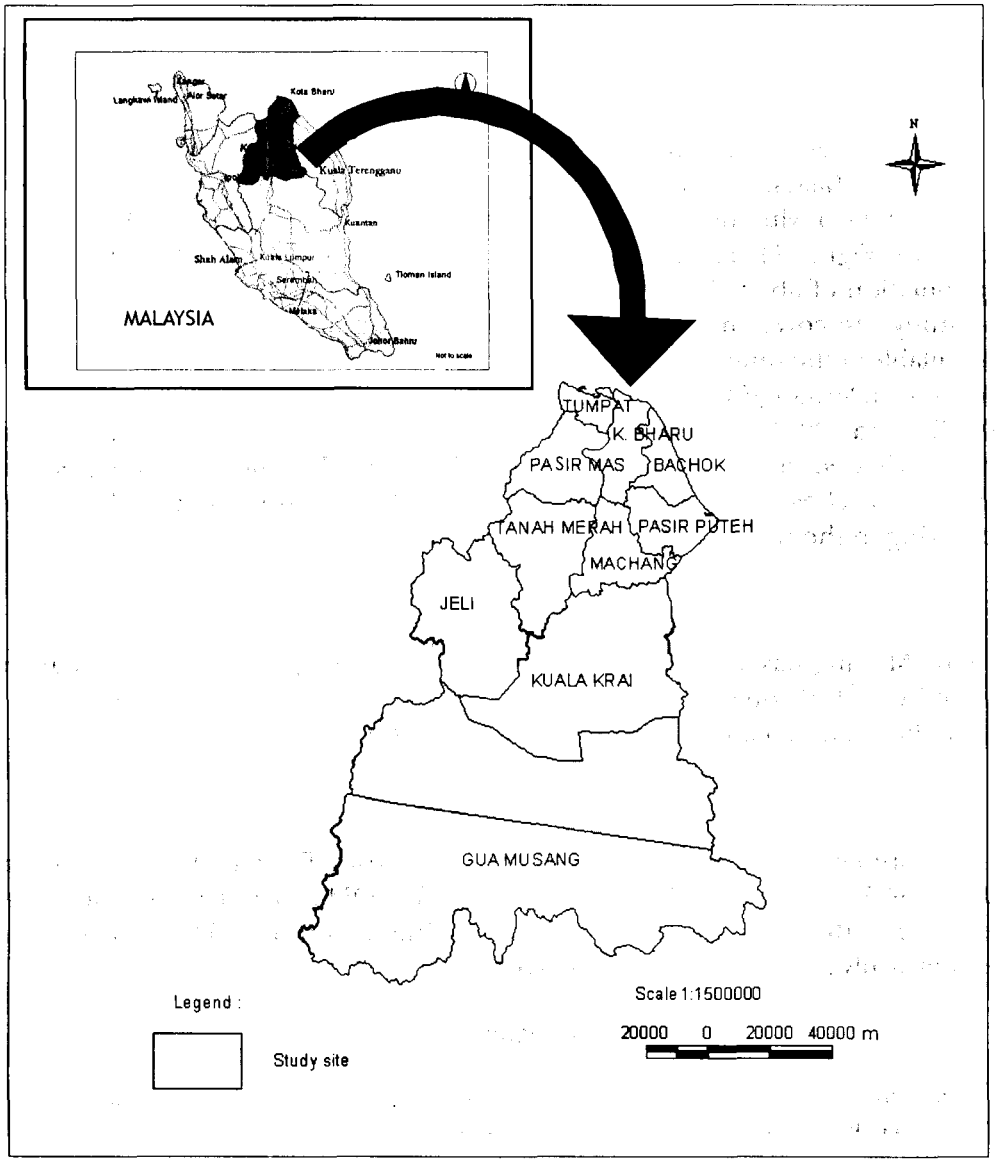
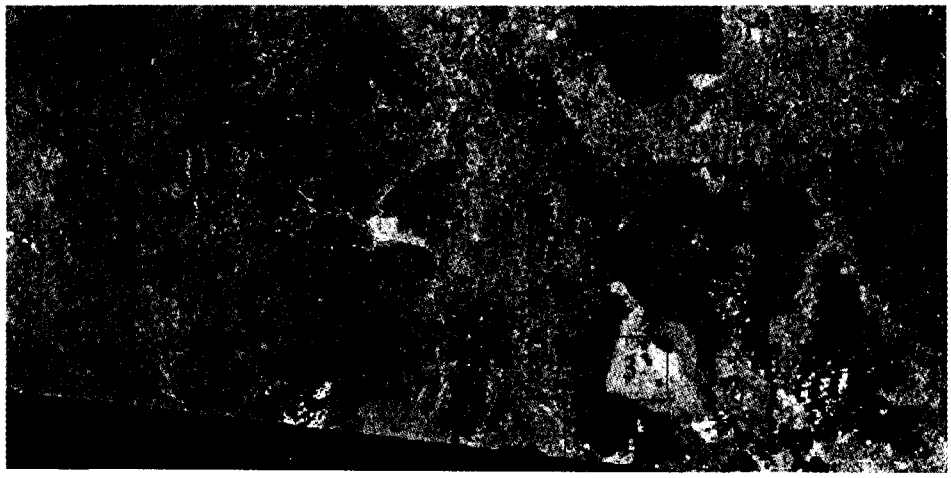


