GIS as a Tool for Development Planning and Monitoring

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Abstract

Planning methodology has changed over the years following the shift of emphasis from producing plan, which described a state of affairs expected of some future date, to one acknowledging the continuous and cyclical nature of planning. This necessitates planning be based on the identification of needs and goals, the formulation and evaluation of alternative courses of action and monitoring of adopted programmes. It can be traced that the development of planning support system run parallel from the 'database' to 'information' approach, starting from a focus on applied science in the 1960s through a profound consideration on the political process in the 1970s and to an emphasis on communication in the 1980s. Currently, the employment of Geographical Information Technology (GIT) as a tool for development planning in Malaysia indicates the growing GIT application in planning process. Using examples from current Geographical Information Systems (GIS) implementation projects, this paper will discuss GIS development and application for plan preparation and monitoring of development. The application indicates that the functionality of GIS can be enhanced by adding new model and analytical tools to existing system and by using the GIS toolkit to the best effect. GIS for the purpose of plan preparation and monitoring of development extend beyond a well-integrated and comprehensive database. Current focus is seen directed toward organisation of the system to facilitate ad-hoc query, analysis and development planning and control as well as the use of planning support systems (PSS) to enhance spatial modelling and scenario generation. The use of plan evaluation technique such as Spatial Multi-Criteria Evaluation (SMCE) is also part of the important elements that could determine the ultimate success of GIS application in plan making. Consequently, it will be used to assist decision-making, taking into account among other things, the current scenarios of the proposed development, physical constraint and future impacts. On the other hand, development of web-based GIS to encourage public participation and establish data sharing between planning authorities is also among the efforts adopted to enhance the development planning process. Toward conclusion, this paper will address further the issues of GIS development and application, in particular the GIS capacity building and geodata infrastructure.

Key words: Planning, GIS, Development Plan, Planning Support Systems

Introduction

The current method of urban and regional planning adopted a continuous, cyclical system approach based on the identification of needs and goals, the formulation and evaluation of alternative courses of actions and monitoring adopted programmes. The task typically involves the identification of emerging land use patterns which are normally linked with other planning statistics such as population, employment and housing before the full significance of land use changes are apparent. This task is made difficult in many parts of the world where rapid urbanization is presently taking place.

With the continued development of Information and Communication Technology (ICT), there is a major opportunity for the authorities to use it to manage the allocation of scarce resources in a rapidly changing environment. The quality of urban planning and management can be upgraded when available and valid data are handled in an advanced manner with the aid of computers. The adoption of innovative technology can support planning and decision-making by offering relatively quick response on analytical questions and monitoring issues. Some of the important functions include the ability to retrieve information rapidly and efficiently, to model different scenarios and to evaluate alternative solutions generated by various modelling procedures.

The recent widespread introduction of Geoinfomation Technology (GIT) provides an exciting potential for geographic information to be used more systematically and by greater diversity of discipline than ever before. On the other hand, the ease with which Geographical Information Systems (GIS) can manipulate geographic information has also created a major difficulty. Users unfamiliar with GIS techniques or the nature of geographic information can just easily conduct invalid analyses as valid ones. Valid or not the results have the air of precision associated with sophisticated computers graphics and volume of numerical tabulations. A better understanding of GIS technology by user, managers and decision-maker is thus crucial to the appropriate use of the technology. The objectives of this paper is to look at the development of ICT particularly GIT in development planning and monitoring and to raise concerns as regards to its uses. It will first look at the evolving concerns of planning followed by the examination on the relationship between Information Technology (IT) and planning practice.

Information System and Spatial Planning

The idea of urban and regional planning in Malaysia is said to have originated from the planning concept first introduced in Britain, whereby planning is defined as ‘a process of human forethought and action based upon that forethought. It aims at the best use of land and greatest possible ‘improvement in the human environment’ (Chadwick, 1971). Physical planning, on the other hand, is seen as referring to the ‘physical design or plan of some artefacts or building which might exist in the future’ (Bruton and Nicolson, 1987). Much of planning has to do with the use of land and how the different types of land use relate to one another. Spatially referenced data including parcel boundaries, building on site and ownerships of land and buildings are a fundamental part of an-information based approach to spatial planning. This data combined with socio-economic data, such as census data or natural and environmental data, provides more meaningful information for planners and decision-makers. Hence, an information system is certainly required to handle all the

information needed throughout the development planning process to ensure a more rational and effective decision.

The evolving discourses in the planning field have been accompanied by fundamental although interdependent changes in the prevailing views of proper information system in public and private sector organisations. Klosterman (2001) has succinctly provided the evolving concerns of information technology (Table 1). In the 1960's, the focus was in data handling in which the prevailing technology was batch processing of custom design, single-purpose, and transaction based information systems on mainframe computers. In the 1970's, the emphasis changed from data to conversion into meaningful form or information. Consequently data processing for operational needs shifted to Management Information Systems (MIS). MIS began to be integrated with the development of Urban Information System (UIS), Geographical Information Systems (GIS) and Land Information System (LIS). The next decade saw the needs of decision makers' desire for analytical modelling capabilities are more than what MIS can offer. The 1990's saw a number of intelligence-based information technology projects. The Planning Support System (PSS) will provide intelligence in handling novel problems and to use experience and knowledge to guide behaviour, and designed to facilitate collective design, social interaction, interpersonal communication, and a community debate (Klosterman, 2001).

Table 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 integrate diverse data sets to serve management needs.
1980s	Knowledge	'Understandings 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 behavior' Possible concern of planning support system (PSS), which will promote discourse and interaction to facilitate collective design.

Source: Brail & Klosterman (eds), 2001. Planning Support Systems: Integrating Geographic Information System, Models and Visualization Tools. ESRI Press, California.

The evolution of computer and information over the last few decades provides significant impact on the planning profession. Among the technological advancements, after microcomputer per se, GIS is perhaps the one that has been most attractive to planners. With its powerful capacity for spatial data management, spatial analysis and visualization, GIS provides planners with new tools to implement their work more efficiently.

