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Ayer Hitam Forest (AHFR) from Space Using Satellite Remote Sensing

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ABSTRAK

Terdapat permintaan yang tinggi terhadap peta dan pengawasan penggunaan tanah dan penaksiran disebabkan keadaan ekonomi dan ekologi. Maklumat tentang tanah dan liputannya serta pembahagian kependudukan adalah satu keperluan yang amat penting dalam mana-mana program perancangan, pembangunan dan pengurusan. Di dalam kajian, perolehan data Landsat TM pada tahun 1998 di Hutan Simpan Air Hitam (HSAH) dan sekitarnya, menunjukkan ianya meliputi lebih dari 1,300 ha. Objektif kertas kerja ini adalah untuk memetakan Hutan Simpan Air Hitam (HSAH) dan menaksir/ menilai kawasan liputan HSAH dan sekitarnya pada tahun 1998, di mana ianya menggunakan Teknologi Remote Sensing (Penderiaan Jauh). Pemprosesan data digital dan penganalisaan dibuat menggunakan peralatan PCI/ EASI PACE yang terdapat di Fakulti Perhutanan, UPM. Kaedah 'False Color Composite' (peniruan gabungan mewarna) menggunakan Landsat TM band 4-5-3 (RGB) digunakan untuk mengelolakan/ mengawasi pengkelasan menggunakan ' Maximum Likelihood Classifier" (Pengkelasan secara maksimum). Daripada tafsiran pandangan, keadaan HSAH boleh dibahagikan kepada sistem jalan, jalan hutan, kawasan lapang, kawasan yang sedang dibangunkan, ladang kelapa sawit, kawasan berair, kawasan penanaman getah dan sebagainya. Dalam pada itu, pengkelasan digital menunjukkan bahawa terdapat 7 pengkelasan kawasan penggunaan tanah berdasarkan penggunaan tanah di sekitar HSAH , iaitu hutan, hutan sekunder/ hutan pokok renik, ladang kelapa sawit, ladang getah, kawasan yang dibangunkan, kawasan yang dilapangkan dan kawasan berair yang boleh dipetakan dengan mudah. Secara keseluruhannya, pengkelasan secara tepat mengandungi 86.06 peratus dengan ketepatan 86.64 peratus. Pemetaan satelit terhadap HSAH di dapati amat berguna untuk perancangan makro dan pengurusan terutamanya pada penilaian/ penaksiran kesan persekitaran jika pembangunan pada masa akan datang dipolitikan.

ABSTRACT

There is a high demand to map and monitor the land use and assess their condition for ecological and economic reasons. Information on existing land and cover and their spatial distribution is a pre-requisite for any planning, development and management programme. In this study, Landsat TM data of 1998 were acquired over the AHFR and it's vicinity which covers an area more than 1, 300 ha. The objective of this paper is to map AHFR and assess the land cover of AHFR in 1998 as well as its surrounding area using remote sensing technology. Digital data processing and analysis were carried out using PCI/EASI PACE software, version 6.2 available in Faculty of Forestry, UPM. A false Colour Composite (FCC) of Landsat TM band 4-5-3 (R-G-B) was used in supervised classification using Maximum Likelihood Classifier (MLC). From a visual interpretation, several features of AHFR could be identified such as federal road, forest road, cleared land, built-up area, oil palm, water bodies and rubber plantation etc. Meanwhile, digital classification showed that seven land use types surrounding AHFR such as forest, secondary forest/shrubs, oil palm, rubber, built-up area, cleared land and water bodies could a easily be mapped out. The mean overall classification accuracy obtained is 86.08 percent with an average accuracy of 85.64 percent. Satellite map of AHFR is found to be useful for the macro planning and management purposes especially on the Environmental Impact Assessment (EIA) if further development on the area is to be politicized.

