GIS as Tools for Monitoring the Urban Development in Metropolitan Region: A Case of Klang Valley Region, Peninsular Malaysia

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Abstract

The monitoring of urban land use change forms an integral part of the regional planning process whereby policies and strategic plans are reviewed and updated. This task typically involves the identification of emerging land use patterns which are normally linked with other planning statistics such as employment, housing and population before the full significance of land use change are apparent. This requires planning programme to be adapted during their implementation as and when incoming information requires such change. Among the myriad of urbanisation issues faced by the local authorities in Klang Valley region includes traffic congestion, provision of housing and amenities and declining environmental situation. With a rational planning approach, the quality of planning and decision making process can be substantially improved with valid data appropriately and efficiently handled. Against this background, this paper will discuss and demonstrates the design and development of a GIS database as well as the customised applications for planning and monitoring the development of the region. The database was designed and developed to support ten application modules namely built up area, green and recreational areas, traffic and urban transport, squatter and low-cost housing, environment, utilities and community services, industrial and commercial development, population and socio-economic, tourism facilities and geohazard. This required as many as more than 100 map layers including base map, administrative boundary, physical characteristics, environmental quality, traffic and urban transport, green and recreational areas, public facilities and utilities. Above all the application and analysis, a user interface and modelling was developed to facilitate an easy and friendly use of the system. Lastly, a web-based GIS for Klang Valley was also developed to integrate the data set and to encourage data sharing between various agencies involve in shaping the urban environment in Klang Valley region.

Keywords: GIS, Monitoring, Urban Development

1.0 Introduction

Much of regional planning activities have to do with the use of land and how the different types of land use relate to one another. At the same time, the monitoring of urban land use change forms an integral part of the regional planning process whereby policies and strategic plans are reviewed and updated. This task typically involves the identification of emerging land use patterns which are normally linked with other planning statistics such as employment, housing and population before the full significance of land use changes can be apparent. As such, spatially referenced data including parcel boundaries, buildings on site, ownership of land and so forth are a fundamental part of an information-based approach to regional planning. This information combined with socio-economic

data such as the population census and environmental data, provides more meaningful information for planners and decision makers. This approach also brings increasing rationality to the decision making process.

The land use planning system is also considered a positive and innovative method. The preparation of development programmes adopted a continuous, cyclical system approach based on certain stages such as identification of needs and goals, the formulation and evaluation of alternative courses of actions and monitoring of adopted programmes. In contrary, planning programmes also provide opportunities for public participation. The Appeal Board is also established to avoid the abuse of power by the responsible planning authority.

The activity of planning should be seen as a process (McLoughlin, 1973: Chadwick, 1971) and not be carried out just once and for all. Thus, the plan making procedures may have to move in a direction that would substantially improve its ability to use information systems. This philosophy is based on the concept of feedback of information to evaluate plans and the plan making process (Geddes, 1949). In the plan making process, Calkins (1972) suggested that, 'better planning will be achieved through better information, and better information will necessarily flow from an information system'.

Given the dynamic nature of planning and management, it is particularly important to have a well conceived information system, which can serve as the eyes and ears to a regional development planning and monitoring process. It provides for the monitoring and surveillance of compliance with planning regulations and it serves as an early warning system with regard to sources of friction, imbalances, shortfalls and failures in the process of planning and management (Yaakup, Johar and Dahlan, 1997). Up-to-date, reliable information is therefore needed at the management level to facilitate administrative procedures, policy planning and implementation as well as development strategy. It is a necessity for forecasting, modelling and evaluation of current situation and changes that are in progress. Information is utilised to perform two sets of task. Firstly, information has a role in the process of deciding what action to take, including both operational and strategic decision making and secondly, how activities are organized in terms of managerial control.

The major functions of information system in planning should include as follows:

i. The descriptive function – information should help to describe situation;

ii. The cognitive function – information system also contribute to improved understanding of regional problems by providing the key factors and variables that can be analysed using regional modeling and other statistical techniques;

iii. The normative function – the information system can also contribute to improved action by reducing the cost of actions with known consequences of actions already taken or about to be taken.

The advent of Geographical System (GIS) has created a large field of opportunity for development of new approaches to computer processing of geographically referenced data, which add a new dimension to the management, analysis and presentation of large volumes of information required in decision-making process. The use of GIS has enhance the rationality of the decision making process by improving data accuracy and accessibility and as a consequence leads to better decision. GIS provide the facilities to deal with the data requirement for the functions mentioned above. One important GIS capability is in handling both digital cartographic data and the associated databases of attribute information for map features (Healey, 1988). GIS systems can store the map coordinates of point locations, linear and areal features. These features 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 applications, which require data on a wide variety of physical and environmental attributes.