The Role of Geographical Information Systems (GIS)

The major functions required from an information system can be identified as follows:

i) The descriptive function – information should help to describe a situation;
ii) The cognitive function – information system also contribute to improve understanding of urban and regional problems by providing the key factors and variables that can be analysed using urban and regional modelling and other statistical technique;
iii) The normative function – the information system can also contribute to improved action by reducing the cost of actions with known consequences or by reducing uncertainty about the consequences of actions already taken or about to be taken.

In an era of increasing urban and regional problems, the planning authorities therefore must increase their effectiveness by developing innovative ideas in carrying out their functions. The urban system can no longer be treated in terms of simple land use and traffic concepts. The planner's conception of the urban system must extend to include a host of social, political and economic variables. The mixture of problems which must all be resolved together, creates a situation in which many alternatives must be tried, combined, improved and tested by analysis, by experiment, and by public discussion.

The information system therefore must expand correspondingly if anything like effective understanding and control is to be achieved. An information system is part of the mechanism for reducing uncertainty in the knowledge and understanding of the environment. The development of GIS provides a tool which can contribute to much clearer understanding of real planning problems as well as prescriptive planning scenarios to enhance the quality of urban planning and management (Yaakup, 1991).

A GIS provide the facilities to deal with the data requirements for the functions describe above. An important GIS capability is in handling both digital cartographic data and the associated databases of attribute information for map features (Healey, 1988). GIS can store the map-coordinates of point locations, linear and area features. These functions have attributes that must be stored in the database. Once all the data are stored, both the digital map and the database can be manipulated simultaneously. This is particularly important in many land use planning application, which require data on a wide variety of physical and environmental attributes.

Another main driving mechanism of any GIS is the ability to inter-relate data sets. Since the relative positions of different map features are known to the system, sophisticated analysis of relationship between features across geographical space can also be performed. The primary focus in the manipulation stage is the idea of overlay (this involves combining different maps to identify, for example, any areas having the necessary characteristics for certain kind of development) and neighborhood analysis.

A GIS is able to support all the stages of spatial data processing include manual or semi-automated digitizing, checking and editing of digitized data, edge-matching of digital map files and output of information to a graphics devise or hard copy plotter.

In planning analyses, information is derived from printed map, field survey, aerial photographs and satellite images. GIS systems enable data from wide variety of sources to be

integrated together in a common scheme of geographical referencing, thus providing up-to-date information (Grimshaw, 1988; Coulson and Bromley, 1990). However, GIS alone cannot serve all the needs of planning because the current generation of "general purpose" systems cannot easily accommodate the particular informational, computational, and display needs of planning. Among others things, planning requires (i) information that is effectively "aspatial" at a particular level of analysis; (ii) information over time; and (iii) measures of spatial interaction. None of this can be easily incorporated into current GIS (Harris and Batty, 1993).

Planning analysis and forecasting also required computational procedures that go beyond the standard database manipulation and Boolean function of most GIS. These needs include the ability to (i) compute cross products, manipulate matrices, and conduct statistical analyses; (ii) estimate system parameters and derive solutions interactively; and (iii) support analytical and design functions which incorporate goals, objectives, cost, and benefits. Until recently, GIS has also been unable to produce basic data displays such as bar graph and scatter charts, or to integrate maps with graphic images, sound and video clips, and other display media. They are still unable to produce specialized graphic displays such as population pyramids that are particularly useful for planning.

While many planners have been quick to utilize the new planning tools, it should be remembered that GIS was not originally designed or developed for the planning profession As a result, it is highly unlikely that all computational needs of planner will be incorporated into standard GIS packages. Instead planners will have to adapt existing GIS tools to meet their needs. Traditional programming languages can be used to developed spatial analysis and modelling tools entirely independent of commercial packages. A combination of sophisticated GIS macro commands and traditional programming language also can be used to developed analytical models closely linked to full-featured GIS toolkits (Klosterman, 2001).

However, the inevitable evolvement of IT towards PSS means that the employment of GIS is more significant. The GIS will serve first as a display and communicative device, producing maps and charts that describe past and present conditions and model outputs that suggest alternative futures. Its spatial analysis capabilities will also play an essential role in generating new spatially referenced information required by the computational components of the system.

Apparently, a PSS cannot consist of a GIS alone. It must also include the full range of planners' traditional tools for urban and regional economic and demographic analysis and forecasting, environmental modelling, transportation planning, and predicting future development and land use patterns. It must also include other technologies such as expert system (Han and Kim, 1989), decision support aids such as multiattribute utility theory (Lee and Hopkins, 1995), hyper media systems (Shiffer, 1992), and group decision support systems (Armstrong, 1993; Finaly and Marples, 1992).

GIS for Development Planning and Monitoring

Development planning requires an effective planning approach to achieve the desired goals and objectives, evaluate alternative as well as control development programmes that are in

line with the current and future prospects. GIS technology has long been applied in planning activities which essentially include plans formulation as well as development control (Johar *et al.*, 2003). The Manual published by the Federal Town and Country Planning Department for preparing the various levels of plan has provided that all plans use GIS technology in plan formulation. The different spatial level and form of plans requires different support in term of information system. Various skills are also required for preparing development plans using GIS. They include the ability to build up and manage the database which should incorporate socio-economic attributes of the local population. Managing services at local level would also call for contiguity and proximity analysis. On the other hand, cartographic skills are of importance if plans are to be exhibited.

It should be noted that successful implementation of GIS for sustainable urban and regional planning will largely depend on four factors. The first requirement is the automation of the database. It is costly to collect, store and shift through large quantities of unnecessary data. Hence, the most cost effective approach is to collect only the data required for the specific task. Secondly, data collected either from existing records, aerial photography or field survey will need to be integrated using GIS methods. The GIS will be organized to facilitate adhoc query and analysis. Thirdly, the ability to perform spatial modelling, so that alternative scenarios can be generated. Lastly, application of valid criteria to evaluate the effectiveness of possible planning strategies before the final solution is determined.