INTRODUCTION

There is a high demand to map and monitor the land use and assess their condition for ecological and economic reasons. Information on existing land use pattern and its spatial distribution is a pre-requisite for any planning, development and management programme. Nowadays, science and technology have provided us with a new dimension and view of planet Earth, first through the electronic eyes of sensor systems on spacecraft whirling around the globe, and then through human eyes, fascinated by its vast range of features and colours. From space, we can see the face of the world, with white of its snow, the green of forest and farmland, the blue ocean, and painted deserts in all their living hues of red to brown and purple.

The study of earth including land, oceans, atmosphere and their interactions has made rapid advances in recent time due to continuous regional and global observation through remote sensing. Space-base remote sensing is one of the process of obtaining information about earth from instruments mounted on Earth Observation Satellites (Anon 1991). Satellite remote sensing provides a means to collect area information repeatedly on a regional or global scale, particularly in remote areas which is difficult to access by road (Mohd. Hasmadi and Kamaruzaman 1999). Hence, Remote sensing are useful spatial tools for interactive land use mapping. The vegetation information in a digital format will help focus and stratify the more costly field data collection.

Most countries worldwide are taking advantages and opportunities using remote sensing technique for sustainable management of natural resources, environmental monitoring, hazard mitigation, education and scientific research with great success. In Malaysia, the significance of using this technology for various purposes particularly natural resources management is obviously gaining wider recognition. The objective of this paper is to map AHFR and assess the land cover of AHFR in 1998 as well as its surrounding area using remote sensing technology.

MATERIALS AND METHODS

Description of Study Area

Air Hitam Forest Reserve (AHFR) is a university forest that plays an important role to the purposes in scientific research and education in forestry. It covers an area of 1, 248 ha. which currently comprises of six compartments namely, 1,2,12,13,14 and 15, and has been allocated as an education forest by the State of Selangor during 22nd June 1994 convention at the Selangor State Meeting Council. This forest is situated approximately 20 km south west of Kuala Lumpur and 6 km from UPM, at latitudes between 20 57' N to 30 04' N and longitudes 101° 38'E to 101° 41' E (Fig. 1).

The climate of AHFR area is typically tropical. The mean monthly temperature is 28.36°C with a mean maximum and minimum of 32°C and 22.6°C, respectively. However, the maximum and minimum relative moisture contents are 97.8% and 77.4%, giving average moisture content of 87.6%, respectively. Annual precipitation in the area is approximately 2316.5 mm – 4223.4 mm. The highest rainfall mainly occurs in May and the lowest is in August. The topography of the area consists of low lying hills with narrow river valleys. AHFR is undulating ranging from 15 m to 157 m above sea level. The average slope is about 20% and there are many flat areas. The area was drained by Rasau and Bohol rivers which generally flow in the north to south direction.

Data Acquisition and Digital Image Analysis

Optical satellite data (Landsat TM) with seven bands were used to map AHFR from space and classify land use/cover in AHFR. Landsat TM spectral data taken on 8 February 1998 (path/row 127/58) were acquired in the form of compact disk with a spatial resolution of 30 m. This image covered the entire study area and no haze or clouds were recorded in the scene. Satellite data were processed digitally and visually. Other references data acquired to support the satellite imagery are topographic map (1:50 000) and classified satellite image of 1990 (1: 50 000). Digital analysis of satellite data was done using PCI/EASIPACE (version 6.2) image processing system available in the Center for Precision Agriculture & Bioresource Remote Sensing, Institute Bioscience, Universiti Putra Malaysia.

