Carpathian Journal of Earth and Environmental Sciences, November 2015, Vol. 10, No 4, p. 15 - 28

IDENTIFYING CRITICAL AREAS OF EXPOSURE TO ENVIRONMENTAL CONFLICTS USING EXPERT OPINION AND MULTI-CRITERIA ANALYSIS

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Abstract: Environmental conflicts due to their diverse driving factors are a constant threat to urban systems. They are directly related with changes in the consumption models and the desire for an increased quality of life. We used Bucharest as a case study in developing a methodology for mapping critical areas of exposure to environmental conflicts. From aerial images we constructed a spatial database consisting of urban functions with the potential of generating conflicts, residential areas and buffer areas for each urban function indicated as such in national and international regulation and scientific studies. We tested three methods for mapping the exposure to environmental conflicts – first with all urban functions having the same aggressiveness and conflict potential, second one based on a direct evaluation of their association with residential areas, and the third using a multi-criteria analysis based on an expert opinion survey. Results highlighted that experts tend to minimize the potential of generating environmental conflicts for certain functions and associations when evaluating them directly, the method emphasizing on the importance of industrial areas in urban systems. The use of a multi-criteria analysis based on an expert opinion survey minimizes the bias from the analysis and generates an objective assessment of the conflict potential for each urban function. Mapping the critical areas of exposure to environmental conflicts can constitute a significant tool in the sustainable planning of human settlements.

Key words: environmental conflict, buffer zone, expert-opinion, multi-criteria analysis, critical areas

1 INTRODUCTION

The continuous growth of urban population and the sprawl phenomenon are significant characteristics of present development (Desmet & Rossi-Hansberg, 2014). Therefore, in 2010, 50% of the world population and 75% of the European was living in urban areas (United Nations, 2011). Urban areas are confronted with a series of challenges including changes in consumption patterns (Ioja et al., 2014a) and the quality of life (Pătroescu et al., 2012), increase of built-up surfaces (Gant et al., 2011), the inclusion of peripheral functions inside the city (Niță et al., 2014), environmental (de Luca, 2014) and social problems (Lecourt & Baudelle, 2004). If these challenged are not tackled in a responsible manner they can determine the appearance of environmental conflicts.

Environmental conflicts are defined as incompatible interactions between at least two actors regarding the use of a resource (Mason & Muller, 2007) or as situations in which opposing problems exist (Jeffers, 1999). Environmental conflicts are complex phenomena and their resolution involves simultaneously the economic, social and political dimension (Sevilla-Buitrago, 2013).

One of the triggering factors of environmental conflicts in urban areas is the promotion of sustainable development (Torre, 2010), as an objective of international initiatives such as Agenda 21, Agenda Habitat or Rio+20 "The future we want". Sustainable development shifts population priorities from the economic to the environmental ones so that functions previously tolerated inside

urban settlements are now rejected. More classical driving factors of environmental conflicts are change, competition, legislation and territorial planning (Madden & McQuinn, 2014).

Change is an inherent characteristic of urban areas as functional areas of the cities are continuously confronted to an accelerated dynamic (Onose et al., 2013) and processes of reconversion (Su et al., 2011), revitalization (Loures, 2015) or interaction with other functions (Hansen, 2008).

The competition is present as more land is reclaimed for infrastructures (Timmermans & Beroggi, 2000), services of general interest (Bigotte et al., 2010), residential areas (Thapa & Murayama, 2010) or other functions that impose land-use changes and the emergence of incompatible spatial arrangements (Tudor et al., 2014).

In urban settlements, environmental conflicts are generated especially between various land uses and urban functions (Shmueli, 2008), by the emergence of urban sprawl (Loures, 2015) or conflicting social and economic groups (Darly & Torre, 2013). Conflicts over land-uses and urban functions represent an inherent characteristic of capitalist urban development (Pacione, 2013) especially in Eastern European countries due to their shift from a centralized planning system (Pătroescu et al., 2009).

The effects of environmental conflicts cover a large variety of problems, determined by the urban functions involved, the affected actors and the economic, social and political interests (Ioja et al., 2015).

A large body of literature analyses conflicts, but the complexity of their manifestation and resolution (Tudor et al., 2014) lead scientists generally to case-studies (El-Basyouny & Sayed, 2013; Niță et al., 2014), and less to a general and systematic approach for approaching environmental conflicts in urban settlements (Sevilla-Buitrago, 2013). The majority of studies consider urban environmental conflicts as responses to economic (de Groot, 2006) or administrative development (Jim & Chen, 2006).

Considering that conflicts require the presence of at least two actors (Mason & Muller, 2007) it becomes necessary to evaluate the perception of different groups on the subject (de Luca, 2014). Extensive perception surveys can generate accurate data about the underlying problems (Ioja et al., 2011) and even solutions (Morgan-Davis & Waterhouse, 2010) but they require high costs and human resources.

This obstacle can be removed by using expert-opinion surveys (Sperber et al., 2013) to fill the knowledge gaps (Eycott et al., 2011). Expert-opinion is recommended when the relationship between different variables is not fully understood (Canavese et al., 2014) or when needed variables cannot be quantified (Janssen et al., 2010).