This paper will discuss and demonstrate the design and development of a GIS database as well as the customized applications for planning and monitoring the development of Klang Valley region. This paper will also review the effectiveness of the GIS application (AGISwlk) developed in supporting the role of the Federal Territory Development and Klang Valley Planning Division in monitoring the region. The potential integration of a tailor-made planning support system package with 'AGISwlk' is explored to help enhance its capability in performing the 'planning' task.

2.0 GIS Database Development and Planning Analysis – the Case of Klang Valley

As much as the issues in planning which are sometimes too complicated and 'wicked', planners are responsible in managing the environmental changes. As managers, planners should adopt effective management approach in the planning process to arrange, control as well as lead changes (Bruton and Nicolson, 1987). Planners should thus adopt *incremental* and *contingency* approach to address current issues and pressing changes. In confronting these complex problems, planners have to resolve to consensus and bargaining measures to limit scenario pertaining conflict of interest. Due to the scope, process and methods involved in land use planning, a development programme does not only need a broad set of data and information but they should also be easy to be processed and manipulated base on requirement and situation. This has set the need for planning agency to develop a planning information system appropriate with its urban and regional planning and monitoring functions.

The main challenge in planning and monitoring of an urban region like Klang Valley is the rapid growth of the region itself, resulting in the urgent needs for land development to cater for settlement/housing and facilities. Among the myriad of urbanisation issues faced by the local authorities in Klang Valley region includes traffic congestion, provision of house and amenities and declining environmental situation. With rational planning approach, the quality of planning and decision making process can be substantially improved with valid data appropriately and efficiently handled.

In attempt to keep up with the ever-increasing issues of urban development especially where Klang Valley is concerned, the Application of Geographical Information System for Klang Valley Region (AGISwlk) project was first initiated in 1995 and has been improved since then. This project is considered successful and significantly contributes to the understanding of the development characteristic of the Klang Valley region and thus helps in planning, coordinating and monitoring the database and utilising every potential of the system mainly as a decision support tool in planning and monitoring the development programmes of the area.

The database for the Application of GIS for Klang Valley Region (AGISwlk) was designed and developed to support ten application modules namely built up area, green and recreational areas, traffic and urban transport, squatter and low-cost housing, environment, utilities and community services, industrial and commercial development, population and socio-economic, tourism facilities and geohazard. This required as many as more than 100 map layers including base map, administrative boundary, physical characteristics, environmental quality, traffic and urban transport, green and recreational areas, public facilities and utilities (Figure 1).

The database development for Klang Valley region basically involved gathering of data, spatial and attribute data entry, and generating of data layers based on the described 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 using the ARC/INFO and Arc View software.

Since the geographic information is stored in its primary form, analysis can be more quantitative and rational. The modeling stage which is called for in planning process, requires planner to make explicit their criteria for the selection of alternative programmes. This encourages the selection of objective

criteria, based on real data about the area under study. Analyses generated in AGISwlk employs the multi-criteria and multi-objectives approach which integrates all possible relevant elements.

