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Urban Forestry Planning Using Remote Sensing/GIS Technique

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ABSTRAK

Perhutanan bandar kini menjadi semakin penting bukan sahaja kepada nilai estetiknya tetapi juga kepada keberkesanannya dalam mengawal persekitaran. Potensi untuk membangunkan hutan bandaran di Malaysia adalah amat besar kerana Malaysia kaya dengan kepelbagaian tumbuhan. Kemajuan teknologi penderiaan jauh dan sistem maklumat geografi (GIS) bukan sahaja berguna untuk pemantauan perubahan persekitaran tetapi juga amat berguna untuk perancangan dan pengurusan hutan bandaran. Objektif kajian ini ialah untuk menilai kemampuan data penderiaan jauh dan GIS untuk memberi maklumat bagi menentukan kawasan yang berpotensi untuk perhutanan bandar di sekitar Lapangan Terbang Antarabangsa Kuala Lumpur. Imej Landsat TM 126/58 (jalur/baris) berbentuk pita komputer padat diproses dan dianalisis secara digital menggunakan perisian PCI EASIPACE versi 6.2. Data sokongan seperti peta topografi, peta guna tanah dan siri tanah digunakan untuk membantu penganalisisan imej satelit. Integrasi kawasan untuk pelandskapan hutan bandar. Kajian akan datang adalah disarankan agar menggunakan data beresolusi tinggi untuk mendapatkan pemetaan yang lebih tepat bagi tujuan proses pelandskapan.

ABSTRACT

Urban forestry has become an important value, not only for the aesthetic but also their effectiveness in the environmental control and health. There is a potential to plan and develop urban forest landscape in Malaysian cities due to her richness in plant biodiversity. The advances in remote sensing technology and geographic information system (GIS) technique have provided an effective tool not just for monitoring the change of environment but also very useful for planning, managing and developing of urban forest landscaping. This study was undertaken to assess the capability of integrating remote sensing and GIS to provide information for urban forest potential sites surrounding Kuala Lumpur International Airport (KLIA) and its vicinity. Landsat TM imagery scene 126.58 (path/row) in the form of computer compatible tape (CCT) taken in May 1996 was digitally processed and analysed using a PC-based PCI EASIPACE software system version 6.2. Ancillary data such as topographical map, land use map and soil series map were used to support the satellite data.

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Integrating satellite data and GIS produced a map showing the potential site for urban forest landscaping at KLIA. Future studies should attempt to utilize airborne hyperspectral high-resolution data for more accurate mapping and landscape planning process.

Keywords: Urban forestry, planning, remote sensing/GIS technique

INTRODUCTION

The Malaysian Government under the Ministry of Local Government and Housing introduced the National Landscape Guideline in 1995. Malaysia is committed to build a beautiful country with green space with systematic and professional task (Anonymous 1995). At the launching of the National Tree Planting Campaign, the government's vision is to turn Malaysia into Garden Nation by the year 2005. The landscape has to be carefully designed and must be properly maintained according to the right technique. This guideline was launched under the impression of rapid landscape destruction on regulated consumption of natural resources.

Urban forestry is a practice of raising and scientifically managing suitable types of woody plants within the environment of all populated places that are used and influenced by urban development and urban population for their sustained environmental, physical, sociological, recreational and economic benefit. Land evaluation is needed to assess the performance of land use for specific purposes. Recently, remote sensing and the GIS technique have become important tools for forestry conservation and management purposes. Space remote sensing is one of the processes of obtaining information about the earth from instruments mounted on satellite (Anonymous 1991). Many studies (Makoto *et al.* 1997; Mazlan and Norhan 1997; Honda *et al.* 1997) have proved that the integration of remote sensing and GIS can be reliable and fast information with affordable cost and workforce for decision-making in forest resource planning and landscaping.

The general objective of this study is to assess the applicability and usefulness of integrating remote sensing satellite data and GIS for urban forest landscape mapping. The specific objectives are (i) to classify and map the different land cover types that are found in the KLIA and surrounding areas and, (ii) to identify, monitor and map the potential areas for urban forest landscapes.