The integration of environmental conflicts analysis in the spatial planning of cities requires the use of decision-making support methods such as multi-criteria analysis (Jeong et al., 2013; Reed et al., 2014; Yavuz & Baycan, 2013).

Multi-criteria analysis represents a flexible instrument for handling both qualitative and quantitative data (Lee et al., 2014), addressing a single topic (Gim & Kim, 2014) or choosing the most appropriate alternative among many (Cay & Uyan, 2013). One of the major strength of multi-criteria analysis is that it can address conflicting evaluations and perspectives (Yavuz & Baycan, 2013) in establishing a final common output (Barfod et al., 2011; Convertino et al., 2013; Grošelj et al., 2015). Numerous studies have used multi-criteria analysis in representing the spatial distribution of environmental issues (Convertino et al., 2013; Ioja et al., 2014b; Jeong et al., 2013).

Mapping the distribution of urban environmental conflicts can represent an important instrument in the general urban planning (Qiu & Zhang, 2011) as it is easy to understand and intuitively appealing to the general public and decision-makers (Mighty, 2015). The combination of geographical information systems and multi-criteria analysis is a frequent scientific practice (De Feo & De Gisi, 2014) in mapping the distribution of conflicts.

Our paper aims at developing a methodology for identifying the critical areas of exposure to environmental conflicts generated by the association between different categories of urban functions and residential areas in an urban settlement by testing three mapping methods and using a multi-criteria analysis based on expert-opinion as input data for the mapping process. The importance of the subject is sustained by the need to find optimal tools useable in the planning process. These tools must have the capacity to incorporate both the scientific knowledge in the field and the perception of the potentially affected population.

We used Bucharest as a case study, since the capital of Romania represents the most complex urban system in the country, concentrating inside its administrative limits a high variety of urban functions. The present structure of the city resulted from four planning systems that succeeded in the last century, offering a diversity of associations between residential areas and urban functions with

environmentally conflict potential.

The objectives of our paper are: (1) to identify the characteristics of urban functions with conflict potential, especially in relation to residential areas; (2) to establish a hierarchy for the conflict potential of urban functions and (3) delineate areas where urban functions have the potential to generate environmental conflicts.

2 METHODOLOGY

2.1 Background data

Based on aerial images (ANCPI, 2014) with a 5m resolution for the year 2010 that were updated on Quick Bird images in Google Earth (Google Earth 7.1.2, 2014) for 2014 we obtained a spatial database containing urban functions with potential to cause environmental conflicts and the residential areas (single-family and collective) they may affect.

Proximity analyses were undertook in order to establish the areas potentially affected by environmental conflicts. Buffer sizes used in the proximity analysis was variable in concordance to provisions indicated in scientific studies or national and international regulations (Table 1).

Table 1 – Buffer distances according to recommendations of international organizations, national authorities and literature (Iojă et al, 2015)

Urban function	**Distances used in the proximity analysis**		
	Zone 1*	**Zone 2****	**Zone 3*****
Industrial area	300[1,2]	500[1,2]	1000[1,2]
Hospital	50[1]	100	200
Hypermarket and shopping mall	50	100	200
Gas station	25	50[3]	100[5]
Transport infrastructure	50[1]	100[4]	200[1]
Airport	1000[1]		
Wastewater treatment plant	60[5]	300[1]	-
Landfill	500[4]	1000[1]	1500
Waste incinerator	500[4]	1000[1]	1500
Graveyard	50[1]	100[6]	250[7]

* high impact; ** medium impact; *** low impact

[1] (Ministry of Health, 1997)

[2] (Environmental Protection Authority, 2005)

[3] (Morales Terres et al., 2010)

[4] (Environmental Protection Authority, 2000)

[5] (Wastewater Committee of the Great Lakes - Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, 2004)

[6] (Government of Saskatchevan, 1996)

[7] (World Health Organization - Regional Office for Europe, 1998)

2.2 Expert-opinion on the conflict potential of urban functions

For hierarchizing the conflict potential of urban functions we conducted an expert opinion using the Delphi method (Munier, 2004) and used the results in a multi-criteria analysis. The survey was designed to assess the relationship of residential areas with different categories of urban functions (see table 1) with environmentally conflict potential. Experts were considered those persons which through their training and education (working or studying in the field of urban planning) or experience (access to information or personal experience) (Kangas & Leskinen, 2005) met the established criteria – knowledge in the field of environmental conflicts. The expert opinion survey highlighted the vision of experts on the causes of association between residential areas and different urban functions, the advantages that may arise, impact size and the probability of occurrence of different problems or conflicts, and the necessity of a buffer area (table 2). The survey contained especially closed-ended questions in order to facilitate further analysis, open-ended questions being used only in relation with the profile of the respondent.

The expert opinion survey was designed to capture the general opinion of the experts regarding the association of the residential area with each considered function (table 2 – question 2). In addition we searched for the detailed opinion based on the aspects considered as important when assessing the conflict potential.