Methods

Briefly, the procedures involved are data acquisition, radiometric and geometric correction, interpretation, output derivation and field verification. Digital and visual interpretations were used to classify Landsat TM data. The geocoding correction was based on ground control points

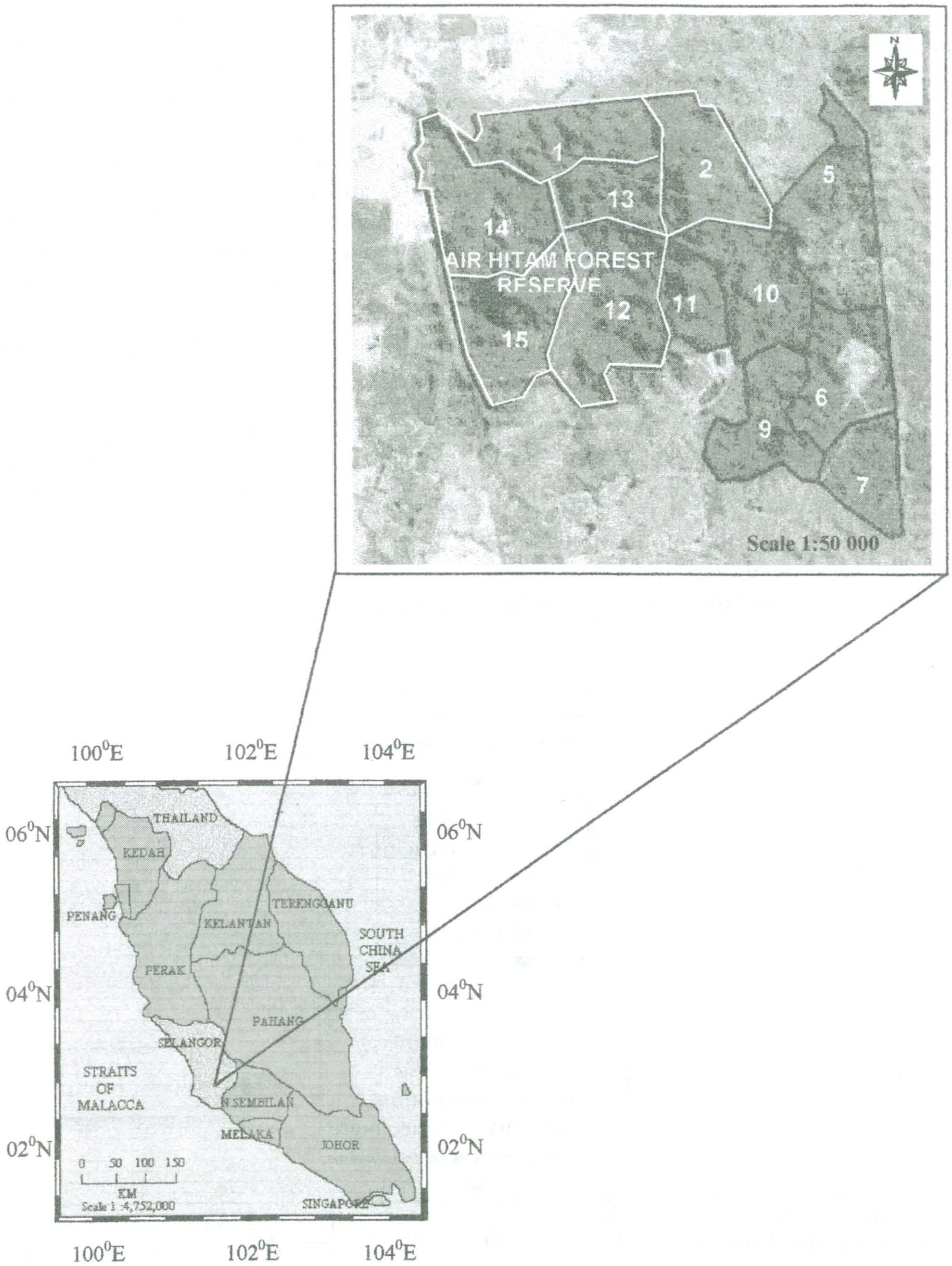

Fig. 1. Satellite Imagery Showing the Location of AHFR and their Compartments

(GCPs), where Landsat TM 1993 were used as a base reference. A total of 10 GCP's were defined to recognize points on both the master and slave data sets (image to image registration approach). The corrected image was enhanced through contrast enhancement and spatial filtering and displayed in a combination of false colour composite. Theoretically, by comparing the spectral signatures of unknown features types with known surfaces, prediction can be made about the of unknown features. The signatures of particular area such as vegetation that was measured by sensor, may not be unique and can vary with time, seasonal changes, angle of sensor, atmospheric attenuation and local environmental differences (Sanders 1983). The image was interpreted to locate training sites for image classification. Automated image classification namely supervised classification was used and Maximum Likelihood Classifier was chosen. The final classified images were generated using several steps as shown in *Fig. 2.*

