Urban Ecosystem Studies in Malaysia

A study of change

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Cover photo: A view of the Kuala Lumpur city centre, the largest and most developed urban area in Malaysia. Photo courtesy of Professor Morshidi Sirat and Abdul Aziz Majid, Geography Section, School of Humanities, Universiti Sains Malaysia, Penang

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Preface

The book, '*Urban Ecosystem Studies In Malaysia-A study of change'* is the first publication from the Malaysian Research Group (MRG), a voluntary research-networking group for Malaysian researchers based in Manchester, United Kingdom. The group was established in August 2001 after a series of discussions between Malaysian researchers in Manchester and H.E. the High Commissioner of Malaysia to the United Kingdom and Eire, TYT Dato' Salim Hashim; the Director of Science, Ministry of Science, Technology and Environment, Dr. Mustaza Ahmadun; and the Director of Malaysian Student Department, Dr. Kamarudin Mohd Nor concerning the roles of Malaysian researchers in this country.

This book examines issues between natural environment and urban ecosystem in Malaysia. The interface between urban geography and environmental studies is a very interesting one as it links the interrelationship between environment and development processes. Urban related issues such as land use, planning, urban governance, hazard, environmental degradation and planning support system are among the topics discussed by the authors of this book through a multi-discipline approach. This book highlights latest research and studies cases and then discusses them based on Malaysian experiences.

We wish to thank not only the authors, but also the main figure behind the setting up of the MRG organisation, Mr. Amran Muhammad who have given the permission to publish this book in association with the research group and to the Malaysian Community of Cheetham Hill (MCCH), that indirectly involved in the making of this book.

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1 FRAMEWORKS FOR INTERACTION IN URBAN ECOSYSTEMS STUDIES

NOORAZUAN MD HASHIM & RUSLAN RAINIS

INTRODUCTION

This book discusses the interaction between natural environment and urban ecosystem issues in Malaysia. The main concern is with the pace of urbanisation in Malaysia and how it affects the physical landscape and the processes acting within it. This is inline with the recent global interest in urban ecosystems. An urban area contains a population that is not involved directly in the primary production such as agriculture or animal livestock. The conversion of natural or agricultural landscapes into highly modified urban landscapes throughout the world is expected to continue and many urbanised areas are expected to become even more highly modified (Alig and Healy, 1987). In the past most urban studies have focussed on socio-economic aspects of cities without much consideration on the impact cities have on the natural environment. Similarly most ecological studies have focussed on the natural/rural environment without much consideration on the human or social aspects. However there is increasing recognition in recent years of the importance of research on urban ecosystems, in part due to increased interest in creating and maintaining cities and regions that are ecologically sustainable (Nilon, Berkowitz & Hollweg, 1999).

There is increasing need to look at cities as an ecosystem that includes people among the living things, and the structures they build among the nonliving things. In an urban ecosystem, humans influence ecological factors (plants, air, soil, animals) and human decisions (where to build houses, parks, highways, schools) are influenced by ecological factors. Looking at cities as sustainable ecosystems draws its inspiration from the cyclical ecosystems of nature itself (UNEP, no date). It is both possible to define the city as one single ecosystem or to see the city as composed of several individual ecosystems e.g. parks and lakes (Rebele, 1994). Urban ecosystems are highly dynamics and in constant evolution. In order to take control of the vital links between human actions and environmental quality, people need to understand how cities work as ecological systems. They require information on urban ecosystem to help better understand the future changes likely to occur in the city, forest and agricultural systems (Nilon, Berkowitz & Hollweg, 1999).

Most of the urban areas in Malaysia were located in nearby lowlands or downstream of main rivers (Table 1.1). According to Khoo & Kate (1996), usually the areas that have more than 10,000 city dwellers can be considered as urban. The overall urban population in Peninsular Malaysia is about 52 per cent in 1991. However according to Samad Hadi (2000), the total urban population has increased nearly to 60 per cent in the year 2000. The industrial states in Peninsular of Malaysia such as Selangor, Kuala Lumpur Federal Territory and Penang emerged to be the most urbanised states and have achieved the urbanisation level of developed countries.

