REVIEW ON METHODOLOGY OF MODELING GREEN SPACE NETWORK IN URBAN LANDSCAPE PLANNING

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ABSTRACT

The development of urban green space networks includes creation of new spatial forms, restoration and maintenance of green patches connectivity as well as protection of existing green spaces. Green space network begins to be recognized as a medium of conserving ecosystem and natural environment in urban area. Several methods have been introduced in regards to formulation of modeling urban green space network. This research paper reviews several methods that are used for modeling green space network in urban planning. Recently, remote sensing and geographic information system (GIS) are being used to produce a model of urban green space network which positively afford nature conservation in city. A study upon various methods of modeling urban green space network which include remote sensing, GIS application through land suitability analysis (LSA) and least-cost path analysis, graph theory and gravity model are initially reviewed to give some understanding to be used for future planning.

1. INTRODUCTION

Urban green spaces play a vital role in improving urban community's life quality in which it contribute to public health as well as urban environment. Green space is an important part of complex urban ecosystems that give environmental, esthetic, recreational and economical benefits to the urban dwellers (Li et al., 2005). Meanwhile, urban green spaces can be defined in many ways depending on their demands and specific requirements. According to Jim and Chen (2003), urban green spaces can be defined as outdoor places contain with varied vegetation species and exist mainly as semi-natural area which accessible for public. Urban green space connectivity offers habitats and corridors which mainly led to the contribution of nature conservation. However, the urbanization has increasingly threatens biodiversity and consequently made loss and isolation of habitats (Kong et al, 2010).

Since the early 1960s, numerous planning models have been developed using computer technology and recently, the application of GIS has created opportunities in developing models (Noorazuan et al, 2003). Additionally according to Rusli and Ludin (2009), the integration of both remote sensing and GIS application in monitoring and managing land uses has widely used in Malaysia. Thus, methods of modeling urban green space network has broadly change time by time and GIS application tend to take good place in development of model of green space network.

2. METHODOLOGY

In respond to the study, literature review was selected based on various aspects of disciplines which include keywords of urban green space network, urban planning and modeling system through landscape metrics, GIS application, remote sensing, graph theory and gravity model. Collective articles and journals were drawn from year 1998 up until recently year of 2011. Initially, the study on modeling urban green space network can be seen as a new paradigm and have yet to be implemented in urban planning and development in Malaysia. In view of that, current methodologies were reviewed to assess changes in landscape and associated approach that suit to the related study of modeling urban green space network. Besides, a

greater emphasis was placed on literature that addressed research concern and trend in modeling landscape network. The aspects taken into consideration were based on the most effective modeling approach that benefits the urban green space networking.

3. RESULTS AND DISCUSSIONS

The previous studies on landscape network modeling shows that there are at least 3 types of network modeling in landscape planning. From the literature review as summarized in table 1, it shows that ecological network has been studied and concerned more compared to the other two. Its focus is also more functional than others. while for urban green space network modeling, it has less in research concern and not very functional as compared to the ecological network. Accordingly, there should be a potential in developing urban green space network modeling as there are some researchers who has made an attempt in conducting research in this studies. Therefore, the previous research can be the benchmark in developing the urban green space network model.

Table 1 A Summary of literature review on research concern and trend in modeling landscape network.

Network Classification	Authors	Research Concern	Focus
Multipurpose Greenway Planning	Miller et al. (1998), Bahari & Said (2010), Teng et al. (2011)	**Less**	**Structure**
Urban Green Space Network	Jim & Chen (2003), Li et al. (2005), Uy & Nakagoshi (2008), Kong et al. (2010)		
Ecological Network	Bunn et al. (2000), Bryant (2006), Chetkiewicz et al. (2006), Zhang & Wang (2006), Bodin (2009), Gurrutxaga et al. (2010)	**More**	**Function**

Table 2 shows an analytical comparison between five journals which is related to the landscape modeling development for nature conservation. It is found that all five journals seems to used application such as ground survey, remote sensing, GIS, landscape matrices analysis and graph theory and gravity model. Most of the researcher use GIS application in the landscape modeling and integrate other application like ground survey, remote sensing, landscape metric analysis and graph theory & gravity model as supported tools. The assessment of methodology used in modeling urban green space network produces a rough understanding what systems are currently applied.

