Developing a model for evaluating the potential of urban green infrastructures for sustainable planning

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Content

Introduction

Cities are challenged with a large number of environmental, economic and social problems which affect their structure and functionality (Niță 2011). The international organizations often promote politics and strategies (Habitat I and II, Agenda 21, European Cities Chart , The Millennium Declaration, etc.) aiming to reach a sustainable development for cities (Schäffler et al. 2013).

A sustainable urban planning focuses on approaching these issues in an integrative manner which considers the local peculiarities (Norton et al. 2015), the decision-makers' view (Vandermeulen et al. 2011) and the local stakeholders arguments (Faehnle et al. 2014) in order to select a proper solution for development (Govindarajulu 2014). The assimilation of all these aspects needs an interdisciplinary and participatory urban strategic planning, which uses more frequently the urban green infrastructures in the decision-making process (DG Environment 2012) as a useful instrument in achieving the sustainability objectives for urban areas (Church 2015).

Urban green infrastructure (UGI) is a concept with many approaches (Newell et al. 2013) but usually it refers to connected networks of multifunctional spaces which support ecological and social processes (Iojă et al. 2014). The fundamental characteristics of urban green infrastructures are *connectivity and multifunctionality*, comprising a wide range of specific elements (Cameron et al. 2012).

The use of green infrastructures in urban planning has increased the capacity to contribute in achieving public policies objectives and targets (Ioja et al. 2011, Young et al. 2014) through sustainable approaches (Bianchini et al. 2012). Green infrastructures are an increasingly used instrument for reaching these objectives (M'Ikiugu et al. 2012) due to their indisputable benefits (Tzoulas et al. 2010). Planning based on green infrastructures is a process which requires additional information (Giordano 2012) especially in regards to the evaluation of their multifunctionality and their capacity in reaching environmental, social and economic goals (DG Environment 2012). This may influence the decision-making process in terms of structure and speed (Marshall 2014).

This report includes the scientific components which answer to the analytical objectives and the main results (publications, participations to scientific meetings and courses) obtained during the project in the period 2015-2017. The team which prepared this report is:

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O1. Overview of the theoretical framework for urban green infrastructures (UGI) analysis and urban planning

1.1. Establishing criteria for UGI classification

Classifying UGI represents a complex process based on different criteria. UGI are often studied from an ecosystem service provision perspective (Hansen et al. 2014), this being one of the method used for ranking UGI, especially through the **variety of the provided ecosystem services**. The most well-known ecosystem services classifications are the Common International Classification of Ecosystem Services – CICES (Haines-Young et al. 2011) and the Millennium Ecosystem Assessment – MA (Millennium Ecosystem Assessment 2005) based on which The Economics of Ecosystem & Biodiversity – TEEB was created (Sukhdev 2010).

Using this argument, the level of detail used in the UGI classification is linked with the typologies of the ecosystem services. Considering that the provision of ecosystem services had a key role in shaping the green infrastructure concept, this type of classification is highly used in the scientific literature and in the official documents of the institutions which regulate this domain.

Another classification of UGI has been proposed by the European Environmental Agency. The criteria were chosen in order to form homogeneous clusters based on the green infrastructures which exist on the European territory (Dige 2011, Niță 2016). The following criteria are being proposed by EEA: ***conservation status, ecosystem value, origin, location, land use*** and ***functionality of UGI***. The American Agency for Environmental Protection and the National League of Cities classify the green infrastructures based on their functionality.

GREENSURGE (Green Infrastructure and Urban Biodiversity for Sustainable Urban Development and the Green Economy) is a project financed by the European Commission which created an UGI inventory using two databases validated and accepted by the European Union: Urban Atlas and Corinne Land Cover. In this document there are 44 UGI components which are being identify, grouped in 8 clusters, based on criteria such as ***scale***, ***location*** and ***function*** (Cvejić et al. 2015). After the analysis of the UGI types identified by the GREEN SURGE report we propose a list of 40 types of green spaces which are suitable for Romania, classified in accordance with 4 proposed criteria: ***scale***, ***function***, ***accessibility***, ***location*** (*table 1 and 2*).

The classification of UGI can be done using specific criteria which can vary from one city to another, or from a type of infrastructure to another. We can specify 3 criteria and approaches in the UGI classification process which were not included into the present study but one cannot oversee their importance.

Table 1 UGI classification based on scale and function

TYPE	CRITERIA								
	Scale			**Function**					
	Macro-infrastructures	Medium infrastructures	Micro-infrastructures	Air filtering	Microclimate regulation	Noise reduction	Rain water drainage	Waste water sewage	Cultural and recreation function
Balcony vegetation			•	•	•				
Green walls			•	•	•				
Green roofs			•		•		•		•
Atriums			•		•				•
Green squares			•				•	•	
Streen trees		•		•	•	•			
Alignments with grass and shrubs		•					•	•	
Private gardens			•	•	•	•	•	•	•
Green spaces related with the transport infrastructures		•				•	•	•	
Playgrounds			•						•
Riparian vegetation		•		•	•				•
Public park/garden	•			•	•	•	•	•	•
Parks and gardens related with the block of flats		•		•	•	•	•	•	•
Botanical gardens	•			•	•		•	•	•
Zoo	•								•
Green spaces related with public institutions			•	•	•	•	•	•	
Green buffer areas		•		•			•	•	
Graveyards	•				•	•	•	•	
Sport gorunds	•								•
Camping sites	•								•
Allotment gardens			•				•	•	•
Community gardens			•				•	•	•
Agricultural lands	•								
Pastures	•								
Orchards	•				•				
Forests	•				•	•			•
Vacant lands		•					•	•	
Swamps/bogs		•		•	•				
Lakes	•				•				•
Rocky areas	•								•
Rivers	•				•				•
Water chanels	•				•				•
Shores	•				•				•
Deltas	•			•	•				•
Bicycle lanes		•							•
Permeable pavements		•					•		
Singular trees			•	•	•				
Ecoducts		•							
Public fountains			•		•				•
Flower squares			•						•

Table 2 UGI classification based on accessibility and location

TYPE	CRITERIA							
	Accessibility			***Location***				
	Unlimited and unrestricted	*Limited access*	*Private*	*Central*	*Peripherial (within the city limits)*	*Individual*	*Periurban*	*Metropolitan*
Balcony vegetation			•			•		
Green walls						•		
Green roofs			•			•		
Atriums			•			•		
Green squares	•			•	•			
Streen trees	•			•	•			
Alignments with grass and shrubs	•			•	•			
Private gardens			•			•		
Green spaces related with the transport infrastructures	•			•	•		•	•
Playgrounds	•				•		•	
Riparian vegetation	•				•		•	•
Public park/garden	•			•	•			
Parks and gardens related with the block of flats	•				•		•	
Botanical gardens		•					•	•
Zoo		•					•	•
Green spaces related with public institutions		•	•	•				
Green buffer areas					•		•	•
Graveyards		•			•		•	
Sport gorunds		•		•	•		•	•
Camping sites		•					•	•
Allotment gardens			•		•		•	
Community gardens	•				•		•	
Agricultural lands							•	•
Pastures							•	•
Orchards							•	•
Forests	•				•		•	•
Vacant lands	•				•		•	•
Swamps/bogs	•						•	•
Lakes	•			•	•		•	•
Rocky areas							•	•
Rivers	•			•	•		•	•
Water chanels	•			•	•		•	•
Shores	•				•		•	•
Deltas	•						•	•
Bicycle lanes	•			•	•		•	
Permeable pavements				•	•		•	
Singular trees	•			•	•			
Ecoducts					•		•	•
Public fountains	•			•	•			
Flower squares	•			•	•		•	

Attractiveness: the level of UGI attractiveness influences the management complexity and also the pressures they confront with (Van Herzele et al. 2003). The attractiveness can be induced by the local history, usage, proximities, location or complexity.

Diversity: The UGI diversity is influenced by the elements which compose it. The diversity of an UGI can activate the level of attractiveness. In the same time, an UGI which has a high level of diversity provides a wide range of services (Calderón-Contreras et al. 2017).

Economic stimulation: The existence of an UGI in a certain location can help the economic development of that space (Netusil et al. 2014) through the increase of land prices or quality of living. A prohibitive price for land can determine a certain conservation state for an UGI. The development of new urban functional areas appears most likely around a green infrastructure which is planned to increase the level of attractiveness of that specific urban area.

1.2. Evaluation of the politics, programs and funding sources for UGI

The urban planning approach promoted in the European space has a long tradition. This is highlighted by the regulatory documents which determined corresponding legal elements on the national legislation level. The politics regarding this subject are the result of the EU state member cooperation and transfer of knowledge. In Europe, the planning of green spaces presents a socio-ecological approach which enhances the compact city concept. Nevertheless, the planning of green spaces has a role in the territorial management and it is influenced by location, demand and administrative structure.

At national level, there are several legislative acts which regulate the distribution and the management of UGI. Law no. 24/2007 was created to support the constitutional right of access to a healthy environment.

The management of green spaces is influenced by the ownership of the land. The public green spaces are managed by the local authorities while the private green spaces are managed by the private owners in accordance to the legislation.

In Romania, the Government offered funds for the rehabilitation and development of green spaces through the National Program for the Environmental Quality Improvement through Urban Green Spaces. For this program, the Romanian Government has allotted almost 40 million euros from which 18 were focused on the urban environments for rehabilitation and the creation of new green spaces (Figure 1).

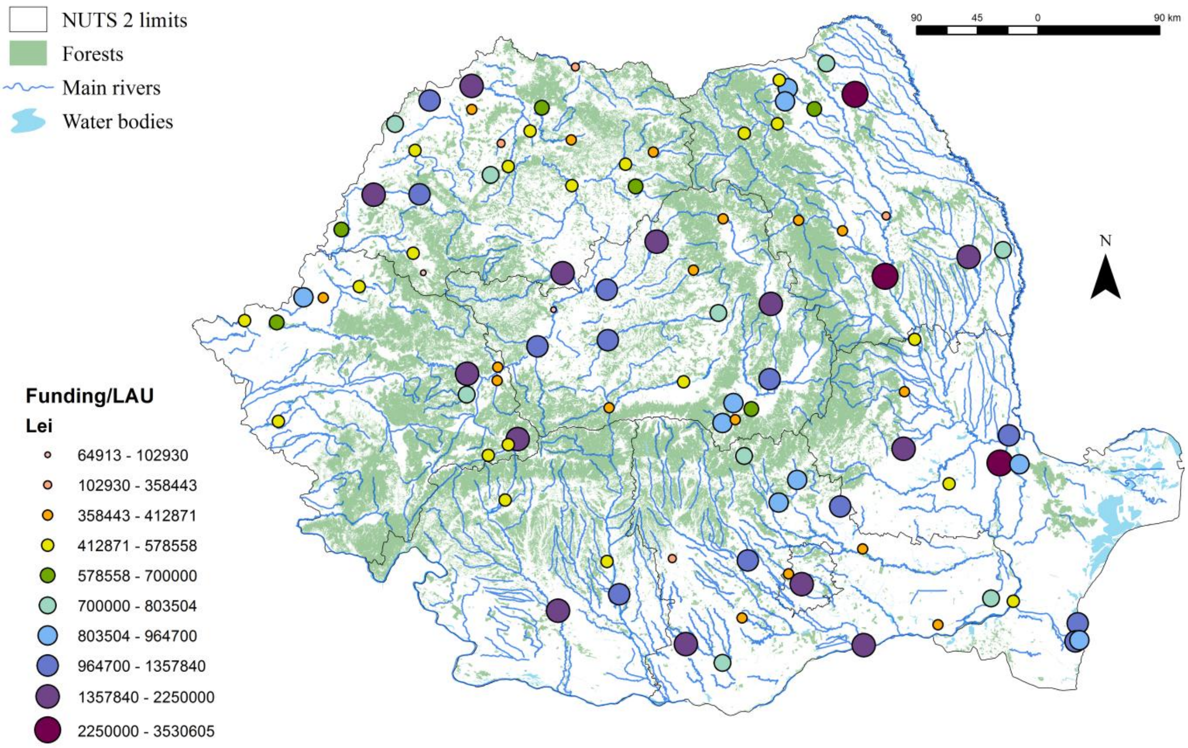

Figure 1 – Cities and municipalities which received funding through the National Program for Improving Environmental Quality through Urban Green Spaces

1.3. Identifying actors and urban planning processes

The green spaces, or the natural capital, can be managed by public initiative but, regardless of their importance (national or local) their management must follow a specific legislation created in an institutional framework that has two major pillars. The first one is described by the European institutions concerning the green infrastructures domain and the natural resources of Europe (Figure 2).

From the European level, the institutional structure continues with a second pillar which concerns the national and local level, involving the member states institutions. The approach used to elaborate the politics regarding green infrastructures and the management of the green capital is validated by these central structures, Parliament and Government. The implementation of politics and strategies falls into the local and counties councils' responsibility.

As a member of the European Union, Romania must have its legislation correlated to the European legislation which means that the national legislation acts must not be in contradiction to the European legislation (Figure 3).

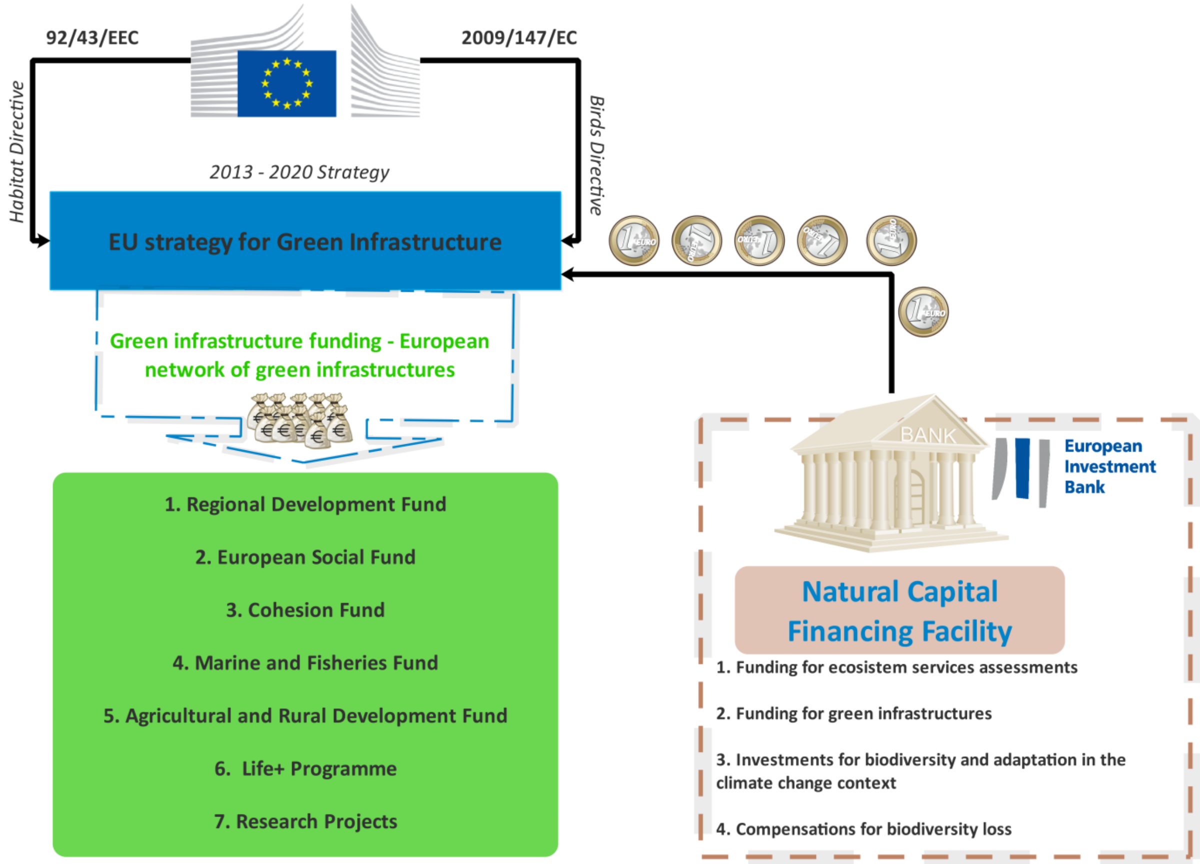

Figure 2 – Funding opportunities and investment mechanism in the green infrastructure and natural capital management domain

Urban planning in Romania has suffered many transformations in the way it sees the urban environment as a results of the socio-economic and cultural changes which followed the shift on the political stage, from the communist regime to capitalism and from a centralized economy to a market economy at the beginning of 1990 (Stanilov 2007, Suditu et al. 2010).

Urban planning in Romania was influenced by the changes on the political stage, more exactly by the European Union admission in 2007. Many European directives have been implemented into the national legislation imposing new standards for settlements quality in urban areas.

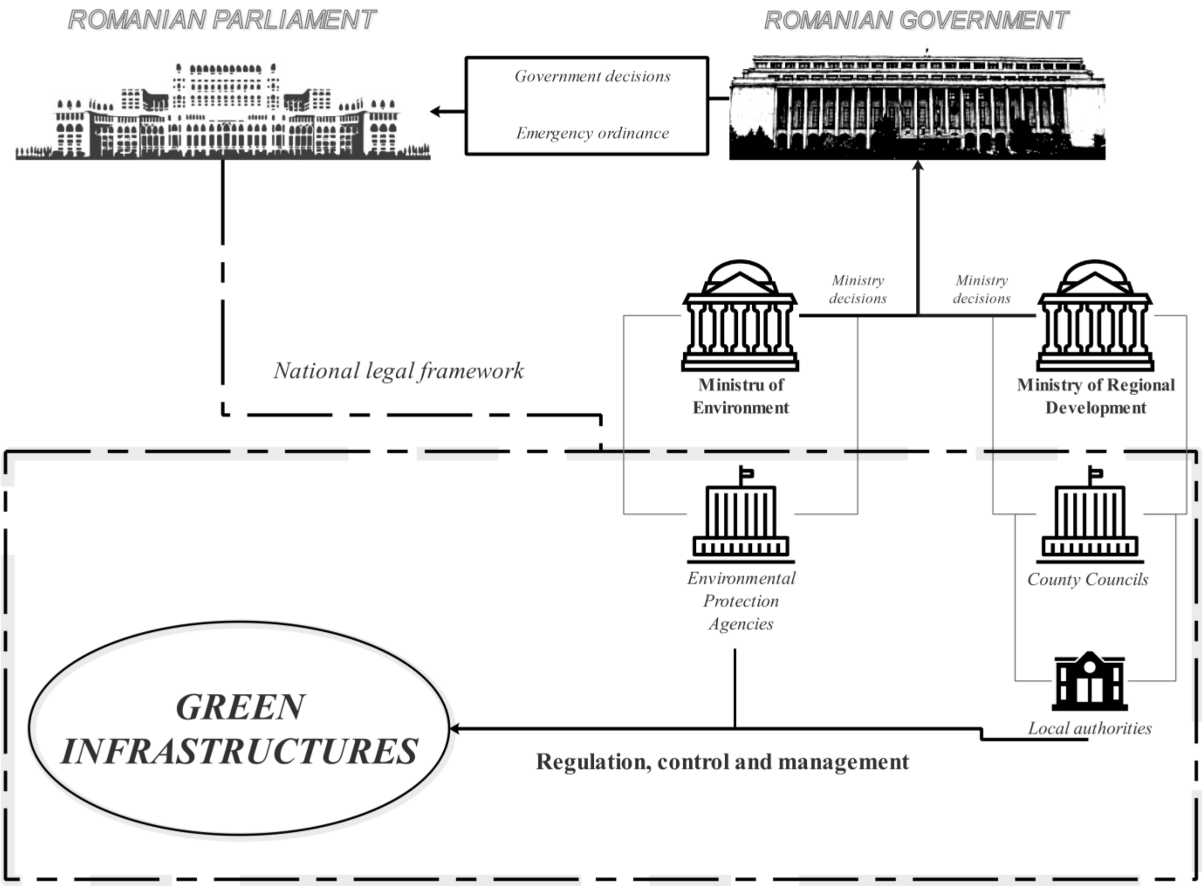

Figure 3 – National structure in the creation and implementation process of the green infrastructures and natural capital legislation

1.4. Identifying urban planning indicators

In Romania, the actual legislation does not regulate all the types of UGI. The Law No. 24/2007 regarding the regulation and the management of green spaces in cities gives a definition of urban green spaces, this being used in the functional zooning of an urban area. At European level, there is a threshold settled for the urban green spaces with a value of 30-40m²/ inhabitant, lower than the target recommended by the World Health Organization (WHO) which is 50 m².

The representative indicators used in this project for the evaluation of urban planning and UGI are: location indicators, state indicators, pressure indicators, financial and management indicators, Land Usage Coefficient (CUT), Percentage of Land Occupancy (POT), carbon sequestration volume, number of flora and fauna species, number of people using UGI, level of satisfaction, land prices, number of jobs generated.

1.5. Establishing representatives case studies for Romania

A proper method of ranking the Romanian cities based on the structure of green spaces typology is using a cluster analysis - *Agglomerative Hierarchical Clustering* method. This method is based on a bottom up approach, starting from a group of elements which separates them in multiple clusters based on their dissimilarities. The outcomes are the clustering and classification of Romanian cities based on the structure of UGI (presence or absence of certain green spaces).

The analysis grouped the 30 cities into 4 different clusters. A total of 24 cities (80%) were grouped in one cluster having strong differences compared to the rest of the cities. The cluster comprises rank II and III cities with a spatial distribution in hilly areas in the historical provinces of Muntenia and Transilvania.