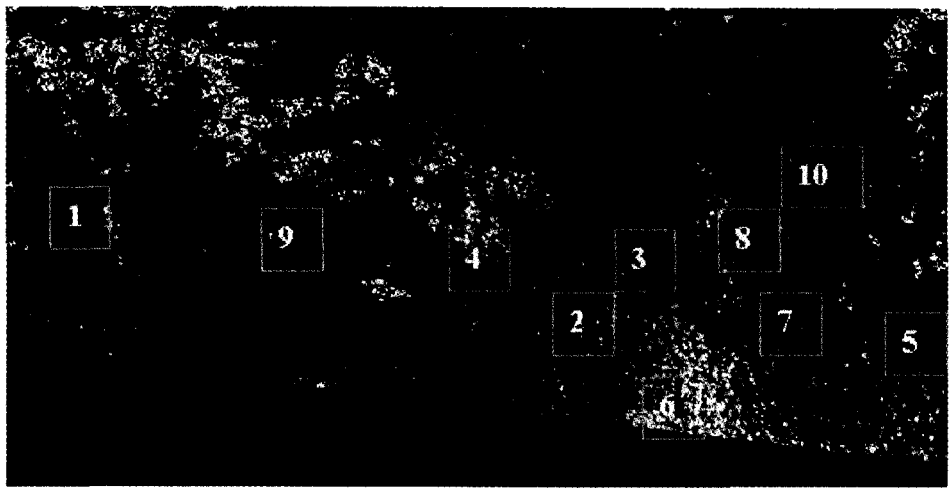
Figure 1 A map showing the state of Kelantan and the study area in Gua Musang

Methodology

The technique used in this study included image enhancement such as contrast enhancement and band combination. A band combination of 4, 5, 2 (Figure 2) was selected and printed out in hard copy scale of 1: 150 000. Visual interpretation was applied to categorise the different land use classes on the images. The land use classes were digitised into ARC/INFO and later transferred into ARC-VIEW. The land use maps were then overlaid with changes analysed, after which a land use change map was produced. Figure 3 illustrates the methodology flow chart of the study.



(a) Landsat TM of 1990



(b) Landsat TM of 1997

1 = undisturbed forest
2 = disturbed forest
3 = oil palm
4 = rubber
5 = shrubs
6 = mixed horticulture
7 = urban
6 = diversity crops
9 = newly cleared area
10 = paddy

Figure 2 Subset image of study area showing band combination of Landsat TM of (a) 1990 and (b) 1997 (4, 5, 2)

Results and discussion

Visual interpretation technique, enabled us to classify the land use classes in the study. The land use changes, from their total area and magnitudes of change in 1990 and 1997, are shown in Table 1.