MATERIALS AND METHODS

Description of Study Area

The Kuala Lumpur International Airport (KLIA) is located in the south of Kuala Lumpur city in the District of Sepang, Selangor within latitude 101° 40'E to 101° 47'E and longitude 02° 44'N to 02° 50'N, cover an area of approximately 50 km by 50 km. KLIA is being developed as the vehicle for information technology (IT) application for airport management services. The distance of KLIA to Kuala Lumpur city is approximately 50 km. *Fig. 1* shows the location map of the study area.

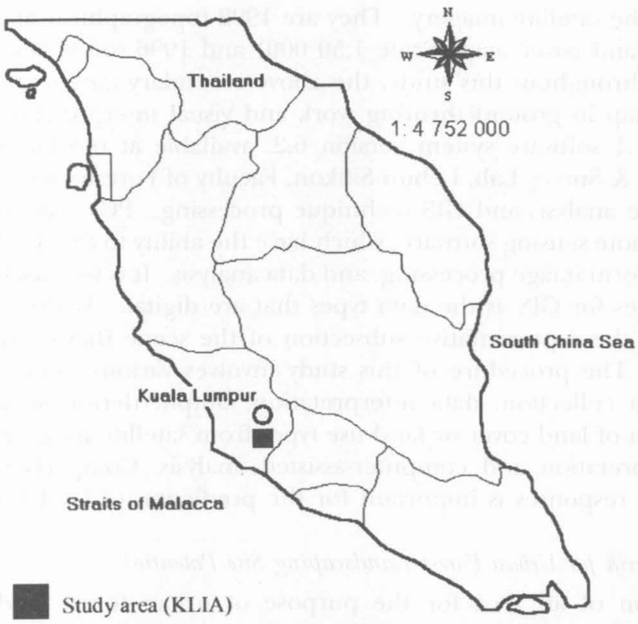

Fig. 1: A map of P. Malaysia showing the location of the study site

The climate of the study area is typically humid tropical and is characterized by year-round high temperature and seasonal heavy rain especially in October or November to February or March. The average rainfall is about 2375 mm per annum with a maximum of 2500 mm and minimum of 2250 mm. The mean annual temperature ranges from 22°C to 32°C. The relative humidity is always high, and ranges from 60% to 97%, with a daily mean of 82.5%. The study area is mainly covered by agricultural crop, mostly rubber, oil palm with occasional patches of forest. In addition, some grassland, shrubs and paddy can be found at the valley area of 70 m to 300 m wide. The topograhpy of this region is generally characterized by hilly and dissected sediment with altitude ranging from 10 m to 120 m. In the lower part of the hill area, slope ranges from 5° to 8°, while in the upper part, slope ranges from 12° to 15°. The main geological content of this region is shales with sandstones and conglomerates (Lawrence 1978).

METHODS

Sources of Data and Image Processing Techniques

The Landsat TM digital spectral data was taken in May 1996 for path/row 126/58 and acquired with spatial resolution of 30 m in the form of computer compatible tape (CCT). The image has been corrected from geometric distortion and atmospheric problem. Satellite imagery was obtained from Malaysia Centre for Remote Sensing (MACRES) in Kuala Lumpur. Secondary data are acquired to support the satellite imagery. They are 1992 topographical map (Scale 1:50 000), 1992 land cover map (Scale 1:50 000) and 1996 soil series map (Scale1: 253 444). Throughout this study, the above secondary data were also used as reference map in ground thruting work and visual interpretation stage. The PC-based PC1 software system version 6.2, available at the Forest Geospatial Information & Survey Lab, Lebuh Silikon, Faculty of Forestry was used for both digital image analysis and GIS technique processing. PCI is an integration of GIS and remote sensing software, which have the ability to digitize image as well as map, perform image processing, and data analysis. It is very useful and is one of the sources for GIS as the data types that are digital. Analysis was initiated by selecting the representative subsection of the scene that is covered in the study area. The procedure of this study involves various steps of processing such as data collection, data interpretation, output derivation and (*Fig.* 2). Classification of land cover or land use types from satellite image involved both visual interpretation and computer-assisted analysis. Comparison of spectral signature or responses is important for the prediction of land cover features.