Also, for the identification of UGI typologies (categories and the percentage of green spaces which defines it) and the cities classification, one can use a *Multiple Correspondence Analysis* which seeks to highlight relationships between the 30 cities based on their similarities.

Figure 4 Cities distribution in the 4 resulted clusters

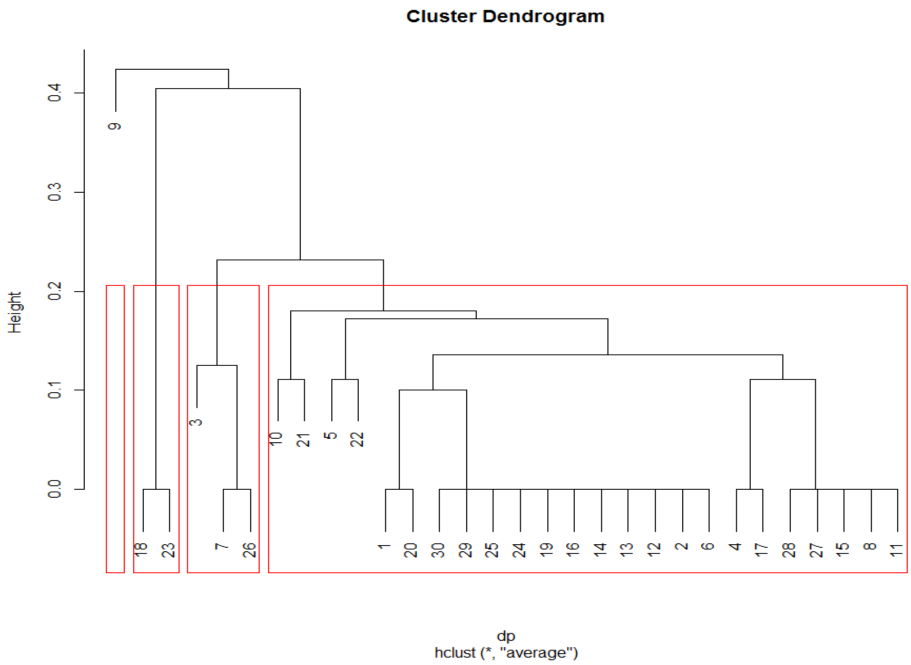

Figure 5 Determining the 4 cities typologies

The input data were obtained through the digitization of the urban green spaces within the 30 cities selected as case studies. The percentages of the 4 categories of the considered green spaces was classify in 7 groups (percentage under <5.0%, 5.1-10.0%, 10.1-20.0%, 20.1-30.0%, 30.1-40.0%, 40.1-50.0% and >50% from the entire city's green infrastructure). Finally, the graphical results were interpreted which offered information regarding the differences and similarities between the cities. We obtained a classification for the cities in Romania based on the UGI typologies.

The classification resulted from the Multiple Correspondence Analysis highlights the cities with a strong rural character, which have been declared cities during the post-communist period. They highlight large surfaces of green infrastructures represented by cemeteries (*figure 6*).

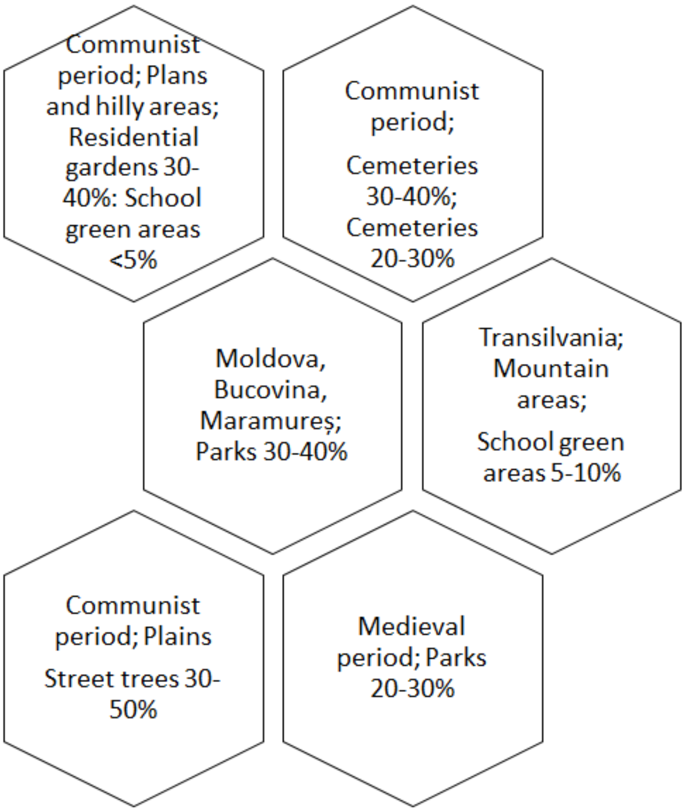

Figure 6 Cities classification using Multiple Correspondence Analysis

O2. Assessment of the influential factors over the UGI development

2.1. Assessing the perception of political and administrative stakeholders

UGI must tackle the negative effects caused by climate changes and air pollution. In the same time, it must provide certain ecosystem services to the urban community. It is hard to establish if the green urban spaces are organized as green infrastructures in Romania. The management of public green spaces is done by the local authorities. Thus, their perception regarding the concept of UGI is important for understanding the context in which urban green spaces are being planned.

During our study, we covered a wide variety of institutions directly or indirectly involved in the UGI planning helping us to evaluate different points of view and approaches. Besides local and county authorities (town halls and county councils) we received answers from institutions like The General Department for Emergency Situations, Constructions State Inspectorate, National Environmental Guard and its subsidiaries, National Land Use Agency and other institutions related to town halls and county councils.

It is important to evaluate how their representatives understand the term of green infrastructure. Almost 50% of the respondents considered that UGI represents the sum of public and private green spaces within a city (*Figure 1*). The respondents marked as very important the public health aspects, the environmental quality, education and public services in the context of a better quality of life. They considered that UGI can influence the increase of green space per capita, environmental quality, the amount of recreational spaces and public health (*Table 3*).

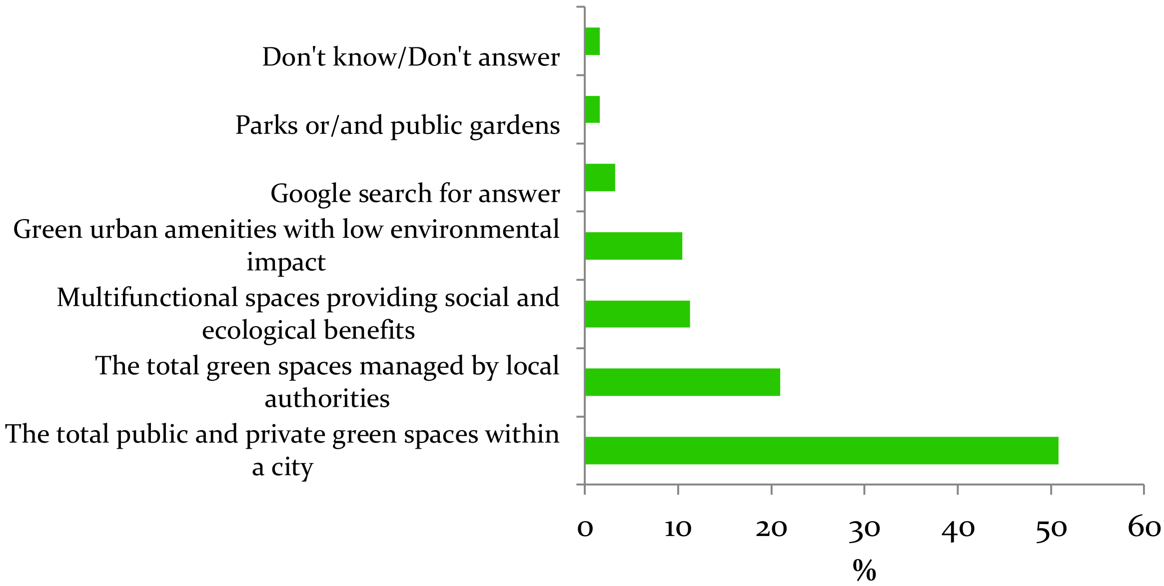

Figure 1 How the public institution representatives define UGI

Table 3 Hierarchy of components which determine an elevated level of quality of life and UGI influence on them based on institutions representatives' perception

Component	Effect on quality of life (1= very high value – 5=very low value)	UGI influence on components (1= very high value – 5=very low value)
Jobs	1,65	3,03
Public services	1,52	2,77
Security	1,65	3,00
Public health	1,29	1,63
Education	1,39	2,18
Recreational spaces	1,67	1,47
Living conditions	1,74	2,58

Environmental quality	1,31	1,31
Social inclusion	2,27	3,20
Access to services	2,04	3,15
Green space surface /inhab.	1,60	1,23

The crucial issues related to UGI were considered: the lack of funding for the development of UGI and the funds for maintaining the existing infrastructure. Little over 50% of the respondents considered that the green surface of cities has expanded over the last 25 years, but 45% of them admit that the main function of vacant land inside or at the edge of cities have not been developed into green spaces.

2.2. Assessing the perception of experts and population

The coverage of environmental problems through different media channels (TV, radio, newspaper, internet) has increased the amount of information provided to the citizens and encouraged their implication in finding solutions. The assessment of citizens' perception over the concept of UGI could not miss from our analysis. As the institutions' representatives, most of the respondents considered UGI as the total sum of green private and public spaces within a city (42%).

Similar with the institutions representatives, the citizens considered a disadvantage the fact that green spaces do not contribute to the local budget and that they need inflated costs for maintenance. Most of the respondents considered that the issues regarding the management and planning of UGI is the scarce implication of local authorities (84%) and the lack of users' education (78%). The respondents consider that the management and the conservation of local green spaces are as much the duty of local authorities as of their users.

During the study, we conducted an AHP analysis (Analytical Hierarchy Process) based on an expert opinion method to identify what criteria must be considered before planning a new green space to be part of an UGI and which urban green spaces are the most suited for this. We involved experts from different domains (biology, territorial planning, geography, remote sensing, GIS etc.) for generating realistic and objective results. Nine criteria were selected: *maintenance costs* (man), *build up easiness* (bld), *level of popularity in Romania* (pop), *efficiency in diminish climate change effects* (cce), *efficiency in the improvement of air quality* (aqi), *profitability degree* (epr), *biodiversity conservation aspects* (bdb), *social interactions stimulation* (sns) and *peculiarity* (spf). The criteria selection is widely explained in *Table 4*.

Based on the AHP analysis the results showed that the most important criteria which must be considered before planning new urban green spaces are: the benefits in the biodiversity conservation, efficiency in fighting against climate change effects ant the efficiency in improving air quality (*figure 8*). These results indicate that the role of an UGI must be oriented to the mitigation of environmental dysfunctionalities because in this way it contributes to the improvement of urban life quality.

Table 4 Explanation of chosen criteria

CRITERIA	EXPLANATION
Maintenance costs	*Total costs for UGI component's maintenance*
Building easiness	*How easy is to plan a new UGI component? Does it require a long time, excessive costs, large surfaces and complicated bureaucratic procedures?*
Popularity in Romania	*How popular is the UGI component in Romania (e.g. Flower and lawn squares have a high popularity compared to green roofs and ecoducts)?*
Efficiency in fighting climate changes effects	*Does the UGI component help in the improvement of climate changes effects?*
Efficiency in the air quality improvement	*Does the UGI component help in improving the air quality?*
Profitability degree	*Can the UGI component generate direct revenue to the public budget?*
Benefits in biodiversity conservation	*Does the UGI component contribute to biodiversity conservation?*
Social interactions stimulation	*Does the UGI component stimulate outdoor activities and social interactions?*
Specificity level	*Does the UGI component need topography or climate specific characteristics or is it independent from the urban landscape morphology?*

We selected 27 types of urban green spaces out of the ones proposed in European documents and projects (EPA 2007, EEA 2011, European Commission 2012). The 27 types of green spaces were classify based on the 9 criteria in accordance with their resulted weights. The results show that the most complex and in the same time recommended type of green spaces which must be included in an UGI are *urban forests* (*table 5*).

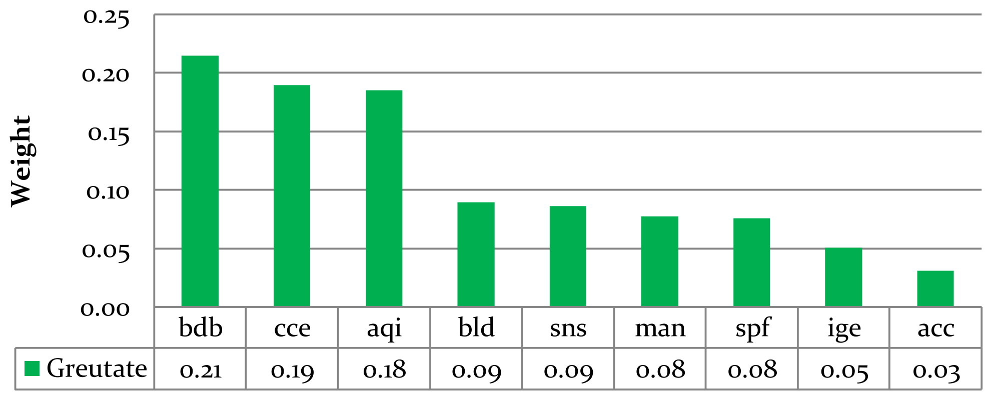

Figure 2 – Criteria weights based on AHP

Table 5 Green space suitability to be included in an UGI network

40-50%	50-60%	60-70%	70-80%	80-90%
flower pots	flowers and lawn squares	trees alignments	protection forests	urban forests
lawn squares	green sewage	ecological farms	local protected areas	
	isolated trees	pastures	meadow forests	
	areas ecologically reconstructed	forest patches	public parks and gardens	
	fish ponds	transitional ecosystems (artificial ecotone)		
	green fences	meadows, channels and rivers		
	ecoducts			
	tunnel passages			
	swamps/wetlands			
	green roofs			
	vertical gardens			
	orchards			
	allotments			
	riparian vegetation			

The suitability level (in percentage) of each type of green spaces was calculated based on the outputs obtained. Of the 27 types selected, 25 scored over 50%, the least suitable types of green space` are flower pots and lawn squares. These have mostly an aesthetic role and are not considered important in a future UGI development.

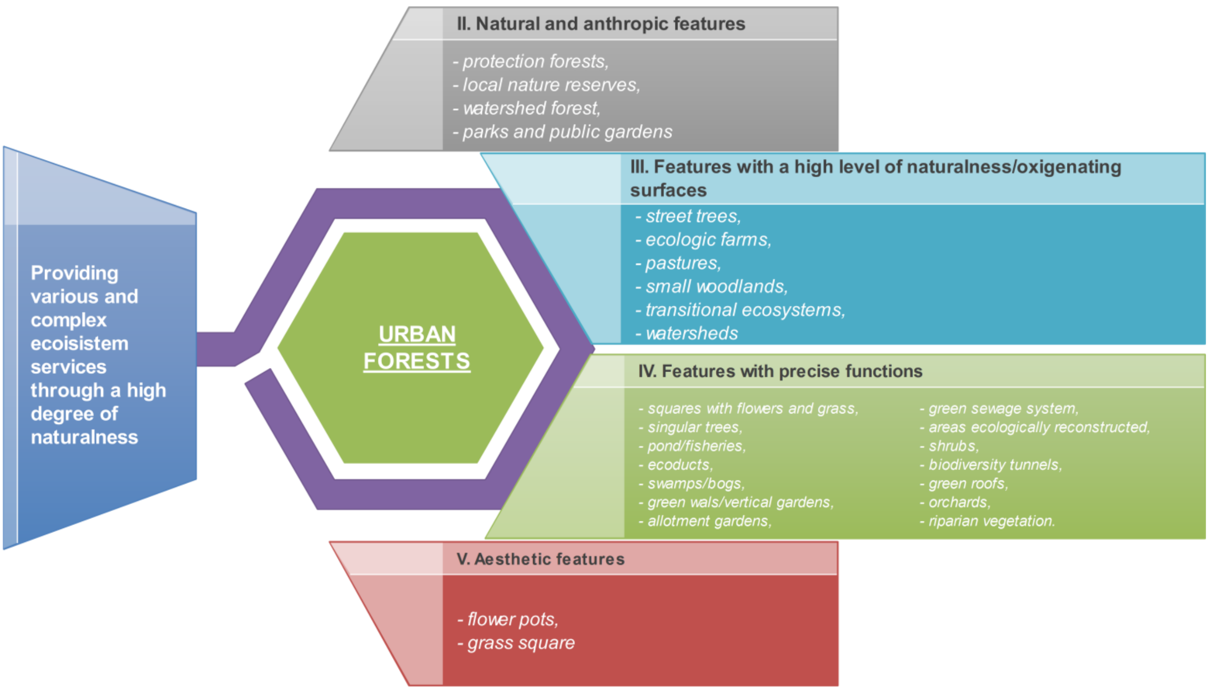

Figure 3 –Conceptual structure of an UGI network

2.3. Evaluation of economic stakeholders' perception in the development of UGI

The economic stakeholders must be considered important actors in the management and promotion of UGI because they can shape specific landscapes in the morphology of an urban area (Gavrilidis 2014, Ciocănea 2017). The presence of certain types of economic activities in the urban environment has encouraged the expansion of built up areas which determined the decrease of natural areas at the edge of cities (Gavrilidis et al. 2011, Saghin et al. 2012). Retail activities, offices buildings and deposits of different merchandises or materials have replaced the industrial and agricultural landscapes in the last 25 years (Mirea et al. 2013).

In this study, the economic stakeholders' perception was assessed in connection to their knowledge about the UGI concept and its necessity. The results showed that the companies' representatives considered that the proximity of certain green spaces to their buildings increase the building's level of attractiveness alongside with the level of environmental quality and employees' productivity. Over 55% have declared that the remained space along the buildings which they managed is use for the development of green areas, whereas 25% have stated that there is no required space for this type of investment. Regarding the difficulties in the management of near green spaces, almost 70% have declared that they don't have any difficulties and over 60% said they had chosen to plan green spaces near their buildings for aesthetic purposes.

The main benefits which the respondents found in having green spaces near their buildings are: the increased level of attractiveness and employees' happiness and the improvement of work conditions.

Overall, the economic stakeholders have a positive attitude towards UGI. They did not raise the same problems as the institutions representatives or the population. Under 10% of the respondents considered that the costs of such an investment are high and 84% would agree to a local authority's decision to encourage economic agents to invest in UGI based on the firm profile and the investment's suitability.

2.4. Integration of structural, functional, administrative and economic criteria in the ranking of UGI components

The management of the existing green spaces and the planning of new ones in the context of an UGI must follow a series of principles. In this study, we tried to establish what are the most suitable types of green areas based on the urban functional zone they are planned in. The actual urban planning is based on a centralized system, which has been transmitted from the communist regime and is characterized by a very accurate delineation of these urban functions inside the city (Gavrilidis et al. 2015). In the last 25 years, the limits of these urban functional zones have been transformed due to the urban dynamic but they can still be distinguished. In the post-communist period, a new urban function has appeared – the commercial zone.

We used the same 27 categories of green spaces and we selected five functional zones which are peculiar for the Romanian cities*: agricultural areas, industrial areas, commercial areas, collective residential areas and individual residential areas*.

Using a Delphi analysis, we tried to identify what type of green spaces is suitable for the five functional zones. We used a *zero* to *five* scale where *zero* means that the urban green space is not recommended and *five* means that it is strongly recommended.

The results showed differences between the residential areas (individual or collective) and the rest (agricultural, industrial and commercial) regarding the types of green spaces which are best suited. These outputs integrate the outputs of previous analysis. The green spaces with a high degree of naturalness, where the anthropic element is reduced are suitable for agricultural and industrial areas (Table 5). In the residential and commercial areas, there are elements which fulfil, besides the ecosystem services demand, aesthetic purposes (Table 6).

Table 6 Recommendations on types of green spaces for non-residential areas

Zone agricole		**Zone Industriale**		**Zone comerciale**	
Categorie	*Scor*	*Categorie*	*Scor*	*Categorie*	*Scor*
Ferme ecologice	4.00	Păduri de protecție	4.19	Aliniamente cu arbori	2.97
Pășuni	3.97	Aliniamente cu arbori	2.47	Arbori izolați	2.81
Ecosisteme tranziționale	3.74	Arbori izolați	2.20	Acoperișuri verzi	2.75
Râuri/Canale	3.55	Acoperișuri verzi	1.99	Parcuri și grădini publice	2.75
Livezi	3.33	Scuaruri cu gazon	1.75	Sistem de canalizare „verde”	2.69
Păduri de protecție	3.14	Areale reconstruite ecologic	1.68	Păduri de protecție	2.33
Păduri de luncă	2.53	Râuri/canale	1.60	Scuaruri cu gazon	2.23
Garduri vii	2.44	Păduri urbane	1.59	Scuaruri cu gazon și flori	2.22
Rezervații naturale locale	2.41	Sistem de canalizare„verde”	1.56	Grădini verticale	2.09
Păduri urbane	2.11	Garduri vii	1.54	Garduri vii	1.99

Table 7 Recommendations of green spaces for residential areas

Rezidențial colectiv		**Rezidențial individual**	
Categorie	*Scor*	*Categorie*	*Scor*
Parcuri și grădini publice	5.00	Parcuri și grădini publice	4.38
Aliniamente cu arbori	3.86	Aliniamente cu arbori	3.26
Acoperișuri verzi	3.32	Sistem de canalizare „verde”	2.95
Arbori izolați	3.17	Arbori izolați	2.90
Scuaruri cu gazon și flori	3.08	Scuaruri cu gazon și flori	2.82
Grădini verticale	3.04	Garduri vii	2.72
Sistem de canalizare „verde”	2.95	Păduri de protecție	2.68
Scuaruri cu gazon	2.79	Râuri/canale	2.64
Păduri de protecție	2.68	Pâlcuri de pădure	2.43
Ghivece cu flori	2.45	Areale reconstruite ecologic	2.12

O3. Determining methods to assess the UGI potential in urban planning

3.1. Classifying and quantifying ecological, economic and social benefits of UGI

Nowadays UGI are the main providers of ecosystem services in urban environments which are affected by climate changes, demographic increases and overconsumption of resources (Rees 1997). The capacity to provide benefits towards the urban community depends on the quality and quantity of UGI elements and their connectivity.

