INFORMATION TECHNOLOGY AND URBAN GREEN ANALYSIS

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ABSTRACT

It is well recognized that green area plays a pivotal role in improving urban environment, such as preserving water and soil, controlling temperature and humidity of air, preventing pollution, flood prevention, functioning as buffers between incompatible land uses, preserving natural habitat, and providing space for recreation and relaxation. However, due to pressures from new development both in urban fringes and urban centres, urban green and open spaces are seen to be rapidly declining in term of allocated spaces and quality. Without careful urban land use planning, many open spaces will be filled with residential and commercial buildings. Therefore, there is a need for proper planning control to ensure that the provisions of green spaces are adequately being conserved for current and future generations. The need for an urban green information system is particularly important for strategic planning at macro level and local planning at the micro level. The advent of information technology has created an opportunity for the development of new approaches in preserving and monitoring the development of urban green and open spaces. This paper will discuss the use of Geographical Information Systems (GIS) incorporated with other data sources such as remote sensing images and aerial photographs in providing innovative and alternative solutions in the management and monitoring of urban green. GIS is widely accepted in urban landscape planning as it can provide better understanding on the spatial pattern and changes of land use in an area. This paper will primarily focus on digital database that are developed to assist in monitoring urban green and open spaces at regional and local context. The application of GIS in the Klang Valley region or better known as AGISwlk developed since mid-1990's is currently being used by various organisations in the region. The focus of AGISwlk is not merely in providing relevant database to its stakeholders but more importantly, assist in making specific and relevant decisions with regard to spatial planning. It is also used to monitor the loss of green areas by using several temporal data sets. The method of classifying green and open spaces in the region is also being discussed. This paper demonstrates that GIS can be an effective tool in preserving and monitoring green and open spaces in an urban area. The contribution of urban green digital database in someway may leads toward landscape sustainability as to satisfy the ever changing society.

Keywords: Urban green space, digital database, GIS, remote sensing, urban planning.

INTRODUCTION

It is well recognized that urban green plays an important role in improving urban environment. It directly benefits human being and their environment by preserving water and soil, controlling temperature and humidity, preventing pollution, flood prevention and preserving the natural habitat (Beer & Higgins, 2000). Urban green space also brings enormous social and economic benefits. In urban planning, it function as buffer between incompatible land uses, enhance aesthetical value and provide space for recreation and relaxation. Despite all these and perhaps green area (vegetation) have always appeared to be self-generating, until recently the need to conserve and preserve green area have often been ignored as an issue in the planning and development process. The expansion of the city due to pressures for new development within the city and urban fringes have systematically seized the limited green area available. In effect there is a decline in the urban eco-environment. Nevertheless, with increasing public awareness, there is a growing concern about the impact of urban green declining within and near the city, and the importance to preserve and value the green area. The government through the Deputy Prime Minister recently directed State authorities to gazette land designated for recreational purpose in a move to stop open spaces being developed for other land uses (NST, 2003).

Its importance to well recognized by the City Hall of Kuala Lumpur. In achieving its vision as a 'world class city', the city plan has identified the need to create a distinctive city identity and image of a tropical garden city incorporated as one of its goal (Kuala Lumpur Draft Structure Plan). In achieving its goal, long term planning of preservation and nature conservation need to be developed. The plan, however, needs to be continuously and closely monitored. Specific data management system for urban green need to be developed and continuously updated. Inventories of urban forests, parks, street trees and other greeneries are indispensable for the high quality management of the urban environment.

Geographic Information Systems (GIS) provide alternative solutions in the management and monitoring of urban green. GIS have evolved by linking a number of discrete technologies into a whole and emerged as powerful technologies that allow user to integrate various data sources, as well as being used in the analysis and modeling beyond the capability of manual methods (Foote & Lynch).

URBAN GREEN INFORMATION SYSTEM

In general green area can be classified into forest, recreational area, agriculture area and water bodies (lake/ex-mining pond), as defined by the National Landscape Department (Jabatan Lanskap Negara). This includes reserved area for road, irrigation and drainage, an idle land or clear land.

Recreational area consists of exercised park based on the concept defined by National Landscape Department and Town and Country Planning Department, Peninsular Malaysia. Recreational area includes playground, Neighbourhood Park, City Recreational Area and Regional Recreational Park, which need to be provided by the Local Authority. Theme and Golf Park can be categorized as private recreational area.

Information on urban green space is important to current planning and monitoring of the urban development as well as for the future. The classifications of urban green space can be defined as recreational area, agriculture area, forest, water bodies (river, lake), shrub and bushes. The information is required for strategic planning and local planning to be used as guidelines and strategies to be followed in planning and monitoring of urban area.