Table 1.1: The main urban cores within downstream of rivers in Malaysia

Urban Cores	***Main Rivers***	Urban Population (1990)
Kuala Lumpur	Kelang	919600
Ipoh	Kinta	293849
Georgetown	Pinang	248241
Johor Bahru	Johor	246395
Kelang	Kelang	192080
K.Terengganu	Terengganu	180296
Kota Bharu	Kelantan	167872
Kuantan	Kuantan	131547

Source: Mohd Ekhwan (2000)

As far as the urbanisation is concerned, the government's priority is to provide adequate shelter, improvement of service facilities for waste disposal, sewage treatment, sanitation, water supply and energy and transport for the population especially in urban areas. Malaysia has formulated a policy regarding the urban issues to ensure more organized urbanization process and well-integrated rural-urban development linkages. The Sixth Malaysia Plan has provided improvement of main urban services to promote 'sustainable development' principles in urban management. Efforts to balance between economic growth and environmental considerations also were discussed in the plan.

The Malaysian government are in their efforts to enhance inter-agency coordination and cross-sectoral integration and institutional capacity building towards achieving their goals in the Vision 2020 i.e. to be a developed nation status by the year 2020. The vision is not only to cover economic sense, but also focuses on social justice, political stability, system of government, quality of life, social and spiritual values, national pride and confidence (Mahathir, 1991).

Urbanization and industrialization have changed markedly the natural landscape and socio-economic profiles of Malaysia. Urbanization also changes the basic ecological mechanism in natural environmental systems. As such, several river basins in Malaysia are now considered as '*dead ecosystem*' as intense pressures from the urban, industrial, and infrastructural developments within the basins are exerted. The model (Figure 1.1) that is applied on the environment-development interaction is based on the Agenda 21, a blueprint developed during the Earth Summit in Rio (1992). The urban sprawl i.e. the expansion of urban areas into surrounding rural areas is common in Malaysia within the last two decades especially in the West Coast of the Peninsular. Such pressures have caused significant consequences on the environment, such as hydrological and ecological changes.

The urban and urbanising landscape is a complex mosaic of human modification and built structure (Zipperer et al., 2000). It is also a mosaic of biological and physical patches within a matrix of infrastructure, social institutions, cycles and order. Pickett et al. (1997) suggested that two ecological approaches are needed to understand the dynamics of urban and urbanising ecosystems: the classical ecosystem approach and a patch dynamic approach. The ecosystem approach focuses on the magnitude and control of fluxes of energy, matter and species. While the patch dynamic approach focuses on the creation of the spatial heterogeneity within landscapes and that heterogeneity influences the flow of energy, matter, species and information across the landscape (Zipperer et al., 2000). To account for human influence on the urban landscape, the basic concept of the ecosystem must also incorporate a human component that recognizes the major rank hierarchies that operate in human societies such as wealth, education, status, property, and power. Like other countries in the region, Malaysia is striving to upgrade its urban socio-economic status as well as elevating problems arising from the interaction between the environment and development.

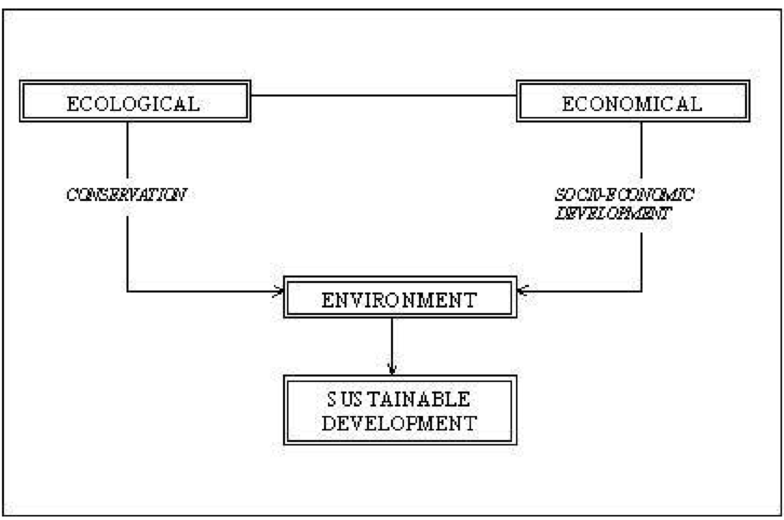

Figure 1.1: Environment and development interaction

This book is divided into 17 chapters according to spheres of urban activity and types of geographical and environmental issues within it. Urban related issues such as land use, planning, governance and environmental degradation are among the topics discussed by the authors through a multi-discipline approach. In each chapter, the present scenario is reviewed and a study case is then discussed based on Malaysian experiences. The first few chapters deal with latest scenario of urban land use modelling, urban governance and urban sustainability efforts done through sustainable development programmes starting from the early nineties especially in the metropolitan areas.