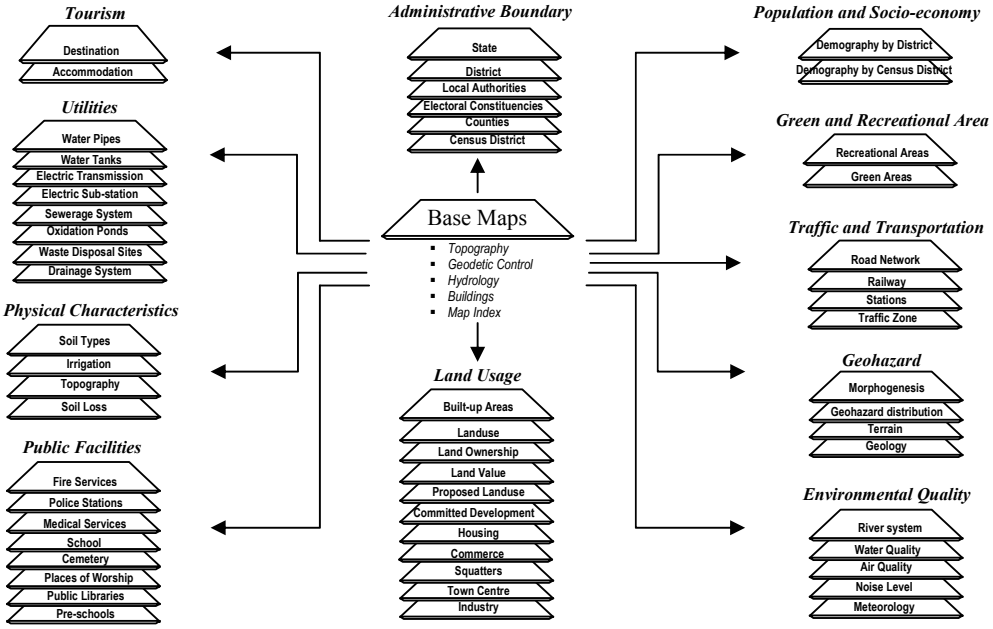

Figure 1: AGISwlk's Database Elements and Map Layers

i) Identification of Environmental Sensitive Areas

The generation of environmental sensitive areas and high-risk zones maps would very much help in planning and decision making process as the identified areas can be avoided from being developed. If development is a "must", these maps could act as guidelines to further justify the type of development that is to be implemented together with comprehensive procedures, standards and preventive measures embedded throughout the development activities. The model for the identification of environmentally sensitive areas involved various criteria while taking into account the limitation of supporting information and database. These criteria include natural habitat which has not been interfered by human activities, natural habitat that has to be managed for human and environmental needs, natural or modified steep slopes as well as water catchment areas. The analysis was done using the GRID operation which includes the use of commands such as POLYGRID, LINEGRID, ISNULL, CON, IF, ARITHMATIC and FOCALMAJORITY (ESRI, 1995). The analysis resulted in the division of the Klang Valley into three environmental sensitive levels namely highly sensitive, moderately sensitive and less sensitive (Figure 2).

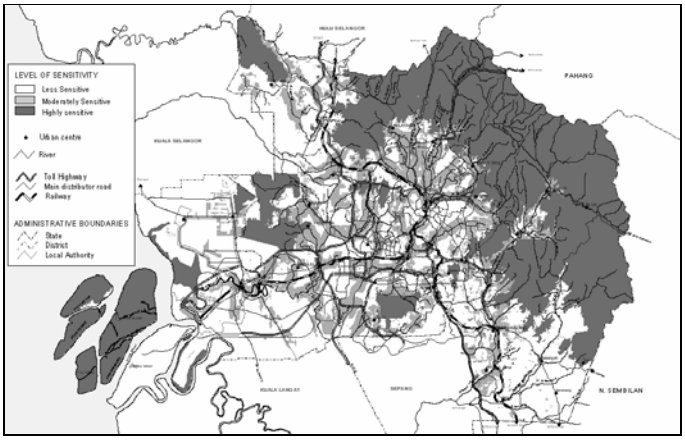

Figure 2: Environmental Sensitive Areas

ii) Assessing Flood Impact on Urban Development

Figure 3 shows the existing and committed housing areas in Klang Valley within the flood risk zones with relative levels of risk identified as low, medium and high (Yaakup *et. al.*, 2001a). Such information gathered and mapped will enable relevant authorities in designing preventive measures to minimize flood occurrences. The appropriate measures include drainage improvement programs for flood risk zones, identification of relief centers for relocating victims as well as educate the public in affected areas on various aspects in confronting flood incidence and their role in preventing it from happening such as ensuring the drains are cleared and not clogged or alerting the Department of Irrigation and Drainage if the drainage system is not functioning well.

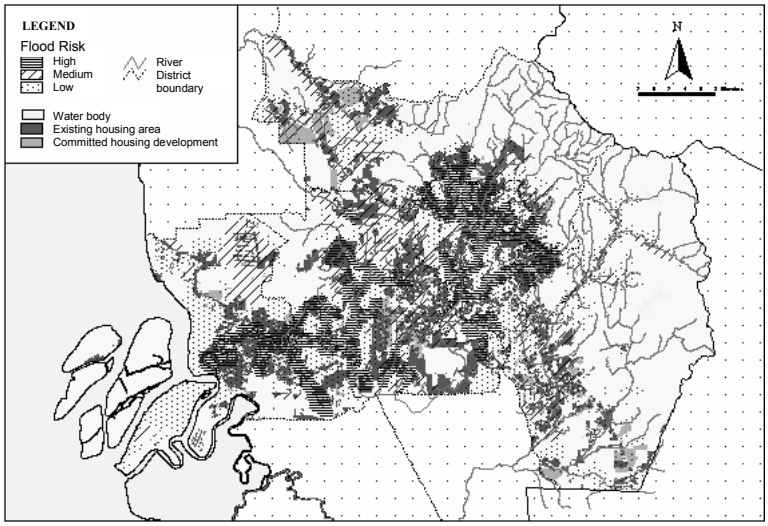

Figure 3: Existing and committed housing areas in Klang Valley within the flood risk zones

iii) Assessing Squatters Resettlement Programmes and Supply of Low -Cost Housing

The distribution, characteristics and associated problems were analysed to assign alternative solutions to be undertaken in solving the problems of squatter settlements. The analysis carried out was able to categorise squatters to three level of action to be taken namely 'Immediate Resettlement', 'Upgrading' and 'No immediate action' (Figure 4). The distribution and particularly development status (*Occupied*, *Ready but unoccupied* and *Under Construction*) of low cost housing in Klang Valley was also monitored (Figure 5). Apart from assessing the development status, the quantity and distribution of the low cost housing is essential in evaluating its supply and demand based on population needs and to cater for resettlement of squatters wherever necessary.