DEVELOPMENT OF ICT FOR URBAN ANALYSIS

The evolving concept of Information Technology (IT) has been accompanied by equally fundamental but largely independent changes in the prevailing views of proper IT in public and private sector organizations. As shown in Table 1.1, the developments can be viewed broadly as an evolving concern with data during 1960s, in which the prevailing technology was batch processing of custom designed, single-purpose, and transaction based information systems on mainframe computers. Then in the 1970s, the emphasis changed from data to conversion into meaningful form known as information. In relation, data processing for operational needs shifted to management information system (MIS) and integrated with the development of urban information system (UIS), geographic information systems (GIS) and land information system (LIS). Next in 1980s, the changes of MIS into knowledge reflected to decision makers on the needs for analytical modelling capabilities. Toward Planning Support System (PSS) in 1990s, PSS should be designed to facilitate collective design, social interaction, interpersonal communication, and a community debate.

Table 1.1: The Evolving Concerns Of Information Technology

1960s	Data	'Observations which have been cleaned, coded, and stored in machine-readable form' Primary concern of electronic data processing (EDP) which promoted efficient transaction processing to improve operational tasks.
1970s	Information	'Data which has been organized, analysed, and summarized, into a meaningful form' Primary data concern of management information system (MIS), which integrated diverse data sets to serve management needs.
1980s	Knowledge	'Understanding based on information, experience, and study' Primary concern of decision support systems (DSS), which facilitated semi-structured decision making to support executive decision making.
1990s	Intelligence	'Ability to deal with novel situations and new problems, to apply knowledge acquired from experience, and use the power of reasoning effectively as a guide to behaviour' Possible concern of planning support system (PSS), which will promote discourse and interaction to facilitate collective design.

Source: Richard K. Brail, et.al (edt), 2001. Planning Support Systems: Integrating Geographic Information System, Models, and Visualization Tools. United States of America

The advent of Digital Mapping System and Geographical Information Systems (GIS) in the 1960's has created a large field of opportunity for the development of new approaches to the computer processing of geographically reference data. With this technology, a more effective solution to various spatial-related problems including those associated with planning matters can be achieved. The aim is to make use of the database by applying various GIS functionalities in describing the existing scenario and the changing pattern of the urban and regional development. It has been argued that the introduction of information technology enhances the rationality of the decision-making process by improving data accuracy and accessibility and as a consequence lead to 'better' decision.

This approach also brings increasing rationality to the decision-making process. Since the geographic information is stored and processed in its primary form, analysis can more quantitative and rational. Another reason for improvement being required is the quest for efficiency. The

advent of corporate planning and the continued squeeze on local authority expenditure has led local authorities to examine critically whether service delivery is efficient and effective. Indeed, this has become one of the fastest developing areas of policy planning within local government.

GIS APPLICATION FOR URBAN GREEN ANALYSIS: A Case Study of Klang Valley

Background of AGISwlk

The Klang Valley GIS or better known as AGISwlk was first established in 1995, started of with a modest test site in Kuala Lumpur covering an area of 4.5 km x 2 km. It then grows in several phases to its current state covering the whole Klang Valley Region (2830 square kilometers). The study area covers five districts and 8 local authorities involving Kuala Lumpur Federal Territory, and the districts of Gombak, Hulu Langat, Petaling and Klang. It is considered as the most developed and fastest growing region in the country. The database for AGISwlk consists of more than 70 data layers. Since its inception, AGISwlk has changed its focus from database development to application base and currently providing a knowledge base platform for analysis. Thus, making the focus of AGISwlk not merely in providing relevant database to its stakeholder in the region but more importantly, assist in making specific and relevant decisions with regard to spatial planning.

In 1998, AGISwlk has developed 8 applications and further two new applications were added in 2001 (Table 1). Recently AGISwlk has taken another big step by attempting to develop application and analysis model on spatial data, and creating a web base GIS.

