

Applications of Geographic Information Systems in Urban Land Use Planning in Malaysia

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Abstract

Over the past forty years Geographic Information Systems (GIS) have been used in many planning applications ranging from daily administrative operations to strategic planning functions such as evaluating socio-economic data in land use allocation tasks. This technology has various analytical functions that can be used in dealing with spatial problems such as urban planning and management issues. It is useful in assisting planners, decision makers and the community to efficiently respond to challenges, plan successful future and improve service delivery. Although GIS has become a common planning tool in many western developed nations, its application in many developing nations is still limited.

This paper highlights the applications of GIS in urban land use planning in Malaysia. It will focus on GIS applications by local government authorities; evaluate the role of local universities such as Universiti Sains Malaysia in conducting research on GIS applications; and discuss the future direction of GIS applications in land use planning in Malaysia.

Keywords: Geographic Information Systems; Land Use Planning; Malaysia

1. Introduction

Urban land use is a dynamic phenomenon, changing with both across space and time. Comprehensive planning is essential in order to ensure that new urban development does not produce negative impact on the society, economy and environment of a region experiencing urban land use changes (Kivell, 1993; Devas and Rakodi, 1993). At present urban planners and city managers in developing nations face rapid urbanization resulted from migration or natural population growth (Choguill, 1994). In 1950, for example, urban population in developing nations was less than 300 million. By 1985, however, it had increased to 1.1 billion. Furthermore, future projection suggested that people living in major urban centers of developing nations will exceed 4 million by the year 2025 (UNCHS, 1996). This drastic increase of urban population will create pressure to develop land, due to a high demand for residential dwellings and related services (Kivell, 1993, Choguill, 1994).

2. Urbanization in Malaysia

Malaysia, for example, has experienced moderate urban growth when compared with nations such as Argentina or Brazil (refer to Table 1). Malaysia's urban population in 1975 was 37.6% of her total population of 12.3 million. By the year 2000, Malaysia's population had increased to 22.3 million and more than 57% of this population lived in urban area (Salleh, 2000). Although this figure is less alarming when compared with urban growth experience in Argentina or Mexico, current planning projection suggested that by the year 2020 Malaysia's population will increase to 40.6 million, with 70% of this population living in urban areas (Department of Statistics, Malaysia 2000). Such an increase in urban population will result, over time, in a transformation of the physical appearance of many cities in Malaysia (Ghazali, 1999).

Table 1: Urbanization trends, size and growth of urban areas 1975-2025 of selected developing nations.

Country	1975		2000		2025	
	Total in Thousands (000)	% Urban Dwellers	Total in Thousands (000)	% Urban Dwellers	Total in Thousands (000)	% Urban Dwellers
Argentina	21029	80.73	32762	89.94	43083	93.39
Brazil	66065	61.65	141979	81.21	204791	88.94
Indonesia	26259	19.36	85819	40.34	167393	60.74
Malaysia	4616	37.65	12820	57.49	22942	72.65
Mexico	36948	62.76	79580	77.71	117222	85.82
Philippines	15294	35.56	44005	59.01	77622	74.26
South Africa	12314	47.97	24550	53.12	48673	68.60
Thailand	6244	15.10	13555	21.90	28756	60.74

(Source: UNCHS, 1996).

In order to control or manage urban development, the focus was given on supporting or directing urban growth toward existing conurbations especially in Kuala Lumpur, Georgetown and Johor Bahru, which have the capacity and potential to compete internationally (JPBD, 2006). Figure 1 shows major urban centers with population exceeding 10,000 people in Peninsular Malaysia. This figure shows major urban centers are located along major transport networks especially in the west coast of Peninsular Malaysia. This pattern of urbanization was resulted from Malaysian government policy of industrialization which has created a significant increase of

urban population especially in Penang, Selangor and Johor State (Morshidi et al., 1999).