The types of UGI present ecological, social (cultural and recreational) and economic functions (table 8). Through the provision of these benefits, UGI can improve the quality of living and public health (Niță 2016).

The methods used to classify and quantify the benefits offered by UGI are qualitative methods (for the evaluation of recreational spaces or of social benefits) or quantitative methods (ecological or economic benefits).

Table 8 Benefits provided by UGI

No.	UGI category	Benefits	Examples
1	Urban parks	Ecological benefits	Improvement of air quality(Yang et al. 2008), biodiversity conservation and habitat creation to support local flora and fauna species (Cornelis et al. 2004);
		Social benefits	Aesthetic improvement of the urban landscape, recreational spaces, opportunities for socializing, sports area (Chiesura 2004) and public health improvement (Takano et al. 2002);
		Economic benefits	Improvement of living space attractivity, reduction of energy consumption through the maintaining of constant temperature
2	Urban forests	Ecological benefits	Improvement of air quality through: carbon sequestration, biodiversity conservation and habitat creation for local flora and fauna species (Hobbs 1988), mitigation of isle of heat (Gill et al. 2007)
		Social benefits	Improvement of urban landscape aesthetic; recreational areas
		Economic benefits	Reduction in energy consumption by maintaining constant temperature
4	Block gardens	Ecological benefits	Mitigation of water erosion (Mentens et al. 2006), support for birds, plants and invertebrates species (Cameron et al. 2012)
		Social benefits	Relaxation and socializing spaces
		Economic benefits	Improvement in living prices
3	Trees alignments	Ecological benefits	Improvement of air quality through protection alignments against emissions caused by cars; mitigation of noise pollution
		Social benefits	Walking areas for inhabitants
		Economic benefits	Increase in urban living prices (McPherson et al. 2005)
5	Schools	Ecological	Improvement in air quality due to vegetation input and

	gardens	benefits	mitigation of noise pollution
		Social benefits	Recreational areas and educational activities (Ozer 2006, Iojă et al. 2014).
6	Public institutions gardens	Ecological benefits	Reduction of erosion caused by water
		Social benefits	Recreation and relaxation spaces; Improvement of urban landscape aesthetic
7	Sport fields	Social benefits	Improvement of public health through the promotion of sport activities (Swanwick et al. 2003).
8	Squares	Ecological benefits	Reduction of erosion caused by water
		Social benefits	Improvement of urban landscape aesthetic
9	Industrial and commercial areas associated green spaces	Ecological benefits	Reduction of erosion caused by water
		Social benefits	Improvement of urban landscape aesthetic

The approaches in regard with UGI are oriented to quantify their ecosystem services. Assessing their ecological services represents a quantitative analysis of the UGI benefits, being much more efficient to manage from a decision-making perspective. The European Commission published the ***Mapping and assessment of urban ecosystems and their services*** (Rocha et al. 2015) for the evaluation of urban ecosystem services. In this report, there are presented a series of indicators for the quantification of the provision services, regulatory services and cultural services.

Indicators for assessing UGI's provision services: biomass quantity of large and mature trees per forest hectare (t/ha); number of species with therapeutically value/ha; quantity harvested (no./ha, euros/ha, t/ha); forest coverage (%).

Indicators for assessing UGI's regulatory and maintenance services: Quantity of carbon sequestrated in the trees canopy (t/ha); pollutants retained by trees and shrubs (PM_{10} and $PM_{2.5}$, SO_2, NO_2, O_3, CO_x) (t/ha/year); the capacity to retain water in vegetation and soil (t/km^2); climate cooling effect (°C); greenhouse gas mitigation (%); shading area (urban climate regulation) (m^2); trees cooling potential (t C/ha); total surface of public green spaces (m^2); city's ecological footprint (t CO_2).

Indicators for assessing UGI's cultural services: Suitable space for outdoor cultural activities (m^2); number of recreational sites (number); UGI proximity to alternative travel routes (km); recreational potential (between 0 and 1); parks surface per inhabitant (ha/inhab); spatial distribution of runners and bikers (number of runners and bikers/hour/km); children playgrounds surface (m^2).

In the context of a poor management, UGI can lead to the emergence of environmental issues (table 9). The most known disservices which can affect the quality of urban living are: pathogens dispersion, allergenic plants dispersion, pests and diseases determined by the UGI flora and fauna (Lyytimäki et al. 2008, Dunn 2010). Besides the ecological disservices, UGI can create premises for social problems. For example, planning urban parks at the edge of neighbourhoods with different economic status can lead to social conflicts (Iojă et al. 2015).

Table 9 Environmental disservices examples generated by UGI– (after (Lyytimäki et al. 2008, Escobedo et al. 2011)

Social disservices
Pathogenic agents
Allergenic plants
Insecurity
Diseases (Lyme, rabies)
Discomfort caused by vegetation's abundance
Ecological disservices
Emissions of aerosols and volatile organic compounds
Invasive species distribution and mobility
Economic disservices
Costs for green spaces management
Obstruction of pedestrian ways due to trees roots
Buildings degradation due to wood decomposition
Occupancy of surfaces which can have another more profitable utilization

Even if the green spaces and their associated biodiversity benefits can be larger than the disservices, one must analyse both aspects when planning to fulfil the residents' needs.

3.2. UGI configuration in urban functional zones

Cities are characterized by a mosaic of land uses (Puertas et al. 2014, Salvati 2014). The development of urban centres is influenced by many factors like natural environment, demographic and economic evolution of the city and the urban planning approach. Cities are complex systems which generates socio-economic patterns (Amorim et al. 2014) which can be seen in the urban landscape as a certain functional zone, its purpose being to fulfil social, economic and ecological needs (Jaeger et al. 2010). The rapid transformations which often occur as a consumption of vacant spaces and resources, has raised many problems in the management and planning of these areas.

The urban planning process is based on the Law no. 350/2001 which contains the legal planning instrument – the masterplan (PUG) which has a regulatory power on the functional zoning within the city in correlation with the road infrastructure planning. Its dispositions are focused on medium and long term.

The masterplan represents an important source of information regarding the planning of green spaces in urban areas. This document comprises a written part – the General Report and the Local Urbanistic Regulations – and a graphical one which shows the distribution of functional zones throughout the city.

The important components for UGI are the functional zones defined as green spaces in the masterplan. The important aspects which seek the planning of these areas are: the provision of recreational areas, the control of climatic and hydrological parameters, the habitat creation for the local flora and fauna and food productivity (Niță 2016). The Green Spaces Law no. 24/2007 (47/2012) defines these green spaces in the following typology (table 10).

To analyse the structural and spatial distribution of UGI from an urban planning perspective we used as a main source of data the masterplan. These plans were accessed using local public administrations websites – town halls, urbanism departments. From a total of 319 urban municipalities, only 87 have made public their masterplan documentations through the online environment.

In this way, we analysed 87 masterplans for 87 urban municipalities in Romania (1 – rank 0, 8 – rank 1; 41 – rank 2, 37 – rank 3) (*figure 10*). These documents were the main source for data regarding the green spaces regulated. The following types of information were obtained:

- presence/absence of a type of green space;
- percentage of land occupancy POT,
- land utilization coefficient CUT (*figure 12*)
- list of permitted activities.
- regulations concerning the planted spaces from other functional areas (besides green spaces): central areas, mixt uses areas, residential areas, productive activities areas etc.

After this stage of data collection, maps were created to have a general perspective of the cities included into the study cases.

Table 10 The typology of green spaces in Romanian legislation

A.	**Public green spaces with unlimited access:** **Parks, gardens, squares and planted strips;**
B.	Specialized public green spaces: 1. Botanic gardens and zoos, outdoor museums, exhibition parks, recreational areas for circus animals 2. Green spaces related to public services: nurseries, kindergartens, schools, hospitals, medical and social centres, institutions, religious buildings, cemeteries; 3. Sports facilities: sports parks for performance sport;
C.	Recreational green spaces: recreational centres, recreational poles, sports complexes;
D.	Green spaces for water bodies and rivers protection;
E.	Protection areas for technical infrastructures;
F.	Recreational forests.
G.	Nurseries and greenhouses.

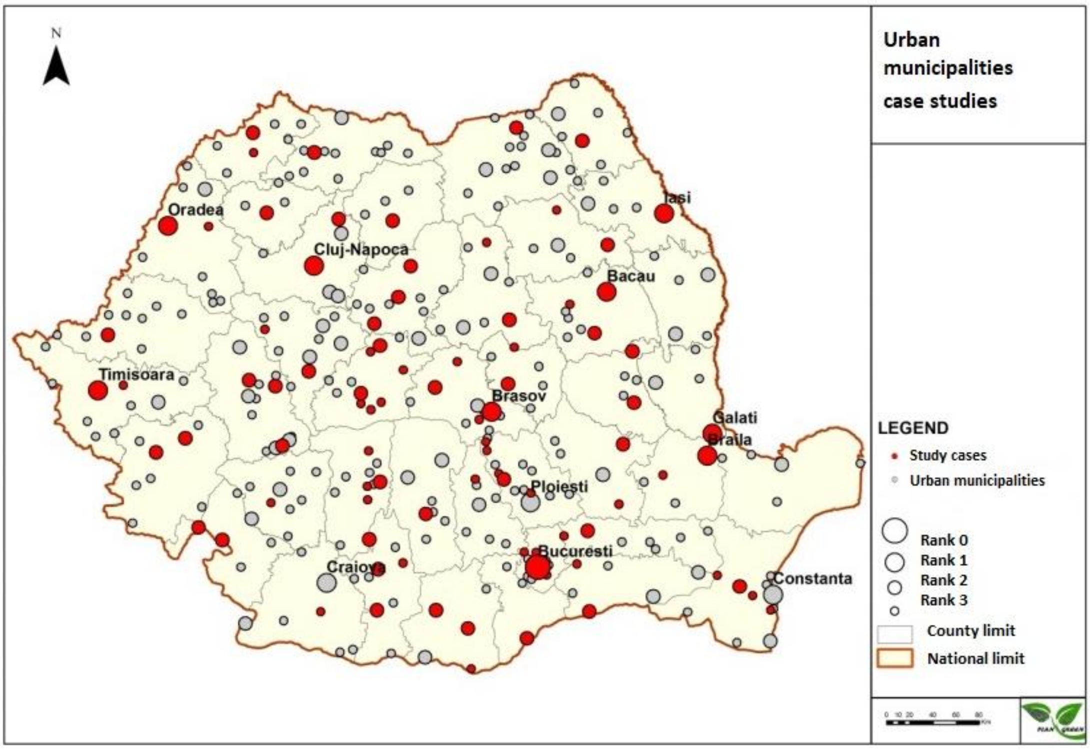

Figure 10 – Cities used as case studies

Regarding the percentage of green spaces, *figure 11* presents the national level situation. A small number of cities stand out with surfaces over 20% of the inner city (Borsec and Arad) along with the ones with a percentage included in the interval 10% - 20% (e.g. Bistrița, Cluj, Abrud, Câmpina etc). The highest percentages of green spaces occur in cities localized in the central part of the country.

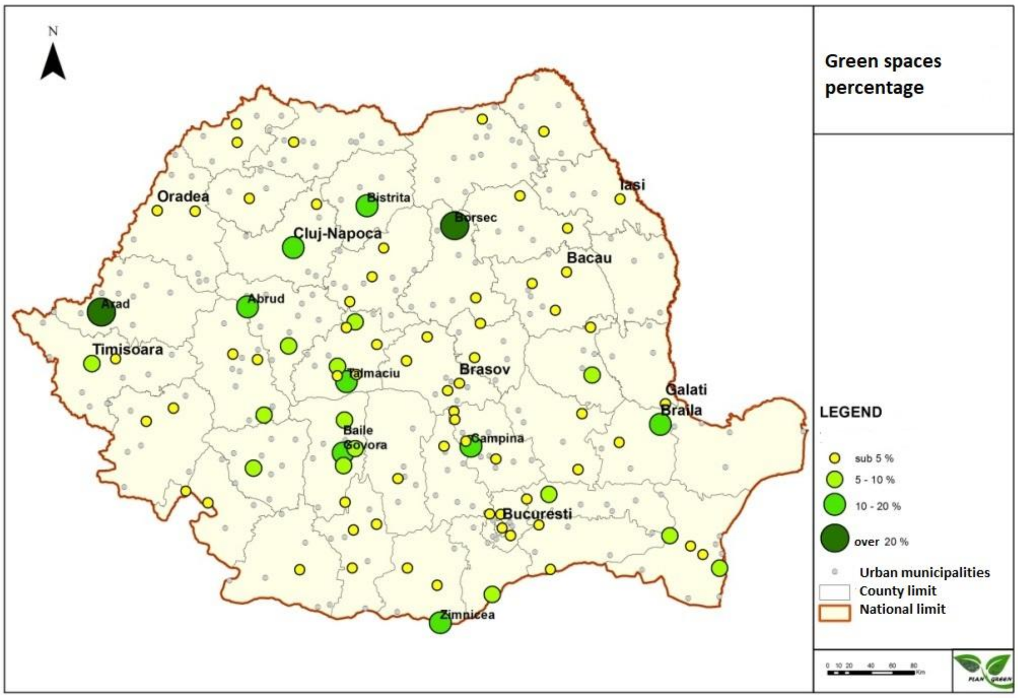

Figure 11 – Green space percentage from the total administrative limits

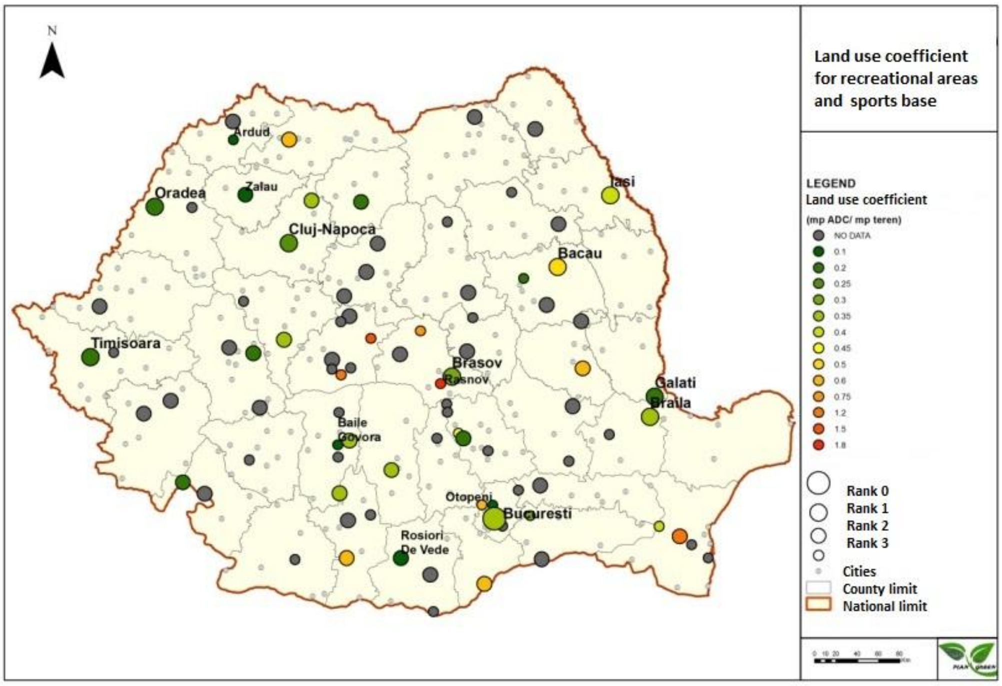

Figure 12 – Land use coefficient – value distributions for the selected case studies

Another aspect which was analysed was the dynamic of green spaces at city level. Because the masterplan presents the development directions of a city through the urbanistic proposals which are comprised in its written and graphical components, the analysis sought to compare the percentage of green spaces between the present state and the proposals.

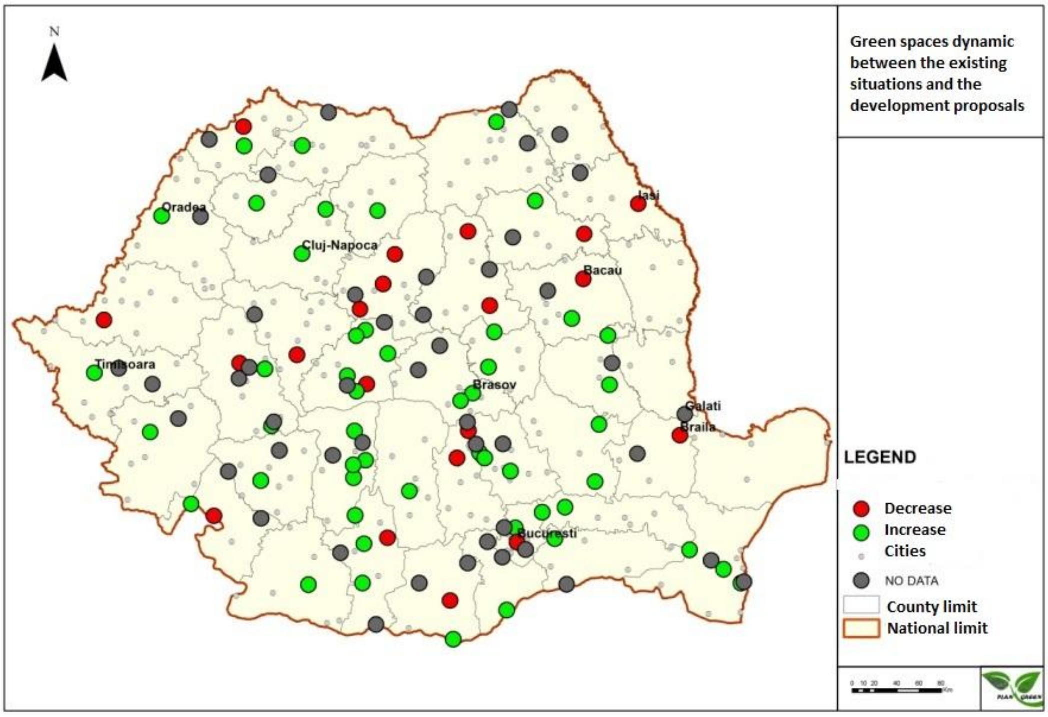

Figure 13 – Urban green space dynamics

From the 87 cities which were analysed, 7 of them were selected. This selection was made to cover all the ranks in the urban hierarchy. Next, the functional zoning was mapped using the graphical part of the masterplan as base map. The preliminary result was the creation of a GIS database which allows the spatial distribution analysis between UGI and other urban functional areas. Next stage included a spatial analysis based on distance indicators.

3.3. UGI connectivity assessment

The connectivity concept represents a key element in a sustainable planning for urban and rural environments. Connectivity can be define as the capacity of an area to sustain dispersion and substance, energy and organisms flow (Taylor et al. 1993).

There are two types of connectivity in biogeography: ***structural connectivity*** and ***functional connectivity*** (Crooks et al. 2006). The first one refers to the capacity of an area to sustain ecological flows of substances and energy without taking into account the needs of an habitat and the species' mobility (Kadoya 2009). The functional connectivity refers to the possibility of organisms to disperse in an area in order to raise the degree of population viability (Taylor et al. 1993, Forman 2006).

Besides the concept of local flora and fauna dispersion, the urban connectivity analysis focused on the inhabitants mobility between urban green spaces to ensure the needs of recreation, socializing or practice of physical activities (Iojă et al. 2014) (figure 14).

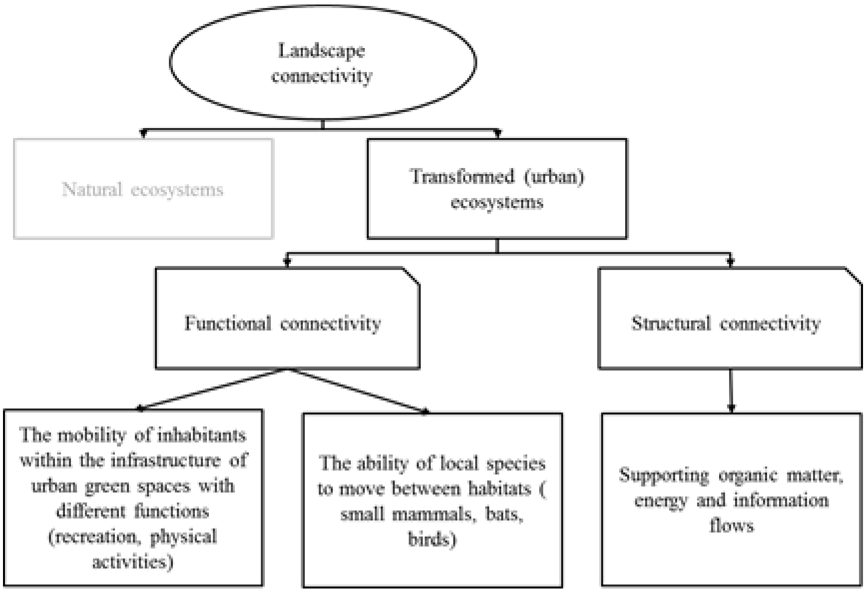

Figure 14 – Hierarchy of connectivity types (after Rudd et al., 2002; Kong & Nakagoshi, 2006; Marulli & Mallarach, 2005)

In order to establish the degree of *structural connectivity* there are certain landscape metrics (Kong et al. 2006, Kindlmann et al. 2008) but often the results obtained are redundant and enable to offer a real image over the ecological processes (Kupfer 2012). Nevertheless, the data obtained from the calculation of these indicators (Table) requires a small volume of data and can be considered as preliminary results in the connectivity assessment.

