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Using multi-criteria analysis for the identification of spatial land-use conflicts in the Bucharest Metropolitan Area

Cristian Ioan Iojă, Mihai Răzvan Niţă, Gabriel Ovidiu Vânău, Diana Andreea Onose*, Athanasios Alexandru Gavrilidis

Centre for Environmental Research and Impact Studies, University of Bucharest, N. Balcescu Boulevard, No. 1, Sector 1, 010041 Bucharest, Romania

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ABSTRACT

The appearance of land-use conflicts represents one of the expressions of the increasing human pressure on the environment, especially in complex metropolitan areas. We used a multi-criteria analysis applied in the Bucharest Metropolitan Area to create a tool for integrating land-use conflicts into the strategies for territory planning at the metropolitan level. We selected ten main criteria for the analysis, divided them into two categories, i.e., spatial indicators and urban development indicators, and standardized their values. Using the method of pair-wise comparison with an expert-opinion system, we determined the relative importance of each criterion in the form of a criteria weight. The spatial indicators reveal high probabilities for land-use conflicts in the proximity of Bucharest (range: 7.19–52.48), whereas urban development indicators show a scattered spatial distribution of land-use conflicts (range: 10.00–30.01). The variability of the total score for the spatial indicators is greater than that of the urban development indicators (standard error of 0.64 > 0.30, respectively). The total scores reveal local administrative units characterized by a critical or high incidence of spatial-land use conflicts as well as their location in the Bucharest Metropolitan Area. Further research should concentrate on improving the expert-opinion input for assigning weights and revealing the potential for replication in other areas or on different subjects.

1. Introduction

Because indicators represent a form of conscious connection to the environment (Golusin and Ivanovic, 2009) and the resilience of nature (Passeri et al., 2013), society uses indicators to simplify reality or for comparison with a normal or reference state (EEA, 2010). Indicators measure the characteristic values of perceived realities (Kurtz et al., 2001) to produce information and describe phenomena relative to other parameters (Antrop and Van Eetvelde, 2000; Caeiro et al., 2012; de Leeuw, 2002; Hasse and Lathrop, 2003).

In the context of the increasing human pressure on the environment, especially in urban and metropolitan areas (Pătroescu et al., 2009), indicators represent instruments that can be used to reduce information gaps (Uuemaa et al., 2013), analyze environmental impacts (Iojă et al., 2007), compare scenarios (Petrov et al., 2011), communicate results to the public (Li et al., 2009) and aid in the decision-making process (Jaeger et al., 2010).

Indicators of land-use changes in metropolitan areas have varied over time, from informal methods to formal methods (i.e., cost-benefit analysis or multi-criteria analysis) (Kamruzzaman and Baker, 2013). The chosen indicators should allow intuitive interpretation based on mathematical simplicity and modest data (Jaeger et al., 2010) and should be quantifiable, sensitive to changes in land cover, temporally and spatially explicit and scalable (Larondelle and Haase, 2013); they should be able to reflect not only the analyzed phenomena but also the particular needs and goals represented by the diversity in a chosen study area (Shen et al., 2011). International institutions and organizations have developed their own sets of indicators for monitoring of environmental aspects, e.g., the core set indicators of the European Environment Agency (EEA, 2011) or the sustainability indicators of the Organization for Economic Co-operation and Development.

Urbanization promotes rapid social and economic development, but at the same time, it leads to many environmental problems (Li et al., 2009) that are becoming increasingly contentious. Therefore, the need exists for instruments aimed at better understanding and management of these issues (Asah et al., 2012). Frequently, these environmental problems lead to the emergence of environmental conflicts (Kamruzzaman and Baker, 2013) between various resource owners and users.

One of the most important environmental conflict sources is land-use changes (Sleeter et al., 2012) due to their effect on the

* Corresponding author. Tel.: +40 213103872.
E-mail addresses: iojacristian@yahoo.com (C.I. Iojă), mihairazvan.nita@g.unibuc.ro (M.R. Niţă), gabi_vanau@yahoo.com (G.O. Vânău), dianaandreea.onose@g.unibuc.ro, diana.onose@gmail.com (D.A. Onose), athanasios_gavrilidis22@yahoo.com (A.A. Gavrilidis).

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natural energy and material cycles of ecosystems (Tong et al., 2012), the local climate conditions, biodiversity, and water resources (Liu et al., 2011). Conflicts over land uses represent a characteristic of urban development, especially in the context of metropolitan areas (Pacione, 2013), which are confronted with a high degree of pressure from various developers (Pătroescu et al., 2009).

As a result, conflicts emerge either between various land uses (residential vs. industrial or agricultural) or between different economic or social groups (residents, farmers, developers, etc.) (Darly and Torre, 2013). Land-use conflicts involve multiple parties who choose terms that favor their respective positions (Shmueli, 2008) and frequently exceed the community scale (Sze and Sovacool, 2013) to involve a range of societal actors, governmental bodies, non-governmental organizations, and private interests (Saarikoski et al., 2013).

The spatial component of land-use conflicts has shown a high manifestation in the last two decades in the countries of Eastern Europe, where the shift from a centralized planning system to an uncontrolled urban development (Pătroescu et al., 2009) has facilitated the emergence of these types of conflicts in various forms and places.