Urban management systems are vital when dealing with urban geography. Some researchers outlined their on-going research in the United Kingdom, for instance the geo-referencing of the urban areas using Geographic Information Systems and remote sensing. Urban rivers are dynamic environment and problematic issues as the urban rivers are located at the outflow of main rivers in Malaysia. There are several chapters in this book deal with the impact of urbanisation on the river basin properties such as the imperviousness and the latest efforts in water quality and landslides modelling in Langat River Basin, one of the most developed river basins in Malaysia. As a conclusion for these papers, some of the results are summarised and a discussion on the frontiers of urban ecosystem is included in the last chapter.

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2 METHODOLOGIES IN URBAN LAND USE MODELLING IN MALAYSIA: CURRENT STATUS, PROSPECTS AND CHALLENGES

RUSLAN RAINIS & NORESAH MOHD SHARIFF

INTRODUCTION

Urban land use planning is complex and future-oriented. For this reason, urban planners have been using various planning models to help them understand the relationship between different elements of the urban system, the dynamics of urban development and as a basis for improving urban development theory. Model is a representation of the real world that can be used to explain existing situation and simulate future condition. Urban planners have been using computer models since the early 1960s when computers became available for public use. Numerous planning models were developed since then. However, it is not until recently that planning models become more commonly used. The recent development of computer technology such as geographical information system (GIS) has created new opportunities for model development and use. GIS for instance, has provided various capabilities for input, management, analysis and display of spatially referenced data. It provides a framework for integrating spatial and non-spatial from different format, sources and time periods. More importantly GIS provides special capabilities for spatial analysis. With these capabilities, it is relatively easier to generate and incorporate various spatial variables in urban land use modelling.

Many researchers and agencies have taken advantage of these advances and developed more comprehensive models especially in the developed countries such as United Kingdom and United

States of America. These include the works of Landis (1994), Landis and Zhang (1998), Batty & Xie (1994), O'Sullivan & Torrens (2001), Klosterman (1999), Itami (1994), Lim and Gar-on Yeh (1998), White and Engelen (1994) and Waddell (forthcoming) – to mention a few. A more comprehensive review of existing urban land use models can be found in Wegener (1994) and U.S.EPA(2000). Unfortunately in Malaysia, the use and development of urban land use models are still limited and need to be improved in the near future.

The purpose of this chapter is to review some of the development in urban land use modelling in Malaysia, their prospects and challenges. It is hoped that it will provide useful insight into what exist and the future research needs in order to make urban land use modelling more acceptable and becomes norm in the planning practices in the country.

RECENT DEVELOPMENT IN URBAN LAND USE MODELLING IN MALAYSIA

To date there have been little efforts in urban land use modeling in Malaysia, This might be due to the lack of need for such efforts. Eventhough the Town and Country Planning Act requires that local authorities formulate development plan (either structure or local plan) for their jurisdictions, most of the planning studies to formulate the plan were outsourced to external professional consultants and there is no requirement to use any kind of land use modeling. It is not until recently that the guidelines for preparing structure and local plan explicitly specify the needs for consultants to use GIS and quantitative techniques in preparing the planning studies (Ruslan et. al., 2002). Nevertheless, several researchers have attempted to develop a number of urban land use models. These include Sung Yong (1995), Narimah and Ruslan (1994); Ruslan and Narimah (1996), Ruslan and Noresah (2000), Ruslan *et al*. (2001) and Faris & Ruslan (2001). The models can basically be grouped into single land use or multiple land use models.

Models of single land use

Sung Yong (1995); Ruslan & Narimah (1996) and Narimah & Ruslan (2001) have developed several single land use models. Sung Yong (1995) used regression analysis to develop several models that predict the relationship between various urban land uses and population and among urban land uses. The urban land uses studied include residential, commercial, industrial, institution and infrastructure. The study found that there was strong correlation between land uses and population, as well as among land uses. These models are aspatial in nature as they only predict the amount of land use required and the factors affecting such needs, but not their location. Ruslan and Narimah (1996) used discriminant analysis to develop residential land use development model. The model was developed using land use changes and associated data for 1974 and 1982 for a small area in Butterworth and evaluated using data for 1982 to 1990. Using areas that were not developed in 1974 as the base, the study classifies the study area into 2 groups: those that were developed in 1982 and those that were not. Eleven variables were used to distinguish between areas that were developed for residential use and those that were left undeveloped. The factors identified as significant in discriminating areas developed for residential and other areas include proximity to commercial centers, proximity to employment centers, proximity to schools, proximity to clinics, proximity to hospitals, proximity to development area, proximity to major roads, scrubs, wetlands, rubber areas and mixed horticulture. The original model developed based on 1974-1982 data was able to predict 84% of the overall development but only 57% for residential development. When tested using 1982-1990 data, the model was able to accurately discriminate 72% of the overall development and 69% of the residential development.