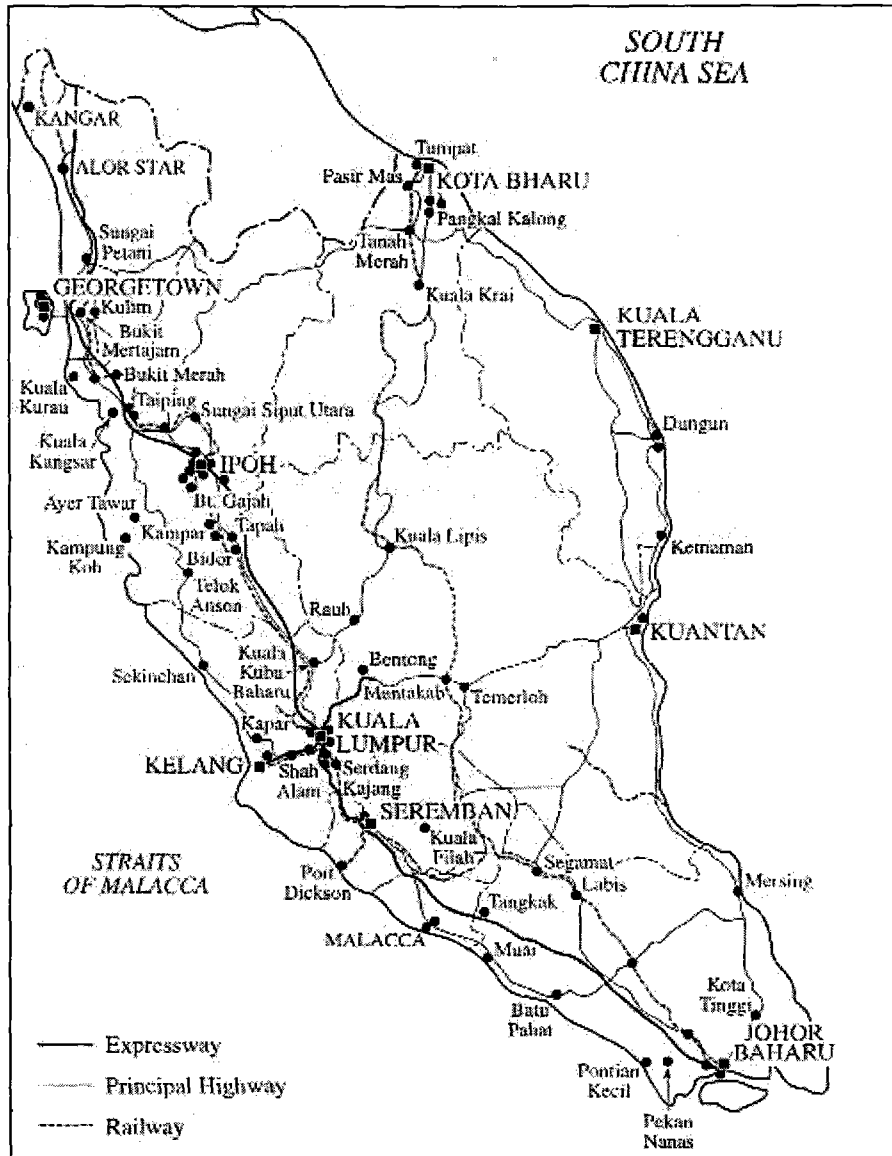


Fig 1: Major urban areas in Malaysia, town shown in capital letters are towns with population exceeding 10,000 people. (Source: Ghazali, 1999).

Table 2 shows urbanization level by state from 1970 to 2000. Apart from the Federal Territory (Kuala Lumpur and Labuan), Penang State and Selangor, for example, become the most urbanized state with an urbanization level exceeding 80% (Department of Statistics, Malaysia, 2000). This phenomenon is due to the migration of young people from rural to industrial urban areas (Goh, 1990; Salleh, 2000).

Table 2: Urbanization Level by State, 1970, 1980, 1991, 1995 and 2000.