A well-integrated and comprehensive database design, which meets the user requirements, is part of the important elements that could determine the ultimate success of a GIS (Chamber, 1989). The GIS database for development planning should be designed based on several important consideration which include:

- The GIS application to be developed
- The need of data for each application
- The availability and format of the existing data
- Size or volume of the database
- Hardware platform and its configuration
- User background
- Organisation structure of the users and facilities

The database development for strategic development plan basically involved gathering of data, spatial and attribute data entry, and generating of data layers based on the applications for analyses purposes. Paper maps and remotely sensed data including satellite data and high-resolution digital orthophotographs are major sources for collecting digital data. Data gathering was carried out based on the type of data needed and sources of data. Data entry was then done through interpretation of the data gathered into the required form (Yaakup *et al.*, 2002a).

The main objectives of a planning agency are to stimulate and guide social and economic development, utilizing the various tools open to it. In the past, planning agencies have been geared to physical planning. More recently, emphasis has shifted to social and economic planning. These two sets of objectives of planning agencies have led to two different views of planning approaches of these agencies.

The philosophy of planning has often been thought of as "top-down", although occasionally there is increasingly emphasis on "bottom-up". In the top-down view, the role of planning is seen as developing a comprehensive plan and adopting it for implementation. The development process involves collection and analysis of large quantities of data, in an attempt to be comprehensive. The time frame of such planning is typically "long-range" and the plan can often be translated into five-years and annual implementation programmes. There is an emerging view that the most effective approach for planning organisation is to see its role as "catalyst" or "bottom-up" in operation. In this role, the organisation focuses on stimulating actions by others to move in desired directions (Yaakup, 2004).

In the light of these alternative roles of planning, Manheim (1987) suggested, there should be two main objectives for GIS in planning agencies in developing countries:

1) to provide support to traditional planning activities, oriented to "top-down" planning;
2) to provide support for the role of the agencies as a catalyst to social and economic development by exploiting the power of information technologies.

Meeting such objectives is not quite so straightforward. In Malaysia, both the "top-down" and "bottom-up" approaches are being used. The following discussions demonstrate the various applications of GIS in Malaysia. It will be shown that GIS can be applied to almost all level of planning including monitoring.

Development Planning System in Malaysia

In Malaysia, the recent amendment to the Town and Country Planning Act, 1976 (Act 172) in year 2001 requires the formulation of plans at various spatial and administrative levels to ensure effective planning as shown in Figure 1.

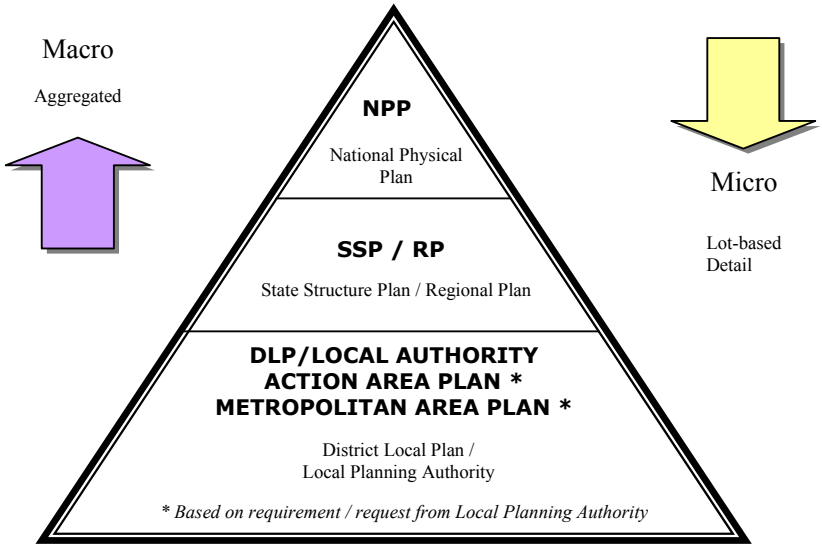

Figure 1: Hierarchical Framework of Malaysian Development Planning System (Federal Department of Town & Country Planning, 2003)

The various plans include:

- The National Physical Plan (NPP), which outlines the strategic policies for the purpose of determining the general direction and trend of the nation's physical development.
- The Regional Plan, which establishes policies to guide and coordinate development of a region especially in the provision of infrastructure and facilities within the region.
- The State Structure Plan (SSP), which sets out the policies and proposals for the development and use of the land in a state.
- The District Local Plan (DLP) which translates the state policies at local level.

This is indeed parallel to the idealized framework of strategic planning suggested by Bruton and Nicolson (1987). Planning in Malaysia is guided by the National Physical Plan at the highest level. The strategic policies which set out the national physical trend of development will be translated at the State Structure Plan. The control of development at the local level is tied to the District Local Plan which is the detailed land use plan that incorporates the national as well as the state development policy.

The National Physical Plan

The National Physical Plan (NPP) outlines the strategic policies for the purpose of determining the general directions and trends of the nation physical development. At national level, GIS is used mainly for data compilation, land suitability analysis and generate suitability maps (Yaakup, 2001).

Several study objectives were addressed for achieving the aims of providing comprehensive database and management system manual for spatial planning, providing indicative maps, providing policies and planning strategies for national spatial development as well as providing public institutional structure responsible for management, implementation and monitoring of the NPP. The study approach for the NPP provides for cyclic and continuous feedback on data compilation, analyses and strategies from the relevant agencies/departments. The NPP study will only focus on major and significant factors determining the level of suitability of areas for future urban development at a macro level. Thus, further detailed criteria would need to be looked into at other levels of planning such as the state and local level studies.

At the national level, the plan essentially requires information of broad land use. It uses GIS to determine land availability according to various criteria taking into account major factors such as existing urban areas, areas with physical constraints, agricultural areas to be preserved and so forth. Objective for carrying out the land availability analysis is to identify land which would be available for future urban development based on the two objectives of maximizing existing resources/investment and the preservation of the natural environment and national assets. The land availability analysis is carried out based on the sieve map technique. Criteria for identification of land available for development include existing urban areas, areas with physical constraints, as well as agricultural, water catchments, proposed dams and environmentally sensitive areas to be preserved.

