

Chapter 14

Spatiotemporal Pattern Analysis of Rapid Urban Expansion Using GIS and Remote Sensing

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ABSTRACT

Rapidly growing urban areas tend to reveal distinctive spatial and temporal variations of land use/land cover in a locally urbanized environment. In this article, the author analyzes urban growth phenomena at a local scale by employing Geographic Information Systems, remotely sensed image data from 1984, 1994, and 2004, and landscape shape index. Since spatial patterns of land use/land cover changes in small urban areas are not fully examined by the current GIS-based modeling studies or simulation applications, the major objective of this research is to identify and examine the spatial and temporal dynamics of land use changes of urban growth at a local scale. Analytical results demonstrate that sizes, locations, and shapes of new developments are spatio-temporally associated with their landscape variations and major transportation arteries. The key findings from this study contribute to GIS-based urban growth modeling studies and urban planning practices for local communities.

INTRODUCTION

Showing a variety of urban forms, the way in which urban areas in the US expand has changed dramatically since the 1970s (Richter, 1985; Heim, 2001). Since understanding the complex

structure and dynamic process of urban growth is essential in dealing with land development issues, urban growth as a spatial phenomenon has intrigued many researchers in the field of geography. A better appreciation of the nature of growing urban areas supports activities of future development and preparation of better plans and

DOI: 10.4018/978-1-4666-0258-8.ch014

appropriate policies, especially in urban planning and environmental studies.

One way to achieve a better understanding of urban growth is through more realistic simulations or modeling of land use/land cover (LULC) changes. In recent years, urban growth modeling studies have greatly increased, focusing on dynamic urban growth and land use changes in the past decades (Landis & Zhang, 1998; EPA, 2000; Clark, 2003; Lee, 2003; Yang & Lo, 2003; Klosterman & Pettit, 2005; Pontius et al., 2008). With the advance in geographic information systems (GIS) technology, recent studies in the field of geography and urban planning have examined changes of urban forms with an integrated and operational approach in order to understand the processes of urbanization. The computer-supported working environments resulting from these efforts are often referred to as decision support systems (DSS) or planning support systems (PSS). A number of relevant works have contributed to the area of DSS or PSS, producing a large number of articles and review of many land use change models (EPA, 2000; Klosterman & Pettit, 2005). The most frequently cited models are categorized by several dimensions, such as types of input data, spatial resolution, analytical tools, outcome, prediction accuracy, and operability in practice. Each of these modeling studies has its own strength and weakness in terms of these dimensions (EPA, 2000; Klosterman & Pettit, 2005; Pontius et al., 2008).

Most current urban modeling studies, however, have not paid full attention to incorporating spatial and temporal aspects of urban growth into their models. These models tend to focus on sizes, locations, and impacts of urban growth on land use. Therefore, methods for modeling such growth are mostly designed to mechanically simulate and accommodate the magnitude of future land use changes. More importantly, these models focus primarily on urban land developments at regional, national, or global levels and may not be able to effectively identify or predict the geographic characteristics of urban growth phenomena in

small urbanized areas. Consequently, we have only a partial understanding of how urbanization progresses in terms of population movements, rural-to-urban conversions, and decreased inner city areas at the local scale.

Because new land use developments, especially outlying growth in suburban areas, often show distinctive shape patterns that are concerned with urban planning issues, another important aspect of urban growth is the shapes of new development patches (Xie, Yu, & Bai, 2006). For example, urban sprawl tends to show low density, isolated locations, and resource consumptive developments. Moreover, in major metropolitan areas around the country, many strip malls are being developed in suburban areas in the shape of elongated corridors around major transportation arteries. New developments often show diverse shapes, such as compact, low density, elongated, or irregular patterns. For this reason, analysis of shapes of new development clusters in newly developed areas can provide a better understanding of urban growth.

Although a few models examined landscapes of LULC change at a regional scale (Mertens & Lambin, 1997; Luck & Wu, 2002; Xu et al., 2007), no urban growth model explicitly involves any specific landscape perspective. In contrast with these urban land use models, studies on urban landscape patterns can be found in many existing studies of urban ecology that have a major goal of understanding the relationship between the spatial pattern of urbanization and ecological processes (Breuste, Niemelä, & Snep, 2008). In these studies, spatial patterns of urbanization and physical, ecological, and socio-economic processes mutually affect one another.

In analyzing urbanization and its ecological processes, various analytical indices have been developed to measure landscape patterns. These landscape indices have been widely applied to analysis of landscape patterns (McGarigal & Marks, 1995; Luck & Wu, 2002; Xie et al., 2006). These indices have facilitated the quantification of landscape texture, path size, shape, connectivity,

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