The expert opinion survey was completed online between 2012 and 2014 by 108 experts from 6 countries – Romania (85%), Switzerland, France, Poland, Slovakia and Algeria. The sample was gender balanced (47.2% women) with ages between 18 and 75 years old, the main categories being represented by experts between 19-35 years old (56.48%) and between 36-50 years old (25.92%). The average experience of the experts answering the survey was 15 years.

The majority (82.4%) of experts work in public institutions, only 12.96% operate in private institutions and 1.85% in non-governmental organizations. The main areas of activity for experts were environmental sciences and territorial planning, both in a strong relationship with the research of environmental conflicts.

Table 2 – Structure of the expert opinion survey for evaluating the conflict potential of urban functions

Social aspects	Components	No.	Question	Variables
Opinion	Causes of the association	1	What caused such association?	natural expansion of cities and villages, spatial planning mistakes, lack of building space, lack of other alternatives, illegal development of houses, normal association within cities/villages
	Association with residential areas	2	How do you consider the association between the two areas?	incompatible, conflicting, indifferent, complementary
Environmental impact	Impact size	3	Associate an environmental impact size for each function	major, medium, low, neutral
	Problems inside residential areas	4	What problems can occur in residential areas because of their proximity to the considered function?	18 categories of problems to choose from
	Conflict occurrence	5	What is the probability that certain categories of conflicts can occur due to the association?	major, medium, low, neutral
Conflict occurrence	Causes	6	To what extent the following indicators could be causes for conflicts occurrence?	to a large extent, to a low extent, only in certain situations, not applicable
Proximity of a function with potential to create conflicts	Necessity of a buffer zone	7	Is required a buffer zone between the two land uses?	Yes / no
	Dimension of the buffer zone	8	What size should the buffer zone have?	under 50 m, 50-100 m, 100-500 m, over 500 m, variable
	Advantages of the association	9	What advantages could result from such an association?	9 categories of advantages to choose from
	Personal experience	10	Are you affected directly by such an association?	Yes / No
Socio-demographic information	Interviewee profile		Institution type (state, private, non-profit organization); Current occupation; Activity area; Years of experience; Place of residence; Participation in planning (access to information, public consultation, participative planning); Gender; Age	

2.3 Multi-criteria assessment of the conflict potential of urban function based on expert opinion

The general outline of the multi-criteria analysis (Beinat & Nijkamp, 1998; Jeong et al., 2013; Munier, 2004) applied in order to assess and rank the conflict potential of urban functions is based on the following steps (Fig. 1):

- Establishing relevant and easy to calculate criteria based on the questions in the expert opinion survey;
- Creating a database with the answers to the expert opinion survey in order to calculate the established criteria for each considered alternative;
- Using the Analytical Hierarchy Process (AHP) to establish the criteria weight through a pair-wise comparison of the criteria relative importance (Saaty, 1990). Each author of the study realized an independent AHP and the results were corroborated in order to minimize the subjectivity of the analysis (Ioja et al., 2014b);
- Calculating the value of each criteria for each alternative;
- Standardizing the values for each criteria through Mathematical Programming (Munier, 2004), considering the maximum value a criteria can achieve as 100% and calculating for each alternative the percent corresponding to the calculated criteria value;

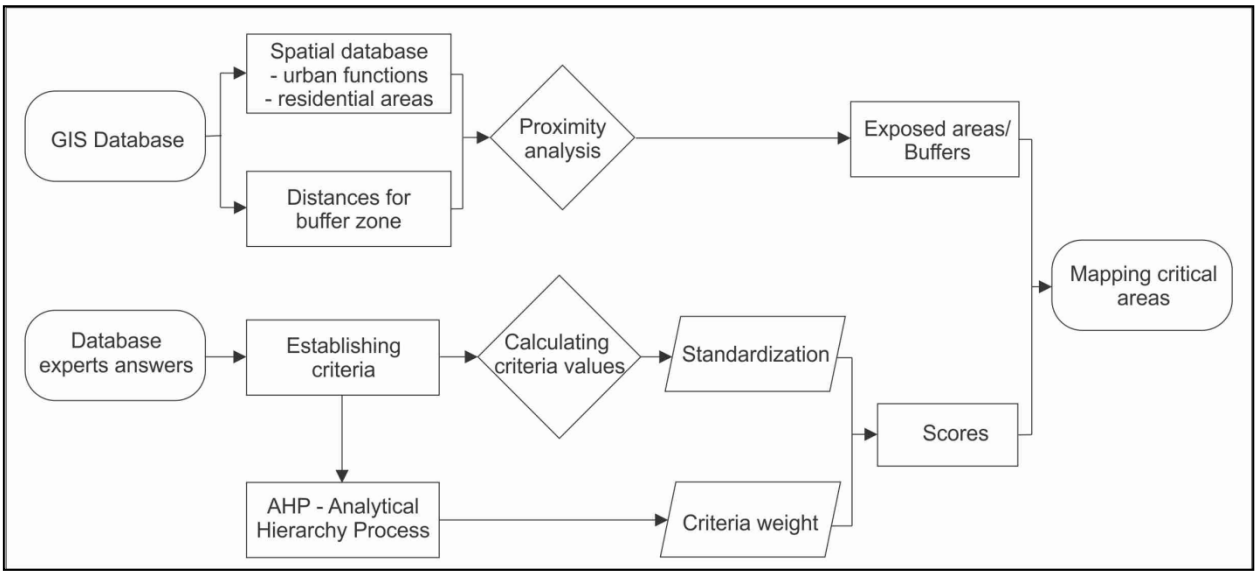

Figure 1 – Flow chart of the methodology for mapping the critical areas exposed to environmental conflicts

- Obtaining the partial score for each criteria by multiplying the criteria value with its weight;
- Adding the partial scores to obtain the final score for each alternative.