Using the same dataset, Narimah and Ruslan (2001) improved and expanded the earlier model by adding one additional development group i.e. other development areas. Instead of two groups, the new model attempted to discriminate three groups: non-developed areas, residential development areas, and other development areas. In addition, the new model also incorporated two additional explanatory variables proximity to urban centres and index of neighborhood development. The index of neighborhood development represents the proportion of adjacent land parcels that were developed and is an indication of development pressure. Theoretically, land surrounded by development is more likely to be developed as compared to those further away (Kaiser, Godschalk and Chapin, 1999). The overall accuracy of the original model derived from the discriminant analysis was only 74%. However the individual accuracy for residential and other development areas was relatively high, 93% and 81% respectively. Variables that are important in discriminating group 2 - residential development, were proximity to commercial centres, proximity to urban centres, horticulture areas, wetlands and index of neighborhood development. Factors influencing group 1 (non-developed areas) include proximity to hospital, proximity to major roads and proximity to developed areas. Group 3 (other development), on the other hand, was influenced by rubber, proximity to employment centres, proximity to hospital, proximity to clinics, proximity to schools and proximity to major roads. In support of the theory, this study also found that index of neighborhood development is the most important variable in discriminating non-developed with developed areas as well as between residential and other types of development. The model was calibrated using the 1982 data, and accurately predicted about 66% of the 1982-1990 development.

Using the same modeling framework, Faris & Ruslan (2001) recently developed a spatial model of commercial land use development for Seberang Prai Tengah, Penang. The study area was divided into 3 groups: areas remain undeveloped (Group 1), areas developed for commercial development (Group 2), and areas developed for other development (Group 3). Eleven factors were identified to influence commercial land use development i.e. proximity to urban centers, proximity to commercial areas, proximity to primary roads, proximity secondary roads, proximity to industrial areas, proximity to residential areas, proximity to agricultural areas, proportion of developed neighbours, percentage of neighbours developed for commercial, percentage of neighbours developed for residential, and percentage of neighbours developed for industrial land use. The overall accuracy of the original model was 74.9 percent, and the accuracy for the individual group was 87.0%, 58.9 % and 63.7% respectively. The model accuracy for commercial development was quite low, and it was found the model greatly confused other development with commercial development. This is not surprising as some of the areas might have been developed as mixed uses and share most of variables influencing such development. The model might need to be improved further by including other relevant factors and more sample data.

Apart from the above models, the same authors have also developed general models or urban growth using different modeling approaches such as logistic regression and cellular automata (Ruslan & Noresah, 2000 and Ruslan & Noresah, 2002). In addition, there is also another major effort to model land use/cover change (LUCC) in Malaysia by a team in Universiti Kebangsaan Malaysia headed by Professor Sharifah Mastura as part of the Global LUCC programs (START, 2001). However the major focus of the research is on land use/cover changes at the broad level of categories especially forest. The research attempted to model the relationship between changes in LUCC with various driving forces especially socio-economic variables. Specifically five driving forces were taken into account. Using regression analysis the research attempted to relate the driving forces to six different kind of LUCC – changes in forest, changes in agricultural land, changes in settlement, changes in bareland, changes in grassland and changes in water bodies. Of these changes, only changes in forest land model was significant at 0.1 level, and the independent variables that were significant at 0.1 level were percentage labor force in agriculture, road density and population growth.

Single land use models are relatively easier to develop but have limited use in a complex urban environment. Most urban areas comprise of more than 1 land use, or at least three major land uses of residential, commercial and industrial. For this reason, multiple land use models are important to the actual practices especially in preparing structure or local plan.