The NPP therefore, requires a comprehensive information system in order to determine trend and pattern of developments as well as identify strategic land use and conservation policies

within a specific time frame (Figure 2). It should also be used to link physical data and socio-economic information which enable inter and intra-regional analysis to be carried out. It should be able to support various analysis and planning model i.e. economic base analysis, regional input-output and shift-share analysis to support the formation of regional strategies.

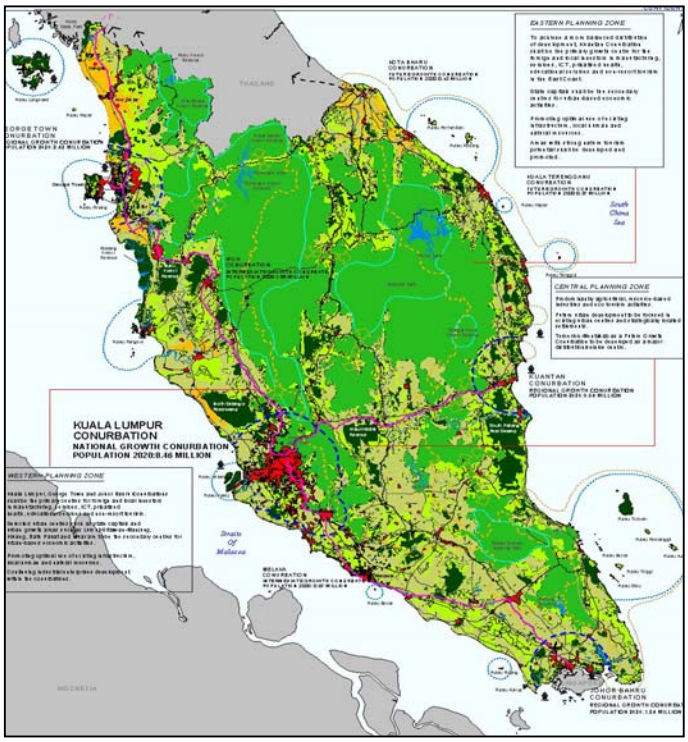

Figure 2: National Physical Plan: Alternative Development Plan Strategy (Federal Department of Town and Country Planning, 2003)

GIS for the NPP should also be able to generate economic growth and job projection. This can be used to analyse the relationship between population and job created in the region. Such analysis becomes important in projecting future requirement for housing, commercial floor space, school, recreational facilities, etc. The analysis can also forecast the future economic linkages, manpower demand and supply. The GIS should support certain economic analysis such as location quotient, minimum requirement techniques, shift-share, economic-based analysis and industrial linkages. Ideally, economic-based model and industrial growth can explain the economic growth for specific cities or regions. This can be used in making future economic decision (Yaakup, 2001). In the context of accessibility and transportation aspect, the transportation models such as trip generation, travel pattern, gravity model and travel mode were useful in transportation network planning either for inter-region or intra-region connectivity. Transportation planning often involves an existing assessment related to mobility demand and the question on how to fulfil the demands.

GIS for the NPP should above all contain comprehensive physical data to enable the evaluation of the development potential and constraint area. Analysis techniques and models including potential surface analysis, carrying capacity, etc., should highlight the suitability of development activities and evaluate the carrying capacity of an area.

The Regional Plan: The Case of Klang Valley Region

GIS is also identified as the main tool in the formulation of regional plan. Introduction of GIS for regional analysis will enhance the rationality of the decision-making process by improving data accuracy and accessibility and as a consequence leads to 'better' decision. Example of GIS application at this level is the Application of GIS for Klang Valley Region (AGISwlk) that was prepared for the Ministry of Federal Territory, which was meant as a planning support system for decision makers in planning and monitoring of the region. A well integrated and comprehensive GIS database had been designed and developed regionally to support ten main application modules namely built up area, green and recreational area, traffic and urban transportation, squatter and low cost housing, environment, utilities and community services, industrial and commercial development, population and socio-economic, geohazard and tourism (Figure 3).

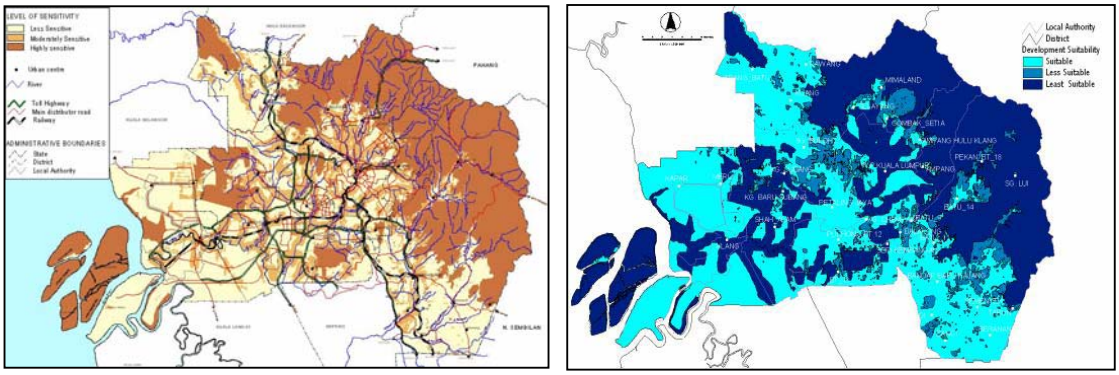

Figure 3: Identification of Environmental Sensitive Areas and Development Suitability Analysis in AGISwlk

Apart from managing the comprehensive GIS database, evaluation becomes an essential step in the planning process especially in selecting the appropriate development scenario alternative to be implemented. Integrated Land Use Assessment (ILA) is a new concept of evaluation model that are recently introduced and developed within AGISwlk, aimed at developing an integrated spatial analysis model with the ability to generate alternative development scenarios by integrating physical and socioeconomic information. The introduction of ILA as an integrated land use planning approach that applies the GIS analysis capabilities while supported by the use of planning support system (*What if?*) is seen as a good alternative for achieving better and more rational decisions. The developed model is expected to dynamically support the preparation of the Klang Valley Regional Master Plan (Yaakup *et al.*, 2004a). The methodology was developed and organized based on the GIS spatial analysis process and planning support system framework as well the identification of policy and strategy to be used as guideline and direction of study in achieving the desired output (Figure 4). The GIS functions involved in the process are the overlay function, classification and measurement. The suitability analysis involves three steps which are selecting the suitability factors, specifying factor weights and ratings in producing the development scenario alternatives (Figure 5).