RESULTS AND DISCUSSION

Band Combination and Contrast Enhancement

Through band combination and contrast enhancement it is possible to visualize the band that gives maximum information of the data. From the image represented by band 4 and 5, one can clearly distinguish the important features in AHFR and its surrounding such as primary forest, skid trail, transmission line, oil palm, rubber, and developed area. Mohd. Hasmadi and Kamaruzaman (1998), and Kamaruzaman and Aswati (1999) claimed that these bands are relatively effective in discriminating from other land use/cover.

However, from the combination of red, green and blue colours of the seven channels, combination of bands 4,5,3 and 5,4,3 (R-G-B) showed equally good images for this kind of study. Using the contrast-stretching enhancement, major land use types such as primary forest, secondary forest, oil palm, rubber, built-up areas, cleared land, skid road, transmission line and water bodies can easily be discriminated. The edge sharpening filter was applied to be used in this study since it is the most appropriate and can clearly distinguish the forest cover in AHFR from other land use/ covers.

Fig. 3a and 3b showed two sets of false colour composite (FCC) image of 1998 using

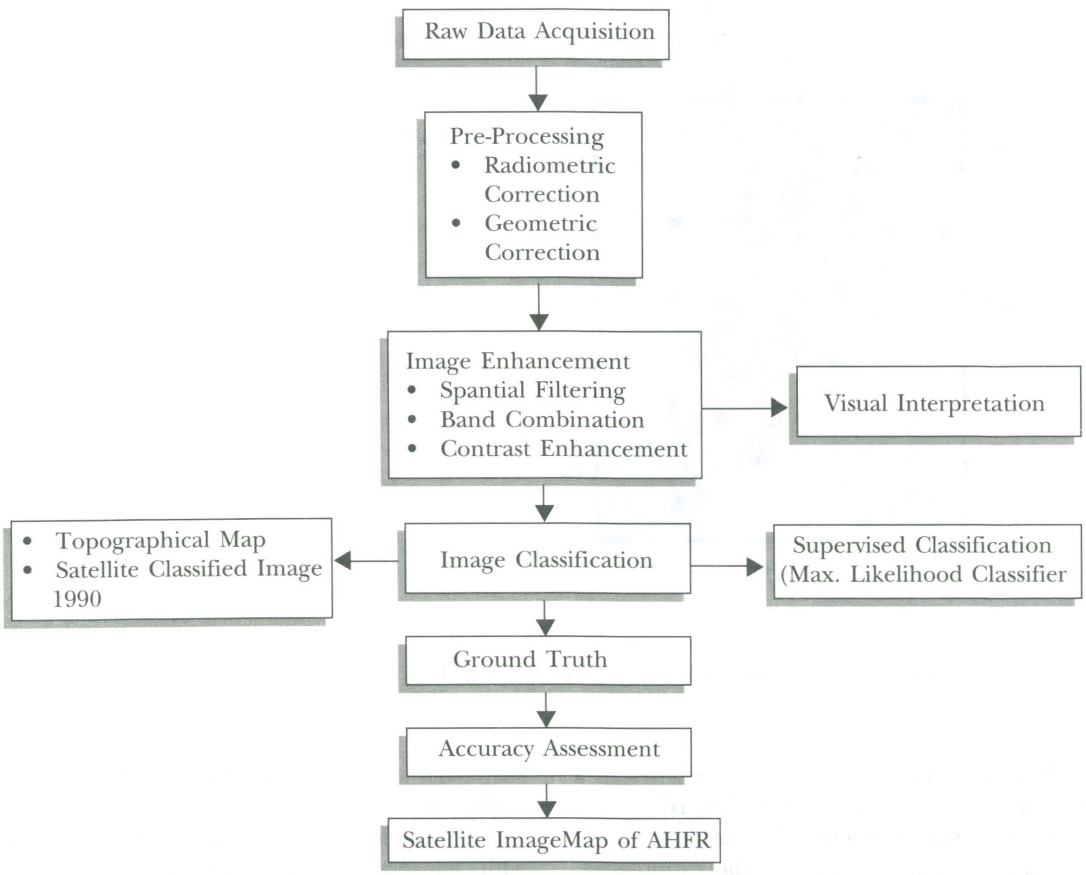

Fig. 2. Flow Diagram of Study

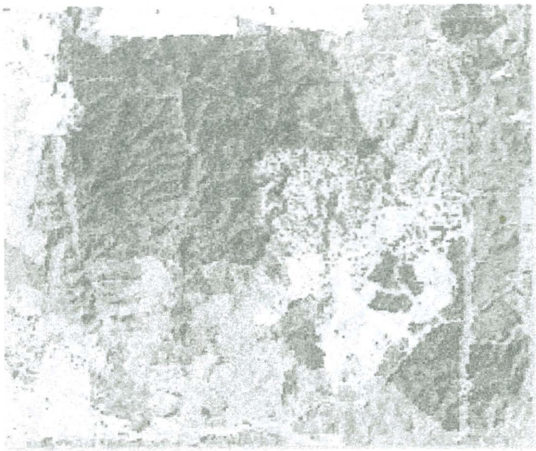