Table 1.2: AGISwlk Applications

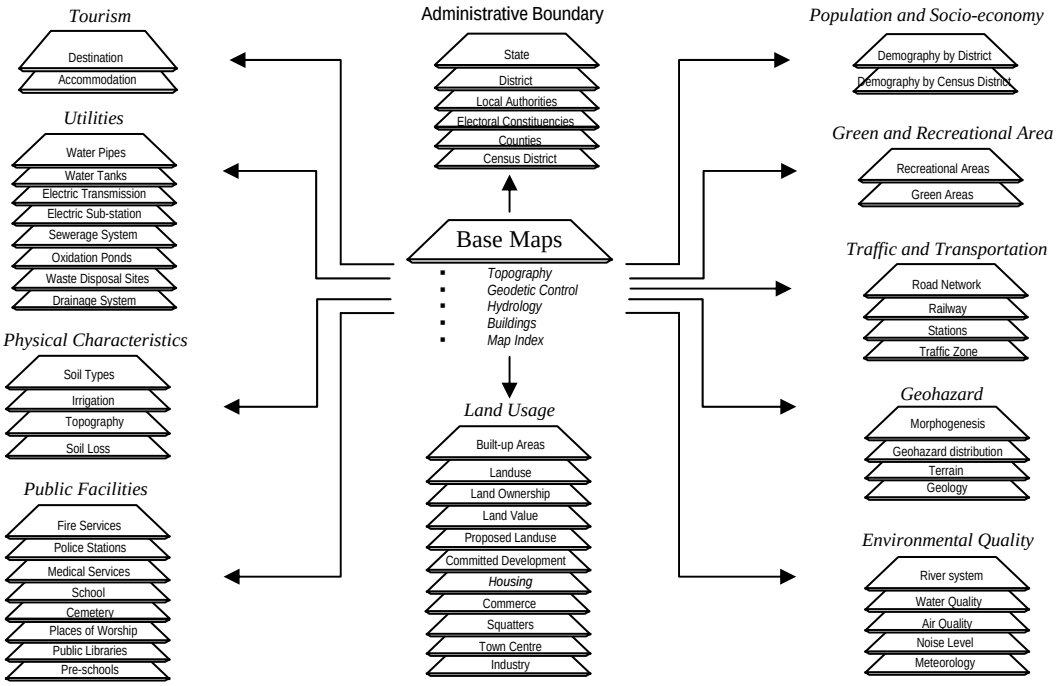
Pre-1998	Physical Development and Built-up Area Green Area and Recreation Environment Population and Socio-economy Low Cost Housing and Squatters Commerce and Industry Public Facilities and Amenities Traffic and Urban Transportation
Post 1998 (new applications)	Geohazard Tourism

Database Design

Generally, the role of Local Authority is to plan, control and monitor the development within the authorized respective area. The application of GIS at micro level will determine the detail of data and information, usually for the purpose of preparing Structure Plan and Local Plan. The allocation of urban green area and recreational area is closely related to the population growth and built up area. The design primarily considers certain criteria i.e. identify and determine urban green coverage, types, hierarchy, and the direction of urban green growth.

The development of urban green database at micro level is to support analyses for demand of land uses, classification of green area, and identification of urban green sensitive area. Figure 1.1, shows the AGISwlk database elements and map layers.

Figure 1.1: AGISwlk Database Elements and Map Layers



Development of Urban Green Database

Collection of data was based on remote sensing images, aerial photographs, site surveys and more importantly data made available by various organizations within the region. Green area in AGISwlk is defined as open space and land developed for recreation, road and river reserve, forest preserved for water catchments, erosion prevention as well as preservation of flora and fauna.

The application focus on forest, agriculture, reserve and water bodies and recreational area with each attribute having own classification such as under recreational area, there are play lot, playground, neighborhood park and urban park. When it was first developed, the main aim is to provide a database for green and recreation area and to assist the government to draw up suitable policy and to assess the demand and supply for green and recreational area. AGISwlk application consists of the analysis on change of Green Area, supply and demand for recreation area, Locational pattern of recreational facilities and the urban green sensitive area. Under these main analyses, several sub analysis has been developed. For example, five types of analyses have been conducted under the analysis for change of green area such as analysis on trend of change for a period of ten years, loss of green area to other land use, noncompliance of green space to structure plan and loss of green according to slope and height.

Preprocessing of data into a standard format suitable for analysis using AGISwlk is essential and thus, data need to be reformat, restructure, changed in term of projection and undergone process of generalization. Simple method of supervised classification has been use to classify the satellite images, Principal Component Data, though vegetation indices technique has only been recently tested to improve image classification. The resultant classified images are those reclassified using GIS database particularly to reduce speckle and cloud interference. Land use polygons are

reclassified using ancillary information to correct or reduce speckle effect, as well as cloud and shadow effect on the classified data layer.