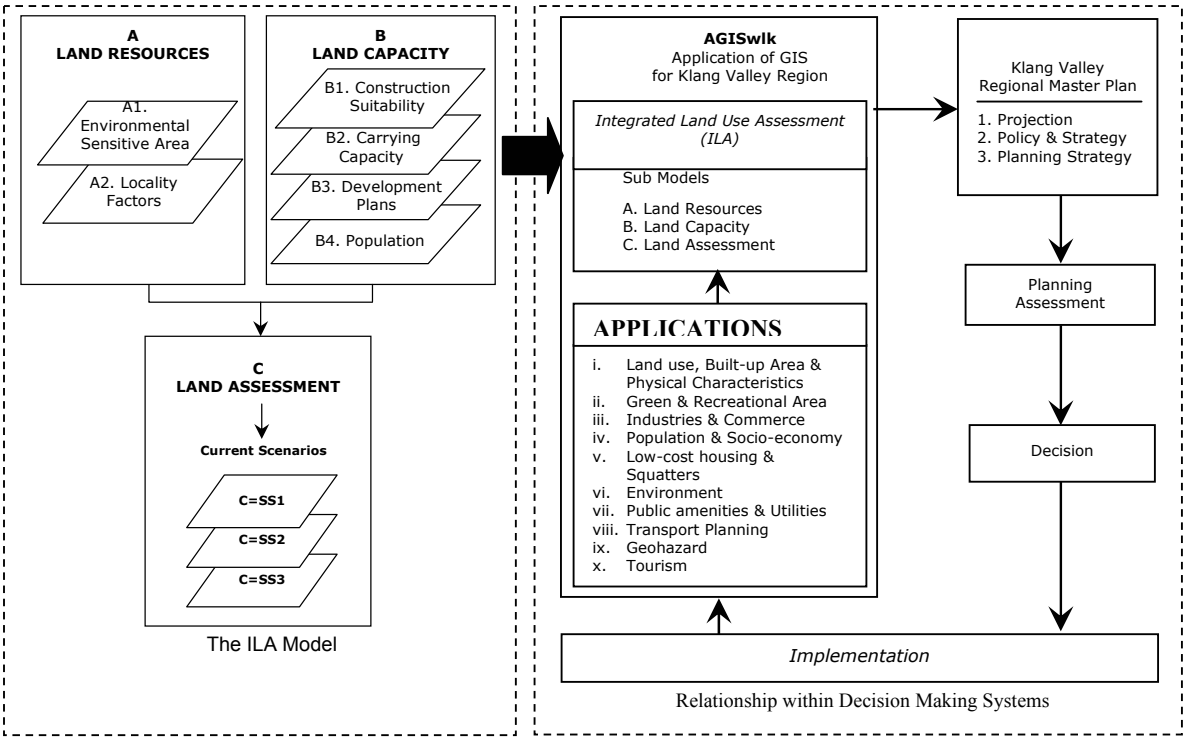

Figure 4: Model developed and implemented for Integrated Land Use Assessment of KlangValley

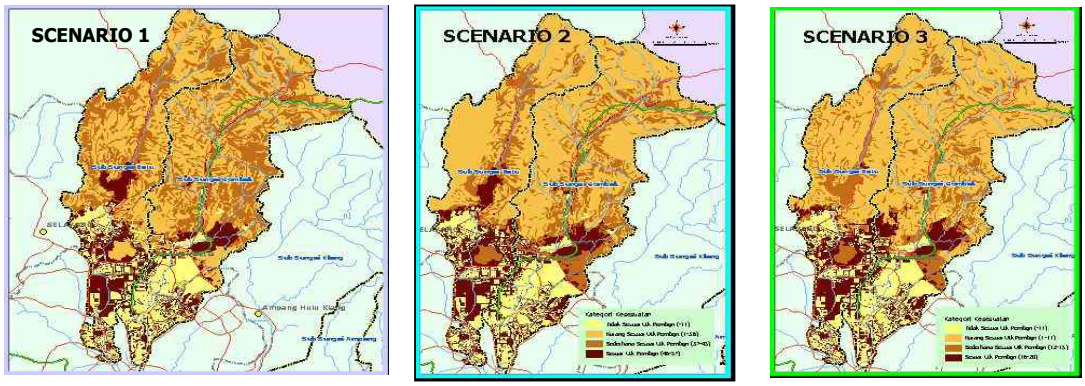

Figure 5: Integrated Land Use Assessment Development Options

For generating various types of scenarios, the GIS layers involved were identified to include the current land use, suitability factors, land use control, infrastructure allocation control, growth trend and administrative boundary, as well as other related information. (Yaakup *et al.*, 2004b). Therefore, the suitability factors and scores, factor weights, factor types and rating as well as land use changes were earlier defined in producing the flexibility for various alternative scenarios adopting the application of Spatial Multi-Criteria Evaluation (SMCE) technique. Apart from all the application and analysis mentioned, a user interface and modelling were developed in facilitating an interactive and user-friendly use of the system through the application of web-based GIS (Figure 6).