Models of multiple land uses

There have been several attempts in this direction (Universiti Sains Malaysia, 1994; Ruslan & Noresah, 2001a; Ruslan et.al., 2000; Ruslan & Noresah, 2001b; Ruslan and Noresah, 2002; Ruslan etc., 2002). The first major attempt to use GIS and develop a statewide urban land use model for generating land use plan in Malaysia was probably carried out during the Penang Land Use Potential Study as part of the Penang GIS (PeGIS) pilot project. The study lasted for a period of 2 years starting August 1992 comprises of four major components: land use (the core), demography, economic and natural environment. The land use model was developed by Ruslan (Ruslan, 1994), and comprises of two basic components: supply and demand. The supply component deals with land available and suitable for development. This was modeled using multi-criteria land use suitability analysis. The demand component deals with land requirement for each major urban land uses i.e. industrial, commercial and residential. The major inputs to the demand side are the population and economic (employment) data that were modeled exogenously in the demography and economic sectors. Based upon this information, the land use model then try to allocate the various urban land use types (demand) to the available/suitable land (supply). This involves a two steps process: allocating the state demand to the planning analysis zone and allocating the demand to specific locations in each zone. The first step is carried out using development potential model (Kaiser, Godschalk and Chapin, 1999) where each zone is allocated the state demand based on its potential to accommodate development, which is calculated based on land availability and suitability for development (Ruslan and Noresah, 2001). The second step involves allocating the zone demand to specific locations based on their suitability – the most suitable was allocated first, followed by the second most and so on until all the demand were met. Land uses were allocated sequentially in the following order: industrial, commercial and residential. The output of the process was the projected land use plan for the State of Penang in year 2005.

Based upon the experienced from the PeGIS project, Ruslan headed a team to developed a regional planning support system for

Klang Valley region (KV-RPSS) for the Federal Territory Development and Klang Valley Planning Division (FTDKVPD), Prime Minister Department (Ruslan et. al., 2001). One of the modules is for land use scenario generation. The major components of module are suitability analysis and land use allocation for three major urban land uses: residential, commercial and industrial. A simple urban land use allocation model was used whereby each land use is allocated in sequential manner according to the user priority. For each land use, the most suitable site will be selected first, second most suitable next and so on until the demand for a particular projection year is met. The model was used to generate three land use development scenarios: dispersed (planning as usual), compact and transit-oriented development.

Ruslan and Noresah (2001a) used multicriteria evaluation (MCE) and multi-objective land allocation (MOLA) modules of IDRISI32 for Windows GIS to formulate a land use plan for Seberang Prai area. The study showed that it is now possible to use GIS with ease to develop urban land use plan or scenarios. It is possible to conduct land use allocation iteratively where the result of an iteration (let say year 2000) can be used as input to the subsequent projection year (let say 2005). This is in contrary with normal/existing practice where, due to limited tool, plan generation was only carried out at once for the end of planning horizon (let say 2020). With such capability, numerous land use scenarios from different assumptions can now be developed.

More recently Ruslan & Noresah (2001b) have developed urban land use change model using stochastic approach known as Markov Chain analysis using a module (MARKOV) already existed in IDRISI32 for Windows GIS software. The result was encouraging (about 70% accuracy), but bound to several limitation specific to Markov Chain model. The major one is the fact that Markov model is aspatial in the sense that it does not consider spatial location explicitly in the predicting land use conversion. One way to overcome this shortcoming is to integrate Markov model (MARKOV) and cellular automata (CA) or more commonly known as CA_MARKOV (Eastman, 2001), a research that worth exploring in the near future.

THE PROSPECT OF USING URBAN LAND USE MODELLING IN PLANNING PRACTICE

Except for the work of Ruslan *et al*. (2001), all the others efforts were research/academic exercises that yet to be turned into practice. Ruslan *et al*. (2001) developed a regional planning support system (RPSS) for the Klang Valley region as part of a much larger study in formulating a regional perspective plan for the region. This was perhaps the first major effort to use GIS and land use modeling methodology in formulating development plan as part of the formal planning process in the country. The initiative came directly from the user agency, and clearly shows a promising beginning in the planning practice in the country. Over time, the potential to use any of the modeling methodologies described in preceding section is promising. Some local planning authorities have also shown interest to use similar system for their local plan preparation and monitoring. Local plan is the lowest and most detail development plan in this country. Started with the year 2001, local plan is prepared at the district level, and is based on parcel information. If the system is to respond to this need, then two changes have to be made to the structure of the system. First, it has to be parcel-based and second, the system should be able to accommodate more detail land use categories either in terms of density or types.