Fig. 3a. False Colour Composite of Band Combination 4,5,3 (R-G-B) over AHFR using Edge Sharpening Filter

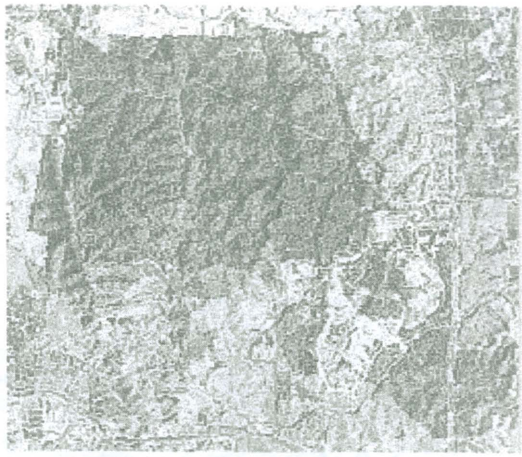

Fig. 3b. False Colour Composite of Band Combination 5,4,3 (R-G-B) over AHFR using Edge Sharpening Filter

edge filter tested, respectively. Visual impression confirmed that a edge filter of 3 X 3 size produced maximum sharpens and the best visibility of detail landscapes such as primary versus secondary forest, oil palm, rubber, built-up area, cleared land and water bodies. However, some of the small patches of shrubs and mix horticulture crop cannot be well visualized due to their almost similar texture and contrast. For example, cleared land and dual carriageway both appear in light blue in 4-5-3 FCC and purple in 5-4-3 FCC, respectively.

Visual Interpretation

The most important step in the analysis was the extraction of spectral signatures that represent selected cover types, after careful investigation of the topographical map and satellite classified image of 1990 and information on the site. Visual interpretation of satellite imagery showed primary forest, secondary forest, oil palm, rubber, built-up area, cleared land and water bodies features based on different spectral reflectance and image contrast. Nevertheless, Landsat TM cannot readily detect significant different or variation in spectral distribution from forest cover types and other vegetation distribution in the scene.