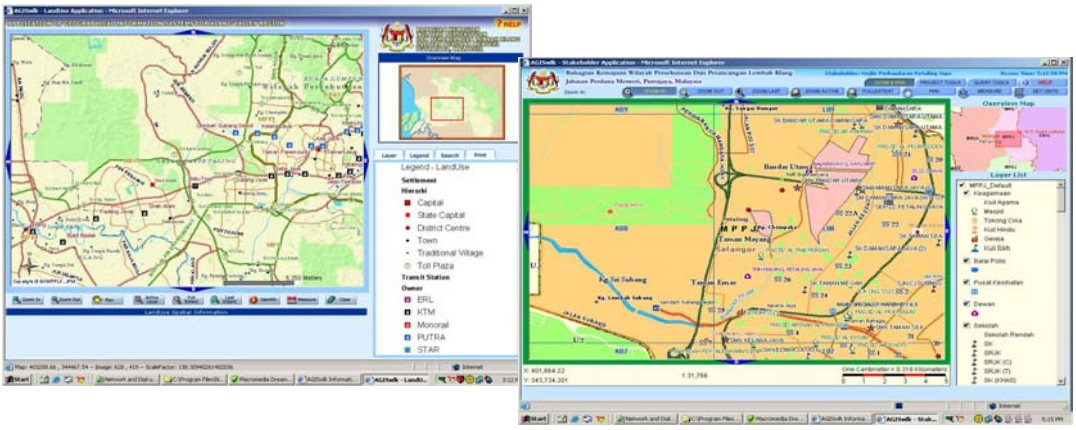

Figure 6: Map display in AGISwlk's Web Application

The State Structure Plan: The Case of Pahang State Structure Plan

Part III of the Act 172 (Amendment, 2001) stated that the State Structure Plan (SSP) is a written statement of the policies and general proposal by the State Planning Committee regarding the development and use of land for the state. According to the SSP Manual prepared by the Federal Department of Town and Country Planning (2001a), the preparation of SSP is crucial to initiate inspection on the state development when required or if changes in the sectoral policies occur, which will consequently affect the pattern in the state development.

The system developed for the Pahang State Structure Plan, covers three main aspects where GIS is concerned. These are the database development, spatial analyses and development of an Executive Information System. The database developed was based on the guidelines outlined by the Department of Town and Country Planning (2002a), to support sectoral studies and analyses relevant to the structure plan formulation. The main concern of the State Structure Plan would be the preparation of the key diagram (Figure 7) that involves a combination of analyses such as determination of area having potential for future development and area for conservation.

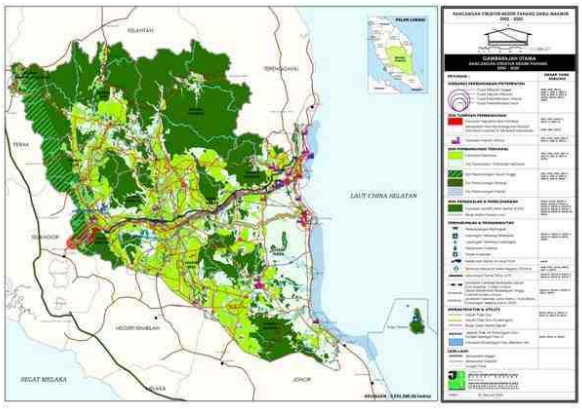

Figure 7: Key Diagram of Pahang State Structure Plan
(State Government of Pahang, 2003a)

The determination of various development alternatives involve enormous collection of data to be analysed for the purpose of formulating policies, strategies and key diagram, which determine the direction of the state development (Yaakup *et al.*, 2004c). The Multi-Criteria Decision Making (MCDM) method is adopted to generate the various development scenarios (Figure 8). The preparation of the key diagram involves determination of area having potential for future development and area for conservation (Figure 9).

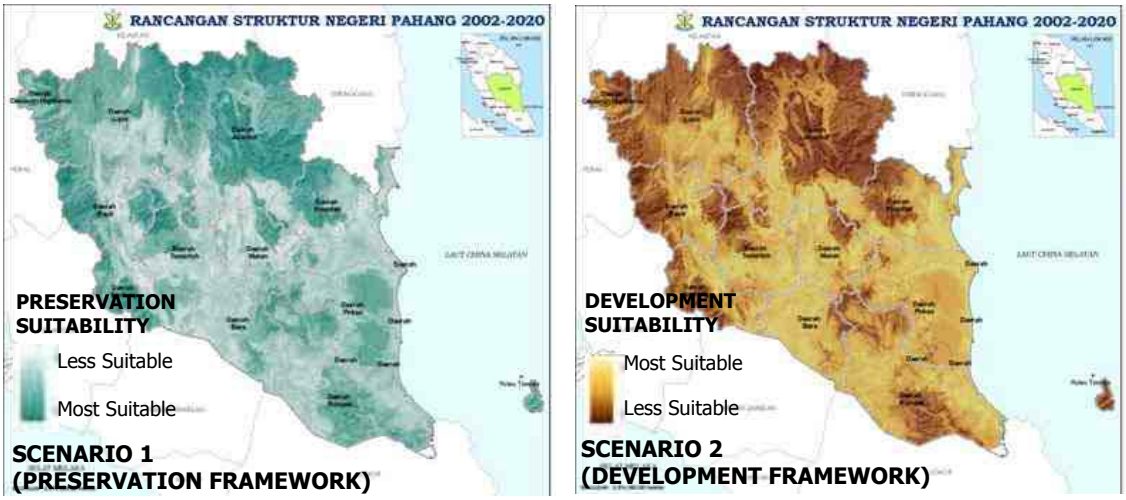

Figure 8: The Resulting Development and Conservation Scenarios
(State Government of Pahang, 2003a)

Figure 9: Conceptual Development Alternatives for the State of Pahang
(State Government of Pahang, 2003a)

The District Local Plan: The Case of Pekan District Local Plan, State of Pahang

At the local government level, the district local plans (DLP) are legal document that become the basis of development guidelines and control. These plans contain such details as land use zoning, development density, building height, plot ratio, etc. which require detailed information of each plot of land. A zoning plan, for example, covers a large area that contains various land uses (Figure 10). It will be a great advantage to be able to evaluate each alternative of a zoning plan using GIS (Yaakup and Healey, 1994).