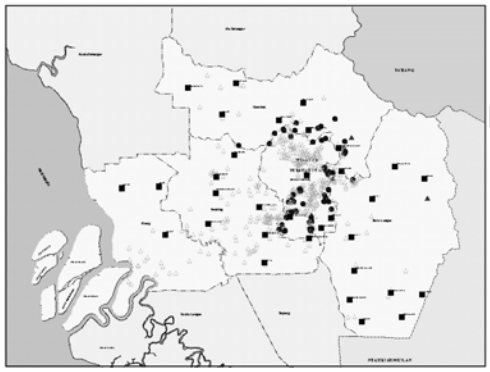

Figure 4: Analysis for Squatter Resettlement Programme

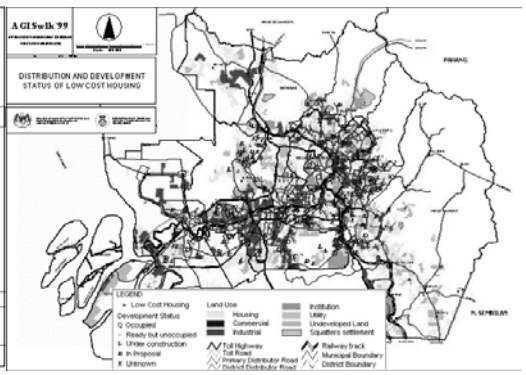

Figure 5: Distribution and Development Status of Low Cost Housing

3.0 Generating Development Scenarios

In the planning evaluation process, it is important to have several alternatives, in which various factors such as the cost-benefit and the socio-economic characteristics have to be taken into account (Yaakup, 1991). In the past, the number of alternative planning scenarios was rather limited due to the difficulties in producing them. This is mainly due to the time consuming procedures of creating scenarios as well as the evaluation that follows. Policy-makers, like most decision-makers, face the difficult task of evaluating and examining the impact of various resource allocations. In the past, the evaluation process appeared to be quite static and limited. Having prepared the evaluation model, the operation can be accomplished within a much shorter time frame by computer processing of the data and computer mapping of the results.

Despite the proliferation of advanced equipment and software in GIS technology, there are still many constraints on the use of GIS in urban and regional planning, which limit their effective application. As pointed out by Scholten and Padding (1990), GIS systems are not advanced enough for mainstream urban policy making because of the rather limited possibilities for analysis built into them and are also rarely user-friendly. As such, they could be positively terrifying for ordinary citizens who would like to use data they contain in making informed responses to government policies. A filter between their professional use and their use as public information system is clearly required. Hence, there is a need to integrate existing analytical techniques and GIS packages by adding modeling software directly into such GIS software or developing easy to use interfaces with already developed planning models (Openshaws, 1987; Worral, 1989; Harris, 1990; Brail, 1990).

The Use of What-If? Planning Support System

'What if?' is a planning support system which incorporates procedures for conducting land suitability analysis, projecting future land use demands, and allocating the projected demands to the most suitable locations. The use of What if? is found to be relatively easy as it requires only a minimum set of data apart from a simple data structure to enable the programme to react with the GIS. It is specifically designed to provide an easy and rational model for urban development process. Generally, it projects future land use patterns by balancing the supply of, and demand for, land suitable for different uses at different locations. Alternative visions for an area's future can be explored by defining alternative suitability, growth and allocation scenarios. For instance, a "Trend" scenario could determine the effects of continuing current development policies, an "Environmental Protection" scenario might consider the impact of policies that severely limit growth in scenic areas and on land that is most suitable for agricultural uses, and a "Build out" scenario would reveal the implications of allowing growth to continue until it reached permitted density levels for all developable parcels in the study area. The system allows users to create alternative development scenarios and determine the likely impacts of alternate public policy choices on future land use patterns and associated population and employment trends.