Table 11 – Landscape metrics used in connectivity assessment – examples, after (McGarigal 2014)

Indicator	Formula and calculation	Importance
Total Core Area (TCA)	$TCA=\sum_{j=1}^{n} a_{ij}^{c} (\frac{1}{1000})$ a_{ij}^{c}= central surface of a patch ij (m^2) based on a specific edge (m)	Total Core Area is a relevant indicator for UGI connectivity. It can be used to quantify the total surface of green elements (at network and category level) after the discharge of an edge buffer. .
Edge Density (ED)	$ED=\frac{\sum_{k=1}^{m} e_{ik}}{A}(10000)$ e_{ik}= total length (m) of an edge at landscape level **A**=total area of the landscape (m^2)	Edge Density evaluates at network and category level, the edge length per hectare.
Euclidean Nearest-Neighbour Distance (ENN)	$ENN=h_{ij}$ h_{ij}=distance (m) from the focal patch **ij** to its nearest neighbour patch from the same class	This indicator offers information regarding the level of patch isolation.
Proximity Index (PROX)	$PROX=\sum_{s=1}^{n} \frac{a_{ijs}}{h_{ijs}^{2}}$ a_{ijs}= area (m^2) of patches ijs from the proximity of patch ij h_{ijs}= distance (m) between patches	This indicator offers insights on the distance between patches in a certain area and calculates the degree of proximity based on their areas.

Indicator	Formula and calculation	Importance
	calculated from their centroids	
Connectance Index (CONNECT)	**CONNECT**=$\left[\frac{\sum_{j=k}^{n} c_{ijk}}{\frac{n_i(n_i-1)}{2}}\right](100)$ $\mathbf{c_{ijk}}$=level of association between patches **j** and **k** (**0**=unassociated and 1=associated), based on a specified distance $\mathbf{n_i}$=number of patches which correspond to the same landscape class	The indicator shows the number of connections between patches transposed in a percentage of maximum connectivity.

The functional connectivity is quantified through complex analysis such as *Travel Cost* (Marulli et al. 2005), *Graph Theory* (Urban et al. 2001, Foltête et al. 2014, Niculae et al. 2016) or through specialized programs which analysis the capacity of species to disperse in an area (McRae et al. 2008, Moilanen et al. 2009, Saura et al. 2009).

Example of connectivity indicators calculation for the Romanian cities

Total Core Area

UGI have the largest central surfaces (Total Core Area) in rank I and II cities (e.g. Iași, Brăila, Piatra-Neamț, Constanța, Oradea) compared to the smallest one which occur in rank III cities (e.g. Isaccea, Negru Vodă, Piatra-Olt, Odobești, Baraolt) (*figure 15*). The reason for this distribution is linked to the pattern of the UGI. There are many parks and residential gardens in major cities.

Edge Density

The calculation of Edge Density indicator highlights a higher heterogeneity than the last indicator. The values are uneven distributed between the three city rank categories (*figure 16*).

The highest values of *structural connectivity* for UGI were obtained in rank I and II cities (Târgu Mureș, Oradea, Ploiești, Iași) (*figure 17*). The city of Băile Herculane has the highest connectivity. It has an UGI which continues with urban forests at the edge of the city. The *Total Core Area* indicator has a similar interpretation. Cities where UGI have a low connectivity are from the rank III category with low importance (e.g. Odobești, Berești, Târgu Lăpuș, Negru Vodă, Isaccea).

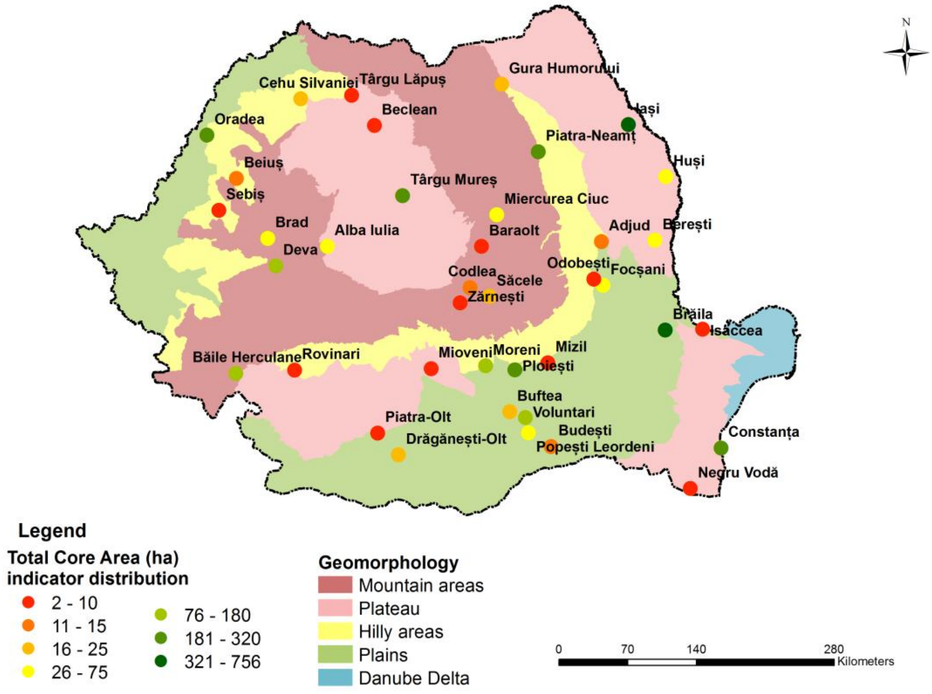

Figure 15 Total Core Area – value distributions in Romanian cities

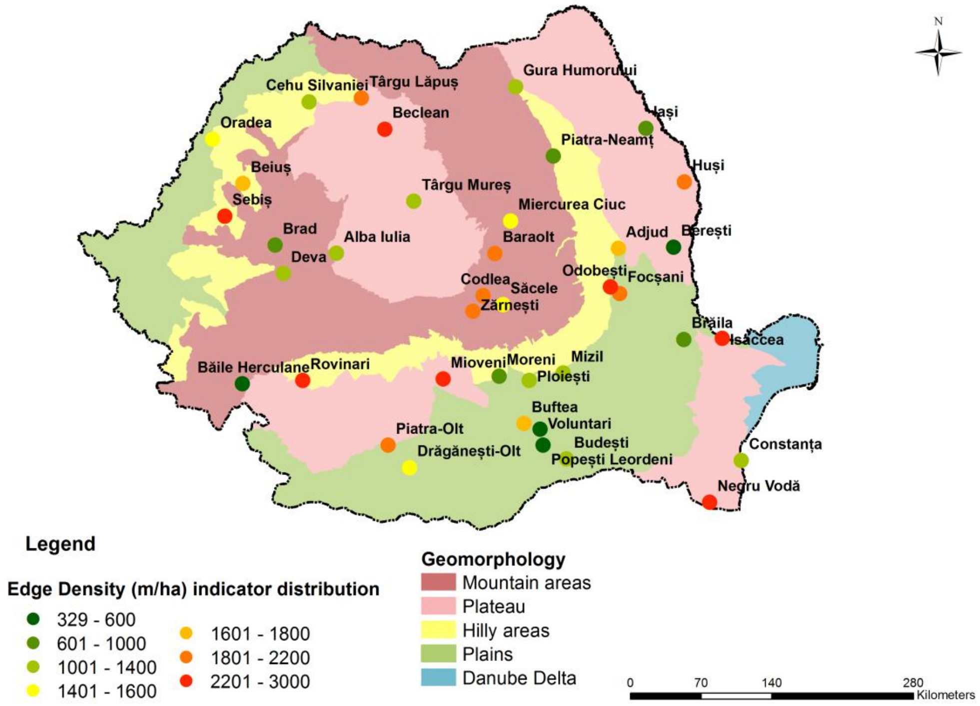

Figure 16 – Edge Density – values distribution in Romanian cities

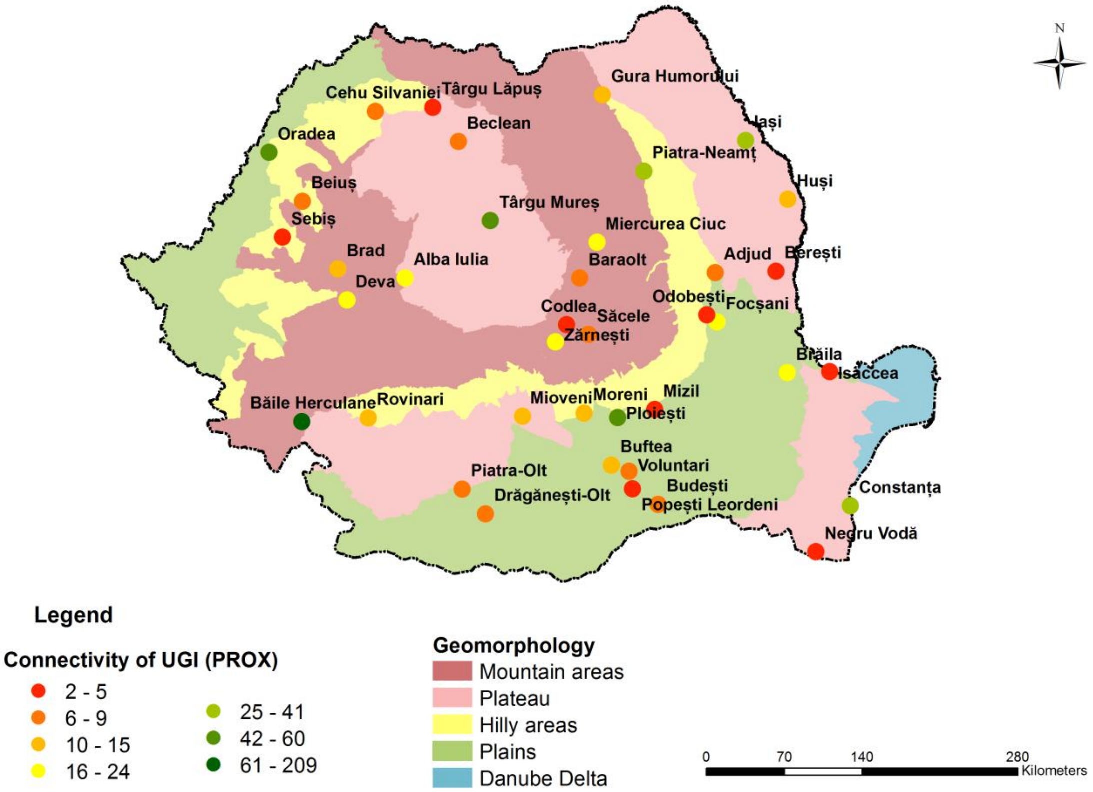

Figure 17 – Proximity Index – values distribution in Romanian cities

Urban parks connectivity assessment. Case study: Bucharest

The functional connectivity is defined as residents' capacity to move between urban parks to fulfil their needs for recreation, social interactions and sports activities, maintaining of these activities during the movement between parks. An efficient feature for improving green spaces connectivity can be bicycle lanes. It promotes a sustainable mode of transport (Midgley 2011) and can connect urban parks while keeping their recreational function along the route.

The purpose of the analysis was to identify the criteria and suitable areas to plan bicycle lanes meant to connect urban parks. To determine relevant criteria in the planning of bicycle lanes, a multicriterial analysis was applied based on *expert opinion*(Clayton 1997). To establish weights for each criterion, experts in the domain of urban ecology and UGI management were involved (Krueger et al. 2012, Iojă et al. 2014).

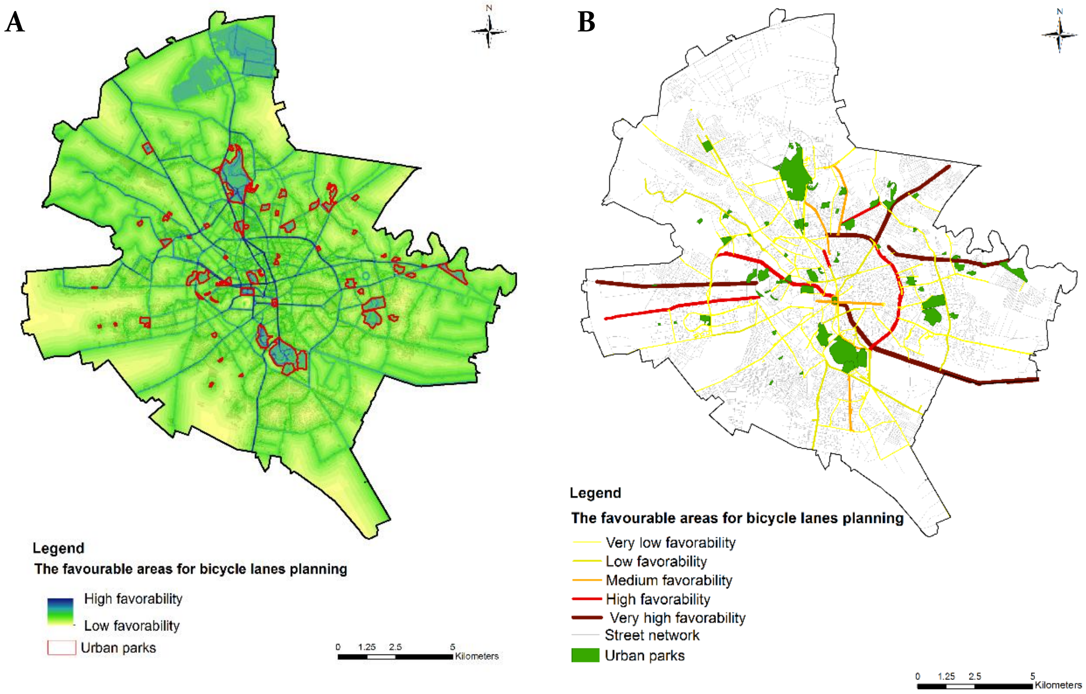

Figure 18 – Suitable areas for planning bicycle lanes (A = multicriteria analysis result; B = population's perception results)

Through the hierarchical analysis, the selected experts have compared the chosen criteria and have established a value ranging from 1 (low weight) to 9 (high weight) based on the criteria importance in the planning of bicycle lanes (Munier 2004). The obtained values were used as weights in the Model Builder (ESRI 2011) application to map the suitable areas for the development of bicycle lanes. To integrate the residents' perception in this type of planning process, a questionnaire was elaborated and applied in 34 urban parks in Bucharest. The questionnaire sought to gather data regarding the attractiveness of parks for bikers, important criteria and suitable transportation routes to plan them. The study consisted in statistical descriptive and spatial analysis applied. Both GIS analysis based on multicriteria analysis and on the residents' perception concluded that the most suitable areas for bicycle lanes planning are the important streets which connect the residential areas to the cultural ones and green spaces (figure 18).

O4. Evaluation of UGI development in representative places in Romania

4.1. Mapping the UGI distribution in representative places in Romania

The data used for the UGI distribution mapping in Romania are different based on their availability and how much detailed information they provide. Aerial images (www.ancpi.ro) with a national coverage of 5 m resolution provide data for mapping green spaces at a prominent level of detail. The disadvantages which come with the use of this type of data are the prohibitive costs to obtain them and the time needed for data processing. Aerial images allow the mapping of urban green spaces for different time to apply a diachronic analysis.

Nowadays the availability of aerial images is high with data since 1970 to the present day. The disadvantages consist in the long time to process and the weak resolution for the opensource images which can vary from 15 m (Landsat 7 and 8), 30 m (Landsat 4-8) and 60 m (Landsat 1-5).

The masterplans can provide data for urban green spaces mapping with a high detailed level and in relation to other functional zones. The low availability of the masterplan as an on-line data represents one of the disadvantages of using them as well as their slow update process. Urban Atlas represents a database created at European level for the big cities which includes the land uses. Although the database allows comparative analysis between cities, it presents the disadvantage of a scale of 1:10000 which is not enough for detailed analysis. Open street map is an opensource spatial database, with a global coverage which includes land use data, buildings distribution, road network, rivers etc. Being a participatory GIS project, the users can edit the data and in some cases the provided data do not correspond with the field reality.

For 38 cities, the UGI were mapped based on aerial images. 5 cities were rank 1, 11 ranks 2 and 22 rank 3. Conclusions were made based on the resulted maps with regards to the distribution of UGI in representative spaces in Romania.

We observed a high heterogeneity between the percentages of each category of green spaces. Rank 1 cities have a complex network of over 10 categories of UGI, most of them important in the provision of ecosystem services: parks and urban gardens, blocks gardens, schools' gardens (*figure 19*).

In cities with medium importance, rank 2 (*figure 20*), there are UGI composed of 10 or more types of green spaces with park of smaller surfaces than the high importance cities.

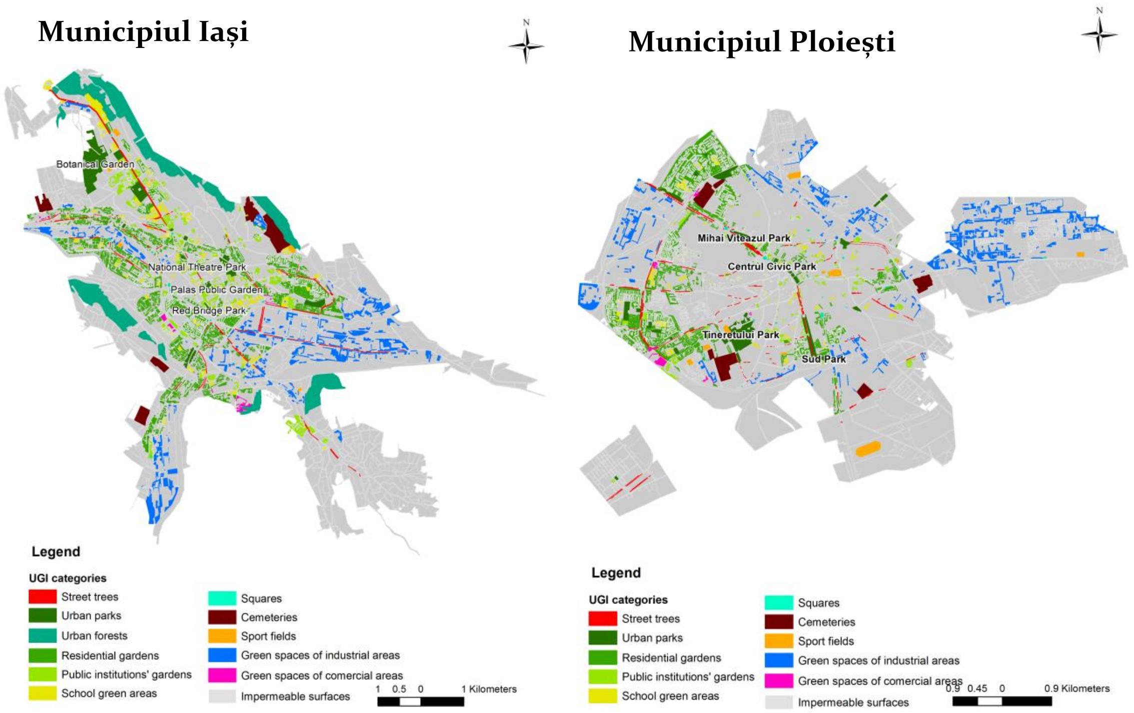

Figure 19 –Distribution of UGI types in high importance cities (rank I)

Regarding the rank III cities (*figure 21*), the UGI lacks important types of green spaces which have a role in providing the ecosystem services and raising the quality of urban life. Among the missing types of urban green spaces, the most often are: urban parks, blocks gardens and sport fields.

The UGI patterns differs based on the topography, historical province where the city is localized or the time when the city received the status of urban municipality. A comparative analysis shows that cities established in the post-communist period and localized in low altitude areas have large numbers of streets alignments (>50%) and parks (>30-40%) compared to the ones establish during the ancient period and localized in high altitude areas which have large surfaces of blocks gardens (40-50%).