Physical Criteria for Urban Forest Landscaping Site Potential

The selection of an area for the purpose of urban forest landscaping was focused on developed and undeveloped areas surrounding the KLIA. The approach was to take an assessment and evaluation according to several factors or parameter, which were shown in Table 1. All parameters consisting of

TABLE 1
Physical criteria for urban forest landscaping site potential

Factor	Criteria/rank 1 (Most potential)	 2 (Moderately potential)	 1 (Least potential)
Slope	Level, gently sloping (0%-8%)	Gently, sloping, moderate steep (9%-18%)	Moderately steep, steep, very steep (19%-35%)
Soil texture	Fine loamy to moderate, clay loam, deeply developed soil with detectable accumulation of organic material	Sandy, silty and clayey alluvial soil. Recent soil development	Sandy soil, silty, clayey alluvial and graveled alluvial deposits
Drainage	Good drainage, good aquifer, surface water and infiltration zone. Infiltration rates of 3.75 to 18.75 cm/hr.	Moderate drainage, interfloor water and spring zone. Infiltration rates of 4.7 to 9.38 cm/hr.	Excessively drained, high runoff. Infiltration rates of 0.75 to 4.69/hr.
Spatial area	> 50 m wide	30 m-50-m wide	< 30 m wide
Availability of natural resources	Dense forest, pond lake, and river, etc.	Secondary forest, stream, plantation,	Shrub, grassland, bare land, swampy,
Vicinity to urban area	< 1 km from urban area	1 km-2 km from urban area	> 3 km from urban area