State	Urbanization Level				
	1970	1980	1990	1995	2000
Johor	26.3	35.2	48.0	51.8	56.4
Kedah	12.6	14.4	33.1	36.9	42.1
Kelantan	14.1	28.1	33.7	35.7	39.4
Melaka	25.1	23.4	39.4	44.0	49.8
Negeri Sembilan	21.6	32.6	42.5	44.7	47.6
Pahang	19.0	26.1	30.6	31.9	33.7
Perak	27.5	32.2	54.3	60.5	67.8
Perlis	-	8.9	26.7	30.4	35.3
Pulau Pinang	51.0	47.5	75.3	80.6	86.1
Sabah	16.9	19.9	32.8	35.2	38.2
Sarawak	15.5	18.0	38.0	43.4	50.5
Selangor	39.5	34.2	75.0	82.6	89.4
Terengganu	27.0	42.9	44.6	45.1	45.7
Federal Territory (Kuala Lumpur)	100.00	100.00	100.00	100.00	100.00

Source: Department of Statistics, Malaysia (1996; 2000).

Significant increase of urban population is the result from Malaysian's government industrialization policy that started since 1970s. Fig 2 shows urbanization level in Peninsular Malaysia since 1970 to 2000. In Penang State and Selangor, for example, urban population has increased from 51% to 86% and 40% to 89% respectively between 1970 and 2000. Penang State has become a growth centre of the Northern Region and leader in manufacturing activities in Malaysia.

Urban population growth has resulted in an increased pressure on land for housing and related services (Devas and Rakodi, 1993). In 2001, for example, built-up area was approximately 3.3% or 437,100 hectares of the total area of Peninsular Malaysia. However, this built-up area is expected to increase to 5.8% or 768,600 hectares in order to cater for urban population expansion by 2020 (Mohd Atan, 2005). Although this value probably seems to be small, changes in land use can generate local, regional or global impact on biodiversity, landscape or living environment. Thus, Local and Federal Authorities at a local or regional level need to be carefully plan and monitor such growth.

