Chapter 27
Monitoring Urban Sprawl and Sustainable Urban Development Using the Moran Index:
A Case Study of Stellenbosch, South Africa

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ABSTRACT

The management of urban sprawl is fundamental to achieving sustainable urban development. Monitoring urban sprawl is, however, challenging. This study proposes the use of two spatial statistics, namely global Moran and local Moran to indentify statistically significant urban sprawl hot and cold spots. The findings reveal that the Moran indexes are sensitive to the distance band spatial weight matrices employed and that multiple bands should be used when these indexes are used. The authors demonstrate how the indexes can be used in combination with various visualisation methods to support planning decisions.

INTRODUCTION

Urban sprawl is a fundamental theme in the sustainability debate (Zhao et al., 2011) and literature often equates sprawl with unsustainability (Le Néchet, 2012). However, what is unsustainable about urban sprawl are its wasteful forms, so that future generations can be deprived as a result of dwindling resources used to make way for urban expansion (Gerundo & Grimaldi, 2011). If urban growth is to continue it better be sustainable rather than wasteful (Ewing, 1997; Veneri, 2010). Planners have accordingly adopted the use of geographic information systems (GIS) and earth observation (EO) data to identify wasteful forms of urban sprawl commonly referred to as hot spots (Levine, 1996; Liu, Dong & Chi, 2010). Most GIS packages are able to do this by providing summary statistics such as means, sums and medians. However, such statistics cannot be generalised over various locations making it difficult to compare various urban

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centres. Moreover, visual representations of such results are also known to be misinterpreted (Zhang et al., 2008). What is required are new software and exploratory data analysis techniques that focus on the spatial aspects of the data such as dispersion, concentration and spatial autocorrelation which can be used to capture the impacts of urban sprawl on urban sustainability (Anselin, 1995; Le Néchet, 2012). This provides a scientific basis for improved sustainable land use planning. Similar analyses have been successfully carried out for pollution (Zhang et al., 2008), conflict (Anselin, 1995), disease (Ruiz et al, 2004; Zhang & Lin, 2006) and crime management (Anselin et al., 2000; Lin & Brown, 2006).

Concerning urban sprawl, a search on Science Direct, Scopus and Web of Science databases[1]indicate that Tsai (2005) was the first to apply the global Moran index (Moran I) to distinguish urban sprawl from compactness. Similar studies citing Tsai (2005) ensued, such as Gerundo & Grimaldi (2011), Le Néchet (2012), Sim & Mesev (2011), Zhao et al. (2011) which employed global Moran index (Moran I) and other metrics to distinguish between urban sprawl and compactness in European, American and Asian cities. Moran I has attracted interest from researchers and planners because it is apparently more robust than other metrics (Bhatta, Saraswati & Bandyopadhyay, 2010). To the best knowledge of the authors, no studies exist that have applied the global Moran and local Moran indexes with cluster and outlier analysis to cadastral data to determine sprawl hot spots and cold spots. This study investigates the use of these indexes with GIS software and cadastral data to identify urban sprawl hot spots. Moreover, the impact of various simulations (weights) of the indexes is explored and the practical implementation of this process in policy change and decision making toward sustainable urban development is investigated.

URBAN SPRAWL

The debate on measuring and monitoring urban sprawl continues unabated (Bhatta, Saraswati & Bandyopadhyay, 2010). However, there is consensus that urban sprawl is primarily characterised by three attributes, namely leapfrog and scattered development, commercial strip development and large expanses of low-density or single-use development (Frenkel & Ashkenazi, 2008; Sayas, 2006; Sims & Mesev, 2011; Tsai, 2005). Leapfrog development, strip and low-density development do not necessarily equate to unsustainable urban development. Consequently, it is a matter of degree and the impact of the development that make various types of urban sprawl unsustainable (Ewing, 1997; Vaz et al., 2012). For example, a housing development may leapfrog a rock outcrop and have a mix of uses which support non-motorised transport (NMT), promote accessibility, reduce vehicle miles travelled (VMT), and encourage social interaction. Such developments are unlikely to be unsustainable forms of urban sprawl (Le Néchet, 2012). It is the quantifiable and related impacts that make development patterns urban sprawl (Ewing, 1997).

The literature identifies poor accessibility as one of the most important indicators of urban sprawl (Cervero, 2002; Irwin & Bockstael, 2007). Accessibility implies that urban development patterns are spatial and that accessibility can be quantified by indicators such as VMT (Le Néchet, 2012). Other urban sprawl indicators include lack of functional open space, visual aesthetics, spatial geometry and densities (Hayek et al., 2011; Schwarz, 2010).

Poor accessibility impacts household travel patterns. Recent studies demonstrate that average trip length and travel time which impact greenhouse gas (GHG) emissions increase with the poor accessibility associated with urban sprawl (Urban Land Institute, 2010). For example, in some low-density single-use developments everything is far apart as a consequence of the separation of land uses leading