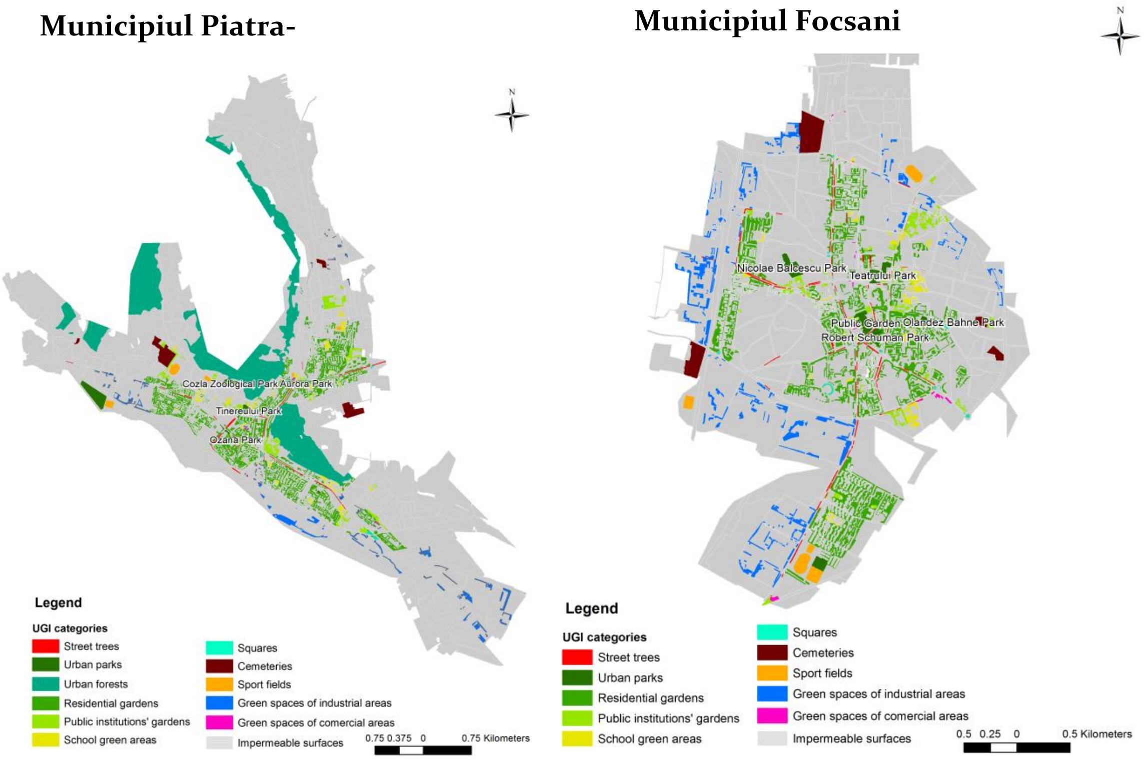

Figure 20 –UGI distribution in medium importance cities (rank II)

In *figure 22* one can observe the details of UGI distribution at a local scale. For local studies, it is recommended to use cadastral plans but their availability is very little. They are historical documents which rarely have been updated after 1990. Besides the topography and the period for city establishment, the UGI distribution is also influenced by the functional zoning of the city. The new neighbourhoods have imposed transformations due to historical, political, economic and social changes.

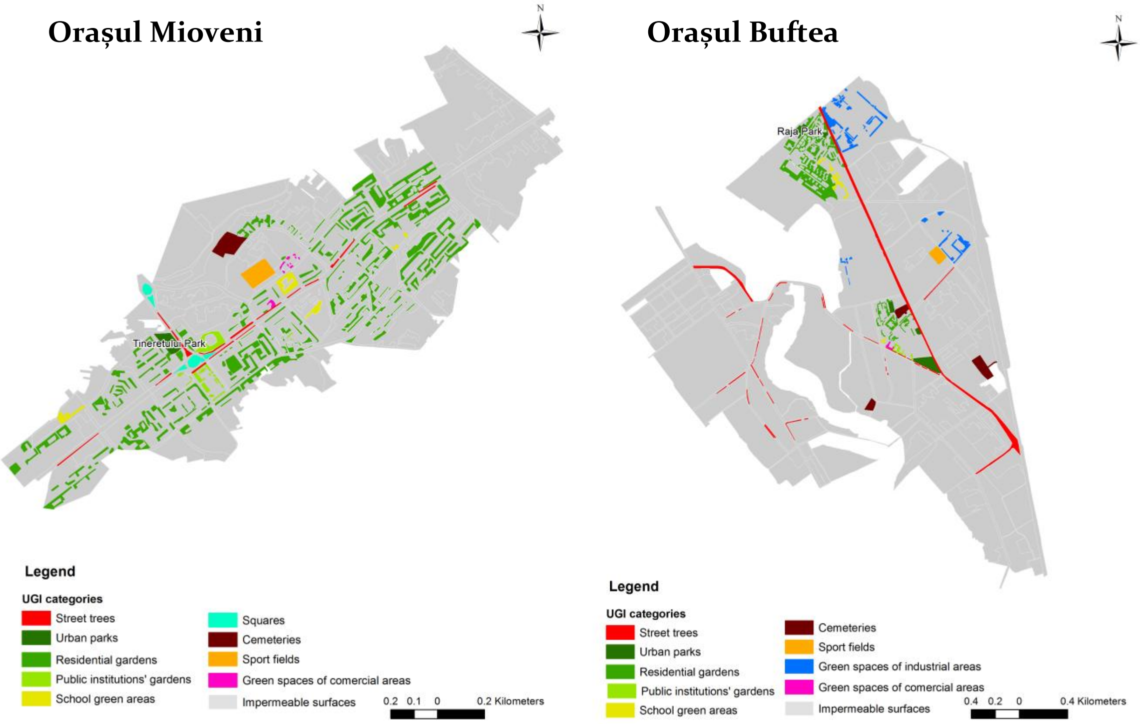

Figure 21 –UGI distribution in low importance cities (rank III)

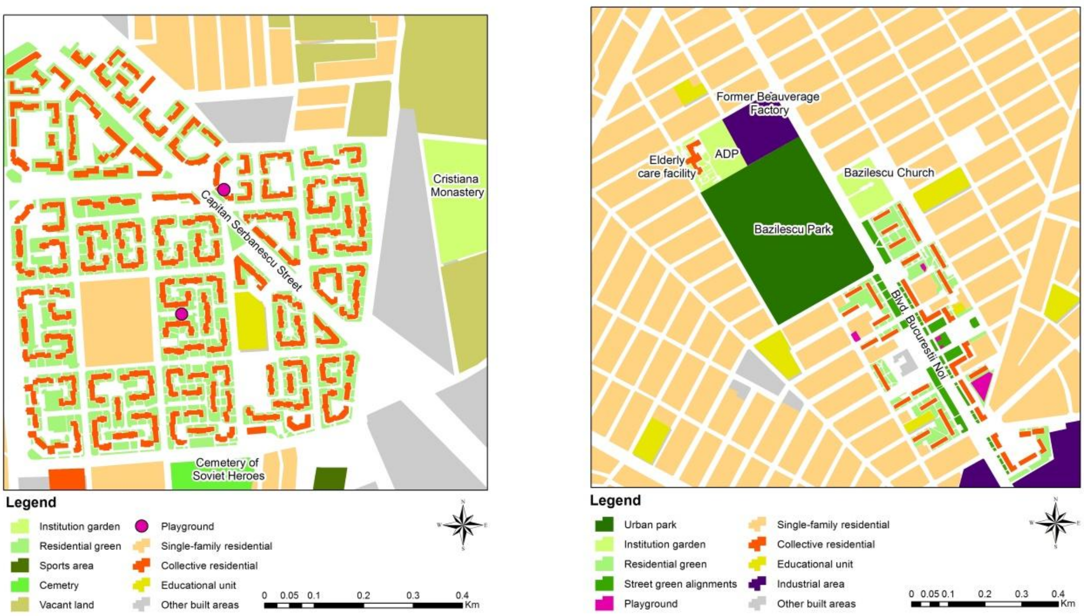

Figure 22 – Local scale studies about UGI distribution

4.2. Identifying changes in the UGI distribution

The dynamic of UGI is linked to the political, economic and social shifts which took place in the last century, the more intense ones relating to the fall of the communist regime. The socialist territorial planning models had a major impact on the planning and development of green urban spaces.

In Romania, the socialist period was characterized by intense systematization in rural and urban areas which led to the growth of the number of cities and to their transformation for sheltering a high number of inhabitants. The socialist system based on a centralized planning approach with a limited local autonomy (Hirt 2005) and the restricted right to have a private property which permitted the implementation of large projects (Hlavacek et al. 2016), enhanced the planning of urban green spaces, most of the large urban parks being established then. The need for green spaces inside the city intensified with the growth of population density. All the residential complexes were accompanied by the creation of parks , block gardens, playgrounds and sport fields based on the first law for environmental protection adopted in Romania (National Great Assembly 1973).

After the fall of the communist regime in 1989 the state lost the centralized planning mechanisms because a large number of urban spaces became private property as part of the restitution process (Romanian Parliament 1991). The resources, including land were distributed based on capitalist economic principles (Hirt 2013). The processes which took place in cities during the post – socialist period led to the regeneration of central areas and the suburbs expansion (Sykora & Bouzarovski, 2012), mostly on agricultural surfaces (Andrusz et al. 1996). In the same time, the public large green spaces were destroyed (Hirt 2013) as a result of restitutions, commercial use and implementation of urban projects. The process of decentralisation permitted to adopt urban development strategies at local and county level (Stanilov 2007). Each territorial administration unit could establish planning objectives which included the management of green spaces. The citizens involvement in the decision making process is a feature of the modern planning approach (Hirt 2005). But this is still at low levels in Romania because the population don't realize yet their role in the local decisions.

Urban green spaces dynamic at county level

The statistics regarding the communist period are reduced and the lack of data of the collecting and aggregation process makes them hard to compare with the data provided by the National Institute of Statistics in the period which followed the year 1989. This way, the analysis regarding the dynamic of green spaces at national level focused on the period which followed the fall of the communist regime.

In 2015, in Romania there were 25778 ha of green urban spaces with 4145 ha more than in 1991. Based on the data provided by the National Institute of Statistics (2017) which refers to the surface of green spaces such as parks, public gardens, squares, trees and flowers parcels, forests, cemeteries, sports fields inside cities considered as public green spaces. There are not included the greenhouses, nurseries, vegetables gardens, agricultural fields and water bodies.

At county level (*figure 23*) 27 counties registered increases in the surface of urban green spaces, the most important being localized in Maramureș (1746 ha), Bihor (407 ha), Prahova (359 ha) and Dolj (350 ha), while other 14 counties registered a decrease (Constanța -462 ha, Brașov -261 ha, Gorj -168 ha, Vâlcea -153 ha). It was supposed that the dynamic of green spaces was influenced in principle by the establishment of many cities (60 after 1990) but the correlation between the two indicators (r=0.214, p=0.18) is not statistical significant. The county of Suceava, where many cities were established in this period (8) the urban green spaces surface diminished. The analysis highlighted a moderate positive correlation between the dynamic of green spaces and the one of the city's built area (the surface where one can build) (r=0.585, p<0.01).

In the post-socialist Romania, there were three ways of increasing the green urban area: the insertion of outside green spaces into the city area, the recognition of some green spaces as part of UGI after they prior had an uncertain status and the planning of new areas. The insertion of new areas inside the city administrative limits can be made by the local authorities or by individuals and companies by elaborating zonal plans that modify the masterplan.

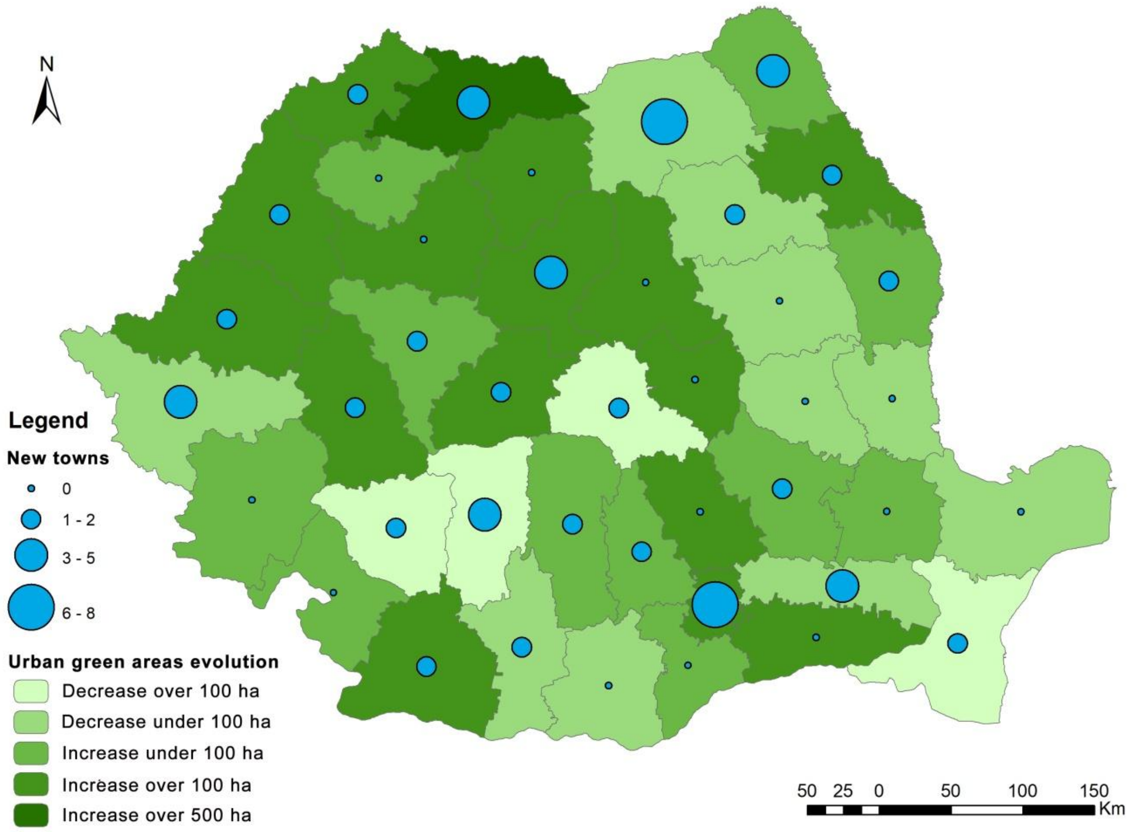

Figure 23 – Evolution of green urban areas and of the number of cities during 1991 – 2015 (data source: National Institute of Statistics (2017))

Green spaces dynamic at city level

At city level, we can observe that there is no correlation (r=0.084, p=0.132) between the dynamic of urban green spaces and the area which legally allows constructions. This aspect highlights the fact that most urban green surfaces increases was implemented through planning and regulating the spaces which already existed inside the city. From the total of 320 urban municipalities, 87 registered decreases in the green surfaces in the analysed period. 61 reported the same surface for green spaces at the beginning and at the end of this period and 172 had increases in this indicator values.

Tests were applied to verify the existence of relation between the dynamic of green spaces and the cities' ranks. The relation with the urban rank (*figure 24*) was tested using Kruskal-Wallis test (8.04, p=0.018) which resulted in significant differences between groups of cities of rank 1 and groups of rank 2 and 3 (95% confidence interval). The urban green space increase with an average of 124.81 ha in rank 1 cities, 25.66 ha in rank 2 cities and only 6.41 ha in rank 3 cities. The intense increase in rank 1 cities is explained by the economic development of these urban areas. Another reason is the need for green spaces to diminish effects of the urban expansion and increase of population density. Also, the numerous sources of funding for this were a key factor.

The geographical location, the city's economic profile and the period of establishment have a direct influence on the dynamic of green spaces. The group of cities established in the ancient period is the only one which registered a negative average of this dynamic. The three parameters do not represent significant indicators in the dynamic of urban green spaces because in the absence of a centralized planning system there are not any objectives which have to be fulfilled based on the city's functional profile.

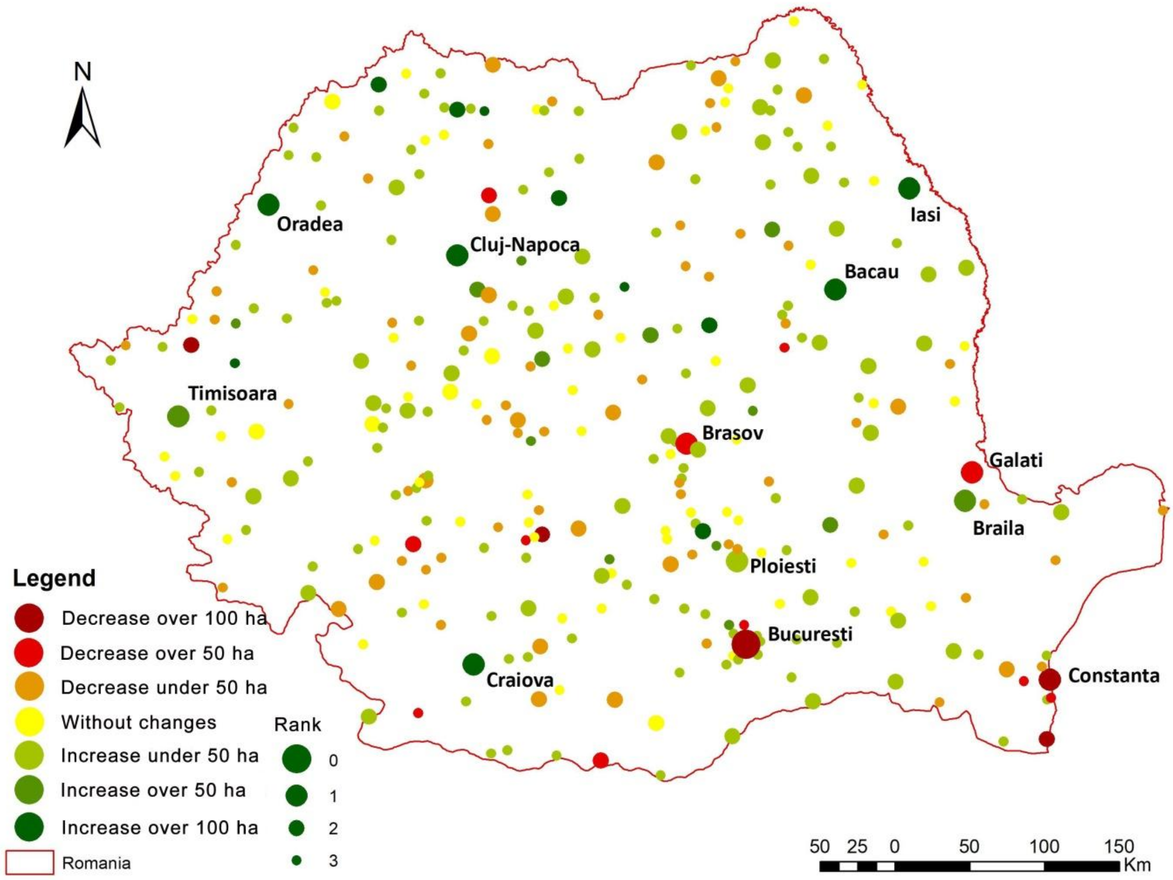

Figure 24 Green spaces dynamic in relation to city's rank

The analysis limitations are the statistical data accuracy but in the absence of some historical maps with a reasonable resolution for the identification of green spaces, a spatial analysis at national level is not possible. The cadastral plans are the only ones which can provide the spatial data needed to compare them with the information extracted from aerial images produced after 2000. Being made at a local scale, many of them are not in a digital format and not available to the public

Evolution of urban parks in Bucharest during 1948 – 2014

Our analysis is a good example of a spatial analysis use in the evaluation of UGI dynamic. The chosen example is the dynamic of urban parks in Bucharest during 1948 – 2014, more exactly from the beginning of the communist period to nowadays. The year 1948 was considered an appropriate choice for the start of the analysis because there were only 10 parks in Bucharest and the actual morphology is the result of the transformations during communist period. The number of parks, their surface and their share per capita continually increased during the communist regime reaching a maximum value in 1990 (105 parks; 848.65 ha; 4.1 m^2/cap). After 1990 these indicators slightly decreased.

The spatial analysis considered three parks classifications:

- Based on the number of visitors, features and functionality – metropolitan parks, municipal parks and neighbourhood and transit parks (Iojă et al, 2011);
- Based on their surface – The law of green spaces (Romanian Parliament, 2007) regulates that parks should have a surface greater than 1 ha;
- Based on their location compared to the city's centre – inside the central ring which is the historical limit of the city in 20th century or in the communist suburbs.

The most significant changes in the analysed period took place with regards to the metropolitan parks surface (204 ha increase) and neighbourhoods parks (242 ha increase), peripherical parks (374 ha increase) and the ones with a surface larger than 1 ha (510 ha increase) and the number of neighbourhood parks (72 new parks) and transit parks (15 new parks). After 1990 there were decreases especially in surface in all parks categories. More specific, the parks were not abolished but several surfaces lost their status of green space, more often were returned and transformed into build up areas.

In the analysed period, we can observe that municipal and metropolitan parks are the largest and important ones (*figure 25*) in their functionality, are the first to be established. In the second part of the socialist period and after 1990 the neighbourhood and transit parks developed very much. Also, the planning of small parks is a characteristic of the second part of the analysed period (40 new parks with a surface smaller than 1 h were planned after 1976). With the development of new residential neighbourhoods at the edge of Bucharest, often on agricultural land and also included rural areas (Nae et al. 2011), the number of peripherical parks increased (almost 60% of the peripherical parks are planned after 1976). In these areas, there were planned mostly small parks.