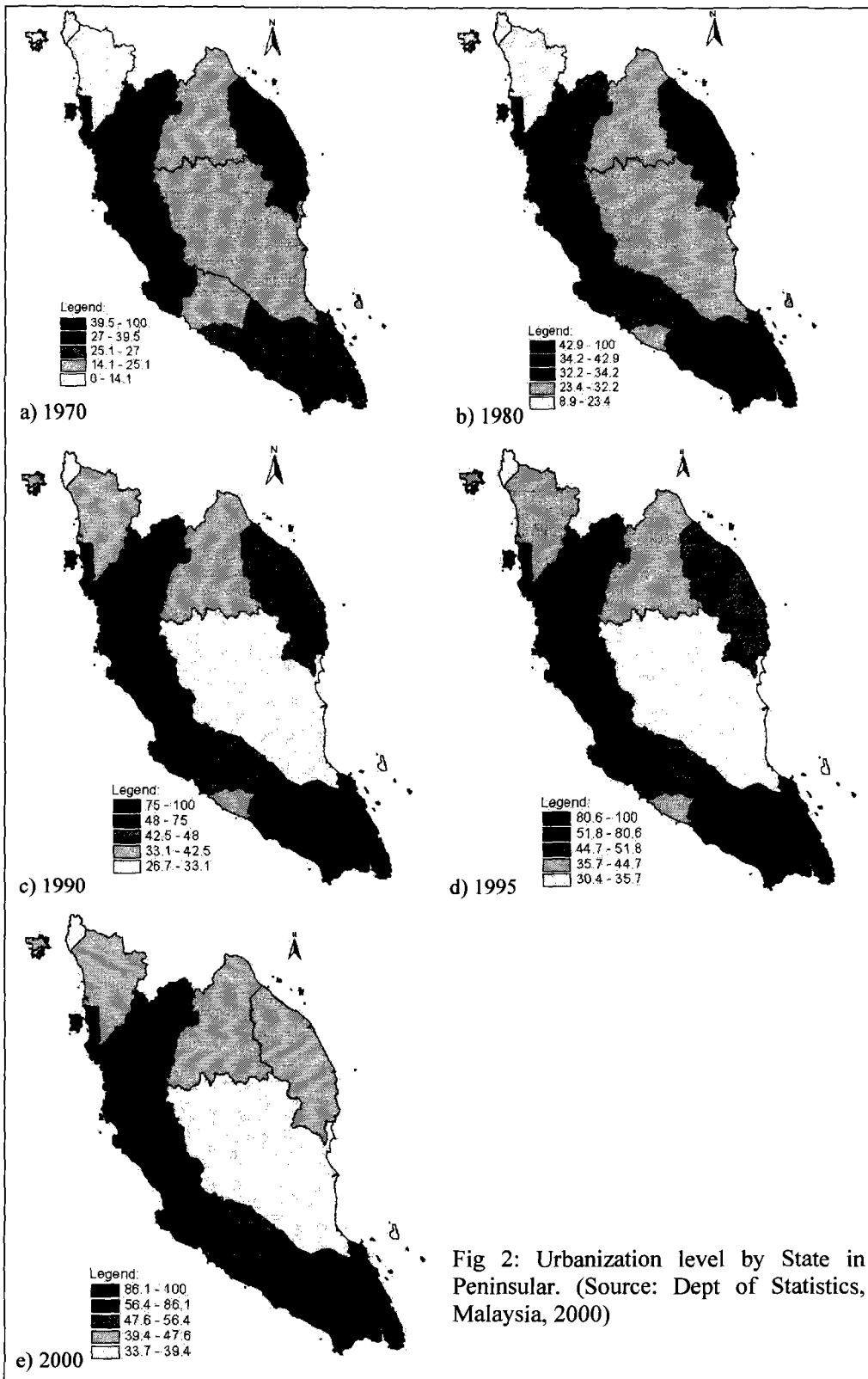


Fig 2: Urbanization level by State in Peninsular. (Source: Dept of Statistics, Malaysia, 2000)

3. The Role of Planning Authorities in Planning and Monitoring Urban Land Use in Malaysia

Urban planning in Malaysia started in 1929, where significant contribution was made by Charles Reade, a planner who was entrusted to remedy haphazard development of Kuala Lumpur (Shamsudin, 2005). After that various planning acts were introduced to control and plan urban development. However, those acts were adopted and used at specific towns in Malaysia (Lee, Abdullah and Rahim, 1990). It was not until 1976, when the Town and Country Act were enacted. This Act imposes a requirement for each Local Authority to be guided by the Structure Plan, comprehensive long-term planning guideline for entire area under Local Authority jurisdiction and Local Plan, short-term plan for specific area within Local Authority jurisdiction (Law of Malaysia, 1998). This planning act was heavily criticized as a replica of the British Town and Country Planning Act 1968 (England and Wales) (Goh, 1990). It is, however, more comprehensive in scope and covering not only planning at local (lowest) level but encompassed Regional and National Spatial Plan (Lee, Abdullah and Rahim, 1990). On the other hand, not much emphasis was given on the need of Malaysian political and administrative structure. The reason for the adoption of such plan, however, has not been explored in detailed (Goh, 1990).

Urban planning and monitoring is the responsibility of Town and County Planning Department (JPBD), which is established to plan, monitor and forecast the use and development of land for the whole county (JPBD, 2006). JPBD also involves in research and development (R&D) in order to manage and plan development effectively. This department becomes a think tank for planning and monitoring urban development in Malaysia. Under this department, Geotechnical Spatial Analysis Research and Development (GSARD), for example, was established to accomplish goals of JPBD, which focus primarily on planning and post-planning practices for various sectors of urban and regional planning processes. This unit is responsible for evaluating and testing the used of new techniques and approach in planning land use development. For example, the department is responsible for testing and implementing Geoinformation Technologies (GIT) for plan generation, plan evaluation, sensitivity analysis, spatial decision support systems (SDSS) and similar systems and analytical tools having spatial or geographical dimensions. Thus, GIS and remote sensing have become important planning tools in managing, updating and mapping land use information (Stillwell et al., 1999; Samat, 2002; Yaakup et al., 2005)