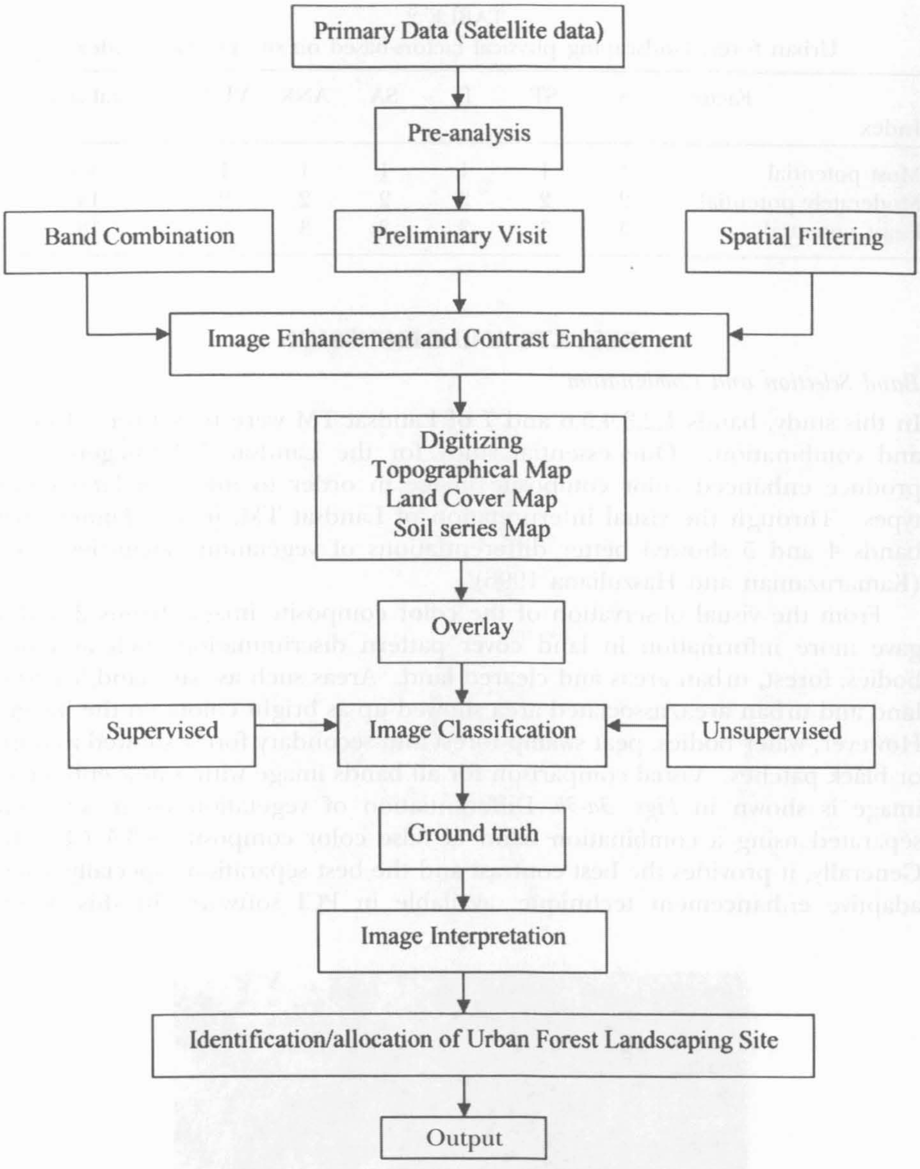

Fig. 2: The flow chart of the study procedure

physical criteria were given rank 1,2 and 3 indication most least potential for urban forest landscaping and development. Meanwhile, the standard range of site potential category is summarized in Table 2, where range from 6-13 (most potential), 14-17 (moderately potential) and 18 and above is least potential, respectively. The lowest score obtained implies that a particular site has the most potential for urban forest landscaping in KLIA and its vicinity.

TABLE 2
Urban forest landscaping physical factors-based on site potential index

Index \ Factor	S	ST	D	SA	ANR	VUA	Total score
Most potential	1	1	1	1	1	1	6
Moderately potential	2	2	2	2	2	2	14
Least potential	3	3	3	3	3	3	18

RESULTS AND DISCUSSION

Band Selection and Combination

In this study, bands 1,2,3,4,5,6 and 7 of Landsat TM were tested for selection and combination. One essential study for the Landsat TM imagery is to produce enhanced color composite image in order to interpret land cover types. Through the visual interpretation of Landsat TM, it was claimed that bands 4 and 5 showed better differentiations of vegetation categories/types (Kamaruzaman and Haszuliana 1996).

From the visual observation of the color composite image, bands 2 and 4 gave more information in land cover pattern discrimination such as water bodies, forest, urban areas and cleared land. Areas such as bare land/cleared land and urban area/associated area showed up as bright colors on the image. However, water bodies, peat swamp forest and secondary forest showed as dark or black patches. Visual comparison for all bands image with a new enhanced image is shown in *Figs. 3a-3b*. Differentiation of vegetation cover was well separated using a combination band of false color composite 4-3-5 (R-G-B). Generally, it provides the best contrast and the best separation especially using adaptive enhancement technique, available in PCI software. In this band,