Land-use conflicts are increased by the fact that decisions on projects and developments for different land uses are still made based on incomplete information (Uuemaa et al., 2013); ideally, these situations would require accurate and high-quality decision-making to resolve these complex issues (Kamruzzaman and Baker, 2013), therefore illustrating the need for adequate indicators to measure the relevant driving forces and impact factors (Mubareka and Ehrlich, 2010).

Authorities and planners should find a compromise to accommodate all of the land uses needed for a specific region (Helbron et al., 2011) by controlling urban sprawl, preventing environmental degradation and addressing the difficulties posed by transport and the provision of public services (Darly and Torre, 2013; Pacione, 2013; Koschke et al., 2012). At the same time, these authorities and planners must continue to provide the minimum amount of buildable land in response to demands for housing and services in rural areas (Darly and Torre, 2013; Pătroescu et al., 2011) and maintain the balance between current and future needs (Sze and Sovacool, 2013; Koschke et al., 2012). The large volume of spatial data that lends geographical expression to the economic, social, cultural and ecological aspects of society (Jeong et al., 2013) requires analysis methods that will integrate these aspects according to their impact on the final outcome (Saaty, 1990).

Multi-criteria analysis (MCA) is one method that can be used in spatial planning to aid decision-makers in exploring and solving multiple and complex problems (Jeong et al., 2013). The MCA represents decision-making analysis based on decision-science theory that is able to quantitatively evaluate alternatives by taking into account different perspectives and priorities to produce a common output (Barfod et al., 2011; Convertino et al., 2013). Choosing the MCA algorithm that best fits the research problem is challenging, however, because the subjective scaling of the clear quantitative numbers needed for pair-wise comparison of elements in the same hierarchy may lead to losses in accuracy (Kowalski et al., 2009).

Various studies (Jeong et al., 2013; Koschke et al., 2012; Convertino et al., 2013) have used MCA to assess the spatial distribution of environmental problems, whereas others have combined the MCA with cost-benefit analysis (Barfod et al., 2011; Gühnemann et al., 2012). All MCA analyses have a common pattern: define the alternatives to be ranked, identify the criteria that will influence the outcome, assign "weights" to the criteria and normalize them, and determine the final values (Convertino et al., 2013). Uncertainties exist with respect to the impact levels and weights, but in most cases, neither the time nor resources exist to follow the full construction of the model (Gühnemann et al., 2012).

The assessment criteria are chosen to a greater or lesser extent by how well they relate to the functional and livable dimensions of land uses (Sze and Sovacool, 2013; Gühnemann et al., 2012). The MCA is employed in land-use conflicts analysis to classify the risk levels of significant impacts on the affected area (Helbron et al., 2011) in the establishment of public policy contexts (Kowalski et al., 2009) or as applied to conflict resolution (Kamruzzaman and Baker, 2013).

Spatial conflicts have a high incidence in the Bucharest Metropolitan Area due to this region's administrative heterogeneity (98 local administrative units from five counties with a reduced degree of law enforcement by local administrations) and its dynamic characteristics (increasing proportion of constructed surfaces, appearance of environmental degradation sources, modification of functional areas, reduction of green areas, fragmentation of properties) specific to the Eastern European countries (Zolin, 2007; Iojă and Tudor, 2012).

The current study develops a methodology for identifying areas prone to spatial land-use conflicts by focusing on a post-communist area in which phenomena such as the abandonment of agricultural activities, increasing attractiveness for residential areas and changes in the profile of industrial activities have a large incidence.

The aim of our study is to provide a tool for integrating land-use conflicts into strategies of territory planning at the metropolitan level.

The main objectives of our paper are the following: (a) to derive a set of indicators with spatial distributions that are useful for analyzing the spatial land-use conflicts in the Bucharest Metropolitan Area and (b) to integrate these indicators into a multi-criteria assessment that will allow (c) the spatial identification of areas characterized by a high incidence of land-use conflicts at the metropolitan level.

2. Methodology

2.1. Study area

The Bucharest Metropolitan Area (Fig. 1) is situated in the south-eastern region of Romania and contains 98 local administrative units (cities and communes corresponding to EU NUTS 5) included in five counties (Niță, 2012) with a total surface of 5080 km^2. We removed Bucharest, the capital city of Romania from our study area, because its characteristics and range of issues are of a completely different type (urban phenomena) than the remainder of the metropolitan area (rural side mixed with urban functions). The land use is mainly agricultural (76.8%), with the built-up environment representing only 4.65% of the metropolitan area's total land (Pătroescu et al., 2011).

The dominant relief is characterized by low elevation plains and river floodplains (Pătroescu et al., 2009). The main rivers are tributaries of the Danube (which represents the southern limit of the metropolitan area and the border to Bulgaria). Forests once covered most of the study area, which is fragmented by lakes and rivers (4.9% is covered by aquatic surfaces), but centuries of human activities (mainly agricultural) have reduced the forests to a small proportion (10.5% covered by forests) (Pătroescu et al., 2011). The study area has a total population of 571,315 inhabitants, but numerous inhabitants of Bucharest have second homes in this area that are inhabited for a smaller or larger period of time (Pătroescu et al., 2009). The average population density is 111.5 inhabitants/km^2 (Rey et al., 2007) with notable territorial variations (range: 21–1010).

The changes in land properties after 1989 (shift from public to private owned lands) has increased the pressure of land-use changes according to individual purpose (Golusin and Ivanovic,