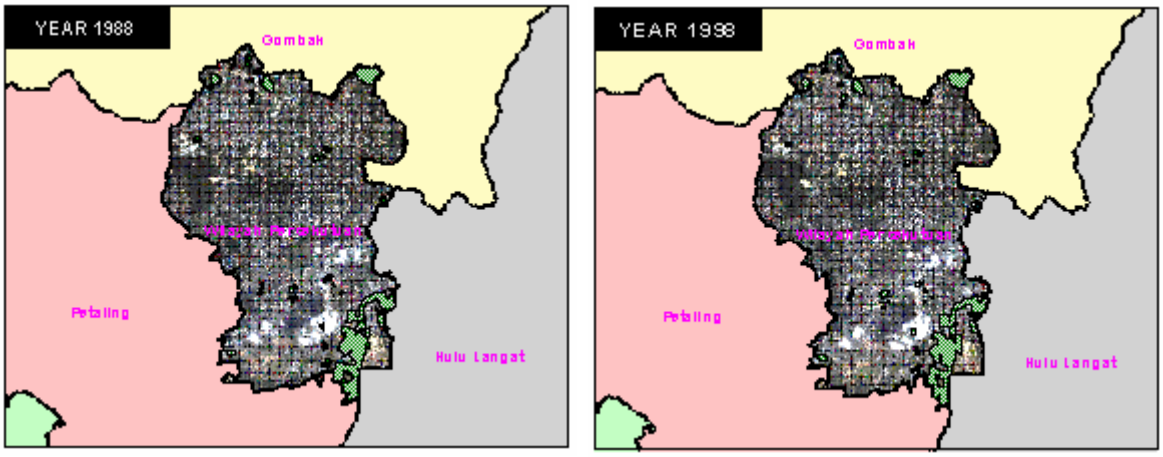
Satellite Images

A Landsat TM image were mainly used to analyse the trend of green in the study area. Images taken at a two-year interval between 1988 and 1998 were used for the study. The images are geometrically corrected and registered to the base map used in AGISwlk. Simple method of supervised classification is used to classify the satellite images that are compressed into principal component. Vegetation indices technique is also tested in the analysis to compare green and built up area. The derived classified image are then reclassified using ancillary information in GIS to eliminate speckle, cloud cover and shadow class.

Landsat TM data

The thermal band of the remotely sensed images was also tested to identify the effect from loss of green in the study area. The result shows there seem to be a relationship between loss of green and increase in thermal heat in the study area. The result however was not validated, as its primary objective was to analyse the trend in the loss of green in the study area. In 2002, AGISwlk acquired high-resolution satellite images, IKONOS covering the whole of Klang Valley. The images being resampled to a 1 metre spatial resolution consist of 47 scenes. The images are geometrically corrected to RSO projection and mosaic to provide a perspective view of the whole Klang Valley. Figure 1.2 shows the changes and differentiation of urban green in Klang Valley between year 1988 to 1998. Currently, these images are being used to update and re-delineate land use boundaries, and validate all data layers in AGISwlk. In addition, the image is also being used to assess certain development proposals in the region.

Figure 1.2: Green Area Coverage 1988 - 1998



Aerial Photographs

Coloured aerial photographs of Klang Valley, at the scale of 1 : 10, 000 are also being used to validate the classified satellite data. The aerial photographs taken in 1997 and 1998, covers a large

part of Klang Valley. Several sections of the study area are not covered. The photographs are also used to delineate boundaries for detail data needed such as squatters and detail recreation classes.

Inventory Ground Survey

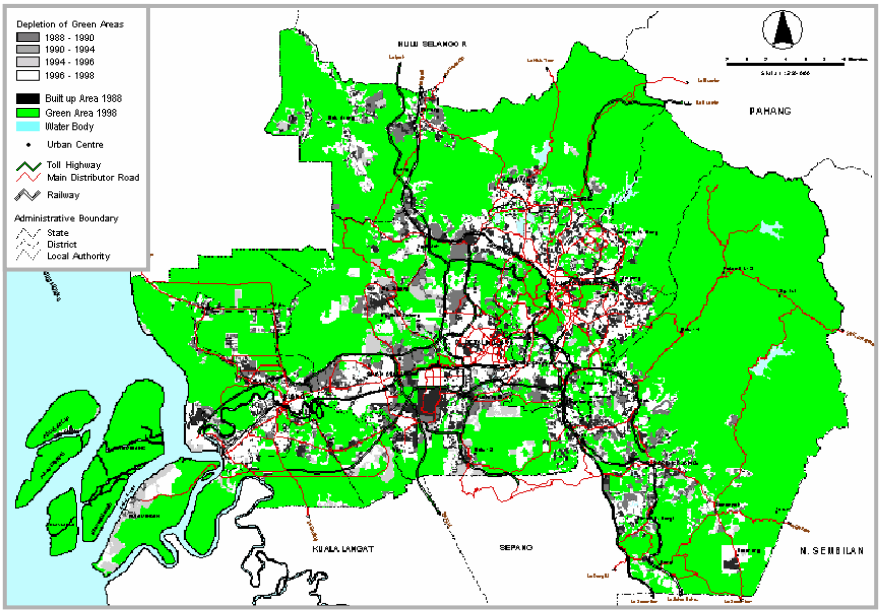
Ground survey was carried out for several applications in AGISwlk. Survey on water and air quality, and updating of land use map contribute to the detail information to be captured in the database. For the purpose of getting urban green information, inventory survey as part of primary data collection is required as to confirm the current land use of Klang Valley.