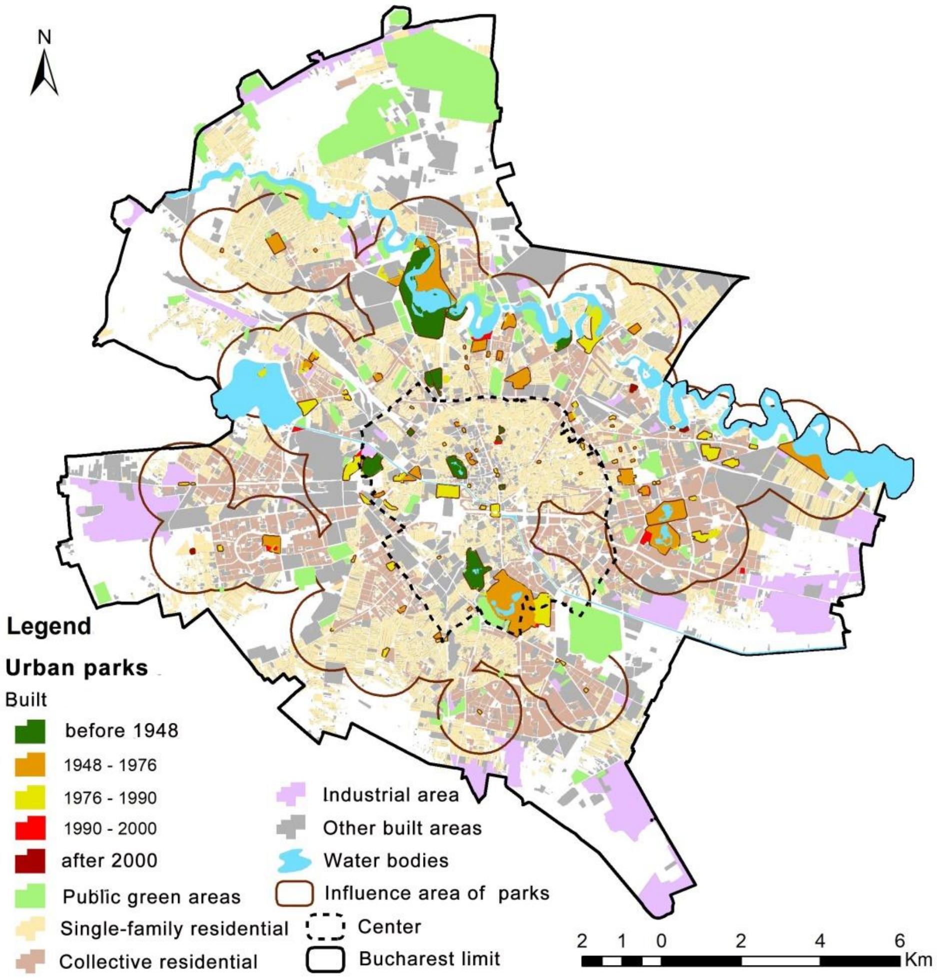

Figure 25 Urban parks dynamic in Bucharest between 1948-2014

The positive dynamic of parks during the socialist era is due to the communist party politics which focused on the expansion of green areas especially in residential areas. The metropolitan parks (average surface of 95 ha/park in 2014) and the municipal (average surface of 20 ha/park in 2014) are the result of the centralized planning system which developed them on wetlands and swamps on formal landfills of construction waste or in areas not suitable for building. The developed parks during 1948 – 1990 are planned in the systematization plans (Great National Assembly 1974) which imposed the reshape of urban areas for the purpose of implementing urban projects such as House of the People (8 ha in the central city area) or the urban space regeneration as a solution for the 1977 earthquake's damages. After 1990, in the context of a densify urban fabric, there have been planned neighbourhood and transit parks in the available small patches of open space.

Transformations in the small surface UGI

The dynamic of urban green spaces in the post-socialist period was intense when it comes to the small surface elements such as street alignments, residential gardens of collective blocks. The lack of historical observations makes the analysis difficult. In many cases, in the last year these two categories were destroyed to make the necessary space for parking lots.

Private gardens of individual residential areas modify their surface (smaller gardens in the context of land pricing). Also, the land use, the flower squares and vegetables gardens were replaced by garages and deposits.

Small urban green spaces did not register only negative changes. In the context of European promoting campaign of durable and resilient cities there have appeared wide ranges of planning solutions based on UGI with small surfaces which are meant to facilitate the adaptation to climate changes and address other environmental issues.

Urban planning solutions based on UGI

The urban planning solutions based on UGI are not regulated by any environmental law at this moment. That is why they are not so common in Romania. Subventions or tax reduction or other sustainable solutions (wind energy production, solar energy, green houses) or other benefits which can raise one's interest, individual or company, to implement them might be a solution for this issue. Another one could consist of the public involvement in the planning process nor in mitigating urban environmental quality.

All the solutions for the urban planning based on UGI amplify the ecological benefits like the mitigation of heat island effect, improvement in air quality and water management and the increase of urban biodiversity.

Table 12 – Urban planning solutions based on UGI in Romania

Planning solution based on UGI	Marginal benefits	Implementation problems
Urban forests – forests park	Aesthetic, public health, economic development, land prices, quality of life (Ordonez et al. 2013)	People behaviour during forest visits: uncontrolled waste, noise pollution which disturbs the flora and fauna
Green roofs	Increase the life expectancy for construction materials, mitigate the noise level and the energy consumption especially in the summer(Susca et al. 2011), can be use as vegetables gardens	Structural challenges for buildings through their weight of soil, water, irrigation systems, high costs for implementation, (Brudermann et al. 2017), unwanted species.
Green walls	Climate amelioration and noise reduction	A slowly surface coverage and its deterioration, implementation and maintenance costs
Green fences	Aesthetic, comfort generated by isolation and the lower risk for accidents	Choosing the right species, maintenance costs
Green streets	Water quality conservation, flood limitation, green corridors for walking	Prohibitive costs for their design and implementation
Permeable pavement	The flood risk mitigation, aesthetic	Maintenance and implementation costs, high vulnerability to climate changes
Urban gardens	Areas with subsistence agriculture, socializing spaces and recreation	Large amount of terrain needed to plan and implement them, need to be in an accessible place
Water courses greening	Rainfall water management, flood protection management	Existing open space, Prohibitive costs for their design and implementation

In Romania, there is a potential to develop these categories of small surfaces in areas which are not used for special purposes –for example green roofs, green walls and fences and permeable pavement. Green roofs can be implemented on important surfaces on block of flats with plane roofs which are common in most of the cities. Only in Bucharest is an available space of 2500 ha of roofs which could be transformed into green roofs totalizing three times the surface of the city's parks. Other potential spaces to develop green roofs are the roofs of commercial buildings having the advantage of offering recreational services to many users. The green walls potential is even bigger than the green roofs one considering that walls can represent the double surface of a building at ground level (Manso et al. 2015). In Romania, there are no special projects for the implementation of green walls, most of the existing ones being naturally developed.

The planning of green streets in Bucharest began with the greening of tram lines, activity which if extended to the whole network of trams (137 km, two ways) could improve the city's green surface by 50 ha. The permeable pavement has started to be promoted especially in the case of the new residential areas as a support for parking lots because the construction permits specify the regulation of having at least 2m^2 green space/capita.

In Romania, there are no allotment gardens which can fulfil the criteria established at European level. In the socialist era, in the collective residential areas the public gardens were often transformed in vegetable gardens, each resident having a patch to take care of it without paying rent for it. This practice stopped in the post socialist period, the gardens receiving other functions. Nowadays, the ones which were not transformed into parking lots or built up are neglected or cultivated with flowers or grass. Romania's potential to develop these types of green structure is low due to the lack of space and changes in the urban population consumption patterns which prefer other type of activity for its free time.

4.3. Prediction model development for UGI in representative places

Prediction models for UGI development must consider the interests and the characteristics of all factors: politics, economic, social. These aspects make harder the creation of a suitable model at different scales, especially in the context of the Romanian society where private interests often exceed the local development strategies.

One of the most efficient prediction models regarding green space evolution is Land Change Modeler Module (LCM), part of the TerraSet / Idrisi system which can be implemented through the ArcGIS package. The module can apply analysis regarding changes in the green spaces distribution (or other land uses) between two moments and it presents the results using maps or graphical elements (using several units, e.g. hectares or percentages). The method presents the advantage of showing changes only for the area with a specific surface allowing the mitigation of errors in the initial database (*figure 26*).

The model offers the possibility of analysing the probability of change of certain land uses or surfaces, to create prediction scenarios and to evaluate the impact of land use changes on biodiversity (habitat evaluation, landscape modelling and other analysis on species distribution). If there are information regarding infrastructure projects, predictive analysis can be applied on this domain.

The disadvantages of this method correlate with the database characteristics. The scale or the resolution of maps must be sufficient to identify the elements needed (in the case of green spaces it can be use the Corine Land Cover to identify regional infrastructure, large urban infrastructures on aerial images and other urban infrastructure more detailed which require high resolution images - which are not free or cadastral plans). In addition, the inexistence of a detail database for a correct analysis on UGI generates a time-consuming process to create the database which increases proportional with the surface included in analysis. Another problem is the fact that this model permits the inclusion of only two temporal moments and the general assumption is that the tendency will be maintained which is not true.

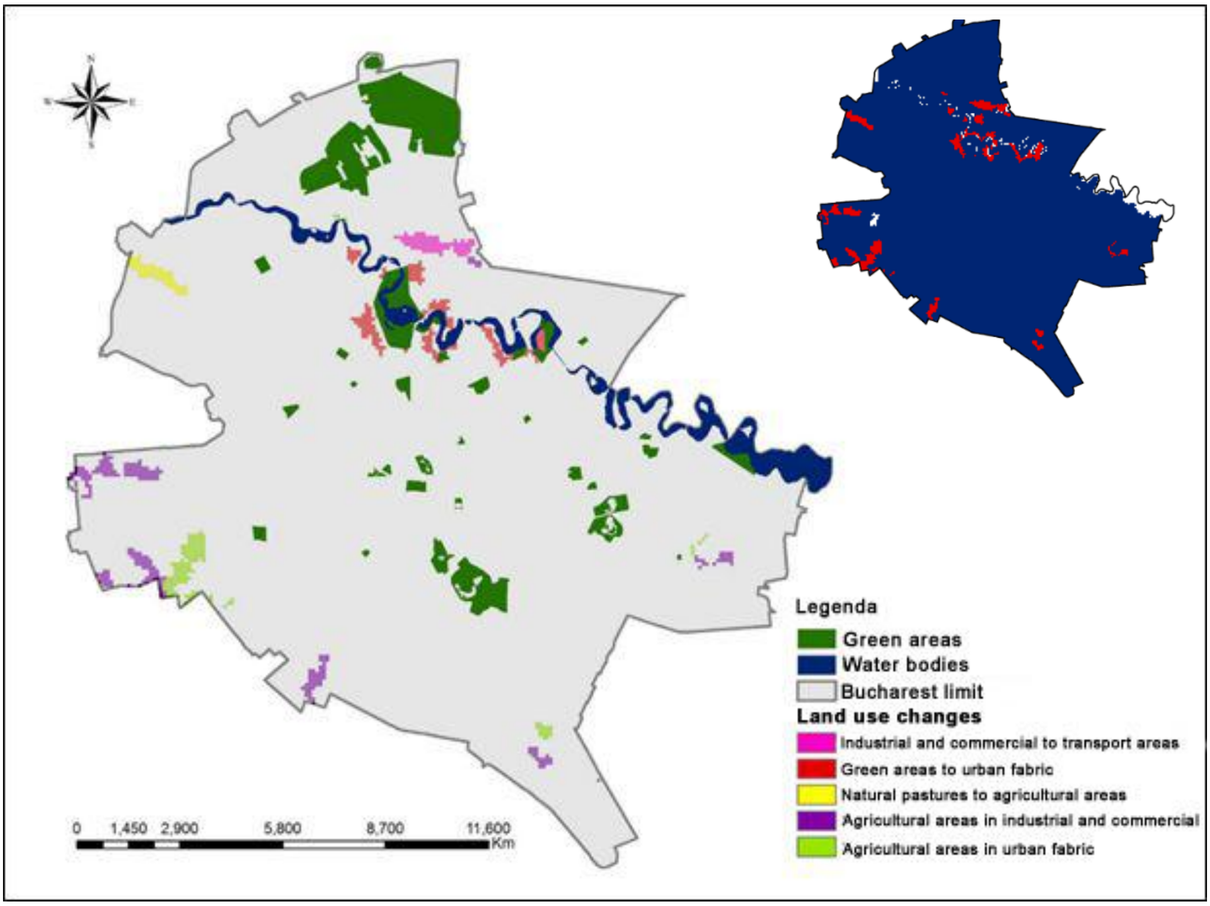

Figure 26 – Land use changes on terrains wider than 50 ha (right up corner – The functional persistence map)

4.4. Building scenarios for UGI development

Although we cannot explore every possible outcome, we need to reduce the complexity of these scenarios to take the necessary measurements and the scenarios are helpful in this matter. They reduce the vast volume of incertitude at the level of some plausible alternatives. The need to model and quantify the services provided by the UGI have led to the development of new representation forms and analysis approach, the scenarios being one of them, very used and accessible to all stakeholders (Pulighe et al. 2016).

It is true that a model or a scenario cannot be validated completely but it can be calibrated for a formal and relative consistency (Saltelli et al. 2008). Scenarios can be calibrated and validated based on the literature's guidelines (Hewitt et al. 2017), but also based on certain key indicators. All these being said, we cannot oversee that planning based on scenarios could encourage the strategical thinking and could help to overcome future barriers (Stojanovic et al. 2014) and to reach the cities' sustainability, at least at political and adopted strategies level.

Frequently, the scenarios tend to pose the economic development against to the environmental protection or to consider significant differences based on the scale of the problem. We considered that in the case of urban planning, scenarios using UGI is wrong. More efficient would be an integrative approach of environmental and socio-economic elements which have the same general picture, regardless the scale, the occurrence of differences being only regarding the applied techniques and the practical approaches to implement certain concepts.

Even though the developed scenarios present plausible tendencies in the urban environment evolution, after their creation special attention is required for elements which could change the working hypothesis like demographic changes, demand and offer for residential areas or land use changes (Lauf et al. 2016) and adopted politics or strategies (Deilami et al. 2017).

Certain values of the decision models or of the scenarios are often subjective, the criteria weights and the scoring system containing a variable number of uncertainties. That is why the question raises concerns in the way in which the alternatives classification can be modified based on the change in values for the decision model parameters. The simplest case is when a single parameter varies. For the multiple parameters models, the hierarchy of the alternatives can contain even a simple sensitivity analysis as a linear function or graphical form (Forman and Selly, 2001).

Sensitivity analysis are instruments to verify the realism and plausibility of scenarios and models. It is a used technique for determining how a single independent variable value variation can influence the dependent variables under a set of constraints. It represents a way to predict a decision result if the situation proves to be completely different in comparison to the principle predictions. The sensitivity analysis can be applied to some diagnosis models (which are meant to explain a certain situation) or prognosis models (which are meant to predict the behaviour of a system in known situations) (Saltelli et al. 2008).

In the case of UGI, the sensitivity analysis results helps in providing useful information to planners and decision making stakeholders in the evaluation of data sources used in the planning process (Frew et al. 2017). This type of analysis for an UGI development scenario must contain green elements but also a stakeholder analysis and their interests (*figure 27*).

Green elements	Stakeholders	Stakeholders interests
• Protected areas • Wetlands • Water bodies • Hidrological organisms • Ecosystem and biodiversity • Biodiversity hotspots • Natural vegetation	• ONG • Population • Tourists • Providers • Bussiness people • Industrial people • Investors • Activists • Different domains workers • Guvernamental agencies • Administrations	• Environmental regulations for the natural capital conservation • economic activities which are dependent on the natural capital • Local communities which use the natural capital • Conservation and sustainable development funds

Figure 27 –Elements which can be included into a sensitivity analysis

Development scenarios for UGI

The scenarios development for UGI in the Romanian cities starts from the existing realities in the present moment and propose an integrative approach which presents for each scenario: the main modalities to get to the proposed situation, a descriptive approach of the way things would look and what are the most obvious benefits and disservices. In this way, main processes and administrative phenomena, politics and current strategies will be analysed along with social and economic situation and environmental impact (*table 13*).

Scenario no. 1 – Base scenario. This is a following of the present situation. It can be created based on a group of factors, the most important being the politics of relevant authorities which are inefficient and do not produce outcomes in general and when they do it is mostly linked to the environmental aspects. As a result, the green politics do not have an effect over the economy, both the traditional sectors and the green economy remaining the same as in the present.

At an administrative level, the institutions keep their actual responsibilities, the collaborations between institutions in the territory remaining reduced. Economy is still based on consumption without a macro strategy for developing and promoting UGI. These do not reach their potential in the Romanian cities, remaining mostly at the green spaces level without a high degree of connectivity and multifunctionality. Local scale elements, like green roofs and green walls or permeable pavements continue to develop only in several points based on private initiatives of economic agents or in big residential developments. The social benefits of UGI are not sought and the peripherical features such as urban forests or water alignments are exposed to a huge pressure from the building developments stakeholders.

Scenario no. 2 – Green growth. The Romanian society suffers a deep change of view oriented to the sustainability and cities resilience growth. The implementation of green politics and strategies is very efficient and all the stakeholders are collaborating for the reach of the urban planning objectives. The UGI development objective is one of the most important. Urban institutions are having very clear responsibilities in the UGI management and often they use communication technologies to improve knowledge on the subject. Romanian cities are becoming smart cities in which the UGI play a significant role in providing multiple benefits. The economic activities which produce negative externalities are eliminated or their taxes are growing. The population have a financial contribution to the development and management of UGI. The costs are high and each new development is obliged to have an UGI. Their development is made within a coherent and functional way in each city. The UGI elements are well connected in a network, both functional and structural and the legislation is very strict concerning their protection. Ecological benefits have a high standard like never before.

Scenario no. 3 – The economic development. Economic growth registers an exponential increase in Romania in all sectors (industry, agriculture, commerce, transportation, services). Cities are the engines of economic development and their attractiveness raises, attracting important demographic growth based on migrations, including external migrations which generates social challenges. The cities administrations create a series of tax facilities for economic agencies. The percentage of built up spaces increases, occupying a vast area but also developing in vertical plan. The resources consumption is very high in cities and their ecological footprint exceeds the support capacity of the environment. The UGI elements cannot resist in the face of urban expansion and they become an important asset for the economic activities. The types of urban green spaces such as parks and public gardens which once occupied large surfaces are shrinking and other types are relocated at the edge of cities. In the urban fabric, the green spaces remain at a local level but without a proper strategy in their development and connectivity.

Scenario no. 4 – Sustainable development. Romanian cities reach a sustainable development from an economic, social and environmental perspective where the quality of life is high. The economic activities are productive, profitable and eco-friendly creating jobs in a community where the demographic dynamic is stable and the life expectancy is high. There are no social problems and the politics rely on transparency, efficiency promoting the population well-being. There are good inter institutional collaborations and the exchange of know how between cities. Urban planning has a participative and adaptive way of operating under a clear legislation, focused on the population needs. UGI have a clear role to play in the planning system and their benefits, services and disservices are well understood and carefully measured through an active set of quantifying indicators. There is a large diversity of UGI typologies which are distributed into a connected network considering the balance between social and economic objectives.

Table 13 Comparison between the main ecological, social, economic and administrative elements which characterized the four scenarios

	1. Base	2. Green growth	3. Economic development	4. Sustainable development
Environmental quality	-	+	-	+
Natural resources	-	+	-	o
Demographics	o	-	+	o
Social factors	o	o	-	+
Economic conditions	-	-	+	+
Labour pool	-	o	+	o
Politics and legislation	o	o	o	o
Institutions	o	+	-	o
Technologies	-	+	+	o

The adaptive planning of cities focused on addressing these problems in an integrated manner taking into account the local conditions (Norton et al. 2015). It seeks to integrate the decision making actors' vision (Vandermeulen et al. 2011) to take into account the local stakeholders arguments (Faehnle et al. 2014) in order to select the best solution for development (Govindarajulu 2014). The integration of all these aspects needs an urban strategic planning characterized by interdisciplinarity and participative components which uses more often the UGI in the decision making process (European Commission 2012) as a useful instrument in reaching sustainability targets for cities (Church 2015).

O5. Modelling the relationship between UGI and urban planning process

The presence of green elements inside cities is not new. Even from ancient times there were gardens and trees alignments associated to human settlements. Their role varied from an aesthetic role to a recreational one for certain social categories or providing food and protection against negative effects of environmental processes.

The solution for a viable city can be found in the equation where urban planning can allow the local community participation in the exchange of flows, energy and matter with the environment. For this process to develop in an efficient way it is crucial that data on the structure and functionality of urban green spaces to be correct and available for the one in charge with the planning decisions. For example, the indicators used for the ecosystem services evaluation in urban green spaces have some limitations, often there is a single value for the hole municipality. That is why the urban planning needs to rely on clear and defined indicators (La Rosa et al. 2016).

Data on the spatial distribution and abundance of green spaces are extremely important in a sustainable planning of the city (Van de Voorde et al. 2008). Discrepancies between planning objectives at different scales from metropolitan to building level (Cajot et al. 2017) determine the planning personnel and the urban managers to make a priority in ensuring the good understanding and conservation of green spaces functionality.

Because the built up spaces have a longer life period, the opportunities to improve the UGI should be associated with structural transformation stages like urban regeneration projects or new developments projects (Gill 2006). This aspect is more important in the post-socialist urban planning system as is in the Romanian example dominated by the powerful interests UGI planning derived from politics, economic and social domain (Ianoș et al. 2017).

For this purpose, the European Union has tried to integrate planning principles and the development of UGI in the main components of public politics and strategies. Nevertheless, applying the same strategies in different geographical, social and economic contexts is limited (Geneletti et al. 2017), thus it requires modern approaches meant to use the space utility beyond the traditional manners and to focus more in the direct usage and economic outcomes.