As stressed by Klosterman (2001), the *What if?* planning support system however, does not attempt to predict future conditions exactly. Instead, it is an explicitly policy-oriented planning tool that can be used to determine '*what would happen if*' clearly defined policy choices are made and assumptions concerning the future prove to be correct. It dose this by explicitly identifying alternative policy choices, allowing users to choose between these alternatives and determine their likely effects on the area being studied. Through preparation of a range of alternative scenario-based forecasts, a range of potential futures can in turn be revealed instead of adopting the unrealistic goal of producing a single "exact" prediction of the future due to the limitations of planners' knowledge, information and resources. Policy choices that can be considered in the model include the staged expansion of public infrastructure and the implementation of land use plans or zoning ordinances, while assumptions for the future that can be considered include future population and employment trends, assumed household characteristics, and anticipated development densities.

Integrated Land Use Assessment

The dynamic nature of planning and monitoring of development in Klang Valley region needs for a continuous evaluation and analysis of the current environment as well as the carrying capacity for future development. Planners should be able to identify and make adjustments to deriving factors as well as evaluation criteria to develop scenarios for generating alternatives to support the decision makers. The choice of deriving factors should include land resources such as agricultural land suitability, suitability for land development and environmental sensitive areas as well as land capacity to cater for development such as the terrain map and public amenities, utilities and infrastructure based on availability of land for development. Figure 6 shows the model developed and implemented for integrated land use assessment of Klang Valley.

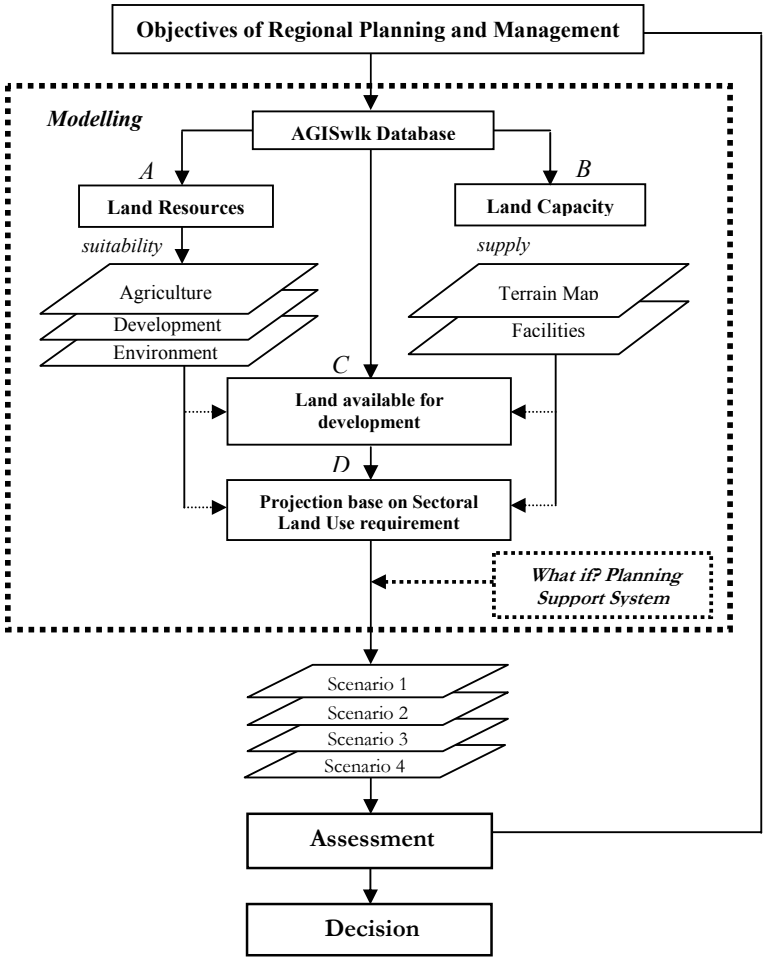

Figure 6: Model for Integrated Land Use Assessment of Klang Valley Region

The model was first applied for the district of Gombak to evaluate the result. Data on Gombak (a district on the northern part of Klang Valley) was interrogated to generate alternative planning scenarios of 'potential areas for development' as well as 'areas for conservation'. Gombak is 72688.16 hectares in area, of which half its land use is considered ecological, and some parts has not been fully developed. For generating the 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. Apart from that, the suitability factors and scores, factor weights, factor types and ratings as well as land use conversion were earlier defined for the suitability analysis. Figure 7 illustrates the four alternative scenarios derived from the analysis of potential areas for development based on categories of suitability.