Table 2 A Summary of literature review on modeling approach in landscape network modeling.

Author	Borre et al (2011)	Kong et al (2010)	Gurrutxaga et al (2010)	Wiens et al (2009)	Taylor et al (2007)
Methodology:					
Ground Survey	X			X	
Remote sensing	X			X	X
GIS	X	X	X	X	X
Landscape Metric Analysis		X			X
Graph Theory & Gravity Model		X			

Table 3 A Summary of literature review on different modeling approaches.

Modeling Tools / Method	Information provided	Data Inputs	Model Assumption	Focus
Landscape Metric Analysis	Less	Less	Implicit	Structure
Graph Theory & Gravity Model				
GIS	More	More	Explicit	Function

Table 3 shows that different modeling approaches require different information and data. Hence, it provide different model assumption and level of focus. The less data we need, the fewer model assumption can be made and the focus become very structural compared to other modeling tools that require more data inputs.

3.1 Remote Sensing – Acquiring synoptic data on habitats

Limited awareness of environmental remote sensing's potential ability to support environmental policy development constrains the technology's utilization. However, remote sensing application is increasingly being accepted by many urban planners as it can help in acquiring accurate image data. Remote sensing is the technique of deriving information about objects on the surface of the earth without physically coming into contact with them.

According to Borre et al (2011), remote sensing is a powerful tool that can acquire synoptic data on habitats as it offers advantages including faster map production, insight

into inaccessible terrain as well as increased repeatability of the mapping process. Additionally, the application of remote sensing has widely used in assessing flood regimes and identifying key area of flood plain forests and their context for conservation planning (Wiens, 2009), and currently used for habitat mapping and reporting (Borre, 2011).

In the past, most conservation planning studies have focused on ground survey and inventory without consideration of new technology approach like remote sensing application for data collections. Such areas for conservation may be large and inaccessible, subject to change and sensitive to surrounding landscape. Additionally, Wiens (2009) has identified that conservation is much more related in ensuring the persistence of biological diversity for protecting areas. Therefore, remote sensing can be seen as a valuable tool that can help in nature conservation planning and eventually this research studies would focus on how remote sensing can be applied for nature conservation planning in urban area.

3.2 GIS Application

Geographic Information System (GIS) is related to the management and spatial data analysis whereby it is mainly used for collecting, storing, analyzing and displaying spatial imaginary data taken by remote sensing (Rusli, 2009).

3.2.1 Land Suitability Analysis (LSA) – Identifying suitable site for developing green space. Identifying suitable sites for conserving and developing green spaces is the first important step to ensure their roles and functions. Thus, in order to identify the most suitable site, land suitability analysis (LSA) can be seen as an appropriate tool to be used. In recent years of 2008, land suitability analysis (LSA) being initially used for urban green space planning. Accordingly, LSA function as an indicator of identifying and evaluating areas with more suitability for green spaces development.

According to Uy (2008), the LSA is supported by spatial analysis functions of GIS application. Jafari (2010) outlined that there must be a wide range of criteria involved in the LSA which firstly name as environmental, followed by social and economic factors. There are four steps involved in the LSA system as shown in figure 1 which includes: spatial data collection, weighting with analytic hierarchy process (AHP), overlapping with GIS analysis and last but not least output evaluation and comparison.

Uy (2008) stated that weighting is a very important process in land suitability identification as it precisely affects the output. Additionally, Jafari (2010) in the International Journal of Environmental Science and Development later mentioned that the analytic hierarchy process can be classified as a powerful tool to identify in detail the most suitable site which then helps for defining effective management plan. From the statements above, it can be concluded that the application of Land Suitability Analysis (LSA) must be integrated with the weighting process to get the appropriate output later.