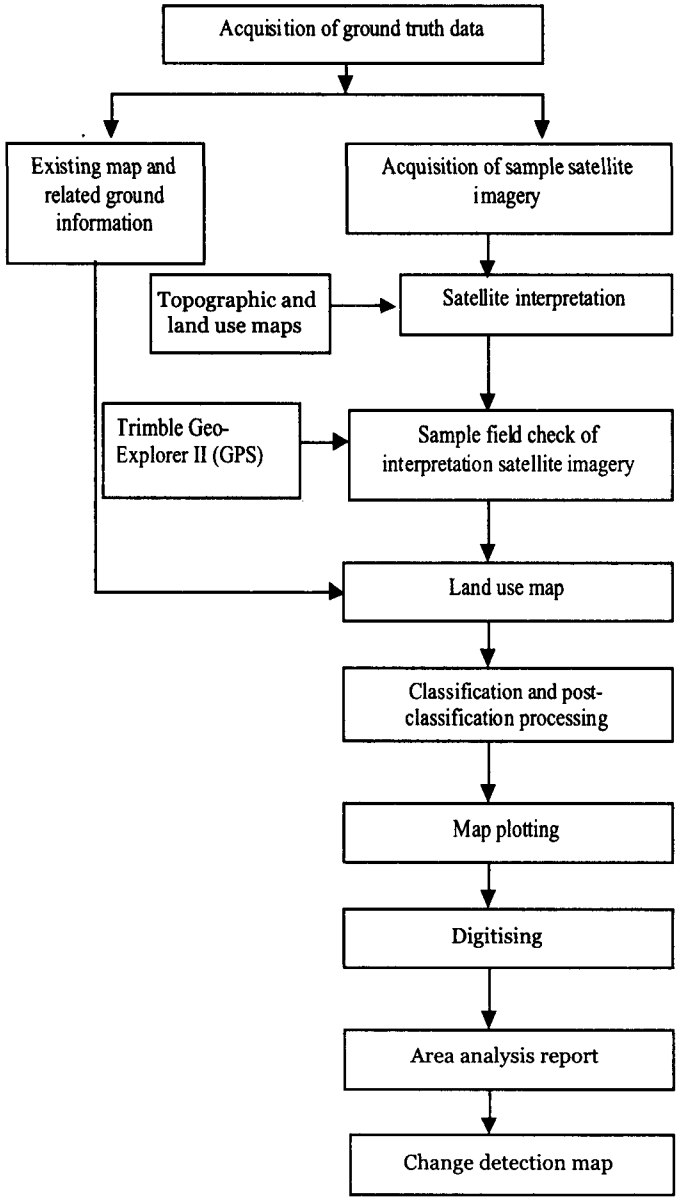


Figure 3 Methodology flowchart

It is evident that the undisturbed and disturbed forests were the most dominant land use types. Their total areas were 75.07 and 11.37% in 1990 and 68.99 and 8.22% in 1997 respectively. Oil palm, rubber and shrub occupied 17 471.77 ha, 15 029.72 ha, 7594.96 ha respectively in 1990. However, their proportion of the total area increased by 2.47, 2.15 and 4.34% respectively in 1997.