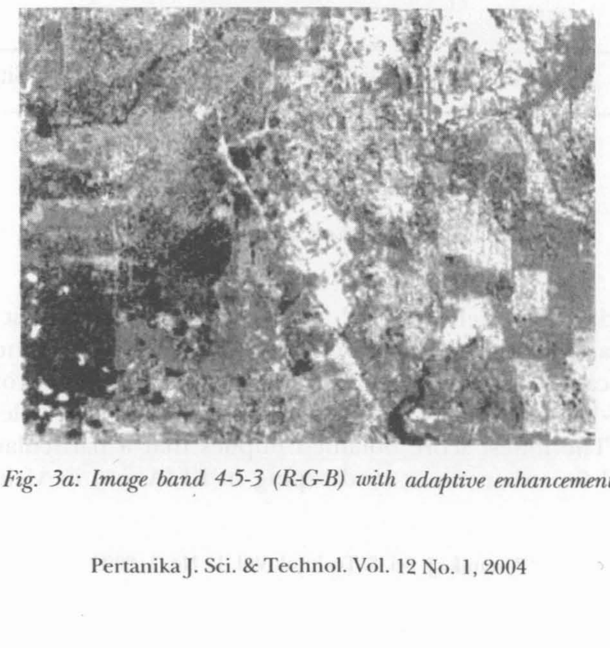

Fig. 3a: Image band 4-5-3 (R-G-B) with adaptive enhancement

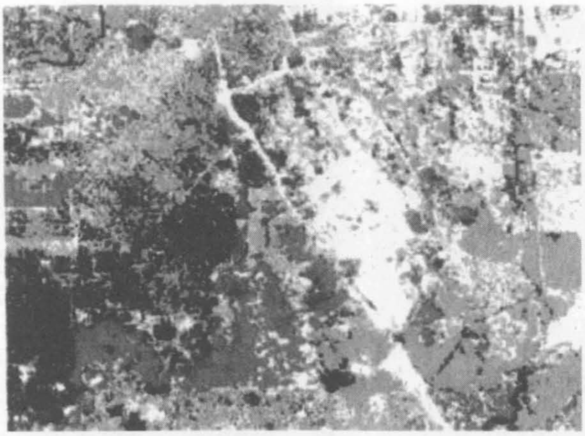

Fig. 3b: Image band 5-4-2 (R-G-B) with adaptive enhancement

vegetation appears in red tones. However, there is a small variation in red tones due to the different forest cover types. Different degrees of brightness can be seen in the non-vegetative areas, which represent the different types or urban areas especially building, cleared land and settlement area. Although the adaptive enhancement technique is applied, mixed horticulture crop and rubber plantation areas are still difficult to differentiate because of their similar spectral reflectance signature.

Supervised Classification

A total of 10 classes were identified/mapped by supervised classification technique as follows: peat and freshwater swamp forest, oil palm, urban and associated areas, secondary forest, grassland/shrub, mixed horticulture crop, cleared land, bush, rubber and water bodies. The result of supervised classification in three bands of (R-G-B) combination is shown in *Fig. 4*. Results indicated that better classification was obtained in supervised classification compared to unsupervised classification approaches. The mean spectral value of the training areas selected showed a satisfactory separation of land cover types. There is difficulty in separating the small urban and settlement areas from rubber trees, oil palms and mixed horticulture crops because the study area is surrounded by a dense plantation and homestead garden. Certain settlement areas (e.g. worker's house in rubber estate) are confused with other classes such as cleared land due to their similar spectral response.

Ground Truth

A total of 25 training areas were selected and visited with the support of satellite imagery and ancillary data. The ground truth work was conducted for two days from 16 to 18 February 1998. For each site, photographs were taken and major types of land cover observed and recorded in the form.