The main land cover/use of primary forest, secondary forest, oil palm, rubber, built-up area, cleared land and water bodies are clearly detected using 4-5-3 (R-G-B) of TM data. This FCC combination is capable to effectively separate built-up areas like residential sites against oil palm, rubber and mix horticulture farms. It capables to separate quite well between the mixed-horticulture area on the west and the cleared upland on the east of AHFR boundary. 90 percent of forested area in the eastern part of AHFR especially in compartments 5, 6, 9, 10 and 11 had also been cleared for housing development by Equine Park and Shah Alam Properties (Lestari Perdana and Putra Permai Park).

The bright areas represented a high temperature zone such as urban area, cleared land, sparse vegetation and grassland/shrubs. Meanwhile, the dark spots such as water bodies' primary forested area and dense vegetation indicated the low temperature zones. The visual images are showed in *Fig. 4*.

Supervised Classification: Maximum Likelihood Classifier (MLC)

Supervised classification with MLC was performed by training the computer to recognize particular ranges of pixel value with the ancillary data available for the study and the knowledge of the interpreter. A total of 15 training samples were used to classify the entire study area according to MLC. The supervised

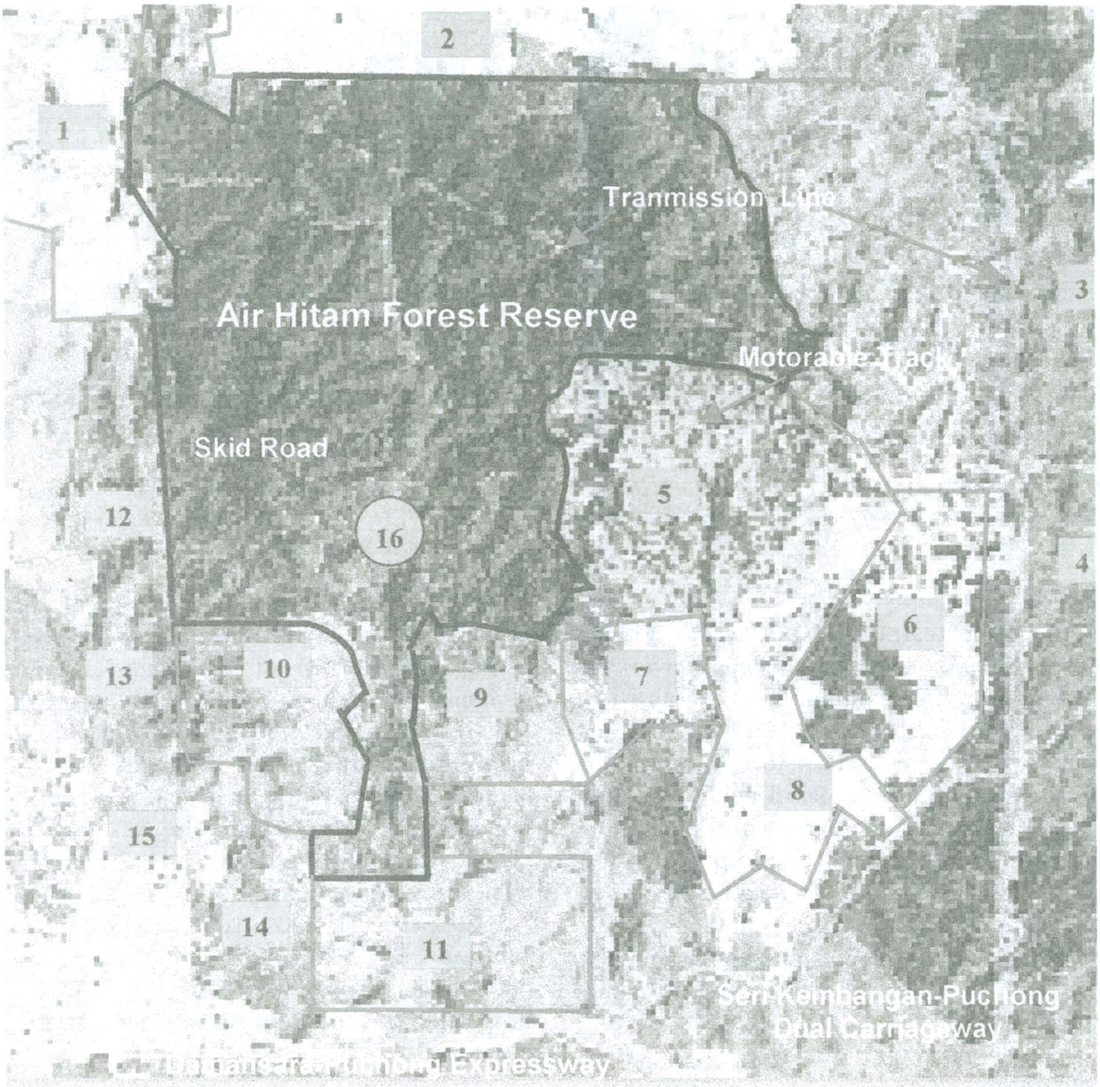

Fig. 4. Visual Interpretation of AHFR from Landsat TM 1998

1. Puchong Industrial Park
2. Technology Park Malaysia
3. Loong Chuan Rubber Plantation
4. Choong Keow Oil Palm Plantation