In order to assess the potential of urban functions to generate environmental conflicts when associated with residential areas we considered 7 criteria corresponding to questions in the expert opinion survey and 10 alternatives of urban functions considered to have conflict potential in the scientific literature.

The criteria used in the multi-criteria analysis were divided in three categories (Table 3): (a) the first category (criteria A and B) related with environmental problems that urban functions generate as the main driver in the occurrence of environmental conflicts; (b) the second category (criteria C, D, E) described the causes, probability and diversity of conflicts, being a direct measure of the magnitude of urban functions and (c) the third category (criteria F and G) expressing required size of buffer areas for each urban function.

2.4 Mapping the critical areas of exposure to environmental conflicts

Bucharest, the capital city of Romania, has a surface of 24,214 ha and a permanent population of 1.86 million inhabitants in 2014 (NIS, 2014). The city is a complex urban system, containing all 10 urban functions (Fig. 2) considered as alternatives in the multi-criteria analysis and assessed through the expert opinion survey. In Bucharest the distribution of urban functions was influenced by the transition from the communist period (when the planning system was centralized and almost all urban surfaces were public property) to the capitalism period - characterized by poor legislative framework, a lack of urban planning practices, prevalence of economic interests and individual initiatives based on continuous extension of private property (Suditu, 2011).

We the data derived from the expert opinion survey and the results of the multi-criteria analysis to spatially represent the distribution of critical areas of exposure to environmental conflicts in Bucharest. In order to map the areas with exposure to environmental conflicts we assigned values to the three rings composing the buffer sizes foreseen in legislation and scientific studies (see Table 1). The first ring (Zone 1) was considered an area with high potential of conflict occurrence and received a value of 3; the second ring (Zone 2) with a medium conflict potential received a value of 2 and the third ring (Zone 3) received a value of 1 (low potential).

In order to evaluate the difference between spatial distribution of conflicts and the perception of experts we used three methods of weighting the magnitude:

- An average when we considered all functions as having equal conflict potential;
- A weighted average based on the experts' answer to the question "*How do you consider the association between the two areas?"* (whereas one of the area was residential and the other the function in question). Weight was calculated as percent from total answers considering the association as incompatible or conflicting;
- A weighted average based on the multi-criteria analysis which detailed the experts' opinion in the matter and objectively sustained their point of view regarding the potential of each urban function to generate environmental conflicts.

Table 3 – Criteria considered in the multi-criteria analysis

Categories of indicators	Criteria	Code	Explanation
Environmental impact	Environmental impact size	A	Weighted average of the impact size of each function (where „major impact" has a weight of 3, „medium impact" – 2 and „low impact" - 1)
	Diversity of the problems that may appear	B	Average number of problems (air pollution, surface and groundwater pollution, noise, soil contamination, improper waste disposal, traffic congestion, blocked land etc) identified by the experts for each function
Conflicts	Probability of conflicts occurrence	C	Weighted average of the probability of occurrence of each of the 5 categories of proposed conflicts (where „major probability" has a weight of 3, „medium probability" – 2 and „low probability" - 1)
	Diversity of conflicts that may occur	D	Average number of conflicts identified as having a major probability of occurrence
	Causes for conflict occurrence	E	Percent of answers indicating that each considered factor can contribute „to a large extent" to conflicts occurrence
Buffer area	The necessity of a buffer zone	F	Percent of answers indicating the necessity of a buffer zone between the residential and the other function
	Dimension of the buffer zone	G	Percent of answers indicating the size of the buffer zone should be larger than 500 m