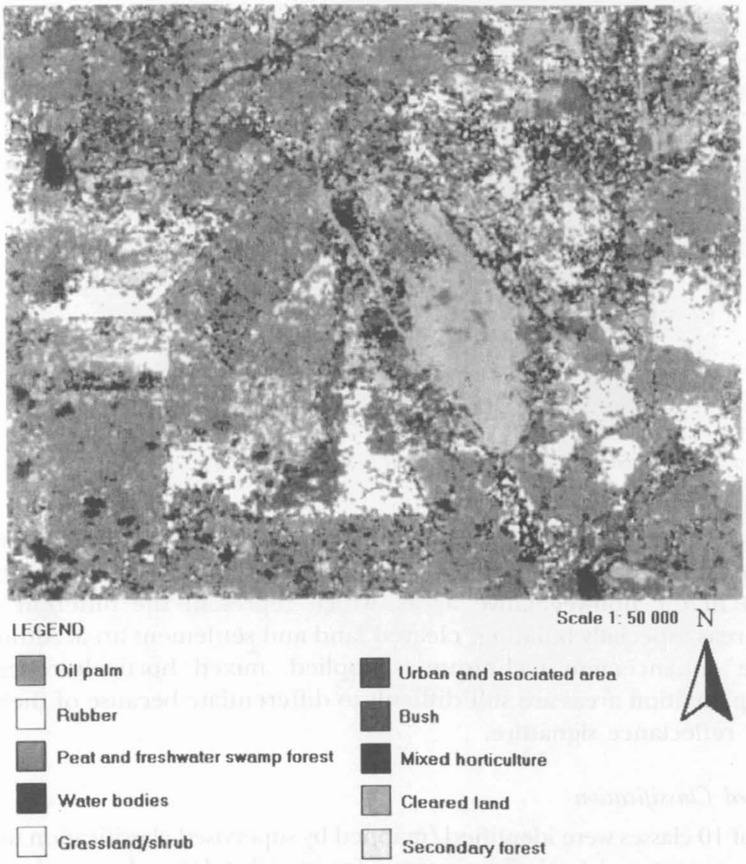

Fig. 4: Supervised classification of KLIA

Accuracy Assessment

The result of confusion matrix was expressed in tabular form and shown in Table 3. The percentage listed in the table represents the accuracy of classification of 10 classes of land cover. From this classification, it is found that the accuracy ranges from 40% for class 7 (secondary forest) to 88% for class 10 (water bodies). The mean overall classification accuracy obtained was 61%. Among them, water bodies showed the highest accuracy since only 12 pixels were confused with peat and freshwater swamp forest. However, secondary forest gave the lowest accuracy because it was confused with rubber, mixed horticulture crop and peat swamp forest.

Allocation of Potential Urban Forest Landscaping Site

The potential site for the urban forest landscaping map was produced after digitizing and overlaying the soil series, land cover and topographical map (*Figs. 5a-5c*). Sites indicating most, moderate and least potential were finally mapped

TABLE 3

Analysis of confusion matrix for 10 classes of land covers

Referred Data	Total Number of Pixels										Total Pixel	Accuracy (%)
	1	2	3	4	5	6	7	8	9	10		
1	472	-	20	-	67	101	-	9	-	-	669	70
2	-	106	24	232	-	-	-	14	2	-	378	61
3	7	11	201	76	-	-	-	-	72	-	367	54
4	122	-	-	328	6	-	-	-	-	-	456	71
5	-	-	-	-	237	2	101	98	-	-	438	54
6	203	-	78	-	8	587	2	-	-	-	878	66
7	10	-	-	-	52	7	76	43	-	-	188	40
8	-	-	-	-	17	-	-	32	-	-	49	65
9	-	-	-	-	18	-	-	-	98	-	116	84
10	12	-	-	-	-	-	2	-	-	112	126	88
TOTAL	826	117	323	636	405	697	196	196	172	112	3665	

1 - Peat and freshwater swamp forest
2 - Urban and associated area
3 - Grassland/shrub
4 - Cleared land
5 - Rubber
6 - Oil palm
7 - Secondary forest
8 - Mixed horticulture
9 - Bush
10 - Water bodies

Mean overall accuracy (%):

$$\frac{472 + 106 + 201 + 328 + 237 + 587 + 76 + 32 + 98 + 112}{3665}$$

= 61%

as illustrated in *Fig. 6.* The most potential site for urban forest landscaping, which was indicted in green has the least score range (6-12) with the fine loamy to moderate soil and with the existence of various natural resources such as river, pond, forest, rubber tree and oil palm plantation. Moderately potential site with a score of 14-17 (yellow color) was mainly focused at the south and northwest of KLIA center and small patches in the north. These gentle slope (9%-15%) sites are appropriate for a 'moderate landscape' area due to the presence of secondary forest, rubber tree and oil palm plantation. Least potential sites, which were indicated in purple, are located at the west of KLIA because the soil is poor with least availability of natural resources. In addition, the area was a little bit far away (about 2 km) from KLIA center.

The Planning and Development of Urban Forest Landscaping in KLIA

The landscape concept at KLIA and its surroundings has been designed to be an airport within a 'forest'. In addition, better planning could be achieved with satellite imagery for urban forestry landscape concept surrounding KLIA. Based on this study, there are still lots of potential for such planning and development in the KLIA vicinity. There is still plenty of 'green cover' in the KLIA surrounding with suitable soil if forest planting needs to be carried out. The gently sloping to rolling terrain features of the forest landscape around KLIA should provide a better 'green cover' with a great scenic view to the tourists upon arrival at the KLIA.