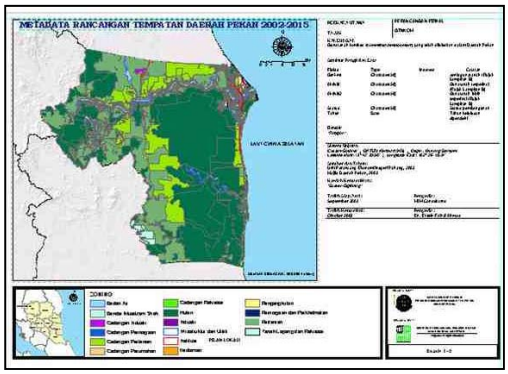

Figure 10: Zoning Plan for Pekan District Local Plan
(State Government of Pahang, 2003b)

As in the case of Pekan district, the GIS database was developed for facilitating the preparation of the District Local Plan (Yaakup *et al.*, 2004d). The district covers an area of about 380,500 hectares, located in the east coast of the State of Pahang. A well integrated lot-based GIS data layers and base map were designed to meet the local authority's requirement. At this level, spatial analyses involve determination of land suitability and allocation (Mohd Anuar Maidin *et al.*, 2004), combining the technique of multi-criteria evaluation (Figure 11 and Figure 12).

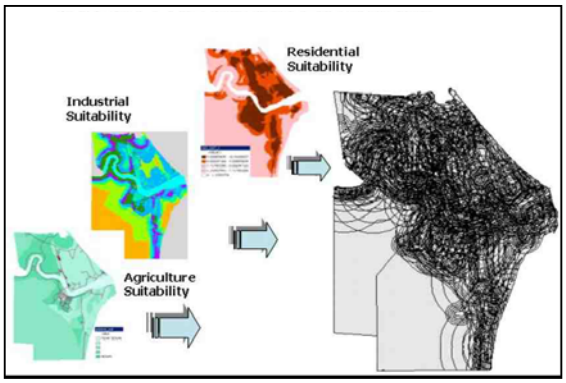

Figure 11: Land Suitability Analysis

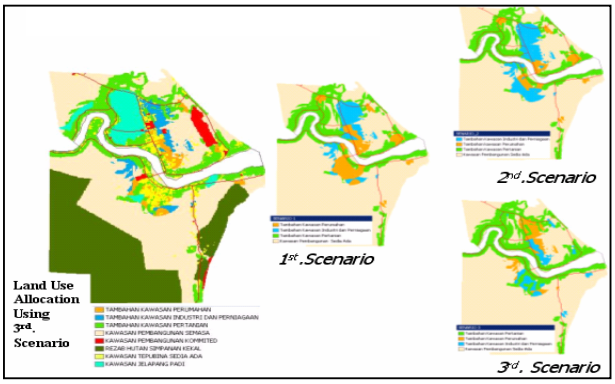

Figure 12: Land Use Allocation

Monitoring the State Structure Plan (SSP) and District Local Plan (DLP) Implementation

An effective planning will not only involve the process of implementation but also inevitably requires the monitoring of its effectiveness as well as plan review and refinement to keep up with the ever-changing economic development phase. Therefore, a monitoring system is imperative to be able to ascertain that the development carried out has achieved the objectives outlined in the development plans.

As in the case of Negeri Sembilan, the monitoring system being developed will need to cover the implementation of the State Structure Plan (SSP) and District Local Plan (DLP). As such, the monitoring system is designed based on the requirement for the two different levels of

planning. The use of GIS as a major component of the monitoring system is significant as spatial information concerning planning and development needs to be organized and update frequently.

The module for SSP monitoring is developed to support the State's Town and Country Planning Department in controlling and monitoring of development projects at the state level. It acts as a tool especially for translating the gazette SSP policies in the form of achievement and compliance units. This is to ensure that every proposed land use plan and development complies with the policies and requirement stated in SSP, either through qualitative or quantitative comparisons. The accomplishment of development targets can be evaluated through specific indicators and assessing of development scenarios within a particular timeframe.

Meanwhile for DLP level, the system emphasises on the ability to ensure that land use development in the district is parallel to the land use zoning strategy stated in DLP. This is done through comparing the current land use development to the one proposed in DLP and thus highlight conflicts.

The monitoring system for development plan implementation support not only development control but also assessment of the effectiveness of current development strategies or policies. Apparently, the system will also be able to provide indication on the percentage of policies accomplished and otherwise. Apart from being a comprehensive tool for policy assessment, it also provides a basis for policy review.

Development Control System

Development control is the most important activity for a local authority. To increase the development control efficiency, planners require the most up-to-date planning data while considering development applications as the basis for decision making. It is seen as a problem for the local authority, especially in collecting planning data which undoubtedly need for the use of new techniques. Thus, an information system is necessary to not only keep and display data pertaining to planning application for the purpose of administrative functions but should also be designed to facilitate planning and development control at strategic level (Yaakup *et al.*, 1997a). The control of development which involves the process of analysing the appropriateness of planning applications requires various data from the relevant agencies. A planning application will be assessed in terms of current development scenario, land information, planning requirements and planning design (Yaakup *et al.*, 2002c; 2003a).

Ideally, consideration for planning and building approval involves a technique for the systematic compilation of expert quantitative analysis and qualitative assessment of project land use and property development viability, including its effect on the surrounding area, and the presentation of results which indicate the resulting scenarios (Yaakup *et al.*, 1997b). It should also indicate the scope of modifying or mitigating these adverse effects. This allows the proposed development to be properly evaluated by the relevant decision making body before a planning permission is rendered (Table 2).

Table 2: Stages involved in planning and building approval and relevant functions of information system

Stages	**Activities**	**Functions of GIS**
Initial Discussion	Consultation to owner/developer regarding potential, planning requirement, policies involved in the area	Data Retrieval: • existing development • development status, approval • development plan • planning policies
Processing of Planning Application	• registration • site visit • gathering data from various departments • identify planning issues • preparing technical report • analysing the application	• identify potential land for development • translate policies formulated into spatial context • identify development pressure area
Consideration by Urban Technical Committee	• comment on technical requirement • recommend the technical amendment to applicant	• data retrieval from various agencies • able to facilitate technical evaluation
Consideration by Town Planning Committee	• formulate and review planning policies • considering planning application	• capable of analysing the development strategy • provide information to evaluate the planning implication

The Computerized Development Control and Approval System implemented by the Planning and Development Control Department, City Hall of Kuala Lumpur, is one of the ICT applications undertaken to facilitate the procedures to control and monitor the city development (Yaakup *et al.,* 2003b). The system being developed integrates several sub systems to execute specific functions, while at the same time interact with one another by sharing information sources (Yaakup *et al.*, 2004d).