Table 1 Land use classes, extent and magnitude of change in northern part of Gua Musang district, Kelantan in 1990 and 1997

Land use class	Landsat TM 1990		Landsat TM 1997		Magnitude of land use change	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Undisturbed forest	237 921.42	75.07	218 650.07	68.99	- 19 271.35	- 8.10
Disturbed forest	36 029.23	11.37	26 050.78	8.22	- 9 978.45	- 27.70
Oil palm	17 471.77	5.51	25 284.43	7.98	7 812.66	44.72
Rubber	15 029.72	4.74	21 821.40	6.89	6 791.68	45.19
Shrub	7 594.70	2.40	21 352.05	6.74	13 757.35	181.14
Mixed horticulture	842.96	0.27	1 170.23	0.37	327.27	38.82
Urban	714.82	0.23	788.45	0.25	73.63	10.30
Diversified crops	601.90	0.19	673.82	0.21	71.92	11.95
Newly cleared area	440.49	0.14	842.97	0.27	402.48	91.37
Paddy	272.16	0.09	284.95	0.09	12.79	4.70
Total	316 919.17	100.00	316 919.15	100.00		

Table 1 also shows the distribution of land use change in northern part of Gua Musang district between 1990 and 1997. The undisturbed and disturbed forest areas had been reduced by 19 271.35 ha (8.10%) and 9978.45 ha (27.70%) respectively. However, the newly cleared land, mixed horticulture and other land use areas increased due to the conversion of forested areas to agricultural use, especially for oil palm and rubber cultivation. The extent of rubber and oil palm plantations increased to 6791.68 ha (45.19%) and 7812.66 ha (44.72%) respectively. There was not much change in paddy area since not much development had taken place during the period of study. However, shrub and newly cleared areas showed big increases compared with other land use classes. From 1990 to 1997 shrub area had a growth of 181.14% (13 757.35 ha) while newly cleared area, 91.37% (402.48 ha). The final output, which is the change detection map, is depicted in Figure 4.

Accuracy assessment is a general term for comparing the known reference data from ground truth and the corresponding results of classification accuracy. The identification accuracy check by sample points is summarised in Table 2.

The result of accuracy assessment indicates that the land use classes had been accurately mapped out. However, seven of the overall total sample points were misclassified. Two of the samples points which were classified as mixed horticulture were actually settlement areas while an area classified as undisturbed forest was actually disturbed forest. Two points, one each as diversified crops and shrub, were actually mixed horticultural areas and two of the disturbed forests were rubber plantations. The confusion was probably because of the prominent cloud cover and the similar reflectance of some land uses on the image.

Table 2 Accuracy check by sample points of visually interpreted 1990 and 1997 satellite images

Land use class	Total number of sample points		Total number of sample points correct		Total number of sample points wrong		Overall total points correct	Overall total points wrong
	1990	1997	1990	1997	1990	1997		
Urban	1	2	1	2	0	0	3	0
Mixed horticulture	2	3	1	2	1	1	3	2
Diversified crops	1	2	1	1	0	1	2	1
Newly cleared area	2	1	2	1	0	0	3	0
Paddy	1	1	1	1	0	0	2	0
Oil palm	3	3	3	3	0	0	6	0
Rubber	4	3	4	3	0	0	7	0
Shrub	5	4	4	4	1	0	8	1
Undisturbed forest	3	4	3	3	0	1	6	1
Disturbed forest	4	3	3	2	1	1	5	2
Overall total	26	26	23	22	3	4	45	7
			(88.46%)	(84.62%)	(11.54%)	(15.38%)	(86.54%)	(13.46%)