The planning of green infrastructures at city level should comprises three main components:

- Initial component: which clearly delimit the procedures and the planning existing mechanisms and in the same time ensure the political and technical support. Based on this phase it will be formulated the vision of the planning process for urban green infrastructures and strategical objectives will be defined together with action priorities.
- The analytical component which compares the previous results with the legal aspects related to the existing situation in the distribution of UGI in cities. The local needs and interest must be identified together with the spatial, organizational and financial challenges.
- The action component which implies the clear definition of strategical elements and priorities in the development of UGI. Also, the management politics in this development stage are important. Action plans will be elaborated, one of their purpose being to present the standards, directions, regulations and necessary recommendations in a quantitative and qualitative manner. This phase will be linked to the control of their implementation.

Starting from the theoretical model, previously presented we tried to see if in the strategical documents of Romanian public authorities, the green spaces are approached at the level of all three components. In this matter, we analysed over 200 strategical documents of Romanian cities, the most frequent being the local/urban development strategy or Agenda 21 type of document. In Romania, there are few strategical documents which approach exclusively the development of UGI. That is why this type of analysis are not possible at national level even though other studies exist on the same theme (Kabisch 2015).

Similarly, with the methods applied in other studies (Dotson et al. 2012, Daw et al. 2013) we gathered data from these strategical documents and organized it in a database which allowed the evaluation through basic statistics. The database contained the metadata (name of the document, year and creators) data regarding green spaces approach (definitions, typologies, benefits and associated challenges, programs etc) perspectives (objectives linked to green spaces, indicators to quantify the process to reach them). Finally, quantitative data were extracted: total green space area by city, by inhabitant and source of the statistical indicators). The scientific literature was consulted to analyse the way cities across European Union manage the green spaces, their specific objectives and good practice examples. All the data that were extracted were grouped in objectives, action modalities and projects. In the end, a data summary resulted.

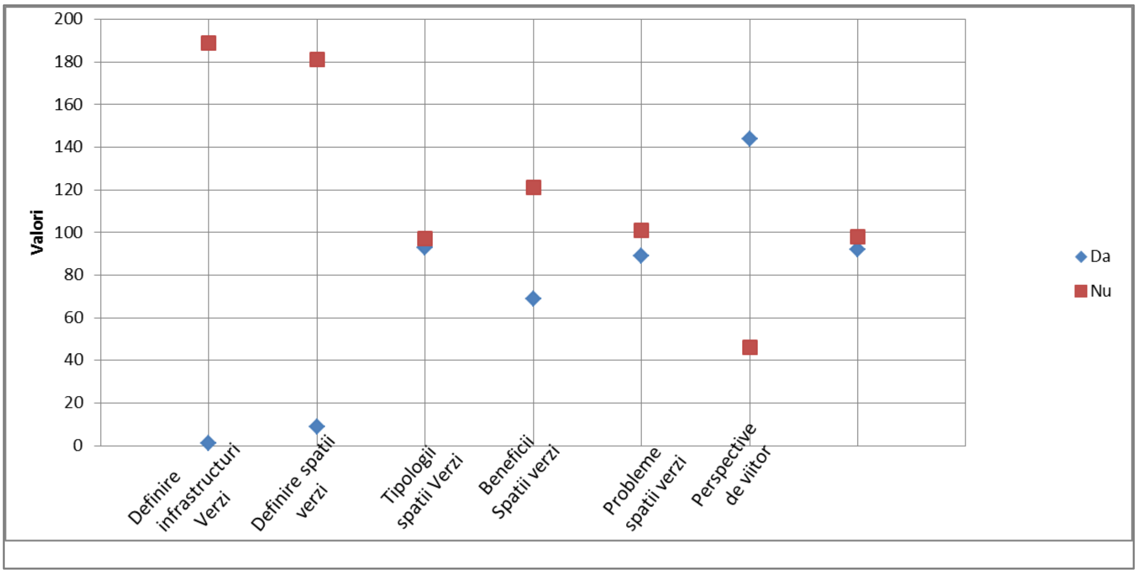

Figure 28 – Approaches of UGI planning in Romanian cities strategies

One can observe that the concept of green infrastructure is unknown at local level. In almost 50% of the documents the UGI are not presented and probably the terms of their typology are not known. There is no information regarding problems linked to green spaces and quantitative indicators are missing (green area surface; green area per inhabitant or the percentage of the city's surface occupied by UGI). A positive aspect is the fact that there are planned programs which come to improve the quality of green spaces and to increase their surface. Nevertheless, the green spaces do not have a special chapter in these documents, being discussed together with other existing problems, most often in the environment section.

From the 213 analysed documents, 165 presented associated objectives to green spaces at city level, 84 presented future perspectives for their development and management and there were only 22 indicators for monitoring and evaluation of its process. Only 12 documents showed all the aspects highlighted for cities as Bistrița, Botoșani, Câmpina, Cisnădie, Dărmănești, Dorohoi, Fălticeni, Gura Humorului, Marghita, Pitești, Reghin and Suceava.

Among the presented objectives, the most frequent is the one related to the increase of green spaces surface at city level (142 documents) with low percentages being the ones concerning existing green spaces conservation (49), development of new typologies (28), and the insurance of green spaces complementarity with social objectives (16) or linked to a more efficient way to manage green spaces (24).

The main perspectives regarding the management of existing green spaces focuses on maintenance activities (49) new projects development (38), educational activities (15) due to improve the level of awareness on the benefits associated to green spaces. The most frequent perspectives are descriptive and focus on projects and actions for the expansion, planning and regeneration of green spaces. The most used indicators are surface indicators reported at the number of inhabitants.

The correlation between objectives and perspectives is a weak one. Only half of the chosen objectives by the institutions coincide with the perspectives and the action plans to reach them. There is a more powerful correlation between new green areas and the number of inhabitants but mostly they focus on green spaces surfaces.

It is obvious from this case study that the green space planning was negatively affected by the institutional failure to recognize their multiple benefits and to offer them a clear role in the Romanian cities. Transparency and security are key elements which can ensure a sustainable resource use but also a well informed decision process (Perera et al. 2016). Sadly, many of these strategies do not meet these two criteria.

O6. Highlighting the UGI potential in urban planning

The adaptive planning of cities focused on addressing these problems in an integrated manner taking into account the local conditions (Norton et al. 2015). It seek to integrate the decision making actors vision (Vandermeulen et al. 2011) to take into account the local stakeholders arguments (Faehnle et al. 2014) in order to select the best solution for development (Govindarajulu 2014). The integration of all these aspects need an urban strategic planning characterized by interdisciplinarity and participative components which uses more often the UGI in the decision making process (European Commission 2012) as a useful instrument in reaching sustainability targets for cities (Church 2015)

The rational model of planning from the 1950-1970 based on assumptions of certainty, providing a single answer to the decision maker, most often this information was generated from a static image of reality. But cities have evolved in time and space, and it is necessary to include this dynamic into every analysis, whether based on directed processes or spontaneous processes in urban planning. City managers need to be agile and transparent to respond to the rapid changes that occur in these situations.

Adaptive planning is a very dynamic which starts from the planning vision and objectives, but after completing all the phases, evaluation, management and control steps, it goes back to the same point and allows the resize and adaptation of the vision and objectives.

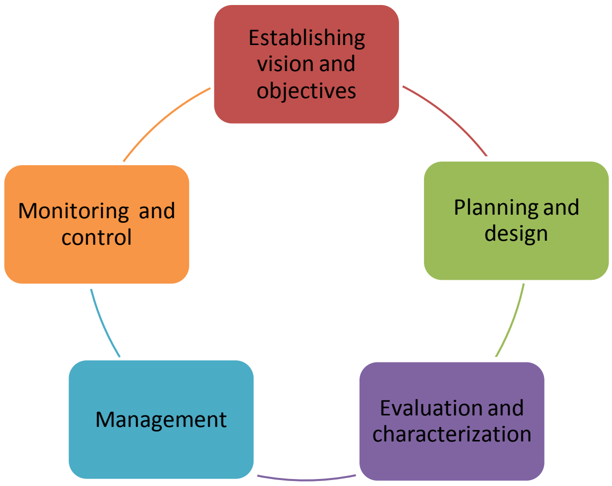

Figure 29 – Simple scheme of an adaptive planning model (after Renn et al. 2013)

Urban planning needs to be done in accordance with ecological changes and conservation of natural resources situated in the city's vital space or at measurable distances, depending on the urban system to which they belong. Areas of influence of the cities constitute receptacles of environmental problems produced by the city (energy consumption, water, emissions, domestic and industrial waste, etc.) or induced by its existence and development. There are differences between the cities' physical limits and the limits in which they manifest their effects (de Graaf 2012). Especially in large cities, their economic and social importance leads to profound changes in their proximity or outskirts. Cities must adopt standards to involve all stakeholders in a common and understandable way. It is evident that the multifunctionality of spaces is a measure to increase the efficiency of these uses, and the temporal and spatial differences between ecological processes and social governance processes underline the need for adaptive planning mechanisms (Kaczorowska et al. 2016).

Adaptive management is different in urban green infrastructures because the strategy is often not orientated towards problematic greenfield patterns (such as green spaces under bridges and passes) but rather an underlining of the potential for adaptive reuse of infrastructures (Meerow et al. 2016). There is a wide range of opportunities arising from accessing the underused or poorly used infrastructures, such as rail corridors, alleys behind buildings, abandoned transport or abandoned facilities or decommissioned industrial sites. Green spaces can grow on these areas as much as surely they will not be used for recreational activities (Wolch et al. 2014).

Although adaptive management has been practiced in the management of natural resources for some time, its use in urban planning is still deficient. The first step is to understand the specific situation of urban tissues, but it is also important to know the planning objectives and to design future developments. Adaptive planning requires an important level of transdisciplinary collaboration between different actors at city level. A framework for actors' involvement in adaptive management is based on scientific approaches and a predetermined set of indicators and metrics of ecosystem services. The framework is carried out in a transdisciplinary manner involving different actors and decision-makers (Ahern et al. 2014).

Table 14 – Implication model of different types of stakeholders in the adaptive planning process (after Ahern et al. 2014)

Steps and actions	Stakeholders
1. Defining urban ecosystem services relevant to the achievement of urban planning objectives	Transdisciplinary process - scientists, field specialists, stakeholders and decision-makers
2. Prioritization of ecosystem services and objectives	Transdisciplinary process - scientists, field specialists, stakeholders and decision-makers
3. Designing the experiment (working hypothesis, plan and alternatives, spatial configuration, materials)	Professionals in planning and designing in consultation with scientists and stakeholders
4. Identify indicators and metrics to quantify the objectives	Scientists and planning specialists in consultation with other actors

5. Monitoring and evaluation of results	Scientists, planning and design specialists, informed citizens
6. Implementation of the main results (if necessary, modify objectives, design, manage or rethink the approach)	Transdisciplinary process - scientists, field specialists, stakeholders and decision-makers

Debates on actors' negotiation styles and governance at local level have often focused on the interests of different actors and their rational judgment towards them. However, the psychological responses of actors as well as emotional components are essential parts of decision-making process and interactions among stakeholders. This happens especially at a small local scale, where actors often have, besides professional relationships and personal relationships which can influence their psychological responses and perceptions. Participating in governance is a process of learning and negotiating. At the same time, when reaching a consensus, adaptive preferences should also be taken into account, especially in the case of peripheral actors in the urban planning process (Shin et al. 2017).

Conclusion

Urban green infrastructures remain in many cases only a conceptual element, an integrated green space approach that allows planners and administrators to maximize their benefits while minimizing service depletion. The multidisciplinarity of the concept of green urban infrastructure determines the existence of many economic, social or ecological factors that condition and shape their structure and functionality. This is more important in the cities of Romania, where economic and social objectives are still in a strong position, even though there have been many arguments about the determinant role of green functional infrastructures in improving the quality of life.

Urban planning has the necessary tools for the integration of green infrastructures, with many documents relating to them starting from the European level to the urban settlement level, which can be tools for urban planning. However, institutional actors are still not fully aware of the role they need to play in this process and in Romania, urban planning has not yet reached a mature system capable of responding to external interference.

The characteristics of the urban environments in Romania, resulted from the evolution of the urban settlements' system in historical time generates differences in the structure of the existing green infrastructures, but also in the development potential of new elements. Differences based on administrative criteria based on the rank of localities and their position within the national settlement system, based on geographical criteria or based on the functional profile of these localities, generates differences in the types of green infrastructure that find or search for a location at the level of the respective cities. Our study clearly highlights the differences between the Romanian cities according to the urban green infrastructure typology and the structure of the green space categories.

If we have previously stated that there is a legislative and institutional framework for delimiting actors and mechanisms involved in green infrastructure planning, we must recognize that it is far from the involvement of authorities and civil society in their management and planning. Our assessments regarding the perceptions of the actors involved still reveal gaps in knowledge and availability of involvement from public authorities, even if economic agents and the population or NGO have a real interest in knowing and implementing urban green infrastructures.

The classification of ecological, economic and social benefits of green infrastructure has proved to be a wide approach but provides a fair view of the existing services and services that these urban functions bring to the settlement level. The same cannot be said about quantifying them by quantitative indicators, and if we move further towards a monetary quantification, useful to local decision makers, the situation becomes even more complicated.

Among the methods that can be used to assess the benefits of urban green infrastructures, they draw attention to the degree of precision and ease of representation of the distinct types of spatial analysis, the use of benefit assessment indicators (status indicators more accessible than performance indicators) methods of economic evaluation. In this regard, we have also provided examples of assessing the benefits of urban green infrastructures Romanian cities through indicators such as minimizing rainwater leakage and flood protection, wood biomass production, or recreational value of urban green infrastructure.

Responding to the question *"why?"* in the case of urban green infrastructures, it is logical that the next step is *"where?"*. We can develop such elements. The local and structural delimitation of urban green infrastructures in the functional areas of urban settlements is a fundamental step, which must be done in parallel with the assessment of the connectivity and multifunctionality of urban green infrastructures. However, to obtain a projection as close as possible to the reality of the current distribution of urban green infrastructures and future potential, all these analyses should be reported to their spatial and temporal dynamics at different scales of analysis.

Urban planning solutions based on green infrastructures should find their role in the legislation and overcome the specific implementation problems at present in the cities of Romania. Unlike classical systems, the implementation of adaptive planning allows a faster response and hence increased efficiency in the development of urban green infrastructures.

We believe that this project has had an innovative approach to addressing the gap between the scientific knowledge of green infrastructures and their implementation in the urban planning process. This is an important contribution to developing an innovative approach to the role of green infrastructures as an instrument in urban planning. The approach correlates with the current trend of the field reality by using and adapting scientific methods such as multicriteria analysis, spatial analysis, spatial modelling, analysis of stakeholders. The interdisciplinary character is determined by the location of urban green infrastructures within the medium, social and economic domains.

This urban green infrastructure planning model, if implemented at city level, will improve the quality of life and promote social interactions. The economic impact is expressed by the economic quantification of the benefits of green infrastructures and the inclusion of the economic operators' perspective in the developed urban planning model. The principles of adaptive planning for urban green infrastructures can be integrated into urban planning policies and strategies, being useful to local governments in their attempt to improve environmental features and quality of life.

Results summary

Workshop

Name: International Workshop Green Infrastructure for Sustainable Urban Planning
Period: 6-9 July 2017
Location: Bucharest, Romania

At the workshop, 20 presentations were submitted, of which 11 were international participation. The results of the project were disseminated through 4 presentations corresponding to the articles published in the project and through the discussions held at the round tables organized at the end of each presentation session.

Handbook

Niță M.R., Onose D.A., Gavrilidis A.A., Badiu D.L., Năstase I.I. (2017), Infrastructuri verzi pentru o planificare urbană durabilă, Ed. Ars Docendi, București

Scientific papers

Papers published in ISI databases

1. **Badiu, D.L.**, Iojă, C.I., Pătroescu, M., Breuste, J., Artmann, M., **Niță, M.R.**, Grădinaru, S.R., Hossu, C.A., **Onose, D.A.** (2016), Is urban green space per capita a valuable target to achieve cities' sustainability goals? Romania as a case study, Ecological Indicators, 70, pp. 53-66, doi: 10.1016/j.ecolind.2016.05.044, Factor de impact 3.190
2. Raymond C.M., Frantzeskaki N., Kabisch N., Berry P., Breil M., **Niță M.R.,** Geneletti D., Calfapietra C. (2017), A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas, Environmental Science and Policy, 77, pp. 15-24, Factor de impact 3.751
3. **Gavrilidis, A.A., Niță, M.R., Onose, D.A., Badiu, D.L., Năstase I.I.** (under revision following review) Methodological framework for urban sprawl control using urban green infrastructure planning, Ecological Indicators – special Issue - From urban sprawl to compact green cities – indicators for multi-scale and multi-dimensional analysis
4. **Niță M.R., Badiu D.L.,** Lafortezza R., **Onose D.A., Gavrilidis A.A.,** Grădinaru S.R., **Năstase I.I.,** (under revision following review), Encouraging the use of bicycle lanes to promote health and wellbeing in cities: the case study of Bucharest, Romania, Environmental Research
5. **Niță M.R**, Anghel A.M., Bănescu C., Munteanu A.M., Pesamosca S., Zețu M., Popa A.M. (under revision following review), Are Romanian urban strategies planning for green?, European Planning Studies
6. **Niță M.R., Năstase I.I., Badiu D.L., Onose D.A., Gavrilidis A.A.** (submitted), Evaluating urban forests connectivity in relation to urban functions in Romanian cities, Carpathian Journal of Earth and Environmental Science

Papers published in BDI databases

1. **Niță M.R.,** Bălaș V.G., Bîndar M.G., Cîrdei G.A., Mocanu E., Nedelea M., Pânzaru M.D.R., Tobolcea T. (2015), Mapping the differences in online public information by local

administrative units in Romania, Forum geografic - Geographical studies and environment protection research, ISSN 1583-1523, Volume XIV, Issue 2, 199-210
2. **Gavrilidis, A.A.,** Ciocănea C.M., **Niță, M.R., Onose, D.A., Năstase I.I.,** (2016), Urban Landscape Quality Index – planning tool for evaluating urban landscapes and improving the quality of life, Procedia Environmental Sciences 32, p. 155-167,
3. **Gavrilidis, A.A., Niță, M.R., Onose, D.A., Năstase, I.I., Badiu, D.L.** (2016), Prioritization of Urban Green Infrastructures for Sustainable Urban Planning in Ploiesti, Romania, Real Corp 2016 Proceedings, pp. 925-929, ISBN 978-3-9504173-0-2 (CD), 978-3-9504173-1-9 (print) - http://www.corp.at/archive/CORP2016_16.pdf

Papers published in International Conferences Proceedings
1. **Onose D.A.**, Iojă, I.C., Pătru-Stupariu I., **Niță, M.R., Gavrilidis, A.A.,** Ciocanea, C.M., (2016), Analyzing the suitability of Bucharest urban parks for children related activities in Moore-Cherry, N. (2016) (eds) *Urban challenges in a complex world: Resilience, governance and changing urban systems*. Dublin: Geographical Society of Ireland, Special Publication 14. ISSN: 0791-0681 –

Abstracts published in Proceedings
1. **Gavrilidis A.A.**, Ciocanea C.M., **Niță M.R., Onose D.A., Nastase I.I**. (2015), Urban Landscape Quality Index – planning tool for evaluating urban landscapes and improving the quality of life, International Conference Environment at a CrossrOads: SMART approaches for a sustainable future, Bucharest, 12-15 November, 2015
2. **Onose D.A**., Patru-Stupariu I., **Niță M.R., Gavrilidis A.A., Nastase I**.I. (2015), Quantifying the role of accessibility in the attractiveness of urban parks. Case study Bucharest, International Conference Environment at a CrossrOads: SMART approaches for a sustainable future, Bucharest, 12-15 November, 2015
3. **Onose, D.A., Niță, M.R., Gavrilidis, A.A., Badiu, D.L., Năstase, I.I**. (2016), Planning for children: evaluating the network of playgrounds in Bucharest, 5th International Ecosummit Ecological Sustainability, Engineering Change, Book of abstracts
4. **Năstase, I.I., Niță, M.R., Onose, D.A., Gavrilidis, A.A., Badiu, D.L.** (2016) Integrating the connectivity of urban forests in the evaluation of urban planning process in Romania, European Forum on Urban Forestry 2016, Urban forests for resilient cities, Book of abstracts
5. **Niță M.R., Onose D.A., Gavrilidis A.A., Nastase, I.I., Badiu, D.L.** (2016) A case study on the attractiveness of Urban Green Infrastructures, The 11th Edition of the International Symposium Present Environment and Sustainable Development, Book of abstracts

International conferences participations
1. **Gavrilidis A.A.**, Ciocanea C.M., **Niță M.R., Onose D.A., Nastase I.I**. (2015), Urban Landscape Quality Index – planning tool for evaluating urban landscapes and improving the quality of life, International Conference Environment at a CrossrOads: SMART approaches for a sustainable future, Bucharest, 12-15 November, 2015
2. **Onose D.A**., Patru-Stupariu I., **Niță M.R., Gavrilidis A.A., Nastase I**.I. (2015), Quantifying the role of accessibility in the attractiveness of urban parks. Case study Bucharest,

International Conference Environment at a CrossrOads: SMART approaches for a sustainable future, Bucharest, 12-15 November, 2015

3. **Niță M.R., Onose D.A., Gavrilidis A.A., Nastase, I.I., Badiu, D.L.** (2016) A case study on the attractiveness of Urban Green Infrastructures, International Symposium Present Environment and Sustainable Development, Iunie 2016, Iași, România

4. **Năstase, I.I., Niță, M.R., Onose, D.A., Gavrilidis, A.A., Badiu, D.L.** (2016), Integrating the connectivity of urban forests in the evaluation of urban planning process in Romania, European Forum on Urban Forestry Iunie 2016, Ljubljana, Slovenia