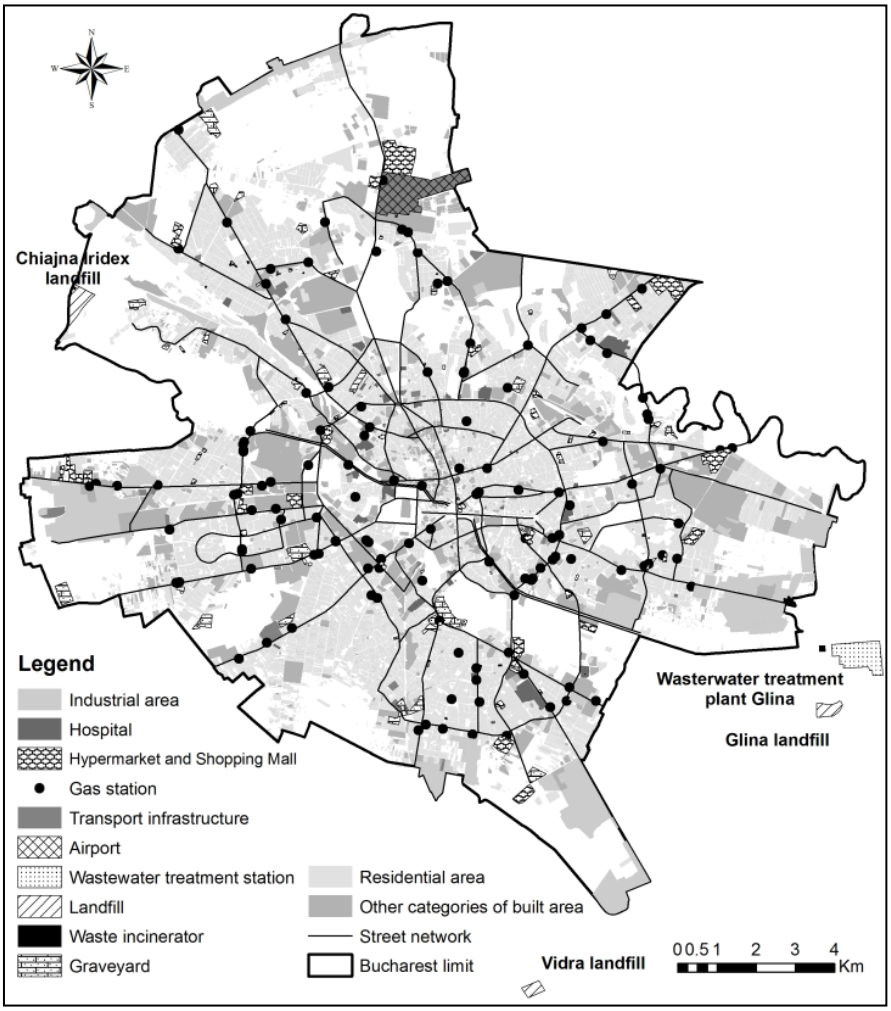

Figure 2 – Spatial distribution of urban function with potential to cause environmental conflicts in Bucharest

For each of the three alternatives, the buffers were weighted accordingly with the magnitude specific for each function – a value of 1 for all the functions for the first method, the results derived from the answers to the question directly regarding the association of the functions (see Table 6, column A) for the second method and the values resulted from the multi-criteria assessment (see Table 6, column B) for the third method.

For each method of calculation a map of the critical areas of exposure to environmental conflicts was derived by merging the critical areas delineated for each urban function and adding their magnitude of creating conflicts.

The results of the three methods of calculation can't be directly compared due to the differences in the maximum values that can be registered. Therefore we standardized the obtained values in order to facilitate the delineation of areas exposed to the same potential of environmental conflict occurrence.

We delineated areas of exposure to environmental conflicts based on five categories – very high, high, medium and low level of exposure and areas with no potential of occurrence for environmental conflicts.

3. RESULTS

3.1 Characteristics of urban functions with conflict potential and residential areas they may affect

The 10 analysed urban functions have the potential to generate environmental conflicts at a medium (e.g. industrial area) or small (e.g. gas station) spatial scale.

The report between the surface occupied by an urban function and the residential areas from its buffer zone (Table 4) underlines how well that function is positioned in the city. High values highlight an optimal location of that urban function in relation to residential areas, while small values reveal functions that with an incorrect affecting a large proportion of built-up surfaces.

Spatial analysis revealed that from the analysed functions, in Bucharest industry, hypermarkets and graveyards occupy the largest areas and affect the most residential areas (Table 4) in their proximity (as expressed by the buffer area). Landfills and airports have an optimal location in the city while gas stations and hospitals are located mainly in the proximity of residential areas.

Analysing the distribution of residential areas between the 3 buffer zones we observe that the largest surfaces are located in zone 3 (Fig. 3), where the potential of environmental conflict emerging decreases considerably. Industrial areas affect a higher surface of residential areas than all the other urban functions combined. The wastewater treatment plant has an optimal location in relation with the residential areas in Bucharest, but the residential areas outside the city weren't considered in the analysis.

Table 4 –Relation between urban functions and residential areas in the buffer area

Urban function	Surface of urban function (ha)	Surface of residential area (ha)	Function surface / residential area
Industrial area	1397.98	3052.11	0.46
Hospital	161.15	531.69	0.30
Hypermarket and shopping mall	307.33	543.68	0.57
Gas station	8.48	138.32	0.06
Transport infrastructure	110.59	235.24	0.47
Airport	150.68	105.08	1.43
Wastewater treatment plant	78.93	0	-
Landfill	67.84	21.1	3.22
Waste incinerator	3.53	328.34	0.01
Graveyard	221.55	554.88	0.4

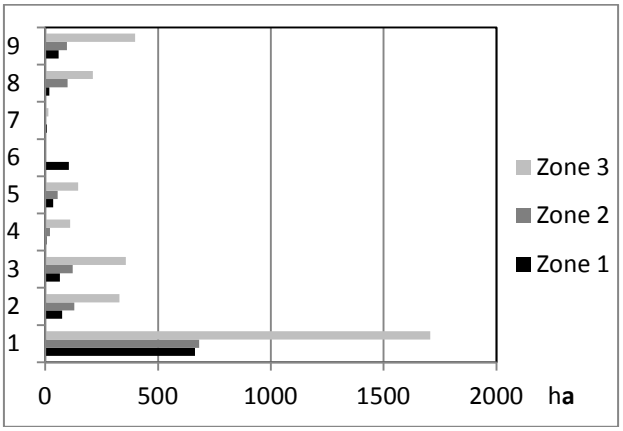

Figure 3 – Surfaces of residential area located in the buffer areas of urban functions