GIS started to play important role in urban planning in Malaysia. In addition, professional and semi-professional staffs also undertake training in various spatial analysis tools

such as multicriteria evaluation techniques, location allocation analysis, land suitability analysis, transport impact analysis, carrying capacity analysis, hazard/risk analysis, SDSS and remote sensing. The aim of GSARD is to apply GIS and decision-making software for structure and local planning studies, relate to plan generation and evaluation purpose. Software currently used include ArcGIS, ILWIS, and DEFINITE for decision making operation (JPBD, 2006). These trainings were conducted locally by the department herself, local universities such as Universiti Sains Malaysia (recently run a course on Using ArcGIS for a group of personnel from Project Office, Department of Town and Country Planning, Northern Region) or Universiti Teknologi Malaysia, private agencies, or internationally such as by ITC in the Netherlands.

At present, daily administrative operation such as updating land use data is undertaken using GIS in most planning department. Strategic planning such as evaluating impact of land use allocation or scenario planning, has yet to become a common operation for all planning departments. Integrated effort in the form of small scale pilot project such as “Application of GIS for Klang Valley Region – AGISwkl project” and “Penang GIS – PEGIS” developed with the expertise from local universities are among successful GIS projects in the country.

4. The Role of Local University in Supporting Planning Authority in Planning and Monitoring Urban Land Use in Malaysia

Although urban planning in Malaysia has started since colonial period prior to 1957, when this nation gained independent from the British government, Malaysia’s planning regulation has significantly influenced by the British planning regulation. Many planners, for example, were graduated from the United Kingdom universities (Goh, 1990). Recently, however, local universities started to play more roles in urban land use planning in Malaysia. Professional course in Urban and Regional Planning, for example are offered by Universiti Sains Malaysia (USM), Universiti Teknologi Malaysia (UTM) and International Islamic University (UIA), while semi-professional course are offered by Polytechnics and UiTM. In addition Malaya University and National University of Malaysia also offer non-professional course (Muhamad Ludin, 2005). USM, for example, offers both a Bachelor of Science Degree in Urban and Regional Planning and a Master of Science in Planning. These programs provide enough graduates for planning sector in Malaysia. At these institutions, graduates also acquired GIS skills.

In addition to providing human resource supply for planning agencies in Malaysia, local universities play vital roles in conducting research on GIS and its applications in urban

land use planning (Rainis, 2002). Early GIS applications in urban planning were limited to the use of functions available within off-the-shelf GIS software packages. These functions include reclassification operation, map overlay, neighborhood operations and distance and connectivity operation, which are useful in dealing with urban planning problems such as undertaking land use allocation operation or suitable site selection (Samat, 2002). Nowadays, Geographic Information System (GIS) has been used in a) recording and mapping the distribution of land uses; b) monitoring and updating land use changes; and c) planning and predicting land use changes (Engelen, et al., 1999); Stillwell et al., 1999). In those applications, GIS provides information and becomes a mechanism by which to implement planning functions which involve managing daily administrative planning operations, planning for future growth and evaluating the impact of planning policy on the economy, society and environment (Couclelis, 1991; Samat, 2002).

A research group called Geoinformatic Unit of USM played an important role in developing spatio-temporal model of urban growth for the Penang State of Malaysia. This group focused on enhancing spatial analytical capabilities of GIS by coupling this technology with other models in order to monitor, plan and predict land use changes. Samat (2002), for example, coupled Cellular Automata Approach and GIS in modeling and evaluating the impact of various planning scenarios on urban spatial growth. Later, Samat (2005) used GIS, Agent Based Modelling and Cellular Automata approach in evaluating top-down (the role of decision makers, planners and political influenced on land use allocation) and bottom-up (the role of private developers and markets) planning decision on resulted urban spatial growth. Other applications include Samat (1995), Samat and Rainis (2001), Faris and Rainis (2001) that coupled GIS and statistical analysis techniques such as discriminant analysis in predicting residential and commercial land development. Such applications are still at experimental stages, since most of urban planning applications are conducted on ad-hoc manner on the basis of a Structure Plan or Local Plan and small numbers of planners or urban managers (Goh, 1991). In addition, USM also involved in developing GIS application for Penang State called Penang GIS – PEGIS. This application is among the most successful GIS application in Malaysia. This GIS centre now plays a major role in providing information for Penang State Economic Planning Unit.

