


Editorial

Spatial Analysis and Geographic Information Systems as Tools for Sustainability Research

Alexandre B. Gonçalves 

CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal; alexandre.goncalves@tecnico.ulisboa.pt; Tel.: +351-218-418-329

The multidisciplinary fields of study on sustainability, which relate to ecological, geophysical, societal and environmental research, demand for the availability and processing of data that is capable to represent spatial phenomena. Over the last decades, technologies and tools that support these demands have emerged and steadily progressed, and are now widespread and available to most researchers. Geographic information systems (GIS) are indispensable tools in studies related with sustainability, due to their analytical capacities to map, visualize, explore, quantify, customize scenarios and relate the complex spatial/temporal interactions in the natural and built environments, at all scales. GIS is not a mere database but a resource for the modelling and prediction of environmental outcomes of natural or human-induced processes, providing a quantification that is needed for supporting location-based actions with positive impacts on sustainability. Moreover, the use of these tools fosters discussions on issues related to spatial data acquisition, modelling, quality assessment and processing that have an impact on the output of research.

The call for the Special Issue asked for contributions on the theory and practice of spatial data analysis and the use of GIS in sustainability studies, regardless of the field of application. Researchers were encouraged to submit contributions through articles, reviews, case studies and position papers focusing on the role and contribution of spatial analysis and geospatial techniques in the wide scope of sustainability. A non-exclusive list of potential topics was suggested to describe the potential contributions:

- planar, 3D and spatiotemporal simulation or modelling of data in resources, energy and land use studies;
- methodological aspects of geospatial data analysis impacting sustainability studies;
- data handling techniques for the spatialization of sustainability-related indicators;
- case studies of GIS-based resources and environmental evaluation;
- impacts of spatial data models, quality, transformation and processing in sustainability assessment;
- applications for spatial data mining, geovisualization or spatial decision-support systems in sustainability-related case studies.

The Special Issue on Spatial Analysis and Geographic Information Systems collects a series of papers describing applications of spatial analysis in a variety of studies in sustainability. A total of eight qualified papers are published as part of this call, representing a contribution that spreads from sensor data processing to land use change assessment and from limited indoor spaces to country-level scales. Spatial statistical analysis with GIS support was the common element to the studies, highlighting the importance of these resources in current advanced studies. The contents of the special issue are described in the order of publication after the peer-review processes were finished.

The first paper, with the title “*Assessing Land Use Changes in Polish Territories: Patterns, Directions and Socioeconomic Impacts on Territorial Management*” [1] describes a study on the land use changes in Poland for three years using the CLC (Corine Land Cover) datasets. It analyses the extent to which land uses are critical for the identification of barriers and opportunities for long-term sustained development. The study enabled us to identify



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the most impacting land use changes in the last decades in the country and explored the relationship between such changes and the socioeconomic impacts on territorial management. The study highlights the importance of using multi-temporal land use/land cover evolution and sustainable development indicators to provide the ground for informed territorial management policies.

The second paper, with the title “*Exploring the Spatial Pattern and Influencing Factors of Land Carrying Capacity in Wuhan*” [2], proposes a framework to evaluate land carrying capacity using a location-dependent index, named *Land Resource Pressure*, based on data from census and socioeconomic statistics. After the index was obtained and mapped for the region of Wuhan, China, several potentially influencing factors in terms of natural resources, economy, transportation and urban construction, were compared with the index value via geographically weighted models. Results point out that most of the influencing factors are highly related to the proposed index, and provide an important precursor for the calibration of the geographically weighted regression.

The third paper, with the title “*Exploring the Relationship between Urban Vitality and Street Centrality Based on Social Network Review Data in Wuhan, China*” [3], uses social network data, namely from a consumer review website, as a source for an indicator of urban vitality and explores the association between it and street centrality. Results for the case study of Wuhan, China, were explored for two displacement modes, walking and driving, and differences on the role of street centrality in shaping the spatial organization of urban vitality between the two modes were found and discussed. After exploratory spatial coupling analyses, spatial regression models were applied to obtain the most significant associations with urban vitality among the pool of centrality indices.

The fourth paper, with the title “*Exploring the Weekly Travel Patterns of Private Vehicles Using Automatic Vehicle Identification Data: A Case Study of Wuhan, China*” [4], describes a case study that processes weekly travel patterns of private vehicles based on automatic vehicle identification via cameras, as a way to understand traffic flows and human mobility. Origin–destination information was obtained, and a clustering algorithm to classify spatial traffic hot spots by camera locations and a later generative probabilistic model, whose goal is to find a set of recurring patterns, were applied. The massive data processing method explored in the paper is expected to support decisions related to urban travel management.

The fifth paper, with the title “*Location-Based Tracking Data and Customer Movement Pattern Analysis for Sustainable Fashion Business*” [5], provides results that might be useful for managers trying to improve the sustainability of their businesses. It describes three field experiments with different visual merchandising displays in stores in a shopping mall in South Korea to analyse customer movement patterns based on indoor location-based tracking data. Spatial indicators, such as the stay rate within each area of the store, were obtained and processed via GIS. The results confirmed that effective store rearrangement could change customer movement patterns and improve the overall sales of store zones, challenging the suggestion that customer spending amounts are proportional to the time spent in a store.

The sixth paper, with the title “*Real-Time Pedestrian Flow Analysis Using Networked Sensors for a Smart Subway System*” [6], describes a grid signal sensor system in a subway station to collect pedestrian location data from sensors, intending to display navigation information for pedestrians to move in a more secure and functional environment. Fingerprinting wireless location-sensing was used to display congestion episodes in real-time, which was based on the calculation of the cumulative presence and movement of pedestrians and represented in heat maps, which were used to forecast the effect of layout rearrangements on the analysed subway station.

The seventh paper, with the title “*Seismic Vulnerability Assessment and Mapping of Gyeongju, South Korea Using Frequency Ratio, Decision Tree, and Random Forest*” [7], compares the prediction accuracies of three seismic vulnerability assessment techniques for Gyeongju, South Korea. For each one, models were built to include geotechnical, physical, structural,

social, and capacity factors. Models' accuracies, expressed as success and prediction rates were verified using ROC curves. The process resulted in the mapping of seismic vulnerability, on which dangerous and safe areas were identified.

The eighth paper, with the title "Identifying Urban Traveling Hotspots Using an Interaction-Based Spatio-Temporal Data Field and Trajectory Data: A Case Study within the Sixth Ring Road of Beijing" [8], combined the data field theory with spatial interactions, and proposed an identification tool to output urban travelling hotspots. For a case study in Beijing, China, which used a dataset of taxi pick-ups and drop-offs, a comparison with other hotspot analysis alternatives was made. Additionally, qualitative and quantitative evaluations were employed to test the accuracy of the proposed method.

The presented case studies demonstrate the applicability of GIS analytical capabilities and support for multidisciplinary in designing sustainable policies or supporting decisions regarding their implementation. Such multidisciplinary has risen in the form of new processes for data acquisition, where recent technologies are responsible for new data sources. Additionally, there are now new application domains, which extend the traditional area of application of geomatics, land management at a large scale, where the object of study is a city, region or country. It is noticeable a trend on the processing of big data, namely travel data from pedestrians, costumers, or vehicles, and in its characterization, regardless of territorial extension, as a corpus of current and future research. New data sources, new methodologies, and new applications will certainly motivate researchers to continue exploring the capacities of spatial reasoning, modelling and analysis. This does not indicate, however, any limitation on the potential of applications of GIS and spatial analysis, as demonstrated by some of the research published in this special issue, which continues to provide new insights on the applicability of spatial analysis for territorial management.

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