5. Shah Alam Properties Development
6. Equine Park
7. Rubbish Dump Site
8. Putra Permai Housing Park
9. Proposed Film park
10. Residential
11. UPM Puchong Farm
12. Puchong Mix-Horticulture
13. Kg. Pasir Baharu Puchong
14. Kg. Sg. Rasau Hilir
15. Kg. Baharu
16. Camp Site

classification using MLC can be seen in *Fig. 4*, respectively. By this technique, seven classes were identified as follows:

1. Forest green
2. Secondary forest/shrubs white
3. Oil palm yellow
4. Rubber purple
5. Built-up area red
6. Cleared land black
7. Water bodies blue

Table 1 shows the statistical results of the supervised classification using MLC for 1998. Built-up areas include Puchong , Kinrara, Equine Park and Lestari Perdana represent the largest i.e. 35.72 percent components of forest conversion activities surrounding AHFR. This is followed by rubber (20.31 percent), oil palm (18.71 percent), cleared land (14.18 percent), forest (6.79 percent), secondary forest/shrubs (3.33 percent) and water bodies (2.07 percent).

Accuracy Assessment

A mean overall accuracy assessment is of 86.08 percent. This is considered acceptable for a satellite image analysis. The summarized statistical

TABLE 1
Statistical results of seven classes by MLC of 1998 over AHFR

Class code	Description	No. of pixels	Areal Extent (ha)	Image percentage(%)
1	Forest	1024	92.16	6.79
2	Oil palm	2819	253.71	18.71
3	Built-up area	5385	484.65	35.73
4	Rubber	3060	275.40	20.31
5	Cleared land	2137	192.33	14.18
6	Water bodies	312	28.08	2.07
7	Secondary forest/shrubs	7	0.63	3.33
	TOTAL	15070	1,326.96	100.00