Starting 2001, the Federal Town and Country Planning Department requires that all local and structure plan study to use and develop a GIS, and explicitly document the models or methodologies use in each study (FTCPD, 2001a and FTCPD, 2001b). With such requirement, it is expected that all local and structure plan will be accompanied with a GIS digital database of the study, which will then be delivered to the relevant local planning authorities for implementation and maintenance. It is hoped that these efforts will eventually develop a comprehensive and seamless spatial database of all planning authorities providing tremendous opportunity for various land use modeling efforts in the future. Apart from the above initiative, FTCPD has also recently embarked on a number of major projects such as the preparation of the National Spatial Plan and the digitization of all previous local and structure plans.

The advances in spatial data handling and modeling technologies as well as the availability of digital database in recent years have opened up opportunities for the development of new models or modeling framework such cellular automata and multi-agent system. Cellular automaton (CA) is becoming a popular modelling approach in urban modelling as well as various other fields (Coulelis, 1987; Itami, 1988; O'Sullivan & Torrens, 2000; Torrens, 2000). This cell-space modeling approach has actually been used dating back to the 1960s such as that developed for Greensboro, North Carolina by Chapin and Weiss (1968) (but the term cellular automaton was probably not yet well-known at that time). A CA is composed of four principle elements: a lattice, a set of allowed states, neighborhoods defined by the lattice, and transition rules. In addition we might consider a fifth, temporal component (Torrens, 2000; Torrens and O'Sullivan, 2001). In land use modelling, the model basically attempts to simulate the dynamic of land use development. The land use evolves from a few cells to a complex urban development. The potential of an area for new land use development is influenced or controlled by a set of transition rules. These rules comprise of factors that hinder or encourage new development to occur from time t to $t+m$. Therefore, the major component of the model is the formulation of a function for the transition rules. The function can be generated by various methods such as heuristic (rule of thumb) or statistical approaches such as discriminant analysis (Ruslan and Narimah, 1996; Faris and Ruslan, 2001), multi-logit (Landis and Zhang, 1998) or other stochastic methods (Almeida et. al., 2002). Transition rules have also been modified and expanded to include notions such as hierarchy, self-modification, utility maximization, accessibility measures, exogenous link and inertia (Torrens & O'Sullivan, 2001).

Cellular automata (CA) have many advantages for modeling urban phenomena, including their decentralized approach, the link they provide to complexity theory, the connection of form with function and pattern with process, the relative ease with which model results can be visualized, their flexibility, their dynamic approach, and also their affinities with geographic information systems and remotely sensed data (Torrens, 2000). CA offer a framework for the exploration of complex adapative systems by mimicking how macroscale global urban structures may emerge from the myriad interactions of simple self-organised local elements. For this reason, CA have been widely applied as a tool for the simulation of space-time dynamics of relatively autonomous spatial systems, like urban systems emerging in a spatial environment (Batty and Xie, 1994; Coucelis, 1989; Itami, 1994; Lim and Gar-On Yeh, 1998; White and Engelen, 1997). The discrete event simulation theory of CA has been relaxed to widens it applicability to also describe non-autonomous spatial processes (Coucelis, 1985; Zeigler, 1976). Such relaxed CA can also be applied in multi-model approaches, like the constrained CA approach (Engelen et al., 1997) or the integration of CA with GIS, multi-criteria analysis (MCA) and analytical hierarchy process (AHP) (Lim and Gar-On Yeh, 1998; Wu, 1998). In Malaysia some forms of cellular-based urban land use models have been developed (Ruslan & Noresah, 2001), but they have not been rigorously tested nor validated. With sufficient funding, data availability and interest from the relevant agencies, further research on this direction can be further enhanced.

Eventhough CA have been widely used, they have several major weaknesses. CA models are constrained by their simplicity, and their ability to represent real-world phenomena is often diluted by their abstract characteristics (Torrens & O'Sullivan, 2001). The assumption of self-organisation in a spatial context means that CA can only be applied to explicit spatial systems that respond to rules, cells and neighbourhoods that are stationary in space and time (Ligtenberg et al., 2001). Eventhough the states, rules and neighborhoods do not necessarily need to be stationary (Coucelis, 1985), but CA themselves do not provide methods to assign dynamic characteristics to the states, rules and neighborhoods. For this reason CA are therefore limited in their use for modeling the human factor in a spatial decision making process. Various researchers such as Deadman (1999) and Openshaw (1995) have emphasized the importance of integrating human system modeling