*1) industrial area; 2) hospital; 3) hypermarkets and shopping malls; 4) gas stations; 5) transport infrastructure; 6) airport; 7) wastewater treatment plant; 8) landfill; 9) graveyard

**the airport had a single zone

*** zone 2 excludes the surface of residential area included in zone 1 and zone 3 excludes the residential area situated in zone 1 and 2

With the exception of hypermarkets and gas stations, all other urban functions affect larger

surfaces of individual residential, rather than collective residential. This is due in part to the planned character of collective residential construction and secondly to urban sprawl encountered in Romania after the year 2000.

3.2 Quantification of the conflict potential of urban functions using the expert opinion

The general opinion of experts for the question "*How do you consider the association between the two areas?*" highlighted a strong rejection of industrial areas (75% of the answers considered it as incompatible – can't coexist without assuming permanent conflicts or conflicting – the association may generate conflicts), followed by the public services (wastewater treatment plants, landfills, waste incinerators, graveyards – 34%). The other categories of functions are mainly considered complementary - hospitals (58%), commercial areas (62.5%), transport infrastructure (61.4%) and shopping malls (70.5%) (fig. 4).

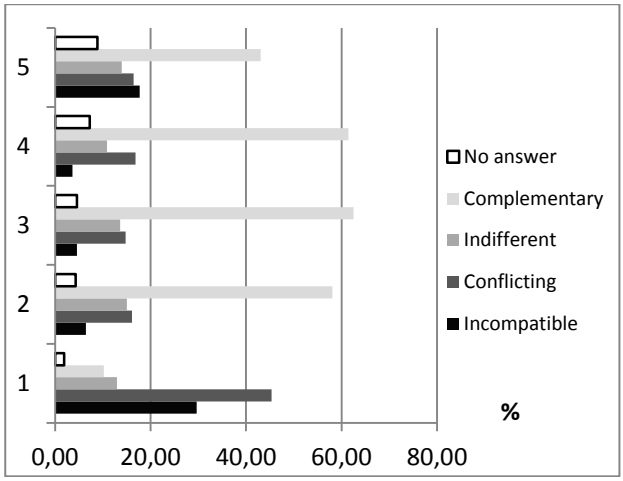

Figure 4 – Experts' opinion on the association of the main urban functions with residential areas.

*1) industrial area; 2) hospital; 3) hypermarket, shopping malls and gas station; 4) transport infrastructure and airports; 5) public services (wastewater treatment plant, landfill, waste incinerator, graveyard)

Regarding the causes that generated the association of residential areas with functions that may present a potential for generating conflicts, expert opinion indicated as main drivers the natural expansion of settlements, spatial planning mistakes (especially in the case of industrial areas), the normal association within settlements (for hospitals, commercial areas and shopping malls) and changes in consumption models. However, the majority of the experts (more than 40%) indicated a combination between these factors as being responsible for such associations.

3.3 Hierarchy of the conflict potential of urban functions based on the multi-criteria analysis

The most important criterion (almost 20% importance) for evaluating the potential to generate environmental conflicts proved to be E – causes for conflict occurrence (table 5). This criterion considers the factors that may increase the aggressiveness of urban functions like size of the space, severity perceived by the residents, social status and number of exposed residents, distance between land uses, emissions, economic and political interest in environmental protection. Public services (wastewater treatment plant, waste incinerator, landfill and graveyard) and industrial areas have the greatest values concerning this criterion due to the large diversity of characteristics they can present.

Table 5 – Weights of the selected criteria

Criteria	Criteria Weight
Causes for conflict occurrence	0.199
Diversity of conflicts that may occur	0.177
Environmental impact size	0.172
Diversity of the problems that may appear	0.156
Probability of conflicts occurrence	0.142
Dimension of the buffer zone	0.079
The necessity of a buffer zone	0.075

Criteria D – diversity of conflicts that may occur and A – environmental impact size have important and similar weights. If in the case of D public services and industrial are still the functions with the greatest potential to create conflicts, when analysing impact size - landfills, waste incinerators and airports are the most aggressive.

In the case of functions like industrial areas, landfills or waste incinerator the values of all criteria are high, while for other functions they are variable. For example, experts consider airports as generating few problems (criterion B) but with a high environmental impact (criterion A), while hospitals can generate only a few categories of environmental conflicts (criterion D), but the diversity of problems is high (criterion B).

A hierarchy (Table 6) of the potential of urban functions to generate environmental conflicts was established by the aggregation of the criteria weights and their values for each alternative and adding partial scores. Therefore industrial areas, wastewater treatment plants, landfills and waste incinerators are considered as the main generators of environmental conflicts in urban areas. Hospitals, shopping malls and hypermarkets have a low potential.