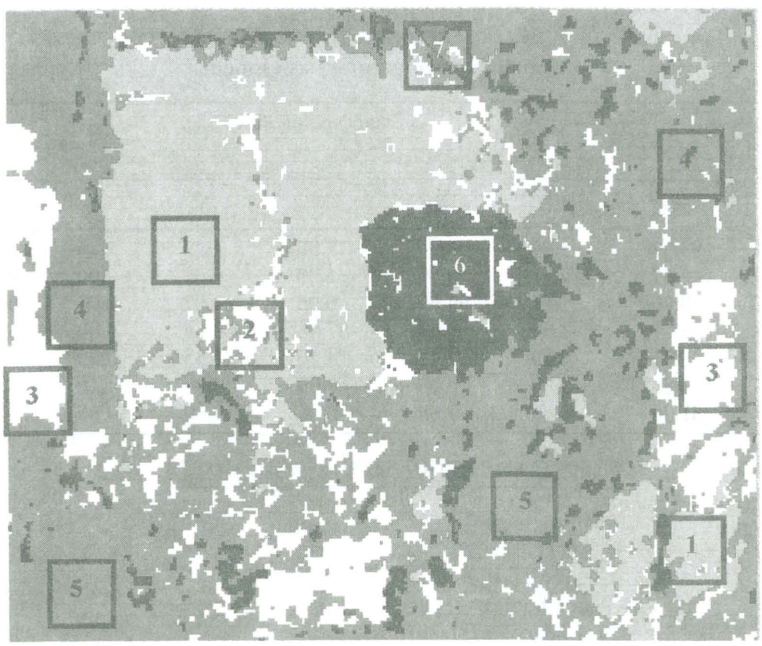

Fig. 5. Seven Clusters of Land use in AHFR 1998 and its Vicinity

result produced from the error matrix is shown in Table 2.

The accuracy ranges from 70.97 percent for secondary forest/shrubs to 94.59 percent for built-up areas. The low classification accuracy for secondary forest/shrubs is due to misinterpreted pixels of built-up areas, cleared land and linear features such as skid road, dual carriageway and transmission line. Although rubber covered the third largest land cover/use in the image, in the actual situation it was very confused with the secondary forest/shrubs due to it age factor and maturity of the vegetation (Mohd. Hasmadi and Kamaruzaman, 1998), canopy closure, background, illumination geometry and spatial resolution of the sensor (Roy, 1999).

CONCLUSION

From this study, several conclusions can be drawn as follows:

- The TM-satellite imagery with 30m X 30m spatial resolution is able to map AHFR from the other surrounding land cover/ use such as oil palm, rubber, built-up areas and dual carriageway. Moreover, visually the forest can be separated into two types namely, primary forest and secondary forest using an FCC combination of 4-5-3 (R-G-B). Built-up area can easily be mapped out in the study area. This includes development project like Puchong Industrial Park, Lestari Perdana, Equine Park, Putra Permai Park, Technology Park Malaysia, and public roads such as Damansara-Puchong Expressway and Seri Kembangan-Puchong dual carriageway.

- Digital supervised classification with Maximum Likelihood algorithm is capable of classifying seven land uses/cover in AHFR with a mean overall accuracy of 86.08 percent. Based on satellite imagery analysis, this percentage is acceptable for land use classification and mapping purposes.

- From the visual and digital interpretation, the main factor influencing forest depletion in AHFR is forest clearance for housing and industrial park.

To develop a complete geographical information system (GIS) database integrating remote sensing image of AHFR is highly recommended for future monitoring and sustainable management of AHFR.

TABLE 2
Error matrix of accuracy assessment

Referred Data	Total of Pixel	Total No. of Pixel							Accuracy (%)
		1	2	3	4	5	6	7	
1	806	83.50	1.74	4.84	3.35	1.49	1.36	3.72	83.50
2	225	2.67	87.11	0.89	1.33	0.00	0.00	8.00	87.11
3	314	0.00	1.91	94.59	0.96	1.27	0.96	0.32	94.59
4	165	0.61	1.82	0.61	87.88	3.64	0.00	5.45	87.88
5	166	1.81	0.00	2.41	14.46	81.33	0.00	0.00	81.33
6	17	5.88	0.00	0.00	0.00	0.00	94.12	0.00	94.12
7	7	31.00	6.45	9.68	0.00	12.90	0.00	70.97	70.97

Mean Overall accuracy : $\frac{83.50+87.11+94.59+87.88+81.33+94.12+70.97}{7}$

: 86.08 percent

1. Forest
2. Oil palm
3. Built-up area
4. Rubber
5. Cleared land
6. Water bodies
7. Secondary forest/shrubs

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