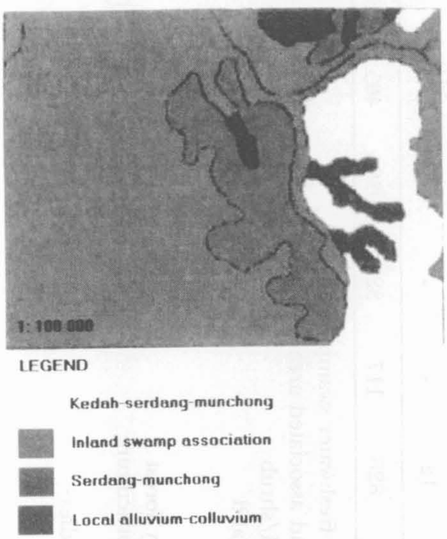

Fig. 5a: Soil series map of KLIA and its vicinity

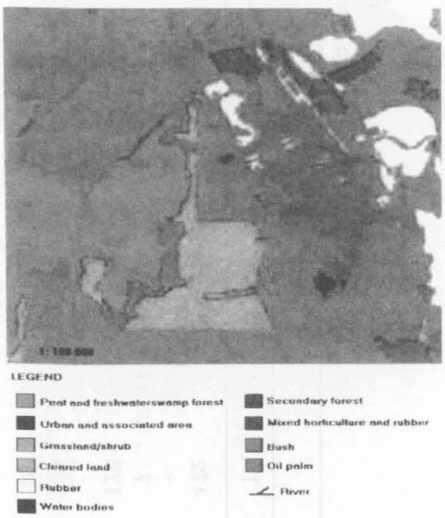

Fig. 5b: Land cover map of KLIA and its vicinity

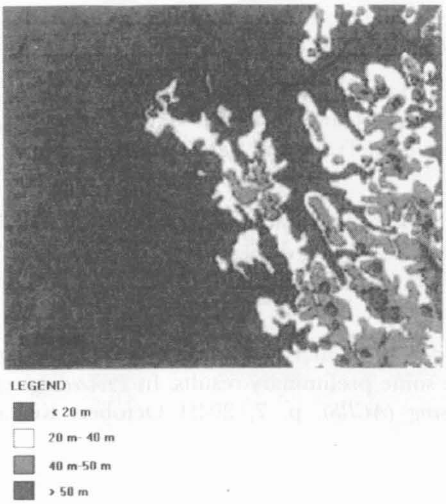

Fig. 5c: Topographical map of KLIA and its vicinity

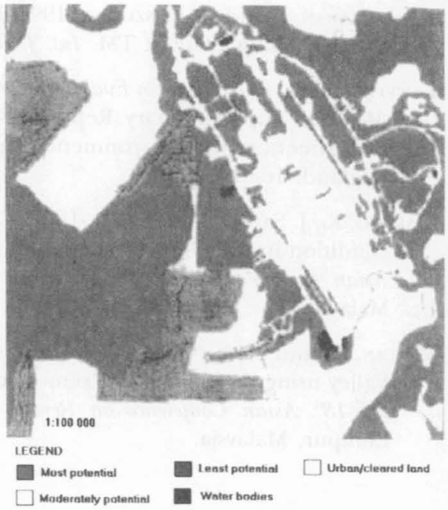

Fig. 6: The urban forest landscape potential map for KLIA

CONCLUSION

Several conclusions can be derived from this study as follows:

1. Integration of remote sensing and GIS technique is a powerful tool for generating base map in order to identify the potential areas for landscape purposes at KLIA and its surroundings.
2. Landsat TM with false color composite (FCC) of band 4-5-3 (R-G-B) using a PCI software processing system has the capability to classify the different 'green cover' types in KLI and surrounding areas with an accuracy of 61%.
3. Supporting information such as soil series, land cover and topographical maps are very useful to aid identification and allocation of potential site for urban forest landscaping.
4. In order to provide a detailed and better landscape planning, additional information such as meteorological and geological data are important to support the GIS to map the potential landscape area using remotely sensed data.

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