Analysis of Urban Green in Klang Valley

Urban Green Change

Green and recreational areas are important and sensitive issues, which need special attention by the government. Several map layers and GIS spatial analysis have been used to measure the lost of these areas to other land uses. The database has also been interrogated to identify the supply and location of open space and recreational area against the demand for recreational facilities. The analysis shows that for the last ten years (1988-1998), about 33.18% of the green area have been lost to other urban land uses especially housing and industries. Refer Map 1 as follows:

Map 1: Urban Green Changes in Klang Valley Region (1988-1998)



Source: Laporan Aplikasi Sistem Maklumat Geografi Wilayah Lembah Kelang, (Aplikasi & Analisis) 2001

Table 1.3: The Loss of Green 1988-1998

DISTRICT	GREEN AREAS (Hectares)				Loss of Green 1988 - 1998	%
	1988	1990	1996	1998		
Gombak	5,099.3725	1,981.2964	2,448.4904	6,966.6644	**16,445.8237**	28.98
Hulu Langat	3,666.9774	2,238.4947	4,490.4468	2,694.5615	**13,090.4804**	16.70
WPKL	368.6260	280.9134	2,565.1901	533.4750	**3,748.2045**	48.46

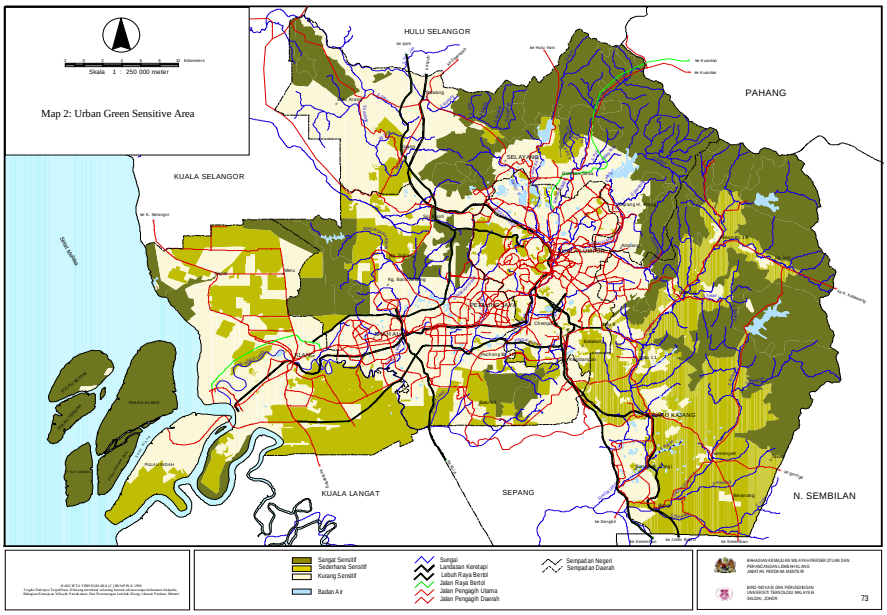
Petaling	9,673.3324	2,020.6212	8,164.9057	1,785.1085	**21,643.9678**	55.53
Klang	4,979.5235	890.8447	4,512.7240	14,262.6627	**24,645.7549**	42.51
TOTAL	**23,787.8318**	**7,412.1704**	**22,181.7570**	**26,242.4721**	**79,574.2313**	**33.18**

Source: Laporan Aplikasi Sistem Maklumat Geografi Wilayah Lembah Kelang, (Aplikasi & Analisis) 2001

Table 1.3 shows the decreasing of urban green based on districts in Klang Valley. Some areas, which were zoned as green area in the development plan has also been developed as other uses. Most of these areas were located in the low land although of late, there has been a trend of developing hill land. Findings indicate that Petaling has the highest percentage in losing urban green area comparing to other districts in Klang Valley.