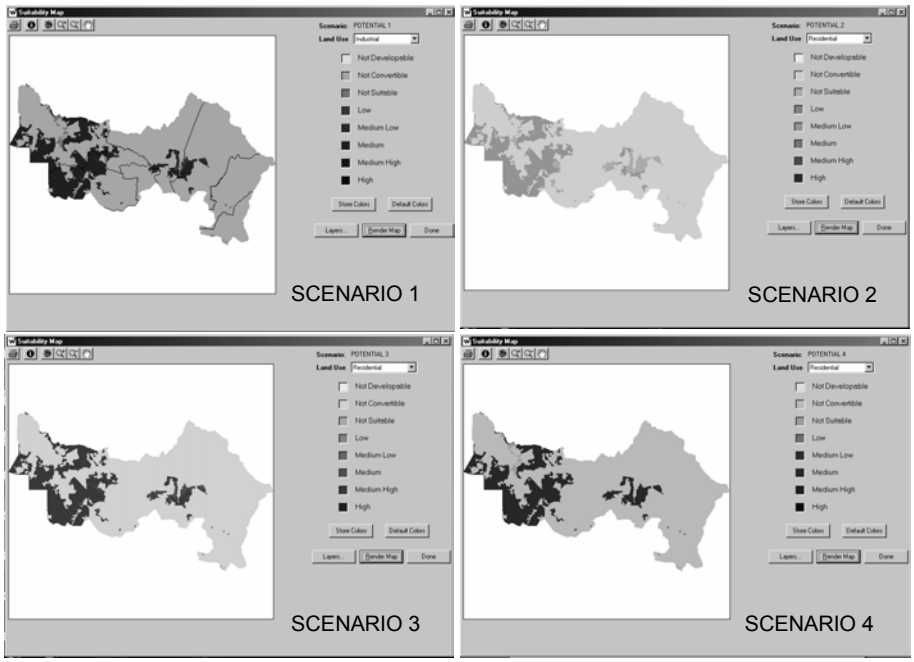

Figure 7: Alternative Scenarios of Potential Areas for Development in Gombak

4.0 User Interface and Web-Based GIS

Above all the applications and analysis, a user interface and modelling were developed to facilitate an easy and friendly use of the system. A web-based GIS for Klang Valley was also developed to integrate the data set and to encourage data sharing between various agencies involve in shaping the urban environment in Klang Valley region.

Web-based GIS for Klang Valley was initiated as an extension to the prior developed Application of Geographic Information System for Klang Valley Region (AGISwlk). While AGISwlk was meant as a planning support system for decision makers in planning and monitoring of the region, the Web-based GIS is more towards inviting public participation apart from providing information in the form of maps and data for public access, and paving the path for data sharing with agencies having the same interest. Various stages of users will be allowed to access the web page via web browsers such as Microsoft Internet Explorer 4.0 or the latest version. The web page allows user to view and use the information displayed for further processing. The GIS web page was developed with the aim to facilitate users, especially BKWPPLK's client to acquire information in digital form. Nevertheless, the web page acts as a source of reference in making decision and evaluation for planning and development purposes where Klang Valley is concerned. The Web-Based GIS for Klang Valley region developed include tables and map-based information for all the applications developed in the system. 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 maps (Figure 8). This application has several useful visualisation functions that are appropriate for Public Participation through interactive uses such like *Zoom In*, *Zoom Out*, *Pan*, *Hyper Link*, *Full Extension*, *Identify* and *Simple Query* (Yaakup *et al.*, 2001b).

Initially, the programming of Klang Valley Web-Based GIS applications was implemented by integrating four software components including Map Objects, Map Objects Internet Map Server, HTML, and Visual Basic. However, various problems were encountered throughout the application development. Advanced knowledge in HTML and Visual Basic application apart from MapObjects and Internet Map Server is required to develop such application. However, HTML application implies difficulty for programmers to identify programming error when occurs as it is not equipped with a

compiler. In addition, there are still weaknesses in preparing icons and toolbars on the web interface produced in the context of customisation processes and interactive system. The ArcIMS is easier to apply with the help of the wizard application and thus speeds up the web page development. Consequently, the customisation activities can be carried out easily using HTML and JavaScript.