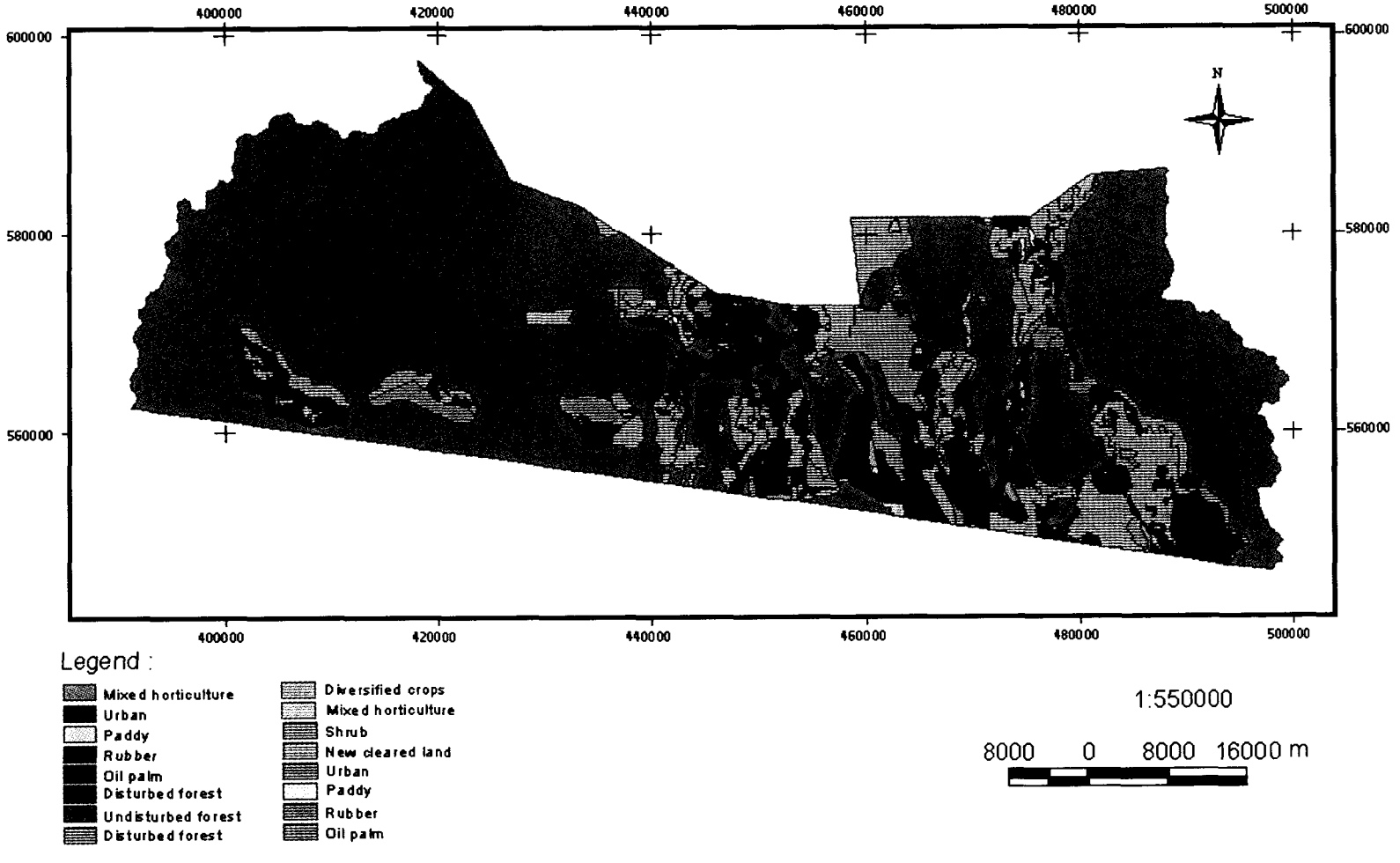


Figure 4 Change detection map of northern part of Gua Musang district, Kelantan, 1990–1997

Conclusions

Based on the results of this study, several conclusions can be derived as follows:

(1) The integration of remote sensing data and GIS can identify and generate land use classes in northern part of Gua Musang district. In this study, remotely sensed data of 1990 and 1997 with the scale of 1:150 000 could identify all the 10 land use classes on both images.

(2) The accuracy assessment of the land use classification based on accuracy check by sample points was visually interpreted. The accuracy for both images were 88.46% in 1990 and 84.62% in 1997. However, the total overall accuracy was 86.54%.

(3) Rapid land use changes occurred in northern part of Gua Musang district. Nearly 36% of land use change was due to the conversion of disturbed and undisturbed forests to oil palm, rubber and shrub areas.

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