Green Sensitive Area

Map 2: Urban Green Sensitive Area

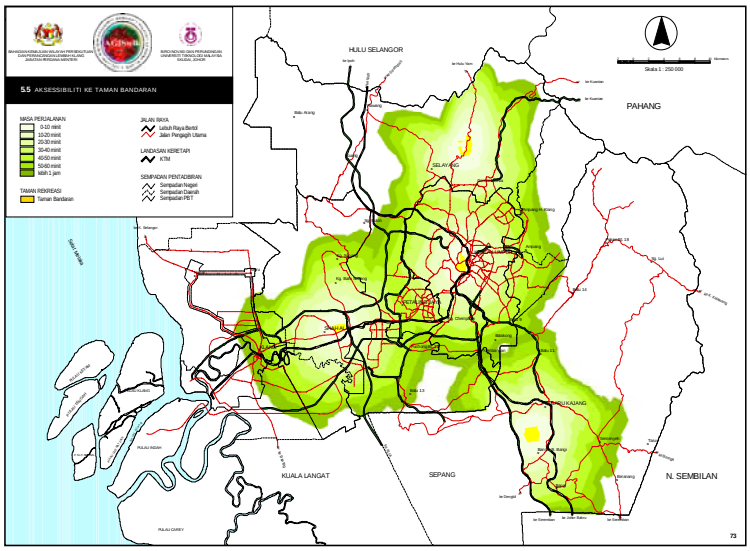


Map 2 shows the detail of analysis on urban green sensitive area, indicating about 65% is sensitive, 5% is moderately sensitive and about 30% less sensitive. The green sensitive area are mostly located in Daerah Hulu Langat where preserved area, forest and water catchments are found. Certain land use pattern generated by the system clearly indicates that there is a tendency of green areas to be developed as other urban uses. This should help the development policy to identify and develop accordingly certain urban green sensitive area such as water catchments area, mangroves and swamps, and water bodies.

Distribution of Urban Green and Recreational Area

Green area was divided into 5 classes that are public recreational area, reserve, water bodies, private recreation and other. The classes was further divided to several categories namely play lot, playground, neighbourhood park, local park, town park, regional recreational area, forest reserve and agriculture, ex-mining area, lake, golf course, theme park and bushes. Analysis on the distribution of green and recreational area is performed to access the accessibility to recreational area, for instance, urban park through indication the walking distance. Example given in Map 3 shows the accessibility to urban park within walking distance of 10 minutes to an hour.

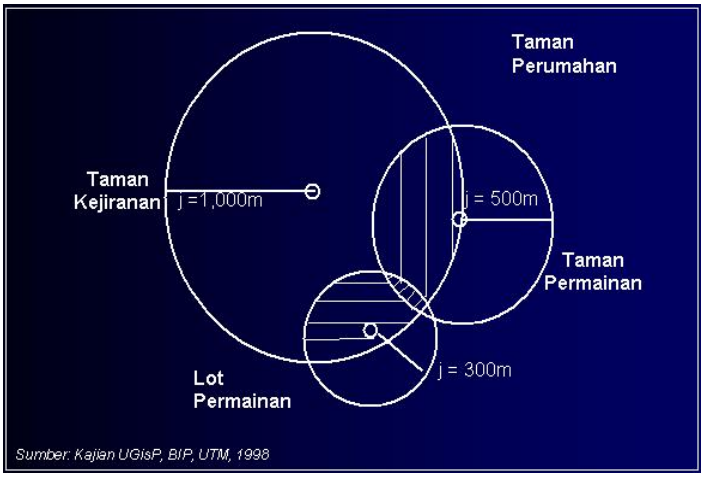
Map 3: Accessibility to Urban Park



The indication of walking distance radius from urban park describe the supply of recreation area is far below the demand of the region. Thus, focus on the need to provide recreational area based on its hierarchy is important in planning and development control of the region

Suitability and Pattern

Figure 1.4: Criteria for Assessing Pattern and Location Suitability of Recreation Area



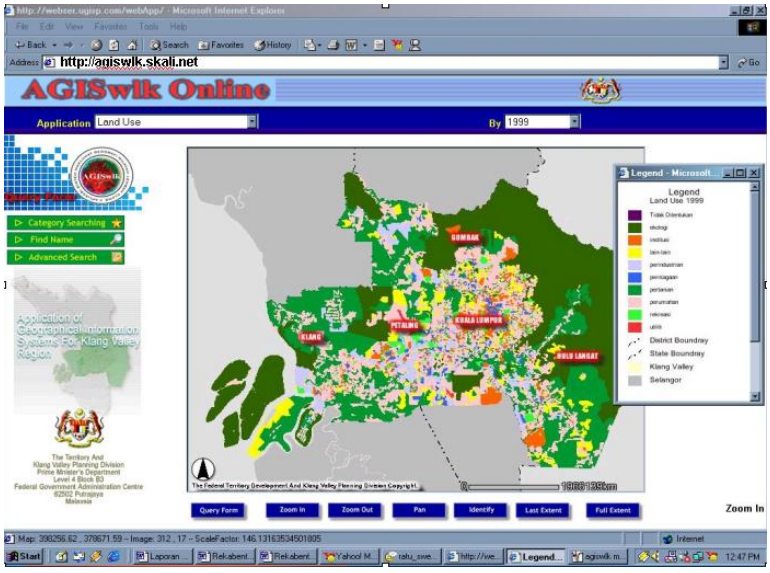
The analysis on the locality of recreational area locality pattern and suitability is important in order to ensure the continuity of urban green and recreational area within regional or local context. Figure 1.4 shows the criteria for assessing location suitability of recreational area for urban area.