Table 6 – The potential of urban functions to generate environmental conflicts, quantified through expert opinion and multi-criteria analysis

Urban functions	A	B	Difference
	Question 1*	Multi-criteria analysis	
Industrial area	0.75	0.652	0.098
Hospital	0.225	0.346	-0.121
Comercial areas	0.193	0.458	-0.265
- Hypermarket		0.4	
- Shopping mall		0.4	
- Gas station		0.43	
Transportation areas	0.204	0.577	-0.373
- Transport infrastructure		0.568	
- Airport		0.553	
Public services	0.34	0.694	-0.354
- Wastewater treatment plant		0.647	
- Landfill		0.675	
- Waste incinerator		0.653	
- Graveyard		0.6	

*How do you consider the association between the two areas?

3.4 Mapping critical areas of exposure to environmental conflicts

The area exposed to environmental conflicts (Table 7) generated by urban functions is the same (62.40 % of the city's surface) for all three cases since we used the same buffer sizes. The surface affected by a very high level of exposure to environmental conflicts was greater when we used the second aggregation method (based on a weighted average of the answers the experts gave to the direct question regarding the associations between residential areas and other urban functions), but overall was the smallest for all the three cases. The areas with a high exposure were significant (14.26 %) for the same method of calculation, meanwhile the ones with a low level of exposure were small compared with the other two cases (28.9 % compared with 55.19 % and 41.53 % respectively).

The methods based on average and multi-criteria analysis gave similar results for the first two levels of exposure (high and very high), but registered significant differences regarding the medium and low levels.

The large surfaces with a high level of exposure to environmental conflicts as resulted from the second calculation method are determined by the great importance attributed to industrial areas, which can generate a high level of exposure in the first buffer ring (Zone 1 – see table 1). We can observe that areas affected by a very high level of exposure can be found inside the built-up area (Fig. 5), in the close proximity of residential areas, but their very small surface facilitates their use for other means than housing.

Table 7 – Surface of critical areas of exposure to environmental conflicts

Level of exposure	Surface of Bucharest exposed to environmental conflicts (%)		
	Average	Question 1*	MCA**
Very high level	0.008	1.066	0.010
High level	0.276	14.266	0.568
Medium level	6.923	18.171	20.286
Low level	55.196	28.900	41.539

*How do you consider the association between the two areas?
** multi-criteria analysis

The areas characterized by low and medium levels of exposure to environmental conflicts are overlapping built-up areas, abandoned spaces or that used in other purposes (e.g. agricultural land). In addition, the city centre has a low or no exposure to environmental conflicts.

4. DISCUSSION

In the present study, we developed a method for mapping critical areas of exposure to environmental conflicts. We used expert opinion and multi-criteria analysis with the aim of quantifying the aggressiveness of urban functions and their potential to create environmental conflicts, thus filling a gap in the field.

Urban planning is often restricted by budget limitations that prevent the implementation of projects aimed at improving the environmental quality (Achillas et al., 2011), as accessibility to transportation and services is considered of greater importance. Therefore, there is no consensus for the measurement and comparison of urban structure (Lee et al., 2013) at international level, and national legislation often forgets necessary regulations for maintaining equilibrium in urban areas. These gaps in legislation characterize many countries therefore some international bodies (e.g. European Union, World Health Organization) aim at presenting guidelines in the subject.