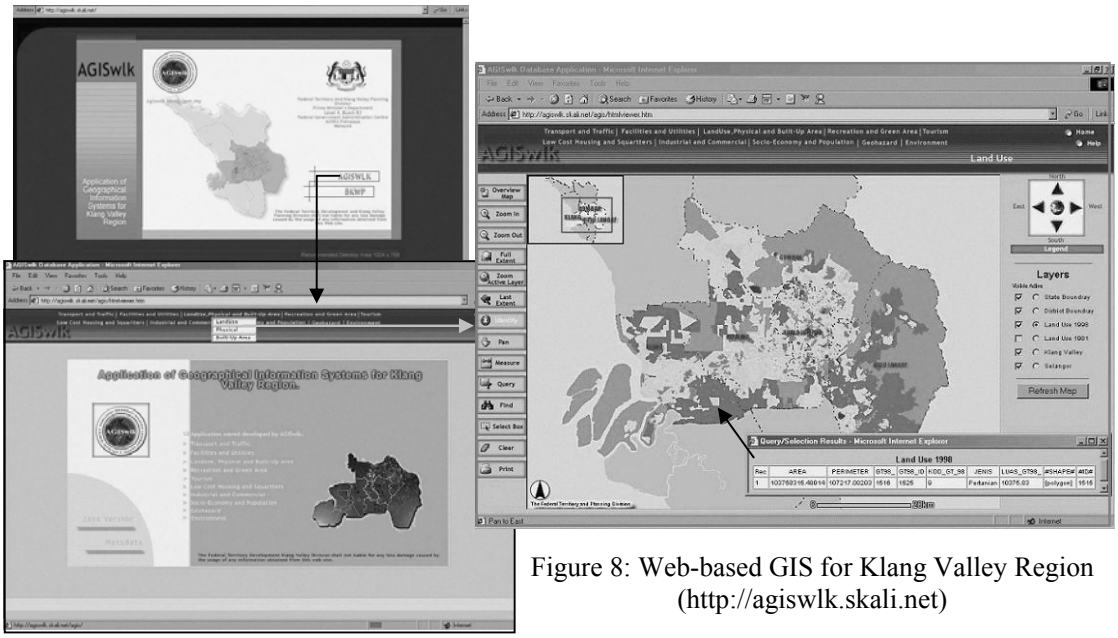

Figure 8: Web-based GIS for Klang Valley Region (http://agiswlk.skali.net)

The GIS application for Klang Valley is still under further improvement to include a more interactive and friendly graphic user interface to provide flexibility in data selection and display, to allow physical planner and decision-maker to view and analyse the planning scenarios interactively before deciding on the final plan. Development of intelligent user interfaces will make GIS systems responsive to user needs, while the user will no longer have to become an expert in the use of GIS in addition to their own field of specialisation. An interactive problem-solving framework will give the user the potential to ask 'what-if' question while the formulation of an answerable question is often obtained in an interactive manner by 'trial and error'. Consequently an information system should facilitate such a heuristic dialogue (de Man, 1988). Using interactive framework, decision-maker should be able to see a cartographic representation of different planning scenarios. In addition to this, evaluation techniques such as those based on cost-benefit analysis can be made more accessible (Yaakup, 1993a).

As in the words of Klosterman (1997; 2001), the ideal planning support system will provide an "intelligent digital toolbox" that helps users select the most appropriate software tools from a range of alternative analysis and forecasting models, applies these tools to data which have been accessed locally or via the Internet, and allows them to quickly view the implications of alternative policy choices in intuitive graphic, map, and interactive video/sound displays.

5.0 Issues on GIS Implementation for Urban and Regional Planning and Monitoring

Much of GIS current usage in urban and regional planning in Malaysia calls for its descriptive function as urban and regional analysis are mainly descriptive in nature, whether for describing the existing situation or future problems. In this instance, the main advantages of GIS are its graphical presentation, data management and spatial analysis and modeling capabilities. However, its spatial analysis is still underdeveloped while its graphical presentation and data management have been its attraction factors. Underutilisation of its spatial analysis feature has hindered GIS from becoming an important tool in solving planning problems. Complete application of GIS in urban and regional planning practice could be effectively realized if these steps are taken. Firstly, through additional of

more functional features in GIS such as analytical functions and decision making functions. Secondly, by complete use of the existing functions in the best way possible, and thirdly, by developing a Planning Support System, i.e. through combining GIS with other analytical software. It is perceived that GIS will contribute more to planning practice if it is integrated with other urban and regional planning modelling software. An information system that could be used in making planning decision is important for effective organization and management of data and is the key to successful planning. The combination of GIS and other urban and regional planning-related software could therefore make a planning information system more effective.

Successful implementation of GIS for a sustainable urban and regional planning will largely depend on four factors. The first requirement is the automation of the GIS database. As it is costly to collect, store and sift through large quantities of unnecessary data, the most cost-effective approach is to collect only the data required for the specific task, in this case for urban and regional analysis and planning. Secondly, data collected either from existing records, aerial photography or field survey will need to be integrated using GIS methods. The urban and regional GIS will be organized so as to facilitate adhoc query and analysis. The third is the ability to perform spatial modeling, so that alternative scenarios can be generated. Last but not least is the application of criteria to evaluate the effectiveness of possible planning strategies before the final solution is determined.