WEB-based GIS for Urban Green Database

The Internet, a world-wide collection of interconnected networks of computers, has facilitated the accessing and sharing of information around the globe. The World Wide Web (WWW) is a project on the Internet that allows hypermedia information retrieval across the network. The multimedia capabilities of the WWW have made it a medium in which visual representation such as images, maps, diagrams, and graphs are as easy to implement as text. It has garnered far ranging interest from those interests in the representation and analysis of geographic information.

GIS data were made accessible on the Internet by a Web-based GIS technology. It could maximize public access to mapping and GIS, and may be the most cost-effective means of providing people in marginalized communities and regions with analytical tools which would not otherwise be affordable. Further, familiarity with the user interface provided by the WWW may enhance usability. Users could focus on learning about the substantive use of mapping and GIS to solve problems, rather than struggling with unfamiliar computer interface. It is expected to revolutionize public awareness in urban green management by allowing anyone to access and use web GIS for capturing and manipulating spatial information with interactive sources and high customization provided. Users can interact with GIS data and map on the Web without having to own GIS software. It is also expected to provide interactive mapping and spatial analysis capabilities for enhancing public participation and collaboration in decision-making process regarding the management of urban green. For regional level database, the Web-based GIS for Klang Valley region is now being developed consisting of 10 applications including green and recreational area. The operations offered a means for the users to display maps, submit query as well as display data sources and data structure base on selected map. This application has several useful visualization functions that are appropriate for public information through interactive uses such like zoom in, zoom out, pan, hyper link, full extension, identify and simple query. Figure 1.3 shows the example of web based GIS design.

Figure 1.3: AGISwlk Online



ISSUES AND STRATEGIES FOR GIS IMPLEMENTATION

Issues and Strategies in IT implementation for Urban Green Space Database

The successes and failure of IT implementation are depending on its strategies. Some important issues need to be solved during the implementation process. Some of the issues are identifying the users needs and IT implementation requirements, developing system customization and application, and recognizing the needs of IT expertise and management.

Identification of User Needs and IT Implementation Requirements

IT implementation and designation is highly depending on the organizational planning and management operation. It helps to decide the IT processes and functions in the organization. The database design is relies on the relationship and requirements of the data. For example, the regional authority like Bahagian Kemajuan Wilayah Perancangan Pembangunan Lembah Kelang (BKWPPLK) of the Prime Minister's Department needs to have accurate data at macro level while the Local Authority such as Kuala Lumpur Federal territory needs to have accurate and more specific and detailed urban green and recreational data for every lot, building and town infrastructure for planning, maintaining and control of urban green space. Before the green area database is created, some research on users requirements should be done to determine the database design, data requirements, data entry method, data analysis, system customization and data display network system.

Data Identification and Validation

One of the factors for successful Urban Green GIS is its data and information. GIS Implementation is very time consuming and costly. Some issues have been recognized in implementing the Urban Green GIS.

I) No standardization of data in public and private agencies
ii) Data come in various shape, format, precision, accuracy and map projecton
iii) Data and information is not customised effectively
iv) Various sources of data and information
v) No cooperation in data sharing and data collection from the agencies

The issues and problems need to be solved using specific strategies in determining:

i) What are the needs for data precision and accuracy?
ii) What type of map projection needs to be used?
iii) What is the accuracy level needed?
iv) Where are the data sources?
v) What are the strategies to enable data sharing?
vi) How to obtain data from the agencies?
vii) What are the strategies and methods for data customization?
viii) What type of information system development that needs to be used?
ix) How to determine the data capabilities?

The answers for these issues will help to establish the GIS development strategies. The implementation can be done either 'bottom-up', which is time consuming of 'top-down', which is gathering of general data. Although the 'top-down' approach is easier and faster, the information

gathered is not accurate. One other alternative is by combining both approaches, which is done simultaneously. However, this alternative requires consistency and efficiency.

Difficulties in gathering information and cooperating between agencies must be overcome through database development. Database development method should be decided to avoid data redundancy since some data can only be shared by certain agencies. Every agency should have their own strategies in customizing data, since not all data need to be customized. Customization method can be through field survey, photograph or remote sensing technique. Customization is important to control the information integrity. Hence, data and information need to be restricted by having certain password in order to ensure data integrity.
The success of GIS implementation is influenced by the development of information system. Some of the strategies are either to complete the existing data before gathering the data or both methods can be done at the same time. Nevertheless, the most suitable approach is in developing GIS step-by-step before developing it comprehensively.