GIS is seen as the most suitable solution for supporting the handling of spatial information throughout the development control and approval process. The advent of GIS has created a large field of opportunity for the development of new approaches to computer processing of geographically referenced data obviously needed in supporting decision-making process. Some of the important functions include the ability to retrieve information rapidly and efficiently, model different scenarios and evaluate alternative solutions generated by various modelling procedures. Hence, a more effective solution to various spatial-related problems including those associated with planning and development matters can be achieved.

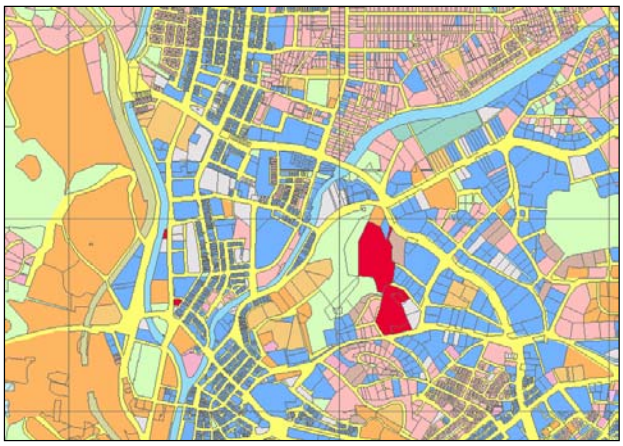

Figure 13: GIS for development control

The development control and approval system being developed stress on interaction between the relational database management and geographic data storage. Based on the database design, the development control system takes an object-based approach to storing of spatial information as an integral part of the database. The spatial data index key is assigned and stored as an attribute in every object in the relational database (Figure 13). It becomes important properties as interaction reference between object information (tabular data) and spatial data (shapefile). Each row in the table has a particular features in its shapefile, and the tables can be queried to return specific subset features from the tables. Therefore, when a user makes a query on the specific module in any subsystem developed, spatial index key is first identified to allow user to use it to perform efficient area retrievals from GIS storage (Yaakup, 2004).

ArcGIS ArcInfo is used for updating or modifying existing features based on more recent information. This can include modifying or adding spatial features or changing or adding values in a dataset's attribute. To provide access to system user, GIS data has been converted into shapefiles to support GIS functions provided in the overall sub systems.

Development of Executive Information/Support System

Executive Information System (EIS) or Executive Support System (ESS) is a GIS-based support system developed for planning authorities to assist the display and query of information through a user-friendly interface especially for users without or with limited GIS skills. GIS display capabilities are also utilized for the purpose of public participation which is legally required in preparing development plans. This is important to gain feedback from the public for the review of plans. EIS or ESS is designed for simplicity, ease of use, through a windows-based interface, and to tailor data requirements available to local authorities and is expected to assist in the decision making process. Example of such system is one developed for the Department of Town and Country Planning for the preparation and review of Pekan District Local Plan (Figure 14).

Figure 14: Spatial Searching Function for Lot-based Query developed in Executive Information System for Pekan District Local Plan

The system developed provides access to a comprehensive database which includes spatial data and analyses results, policy and guidelines for the purpose of planning and reviewing where development plans preparation is concerned. The implementation of EIS/ESS with user-friendly and interactive interface through customization of standard GIS software will ease the process of files or data retrieval, manipulation and updating apart from reviewing of plans, policy and guidelines (Yaakup et al., 2004e).

Apart from for the purpose of public participation, a customized system can be prepared especially for the handling and monitoring of planning application for an area. For example, the Planning Information System developed for Batu Pahat Local Authority, State of Johore, is implemented based on the workflow of planning application processing procedure (Figure 15).

Figure 15: Planning Information System developed for the Batu Pahat Local Authority

The database was built using database management system software such as Microsoft SQL Server 2000 and could be accessed through the local area network. The use of the database management system (DBMS) helps simplify the administration and maintenance of the

database as it provides components for managing data as well as users. The data query process and display of requested information is made easier and faster through a friendly user interface which was developed using the Microsoft Visual Basic software (Yaakup and Sulaiman, 2003).

Web-Based GIS Executive Information System (EIS)

The planning and management process involves many stages of decision-making and expertise from various fields and hence necessitates for collaboration among the parties involved. In Malaysian planning system, the preparation of the development plan called for participation as a value consensus mechanism, not only from the public at large but other agencies or stakeholders to allow data sharing and to ensure more informed decision (Yaakup *et al.*, 2004f). Currently, GIS data which were made accessible on the Internet by web-based technology, has offered an effective medium for public participation and collaborative planning. An example is the development of web-based GIS for the Malacca State Structure Plan (Figure 16) which aimed at disseminating information in the forms of spatial and non-spatial data especially regarding policies and guideline involved in formulation of development programme for the state. Ideally, the web-based Executive Information Systems (EIS) should provide opportunities for users to refer to information relevant to the development plan through the GIS functions provided. The web was developed to include several modules that basically support the activities of structure plan formulation and review, namely the main web page as well as modules for sectoral selection, display of the general policies and display of the subject policies (Yaakup and Abu Bakar, 2002).

Figure 16: Interface developed for implementation of Web-based GIS for Malacca State Structure Plan

Conclusion

GIS has proved to be invaluable tool for evaluating alternative solutions to planning problems. Planning database can be extensively interrogated to generate several alternative solutions to strategic planning problems. Various scenarios which take into account the socio-economic characteristic of dwellers, the constraints of physical development, availability of

land and land suitability for different kind of development can be generated. Apart from that, web-based GIS is currently one of the GIS-based innovative technologies being employed intended at upgrading the quality of urban planning. To optimize its use, more research and attention need to be directed toward organisational and institutional issues, as well as developing the technology for planning and management purposes. In Malaysia, the growing interest of developing web-based GIS in government organisation as well as public sectors has been a positive sign in extending the use of GIS application to the public, apart from allowing for referring and acquiring of geographic information in digital form. The need to obtain views and feedbacks from the public is the main factors that motivate the development of web based GIS pertaining to their relevant field of activities.

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