Forecasting High Correlation Transition of Agricultural Landscapes into Urban Areas: Diachronic Case Study in North Eastern Italy

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ABSTRACT

One of the most critical challenges modern society is facing deals with the uncontrolled spread of urban environment among surrounding natural environments, with agricultural and wild landscapes being the ones that suffer the effects of urban and suburban pressure (Ewing, 1994). This phenomenon known as urban sprawl is controversial because even if its conceptually well known there is not a universally shared definition of causes and consequences (Brueckner, 2002). The main aim of this research is to develop a methodology to successfully investigate the evolution trend of sprawl on a specific case study and to get empirical evidences of the tight correlation between urban growth and loss of agricultural and natural lands over time. The research is developed in two phases: the diachronic analysis of landcover changes occurred in the recent past through the use of satellite imagery; the forecast of possible landcover scenarios through the use of cellular automata model. Combining the results obtained in the two phases will build up a longer time span on which investigate the phenomena previously described.

Keywords: Cellular Automata Model, Diachronic Analysis, Evolution of Urban Growth, Urban Environment, Urban Sprawl

1. INTRODUCTION

The research is based on a double header approach, on one hand urban sprawl is investigated from a theoretical point of view, while on the opposite hand evidences are taken from the case study hereby presented. The combination of these two perspectives let us offer some objective observations about the specific case study but also to develop some general hypothesis on the nature of the phenomena investigated. The case study is represented by the metropolitan area of the Municipality of Pordenone in north eastern Italy. As said, past landcover changes have been analyzed by the use of remote sensing images and techniques. The dataset comprehends four images from 1985 to 2005 (Aster and Landsat) that have been classified using machine learning methodologies; for what concerns the development of future possible
scenarios an automata cellular model called SLEUTH have been applied. Final aim is to
draw a thematic cartography of possible future scenarios in order to proficiently forecast, so
possibly to anticipate, harmful in terms of natural land consumption, land cover transitions.

2. CASE STUDY - PORDENONE AS A SPRAWLING URBAN CENTER

In 2006 the European Environment Agency (EEA) portrayed the Pordenone area as one of
the most explicative examples of urban sprawl in eastern and central Europe. This led us to
choose the region for a study of sprawl, its development over time, and likely development
in the future. We adopted a methodology that integrated satellite imagery with land cover
cartographic data (Corine Land Cover 2000), topographic map data at a scale of 1:25000 of
the Friuli Venezia Giulia (CRN) province, in situ data collection, and an orthophoto-image
from 2003. The time span considered was from 1985 to 2005, requiring the merging of data
across different sensors and resolutions. This also required the homogenization of the land
classification so as to permit temporal comparison and involved data fusion across different
spatial and radiometric resolutions.

The area of study is bounded by the trapezoid shown in Figure 1, and includes the
municipalities of Fontanafredda, Roveredo in Piano, San Quirino, Porcia, Pordenone, and
Cordenons; all part of the Pordenone metropolitan area (Figure 1).

Much land use change research is based
on satellite imagery classified with relatively low or even unknown levels of accuracy. We
sought more accurate data, since changes from image to image should be due to actual change
on the ground, and not errors of automated classification procedures. The methodology
used in this research was based on a new method of classification of satellite imagery to
allow the more accurate analysis of urban growth from 1985 to the most recent image. The data
also were also used as the input to a cellular automata modeling methodology for the prediction
of future urban extents, specifically the SLEUTH land use change model. Four summer
(leaf-on) satellite images were classified to extract land use, including urban land. These
images were, in chronological order, Landsat Thematic Mapper data from 10/18/1985 and
8/18/1992, a Landsat 7 Enhanced Thematic mapper image from 8/3/2001, and an image
from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)
dated 07/29/2005. All data were supplied by NASA.

2.1. Classification Methodology and Landcover Classification Schema

Operations to homogenize the imagery were performed, including georeferencing, orthoresolution and adjusting the spatial resolution to a common 15 meters for all the images by resampling. The classification technique, involved comparing the accuracy assessment values of different classification methods applied to each image with the goal of selecting the most accurate classification. Each automated classification procedure groups all the pixels into homogeneous classes in order to portray the coverage and the spatial distribution of different features detected by the sensor. The choice of the methodology depends both on the way of sampling pixels and on the a priori analyst’s knowledge of the scene object of study (Favretto, 2006). The standard supervised and unsupervised classification methods were compared in an innovative way to machine learning algorithms released with the Image Analyst module within Erdas Imagine software. The method looks at a pixel and determines the rules of classification not only on the base of spectral properties of pixels but also on the context, the positional relation with neighboring pixels.

For an accuracy assessment, the image chosen to compare the different classifications results was the Landsat image from 2001; this image was classified with all three methods.
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