Choosing the appropriate hardware and software for urban green database

Choosing hardware and software for Urban Green Database implementation depend on its needs and functions. Various technical factors such as system performance, ability to process data and ability to perform GIS functions from data entry and data management to display and analysis. However, it should match the technical users capabilities as well as sufficient financial budget. Beside, the organization also needs to decide the type of system they want to implement either as a network system with various node or as a stand-alone system. The software chosen also can vary from sophisticated software to simple and easy to use software. Regardless of the choices, the organization must make sure that the system decided to be used must be compatible with the technical users and financial capabilities as well as consistent with their goals and objectives. The best strategies can be either having an economical and uncomplicated system or having advanced and pricely system.

Developing System Customisation and Application

The usage of Urban Green GIS is proven to be an important tool in planning and managing urban open space and recreational area. However, GIS itself is unable to do planning if there is a problems in managing urban green space since there is limitation in using GIS. According to Brail (1990), GIS problem can be divided into three which are its drawback in projection, inabilities in making evaluation and limitation in user interface. Nevertheless, the example of GIS usage illustrate most of its problems can be reduced although it cannot be solve completely. The emergence of new software and better analysis functions manage to overcome these problems. This capability should be discovered and combined with Decision Support System (DSS) that based on logical reasoning and operation planning model by establishing Planning Support System. Other issues that need to be considered are the growth of user interface in GIS usage for planning and managing purpose at all level. This can attract the amateur users to use GIS before creating a more sophisticated PSS.

The Need of Expertise and Commitment from Management Level

The usage of GIS is more efficient if the user or individuals of the involved agencies are more dedicated and committed towards GIS importance, capabilities and potentials. The success of GIS usage is depending on apparent leadership and commitment from top managerial level in realizing the GIS potential in planning and managing urban green space. The lack of awareness and

technical competency between the planning and managing development agencies is one of the reasons for some agencies to have 'wait and see' concept before implementing GIS. Beside, some agencies have limited budget and lack experienced personnel to implement and manage the system.

Sometimes, it is difficult to receive commitment from the top managerial level since the effectiveness and advantages of GIS is not clearly defined. Hence, it is not easy to earn confidence from the managerial level since they are not certain if GIS is profitable. Beside, there is question on how GIS can save time in compiling information compared to manual method and also how GIS can produce accurate results. These questions must be answered to earn confidence from managerial level in GIS capabilities and potential.
To have an effective and efficient GIS for urban space management, it should be designed as part of the planning information system concept. A special unit must be responsible to implement and customize the urban green database to satisfy other unit or agencies need for planning and control strategies. This will boost the awareness of other employees in the agencies to use computer in decision-making.

CONCLUSION

Proper planning and efficient green area management is vital to maintain and enhance the quality of urban environment. Green area and open spaces must be conserved and preserved for the future generations. Relevant agencies concerns need to find effective solutions for short term and long term planning to conserve and preserve green area and open space. GIS has prove to provide innovative solutions for planning and monitoring of green area and open spaces in the Klang Valley region.

However, usefulness of GIS depends on the extent to which information technology can assist in decision-making processes that require access to and evaluation of multiple sources of information. Proper co-operation and co-ordination between relevant agencies, and the need for data sharing between agencies are the key factors to sustain the use of GIS. The database in GIS needs to be continuously updated and improved, whilst new model and methodology of analysis need to be explored and tested. This will ensure that use of GIS is far beyond routine retrieval of information from the database, but more towards knowledge base application through development of analysis models. Recognizing these facts, AGISwlk has undergone several phases of development and still new dimensions are being explored with the support from BKWPPLK.

REFERENCES

Box, Paul (1999) **GIS and Cultural Resources Management: A Manual for Heritage Manager.** UNESCO Principal Regional Office for Asia and the Pacific , Bangkok

Foote, K.E and Lynch, M. (2000) **Geographic Information Systems as an Integrating Technology: Context, Concepts, and Definitions.**

McHarg, Ian. 1992 (1969). **Design With Nature.** John Waily and Sons, New York

Steiner, Frederick 1981. **Ecological Planning for Farmland Preservation**. A Sourcebook for Educator and Planners, American Planning Association.

Tahir, M.S, Yaakup, A.B and Said, I., (2001). **Establishment of a GIS Model for Urban Open Space Planing in Malaysia.** AURISA 2001: The Spatial Information Association: Creating the Link, melbourne, Australia, November 19-23, 2001.

Yaakup A.B, Jamaa'an J., Abu Bakar Y., and Sulaiman S. (2001) **Web-Based GIS for Public Participation in Urban Planning and Management. Case Study: Klang Valley Region**. Conference Paper in Asia GIS 2001, Tokyo June 20-22, 2001.

Yaakup, A.B and Abas, K. (2001) **The Role of GIS Toward Sustainable Environment in Malaysia**. The Second International Seminar on Sustainable Environmental Architecture: Design Methods Innovation for Sustainable City Design in Tropics, Semarang, Indonesia, July 21-22, 2001.