Chapter 72
Quantifying Urban Sprawl With Spatial Autocorrelation Techniques Using Multi-Temporal Satellite Data

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ABSTRACT

This study deals with the use of satellite TM multi-temporal data coupled with statistical analyses to quantitatively estimate urban expansion and soil consumption for small towns in southern Italy. The investigated area is close to Bari and was selected because highly representative for Italian urban areas. To cope with the fact that small changes have to be captured and extracted from TM multi-temporal data sets, we adopted the use of spectral indices to emphasize occurring changes, and geospatial data analysis to reveal spatial patterns. Analyses have been carried out using global and local spatial autocorrelation, applied to multi-date NASA Landsat images acquired in 1999 and 2009 and available free of charge. Moreover, in this paper each step of data processing has been carried out using free or open source software tools, such as, operating system (Linux Ubuntu), GIS software (GRASS GIS and Quantum GIS) and software for statistical analysis of data (R). This aspect is very important, since it puts no limits and allows everybody to carry out spatial analyses on remote sensing data. This approach can be very useful to assess and map land cover change and soil degradation, even for small urbanized areas, as in the case of Italy, where recently an increasing number of devastating flash floods have been recorded. These events have been mainly linked to urban expansion and soil consumption and have caused loss of human lives along with enormous damages to urban settlements, bridges, roads, agricultural activities, etc. In these cases, remote sensing can provide reliable operational low cost tools to assess, quantify and map risk areas.

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1. INTRODUCTION

Urbanization and industrialization are the key factors for social and economical development and represent a specific response to economic, demographic and environmental conditions. During the last few decades, in many European regions, abandonment of agricultural land has induced a high concentration of people in densely populated urban areas. This phenomenon has been observed throughout the world. In 1950, only 30% of the world population lived in urban areas. By 2000 that proportion rose up to 47%, and by 2030 the estimated number will be around 60% (United Nations Population Division, 2001).

Such a rapid industrialization and expansion of urban areas has caused strong and sharp land cover changes and significant landscape transformations, which significantly impact local and regional environmental conditions. Nowadays, the increase of people concentration in densely populated urban areas is considered as a pressing issue in developing countries. For example, following land reform initiated in 1987, vast areas of China have been involved in a rapid urban expansion with new urban settlements (Cheng & Masser 2002), so that in a few years, several cities rapidly have become big centres or regional nodes.

The analysis of city size distribution deals with different disciplines such as planning, geography, economy, demography, ecology, physics, statistics, etc., because the evolution of a city is a dynamic process involving a number of different factors. An issue of great importance in modelling urban growth includes spatial and temporal dynamics, scale dynamics, man-induced land use changes. Although urban growth is perceived as necessary for a sustainable economy, uncontrolled or sprawling urban growth can cause various problems, such as loss of open space, landscape alteration, environmental pollution, traffic congestion, infrastructure pressure, and other social and economical issues. To face such drawbacks, a continuous monitoring of urban growth evolution in terms of type and extent of changes over time is essential to support planners and decision makers in future urban planning. In this discipline there is a partially wrong common opinion that soil consumption can be reduced adopting constraints. Constraints cannot be the only way to preserve the environment. In a lot of cases, after several years, it is allowed to partially remove them changing completely the original spatial planning objectives.

Soil is a limited resource which allows biological productivity and exchange of material and energy; often there is confusion between soil and territory. Soil is a sort of thin interface within which great part of the processes that govern life occur. Territory is a wider concept strongly related to government aspects, while soil is mainly associated with safeguard policy.

Since 1998 a program has been developed in Germany, for the reduction of soil consumption. Current Chancellor, Angela Merkel, in that period Minister for the Environment in the government led by Helmut Kohl, approved an ambitious program with the goal of reducing soil consumption from 130 to 30 hectares per day within 2020.

Since 2004 in the United Kingdom, new urbanizations have to be located in brown-field sites and the Density Direction established a mandatory minimum density of 30 dwellings per hectare in new areas of expansion..

In Italy, where eight square meters of soil are consumed every second, several laws have been proposed to the parliament in order to reduce the phenomenon.

All programmes and laws need quantifiable indicators and detailed methods, techniques and procedures for their calculation.

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