A research group called GIS and Planning Unit of UTM also is actively involved in promoting GIS applications in urban planning in Malaysia. This centre, for example, had involved in various research projects concentrating on building planning support systems

such as “Application of GIS for Klang Valley Region – AGISwlk project” (Yaakup et al., 2005). In this project, a similar approach as undertaken by Klostermann (1999) was adopted, where a “what-if” model was used. This research centre also is involved in developing a planning monitoring system for Negeri Sembilan State called GIS9 (Hamdan et al., 2005). This system is intended to be used in complement with existing Structure Plan, and act as a system to monitor manual document of the Structure Plan. The success of this system has yet to be seen, since it is still at a developmental stage.

5. The Prospects and Challenges of Using GIS in Planning and Monitoring Urban Land Use in Malaysia

GIS has become a useful planning tool in urban land use planning in Malaysia. As discussed above local universities play vital role in this matter. This scenario creates two levels of users, that is local universities as an application developer and Planning Authorities as a user of such application. Although this is probably a positive sign for GIS development in Malaysia, it creates a user who is dependent on an application developer to come up with ideas or solution to urban planning problem. There is a prospect of using GIS in land use planning, however, three challenges needs to be overcome such as data, personnel, and organization.

Data and its availability in digital format is very important in evaluating urban land use problem (Verburg and Veldkamp, 2003). Data has to be updated, come from reliable source and available at suitable scale. In Malaysia, very few useful digital datasets is available for such application. Malaysia’s government effort to establish Malaysian Geospatial Data Infrastructure (MyGDI) hopefully help to solve this problem. The intention was to become data provider for the nations (Samat, 2005). This agency is hoped to reduce the burden of data input for many GIS project in the near future. At the state level, Penang GIS (PEGIS) for example, has an established digital data for Penang State, however, at present the cost of acquiring digital data from this centre is quite high. Other issue related to data is spatial and temporal scale. Data must be available at different time period and should be transformed to uniform spatial scale. It is quite problematic to build such datasets since not many agencies keep record of historical land use data (Samat, 2002).

Other issue in using GIS in urban planning is personnel who might be responsible for using GIS for updating land use map and evaluating strategic plan. At present land use allocation is conducted in ad-hoc subjective fashion often on the basis of knowledge and experience of a small group of senior planners and suggestion made by private consultant (Goh, 1991). On the

other hand, management of spatial data using GIS is handled by technical staffs. Thus, in many cases GIS has only been used in presenting maps or updating land use information (Lee and Tan, 2001). In order to use spatial model in urban planning, planners have to understand and be able to use GIS and translate planning ideas towards a modeling framework. Other problem that is related to personnel is transferred of staffs between department at state and national level (Rainis, 2002). Thus, GIS project is difficult to sustain once the responsible staff move to other place.

Finally, other challenge is using land use model is organization. The implementation of new technology such as in developing a GIS unit requires support from various levels especially top management within the organization. Continuous support from top management ensures sufficient funding or enough resources being allocated toward such project. In many organizations, implementation of GIS failed due to lack of organizational support. In Malaysia, for example, such problem might be overcome. The adoption of National Spatial Plan, as mention above, a strategic plan for the whole nation, requires automated planning tool to manage and monitor land use development. It is imperative that GIS should play more role in managing, monitoring and planning land use development in Malaysia.

6. Conclusion

Current population projection and related planning policies suggest that Malaysia will experience rapid urbanization at least until 2020. At present, however, land use allocation is still being conducted in rather ad-hoc manner, often on the basis of knowledge of a few decision makers and local planners. Various effort by local universities either working jointly with JPBD or independently to conduct research or develop planning support systems using GIT. Although the adoption of GIS at all level of land use planning is quite slow, the development of National Physical Plan, for example, is seen will spurt the use of GIS in urban land use planning in Malaysia.

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