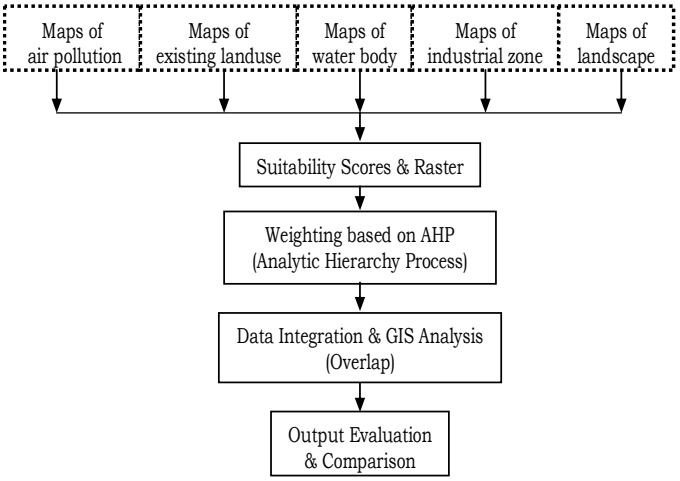

Fig. 1 Flowchart indicating the land suitability analysis (Uy & Nakagoshi, 2008).

3.2.2 Least-Cost Path Analysis – Identifying potential corridors and linkages. Least-Cost Path Analysis allows landscape connectivity to be examined and accordingly it is a method of measuring most effective distance between habitat patches. Two spatial data layers are required in the least-cost modeling which are resistance or friction surface indicating travel cost and source patch layer to which the cumulative travel cost for each cell is measured (Kong, 2010). Accordingly, the Least-Cost Path Analysis has been now enabled by GIS technology which make it easy to be used to indicate and identify corridors in landscape networking planning.

3.3 Graph Theory and Gravity Model – Identifying optimized network and to choose which corridor to develop first

Graph Theory commonly used in the study of mathematics and computer science. It is rarely used in the work scope of landscape and urban planning. According to Urban in 2009, he stated that the concept of graph theory is mostly dealing with problems which related to the connectivity, routing and flow in networks. This shows that Graph Theory is capable enough to be used in the landscape networking planning as it is also called as a network theory. Additionally, the sensitivity of landscape connectivity also can be explored through graph operations concerned with edge definition (Bunn, 2000). After all, the advantage of a graph-theoretic approach over other modeling techniques is that it is a heuristic framework which can be applied with very little data and improved from the initial results. Thus it is easier to apply this approach in identifying optimized network and to choose which corridor to develop first.

CONCLUSION

Different modeling approaches provide different information and require different inputs and assumptions. The result shows that Landscape Metric Analysis require less information and data but of course it is the one which has implicit model assumption. Its focus is more structural compared to the other approaches like GIS and Graph theory and Gravity Modeling. From the literature review, it can be seen that most of the researchers used GIS to produce landscape model. Other tools like Graph Theory and Gravity Modeling only act as supported tools that has the capability in identifying optimized network. As for that, we have proposed potential steps involved in the development of green space network as shown in Fig. 2 to help with modeling system for urban landscape planning. From the results of literature, remote sensing could be proposed to be first step implemented into the planning system as it acquires accurate image data. The following steps could be GIS application which helps in processing the data from remote sensing. Accordingly, graph theory and gravity model could then being integrated to determine interaction between nodes. Thus, the integrated method of application can be assumed as an innovative approach in modeling urban green space network.

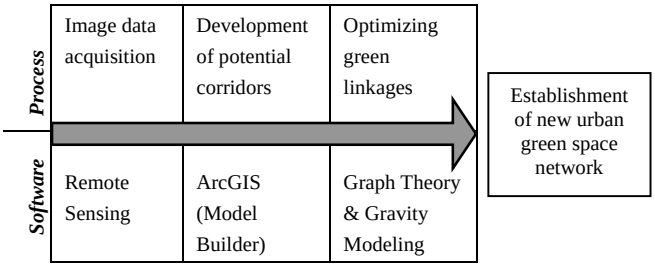

Fig. 2 Software application for modeling green space network.

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