Matching Database Design with user's requirement

Design of a regional information system should be based on an understanding of how regional operations and planning are carried out. This should take into account the data requirement and relationship between data, based on the need of user or organisation. The organisational functions or tasks, and types of data which support them, comprise the vital elements involved in operations and planning of the region. The task and supporting data will provide the fundamental framework upon which a conceptual model of geographic data entities and relationships can be developed. The major obstacle to GIS implementation in the urban planning context in Malaysia, however, remains to be the very large volume of of both cartographic and attribute data that have to be converted into machine readible form. Creation of the database is a difficult and costly undertaking, a task that commonly represent 75% or more of the total cost of implementing GIS, apart from the substantial on-going maintenance cost to keep the database current. Furthermore, several problems have complicate the data situation considerably. For example, few data sets are collected apart from being incomplete and the quality of data is much lower than developed countries, especially in parts of informal sectors like squatters areas (Yaakup, 1993b).

Since urban and regional GIS users will come from different administrative units and with different requirement, it naturally follows that each will have different accuracy requirements. To satisfy the demands of all users, the GIS data would need to be accurate enough for all users. In defining information levels and detail, users have to be clear of their aim and objective of the database development so that the data stored is able to support the intended analysis to be carried out. Clearing the database of unnecessary data would ultimately cut down the cost, time and effort devoted to the development of the database.

Development of the Planning Analysis Model and Planning Evaluation Model

The analysis process needs a critical and relative action to acknowledge certain situation and comprehend the collected data (Wahab, 1991). In defining the analysis model, a few questions need to be asked in order to obtain rational results. Selection of the right model will lead to integrated and sustainable development in the future. The consequence due to failure in choosing the appropriate model will be worst if decision-makers are not well informed where planning is concerned.

Evaluation is an essential in the planning process especially in selecting the appropriate alternative development scenario to be implemented. Among the usual evaluation method employed include the cost-benefit analysis, the development goal achievement matrix analysis, the policy achievement and

development strategy analysis, and some others. As such, in this phase, it is necessary for decision-makers to define the suitable planning evaluation model so that the alternative development scenario chosen could cater for future planning and its implementation is beneficial to the public. In defining the planning evaluation model, the development scenario alternatives should satisfy various criteria such as taking into consideration the planning objectives proposed and measuring all the costs and benefits for every sector.

Organisational Issues and Integration of information from multi-sector planning

One of the biggest challenges in the development and operation of GIS is the adaptation of the organisation to the new technology. This is not to say that the organisation should be technology driven, but that some new organisational structure and operation may be required to take fullest advantage of the benefits that GIS can offer. Lack of trained personnel, finance and political consideration may cause changes in public organisation difficult to be accomplished (Yaakup, 1993a). Data management is most important for an organization so that the information can be shared with other related agencies. Most data for planning and management purposes does not possess the appropriate quality for GIS application. Data from multiple agencies consist of different levels of accuracy and is not systematically organised. The issue of data sharing will remain unsolved as data is not easily provided by some agencies due to its confidential status and too sensitive to be shared.

Nevertheless, Masser (1998) pointed out that the question of digital data availability was much more a question of central and local government attitudes towards the management of information, rather than a matter of information rich verses information poor. Countries with relatively low levels of digital data availability and GIS diffusion also tend to be countries where there had been a fragmentation of data sources in the absence of central or local government coordination. While countries where government had created a framework in terms of responsibilities, resources and standards for the collection and management of geographic information also tended to be those with relatively high levels of digital data availability and GIS diffusion.

6.0 Conclusion

Although the Klang Valley GIS was successfully implemented, the project raised several issues that have to be solved. Some of these are difficulty in translating all the user requirement; difficulty in integrating the data sets as they are available in different forms, formats and characteristics; difficulty in getting full cooperation from various agencies which hold the data and lacking of clear work procedures and methods of analysis as being practiced in the present system. The challenge that remains is updating and maintaining the database and utilising every potential of the system mainly as a decision support tool in planning and monitoring of urban development of the region.

A sustainable planning approach inevitably needs a support system that can support the monitoring process to derive at a better decision. The emergence of GIS supported by the 'What if?' software provide an opportunity for its use as an essential tool in urban and regional planning and management activities. The capabilities of GIS can in time be enhanced and updated while collaboration with outside package such as the 'What if?' software will hopefully enable AGISwlk to be an effective and comprehensive planning support system, taking into account the land use regulations such as physical characteristics, transportation and environmental impact of the growth scenarios. However, related technical, organizational, statutory and human issues need to be countered before GIS can really be applied for planning and management purposes. Hence, planning strategies play an important role in defining the success of a GIS development. Subsequently, effective implementation of the PSS technology very much depend on an overall management strategy based on the needs of users in the organisation.

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