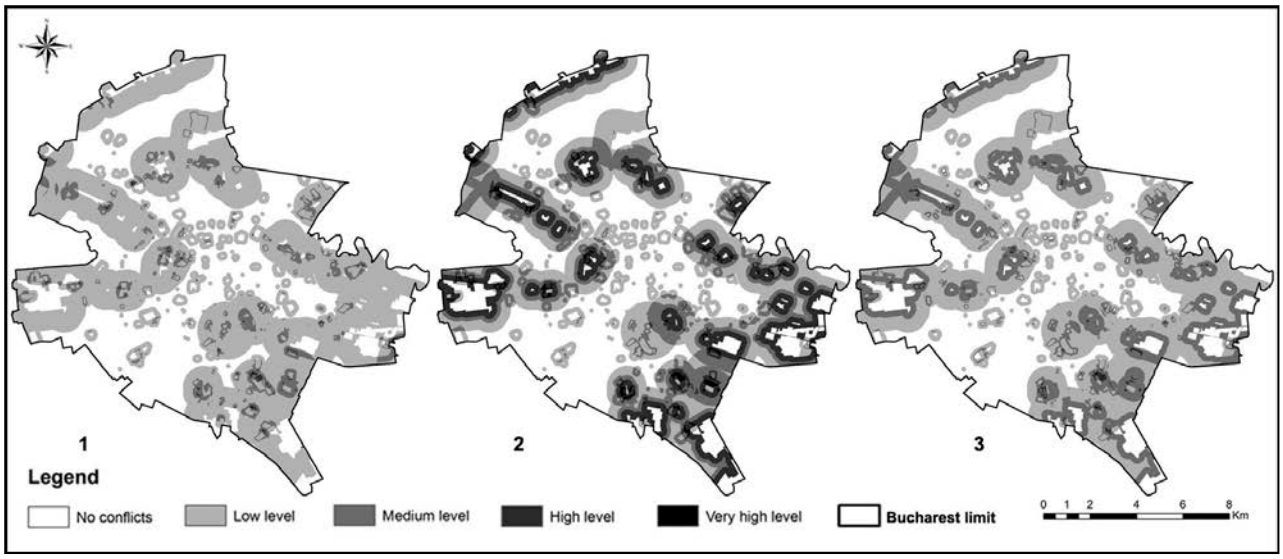

Figure 5 – Mapping critical areas of exposure to environmental conflicts.
1- all urban functions have the same potential to generate environmental conflicts; 2 – based on the answers of the experts at a question assessing directly the association of residential areas with different urban functions; 3- using the results of the multi-criteria analysis based on the expert opinion survey

Besides the objective association of two urban functions, the perception is highly important in spatial planning for environmental conflicts, as most land uses exert negative influences (Tudor et al., 2014) over the areas in their proximity. Considering this aspect, we balanced the sample of experts answering to the expert opinion survey between Romanians and foreigners. Due to the length of the survey this was not entirely possible, therefore our study can't cover all the cultural differences, as in some Asian countries, for example, cemeteries are associated with disease and therefore avoided as proximity (Jim & Chen, 2009).

This study comes to support the use of expert opinion as a method of data gathering. As much of the work implying expert opinion is unclearly presented and information about the data gathering is scarce, the method may hinder repeatability (Eycott et al., 2011). The multi-criteria analysis, which may be one of the most-frequently used methods for decision support (Durbach et al., 2014) was chosen because it can be applied in any stage of the planning process (de Luca, 2014) conferring great autonomy. The combination of the two methods minimizes the subjectivity characterizing the knowledge and judgment of each expert (Yavuz & Baycan, 2013) averaging their answers and giving an objective outline further used as basis for mapping the distribution of critical areas.

Mapping the distribution of areas exposed to environmental conflicts is very easy to implement in the GIS environment (Akıncı et al., 2013) and can provide a useful tool in solving the planning problems in urban areas, lowering the risk of conflict development (Tudor et al., 2014).

Our results showed that depending on the method of calculation, when spatially delineating the critical areas, differences can be significant. The first calculation method was used since, in the absence of a clear hierarchy of the urban functions with potential to generate environmental conflicts, their aggressiveness is often ignored. The other two methods are based on hierarchies derived from the expert opinion survey. If the hierarchy derived from the first question in the survey (the one regarding the direct association between functions) can be considered as biased and affected by experts prejudices concerning some urban functions, the one constructed using the multi-criteria analysis based on the answers to multiple questions in the survey can be considered objective. This last method underlines the idea that not all criteria affecting land suitability have equal levels of significance (Akıncı et al., 2013).

Beside industrial areas, all other functions were considered less aggressive and with a lower potential to create environmental conflicts when the association was directly assessed (through the single question). The values almost doubled when the detailed analysis was undertaken.

We recommend mapping critical areas of exposure to environmental conflicts using the result of the multi-criteria analysis based on the expert opinion since the urban functions don't have the same potential of aggressiveness, as assumed when using the first method of calculation (considering all urban functions have the same conflict potential). Moreover the second method of calculation used, based on the direct evaluation of the association

between residential areas and certain urban functions, emphasizes too much the importance of industrial areas inside urban systems, minimizing the effects of the other functions.

The methodology is aimed to provide support to decision makers and residents, in taking coherent decision regarding urban planning and making informed choices about their residence. The limitations of the method are related with the high diversity of urban functions that have to be divided in categories, ignoring their particular characteristics and therefore raising the possibility to emphasize or diminish the effects of some of them.

We recommend further studies on the differences registered between experts from different countries and scientific background or based on the professional experience in the field.

5. CONCLUSION

We succeeded in developing an objective method for mapping the critical areas of exposure to environmental conflicts. The method has a high potential for generalization and can be used when studying urban systems across Europe. The model has to be calibrated if the national legislation of the country has more specific guidelines regarding buffer sizes for urban functions than the Romanian one. The method can be successfully used in the initial phase of the planning process, when new areas are designed, and during the restructuration and remodelling of urban systems. If optimal used it can provide sustainable planning solutions contributing to an increase in the residents quality of life and to the emergence of sustainable human settlements.

ACKNOWLEDGEMENTS

This work was supported by a grant from the Romanian National Authority for Scientific Research, CNDI-UEFISCDI PN-II-PT-PCCA-2011-3.2-0084 – "*Dynamic interaction between the natural and human components based on the synergy of ecological and socio-economic factors in the rapidly urbanizing landscapes"* and the strategic grant POSDRU/159/1.5/S/133391, *Project "Doctoral and Post-doctoral programs of excellence for highly qualified human resources training for research in the field of Life sciences, Environment and Earth Science*" cofinanced by the European Social Found within the Sectorial Operational Program Human Resources Development 2007–2013.

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Received at: 08. 01. 2015
Revised at: 07. 04. 2015
Accepted for publication at: 02. 07. 2015
Published online at: 29.07. 2015