5. **Gavrilidis, A.A., Niță, M.R., Onose, D.A., Năstase, I.I., Badiu, D.L.** (2016), Prioritization of Urban Green Infrastructures for Sustainable Urban Planning in Ploiesti, Romania, 21st International Conference on Urban Planning and Regional Development in the Information Society, Iunie 2016, Hamburg, Germania

6. **Onose, D.A., Niță, M.R., Gavrilidis, A.A., Badiu, D.L., Năstase, I.I.,** (2016), Planning for children: evaluating the network of playgrounds in Bucharest, 5th International Ecosummit Ecological Sustainability, Engineering Change, 29 august – 2 septembrie, Montpellier, Franța;

7. **Niță, M.R., Năstase, I.I., Badiu, D.L., Onose, D.A., Gavrilidis, A.A.** (2016), Evaluating the relationship between urban forest location and urban functions in Romanian cities from Carpathian region, The 4th International Conference Forum Carpaticum – Future of the Carpathians: Smart, Sustainable, Inclusive, 28-30 Septembrie 2016, Bucuresti, Romania;

8. **Niță, M.R., Gavrilidis, A.A., Onose, D.A., Badiu, D.L., Năstase, I.I.** (2016), Planificarea infrastructurilor verzi urbane din România prin integrarea percepției experților și actorilor locali, International Conference Re-shaping Territories Environment and Societies: New Challenges for Geography, Noiembrie 2016, București, România;

9. **Badiu, D.L., Niță, M.R.,** Pătroescu, M. (2016), Indicatori pentru evaluarea beneficiilor infrastructurilor verzi urbane în studii de caz reprezentative din România, International Conference Re-shaping Territories Environment and Societies: New Challenges for Geography, Noiembrie 2016, București, România;

10. **Gavrilidis, A.A.,** Avram, M., **Niță, M.R.**, Niculae, I.M., Vânău, G.O., **Onose, D.A., Badiu, D.L.**, Ciocănea, C.M., Iojă, C.I., Pătroescu, M. (2016), Categorii de suprafețe oxigenante urbane în orașele României – locul și rolul lor în peisajul urban, International Conference Re-shaping Territories Environment and Societies: New Challenges for Geography, Noiembrie 2016, București, România;

11. **Niță M.R., Gavrilidis A.A., Onose D.A., Badiu D.L., Năstase I.I.** (2017), Strategies and perceptions in planning for urban green infrastructures in Romania, Panacea Green Infrastructures, 16-17 februarie 2017, Essen, Germania;

12. **Niță M.R., Gavrilidis A.A., Onose D.A., Badiu D.L., Năstase I.I.** (2017), An overview on the presence of green infrastructures in urban policies and strategies from Romania, Nature based solutions for sustainable and resilient cities, 4-7 aprilie 2017, Orvieto, Italia;

13. **Niță M.R., Badiu D.L., Gavrilidis, A.A., Năstase I.I.** (2017), A view on urban green infrastructure in a post-socialist country. Case study: Romania, ALTER-Net International Conference, Nature and society: synergies, conflicts, trade-offs, 2-4 Mai 2017, Ghent, Belgia;

14. **Niță M.R., Onose D.A., Gavrilidis A.A., Badiu D.L., Năstase I.I.** (2017), Using nature-based solutions for sustainable leisure activities in cities, Dresden Nexus Conference, 17-19 mai 2017, Dresda, Germania;

15. **Năstase I.I., Niță M.R., Onose D.A., Gavrilidis A.A., Badiu D.L.** (2017), Evaluation of urban forests connectivity in relation to spatial patterns of urban green infrastructures, The European Forum of Urban Forestry XX „Urban Forest Boundaries”, 31 Mai – 2 Iunie 2017, Barcelona, Spania;
16. **Gavrilidis A.A., Niță M.R., Onose D.A., Badiu D.L., Năstase I.I**. (2017), Participatory plannig of urban green infrastructure. A social network analysis for sustainable development, AESOP Annual Congress, 11-14 iulie 2017, Lisabona, Portugalia.

National conferences participations

1. **Niță, M.R.,** Patroescu M., **Gavrilidis A.A., Onose D.A.** (2016), *Evaluarea locului și rolului infrastructurilor verzi în dezvoltarea urbană durabilă*, Sesiunea anuală de Comunicări dedicată aniversării a 150 de ani de la înființarea Academiei Române – Geografia românească în context European, 1 Iulie, București, România.

<u>Documentation stages and training courses</u>

Salzburg - Gavrilidis Athanasios Alexandru Documentary Training Stage
Location: Paris Lodron University of Salzburg, Austria
Period: 23-29 November 2015
Objectives achieved: consultation with the university library, meetings with Prof. Jurgen Breuste, head of the Urban Ecology and Landscape Department, president of SURE (Urban Ecology Society), visiting examples of good practices in the development of urban green infrastructures

Training course Amsterdam - Niță Mihai Răzvan
Location: Institute for Environmental Studies, VU University of Amsterdam - Department of Spatial Analysis and Decision Support
Period: 18-24 September 2016
Objectives achieved: Exchange of best practices in the field of spatial analysis in urban environments, visiting examples of green infrastructure implementation in the Netherlands

Training course Bari - Badiu Denisa Lavinia
Location: University of Bari Aldo Moro - Department of Agro-Environmental and Regional Sciences, Bari, Italy
Period: 23-29 October 2016
Objectives achieved: During the training sessions, discussions were held on potential partnerships in the research of urban green infrastructures and steps were taken to achieve a scientific article. We also discussed the details of the workshop to be held in July 2017 on the theme of green infrastructure planning in the urban area.

Participation New Pressures Conference on Cities and Regions: Gavrilidis Athanasios Alexandru
Location: London

Organizer: Regional Studies Association. The Global Forum for City and Regional Research, Development and Policy
Period: 24 - 25 November 2016
Main objectives achieved: Identification of the new theoretical, methodological and practical approaches in the management of urban areas in the context of the contemporary threats to the quality of life

Statistics Course - Badiu Denisa Lavinia
The member of the research team Denisa Badiu participated for one month at Statistics 1-Probability and Study Design, organized by The Institute for Statistics Education. By participating in the course, Denisa Badiu based her knowledge on basic statistical concepts for the formulation of research studies.

GIS course - Gavrilidis Athanasios Alexandru
For 6 weeks, the member of the research team, Gavrilidis Athanasios Alexandrou, participated in the Spatial Analysis course organized by the University of Oxford - Department for Continuing Education on Introducing Mapping, Spatial Data & GIS, where he developed the spatial databases and mapping using GIS solutions.

Training course at the Summer School Utrecht Summer School - Badiu Denisa Lavinia
Course: Applied Multivariate Analysis
Location: Utrecht University, Faculty of Social and Behavioral Sciences (UU), Netherlands
Period: 13-25 August 2017
Objectives achieved: During the participation in the Applied Multivariate Analysis of the summer school organized by the University of Utrecht, theoretical knowledge was founded and practical skills were obtained for the following statistical tests: factorial ANOVA, multiple linear regression, logistic regression, ANCOVA, Analysis of Main Components and MANOVA. The course has 3 ECTS credits.

References

Ahern, J., et al. (2014). "The concept of ecosystem services in adaptive urban planning and design: A framework for supporting innovation." *Landscape and Urban Planning* **125**: 254-9.
Amorim, L. M. E., et al. (2014). "Urban texture and space configuration: An essay on integrating socio-spatial analytical techniques." *Cities* **39**: 58-67.
Andrusz, G., et al., Eds. (1996). *Cities after Socialism. Urban and regional change and conflict in post-socialist societies*. Oxford, Blackwell Publishers.
Bianchini, F., et al. (2012). "Probabilistic social cost-benefit analysis for green roofs: A lifecycle approach." *Building and Environment* **58**: 152-62.
Brudermann, T., et al. (2017). "Green roofs in temperate climate cities in Europe - An analysis of key decision factors." *Urban Forestry & Urban Greening* **21**: 224-34.
Cajot, S., et al. (2017). "Obstacles in energy planning at the urban scale." *Sustainable Cities and Society* **30**: 223-36.
Calderón-Contreras, R., et al. (2017). "Analysing scale, quality and diversity of green infrastructure and the provision of Urban Ecosystem Services: A case from Mexico City." *Ecosystem Services* **23**: 127-37.
Cameron, R. W. F., et al. (2012). "The domestic garden – Its contribution to urban green infrastructure." *Urban Forestry & Urban Greening* **11**: 129-37.
Cameron, R. W. F., et al. (2012). "The domestic garden – Its contribution to urban green infrastructure." *Urban Forestry & Urban Greening* **11**(2): 129-37.
Chiesura, A. (2004). "The role of urban parks for the sustainable city." *Landscape and Urban Planning* **68**: 129-38.
Church, S. P. (2015). "Exploring Green Streets and rain gardens as instances of small scale nature and environmental learning tools." *Landscape and Urban Planning* **134**: 229-40.
Ciocănea, C. M. (2017). *Modele de consum ale societății și proiecția lor în peisajul urban. Studiu de caz: Sectorul 3 al municipiului București*. București, Editura Etnologică.
Clayton, M. J. (1997). "Delphi: a technique to harness expert opinion for critical decision making tasks in education." *Educational Psychology* **17**(4): 373-86.
Cornelis, J., et al. (2004). "Biodiversity relationships in urban and suburban parks in Flanders." *Landscape and Urban Planning* **69**(4): 385-401.
Crooks, K. R., et al. (2006). "Connectivity conservation: maintaining connections for nature." *Conservation Biology Series - Cambridge* **14**(1): 1-10.
Cvejić, R., et al. (2015). A typology of urban green spaces, ecosystem services provisioning services and demands, Helsingin Yliopisto, Univerza v Ljubljana, Humboldt Universität zu Berlin, Technische Universität München, Stockholms Universitet, Forestry Commission Research Agency, Fundação da Faculdade de Ciências Da Universidade de Lisboa. **10**.
Daw, J. R., et al. (2013). "Here today, gone tomorrow: the issue attention cycle and national print media coverage of prescription drug financing in Canada." *Health Policy* **110**(1): 67-75.
de Graaf, R. (2012). *Adaptive urban development*, Rotterdam University Press.
Deilami, K., et al. (2017). "Modelling the urban heat island effect of smart growth policy scenarios in Brisbane." *Land Use Policy* **64**: 38-55.
DG Environment (2012). The Multifunctionality of Green Infrastructure. *Science for Environment Policy*.
Dige, G. (2011). Green infrastructure and territorial cohesion. The concept of green infrastructure and its integration into policies using monitoring systems, Technical Report 18. European Environment Agency, Copenhagen, Denmark.[online] URL: http://www. eea. europa. eu/publications/green-infrastructure-and-territorial-cohesion.

Dotson, D. M., et al. (2012). "Media Coverage of Climate Change in Chile: A Content Analysis of Conservative and Liberal Newspapers." *Environmental Communication: A Journal of Nature and Culture* **6**(1): 64-81.
Dunn, R. R. (2010). "Global mapping of ecosystem disservices: the unspoken reality that nature sometimes kills us." *Biotropica* **42**(5): 555-7.
EEA (2011). Green infrastructure and territorial cohesion. The concept of green infrastructure and its integration into policies using monitoring systems. Copenhagen, European Environment Agency. **Technical report No 18/2011**.
EPA (2007). Green Infrastructure. Statement of Intent. U. S. Environmental Protection Agency.
Escobedo, F. J., et al. (2011). "Urban forests and pollution mitigation: Analyzing ecosystem services and disservices." *Environmental pollution* **159**(8): 2078-87.
ESRI (2011). "Geoprocessing with ModelBuilder." *ArcGIS Resource Center*.
European Commission (2012). The Multifunctionality of Green Infrastructure. *Environment Directorate-General, Science for Environment Policy***:** 40.
European Commission (2012). The Multifunctionality of Green Infrastructure. D. Environment. Bruxelles.
Faehnle, M., et al. (2014). "How can residents' experiences inform planning of urban green infrastructure? Case Finland." *Landscape and Urban Planning* **130**: 171-83.
Foltête, J. C., et al. (2014). "A methodological framework for the use of landscape graphs in land-use planning." *Landscape and Urban Planning* **124**(140-150).
Forman, R. T. T. (2006). *Land Mosaics, The ecology of landscapes and regions*. Cambridge, United Kingdom, Cambridge University Press.
Frew, R., et al. (2017). "Investigating geospatial data usability from a health geography perspective using sensitivity analysis: The example of potential accessibility to primary healthcare." *Journal of Transport & Health*.
Gavrilidis, A., Alexandru (2014). *Efecte spațiale și peisagere ale expansiunii și dinamicii urbane în România* Ph.D. Ph.D., University of Bucharest
Gavrilidis, A., Alexandru, et al. (2015). "Land use and land cover dynamics in the periurban area of an industrialized East-European city. An overview of the last 100 years." *Carpathian Journal of Earth and Environmental Sciences* **10**: 29-38.
Gavrilidis, A. A., et al. (2011). Urban Regeneration through Industrial Restructuring of Brownfields in the Local Economies of Post Communist Countries. Case Study: Romania. *47th ISOCARP Congress Liveable Cities: Urbanising World, Meeting the Challenge*. Wuhan, China.
Geneletti, D., et al. (2017). "A review of approaches and challenges for sustainable planning in urban peripheries." *Landscape and Urban Planning*.
Gill, S. E. (2006). *Climate Change and Urban Greenspace*, University of Manchester.
Gill, S. E., et al. (2007). "Adapting cities for climate change: the role of the green infrastructure." *Built environment* **33**(1): 115-33.
Giordano, T. (2012). "Adaptive planning for climate resilient long-lived infrastructures." *Utilities Policy* **23**: 80-9.
Govindarajulu, D. (2014). "Urban green space planning for climate adaptation in Indian cities." *Urban Climate* **10**: 35-41.
Haines-Young, R., et al. (2011). "Common international classification of ecosystem services (CICES): 2011 Update." *Nottingham: Report to the European Environmental Agency*.
Hansen, R., et al. (2014). "From multifunctionality to multiple ecosystem services? A conceptual framework for multifunctionality in green infrastructure planning for urban areas." *Ambio* **43**(4): 516-29.

Hewitt, R., et al. (2017). "Stable models for metastable systems? Lessons from sensitivity analysis of a Cellular Automata urban land use model." *Computers, Environment and Urban Systems* **62**: 113-24.
Hirt, S. (2005). "Planning the Post-Communist City: Experiences from Sofia." *International Planning Studies* **10**(3-4): 219-40.
Hirt, S. (2013). "Whatever happened to the (post)socialist city?" *Cities* **32**: 29-38.
Hlavacek, P., et al. (2016). "Regeneration pojects in Central and Eastern European post-communist cities: Current trends and community needs." *Habitat International* **56**: 31-41.
Hobbs, E. R. (1988). "Species richness of urban forest patches and implications for urban landscape diversity." *Landscape Ecology* **1**(3): 141-52.
Ianoş, I., et al. (2017). "Incoherence of urban planning policy in Bucharest: Its potential for land use conflict." *Land Use Policy* **60**: 101-12.
Institutul National de Statistica (2017). Baza de date TEMPO - Date teritorial-administrative si date asupra dinamicii spatiilor verzi. Bucuresti.
Iojă, C. I., et al. (2014). "The potential of school green areas to improve urban green connectivity and multifunctionality." *Urban Forestry & Urban Greening* **13**(4): 704-13.
Iojă, C. I., et al. (2014). "Using multi-criteria analysis for the identification of spatial land-use conflicts in the Bucharest Metropolitan Area." *Ecological Indicators* **42**: 112-21.
Iojă, C. I., et al. (2015). *Managementul conflictelor de mediu*. București.
Ioja, C. I., et al. (2011). "Dog walkers' vs. other park visitors' perceptions: The importance of planning sustainable urban parks in Bucharest, Romania." *Landscape and Urban Planning* **103**(1): 74-82.
Jaeger, J. A. G., et al. (2010). "Urban permeation of landscapes and sprawl per capita: New measures of urban sprawl." *Ecological Indicators* **10**: 427-41.
Kabisch, N. (2015). "Ecosystem service implementation and governance challenges in urban green space planning—The case of Berlin, Germany." *Land Use Policy* **42**: 557-67.
Kaczorowska, A., et al. (2016). "Ecosystem services in urban land use planning: Integration challenges in complex urban settings—Case of Stockholm." *Ecosystem Services* **22**: 204-12.
Kadoya, T. (2009). "Assessing functional connectivity using empirical data." *Population Ecology* **51**: 5-15.
Kindlmann, P., et al. (2008). "Connectivity measures: a review." *Landscape ecology* **23**(8): 879-90.
Kong, F., et al. (2006). "Spatial-temporal gradient analysis of urban green spaces in Jinan, China." *Landscape and urban Planning* **78**(3): 147-64.
Krueger, T., et al. (2012). "The role of expert opinion in environmental modelling." *Environmental Modelling & Software* **36**: 4-18.
Kupfer, J. A. (2012). "Landscape ecology and biogeography: Rethinking landscape metrics in a post-FRAGSTATS landscape." *Progress in Physical Geography* **36**(3): 400–20.
La Rosa, D., et al. (2016). "Indicators of Cultural Ecosystem Services for urban planning: A review." *Ecological Indicators* **61**: 74-89.
Lauf, S., et al. (2016). "The effects of growth, shrinkage, population aging and preference shifts on urban development—A spatial scenario analysis of Berlin, Germany." *Land Use Policy* **52**: 240-54.
Lyytimäki, J., et al. (2008). "Nature as a nuisance? Ecosystem services and disservices to urban lifestyle." *Environmental sciences* **5**(3): 161-72.
M'Ikiugu, M. M., et al. (2012). "Green Infrastructure Gauge: A Tool for Evaluating Green Infrastructure Inclusion in Existing and Future Urban Areas." *Procedia - Social and Behavioral Sciences* **68**: 815-25.
Manso, M., et al. (2015). "Green wall systems: A review of their characteristics." *Renewable and Sustainable Energy Reviews* **41**: 863-71.

Marea Adunare Nationala (1973). Legea nr. 9 din 20 iunie 1973 privind protectie mediului inconjurator. Monitorul Oficial nr. 133bis din 11 iunie 1948.
Marea Adunare Nationala (1974). Legea nr. 58/1974 privind sistematizarea teritoriului si localitatilor urbane si rurale.
Marshall, T. (2014). "Infrastructure futures and spatial planning: Lessons from France, the Netherlands, Spain and the UK." *Progress in Planning* **89**: 1-38.
Marulli, J., et al. (2005). "A GIS methodology for assessing ecological connectivity: application to the Barcelona Metropolitan Area." *Landscape and Urban Planning* **71**: 243-61.
McGarigal, K. (2014). FRAGSTATS help. Amherst. University of Massachusetts.
McPherson, G., Simpson, J.R.,, et al. (2005). "Municipal forest benefits and costs in five US cities." *Journal of Forestry* **103**(8): 411-6.
McRae, B. H., et al. (2008). "Using circuit theory to model connectivity in ecology, evolution, and conservation." *Ecology* **89**(10): 2712-24.
Meerow, S., et al. (2016). "Defining urban resilience: A review." *Landscape and Urban Planning* **147**: 38-49.
Mentens, J., et al. (2006). "Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century?" *Landscape and Urban Planning* **77**: 217-26.
Midgley, P. (2011). Bicycle-sharing schemes: enhancing sustainable mobility in urban areas, United Nations. Department of Economic and Social Affairs**:** 1-12.
Millennium Ecosystem Assessment (2005). "Millennium ecosystem assessment." *Ecosystems and Human Well-Being: Biodiversity Synthesis, Published by World Resources Institute, Washington, DC*.
Mirea, D. A., et al. (2013). "Spatial and temporal dynamics projection of industrial landscape in the environmental state. Case study: 3rd district of Bucharest." *Present Environment & Sustainable Development* **7**(2).
Moilanen, A., et al. (2009). "The Zonation framework and software for conservation prioritization." *Spatial conservation prioritization* **196-210**.
Munier, N. (2004). Multicriteria environmental assessment: a practical guide, Springer Science & Business Media.
Nae, M., et al. (2011). "The new Bucharest: Two decades of restructuring." *Cities* **28**: 206-19.
Netusil, N. R., et al. (2014). "Valuing green infrastructure in Portland, Oregon." *Landscape and urban planning* **124**: 14-21.
Newell, J. P., et al. (2013). "Green Alley Programs: Planning for a sustainable urban infrastructure?" *Cities* **31**: 144-55.
Niculae, M. I., et al. (2016). "Evaluating the Functional Connectivity of Natura 2000 Forest Patch for Mammals in Romania." *Procedia Environmental Sciences* **32**(28-37).
Niță, M. R. (2011). *Dinamica rezidențialului în zona metropolitană a municipiului București și proiecția ei în starea mediului* phD, University of Bucharest.
Niță, M. R. (2016). *Infrastructuri Verzi - o abordare geografică*. București, România, Editura Etnologică.
Niță, M. R. (2016). *Infrastructuri verzi. O abordare geografică*. București, Editura Etnologică.
Norton, B. A., et al. (2015). "Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes." *Landscape and Urban Planning* **134**: 127-38.
Onose, D. A., et al. (2015). "Identifying Critical Areas Of Exposure To Environmental Conflicts Using Expert Opinion And Multi-Criteria Analysis." *Carpathian Journal of Earth and Environmental Sciences* **10**(4): 15-28.
Ordonez, C., et al. (2013). "An analysis of urban forest management plans in Canada: Implications for urban forest management." *Landscape and Urban Planning* **116**: 36-47.

Ozer, E. J. (2006). "The Effects of school gardens on students and schools: conceptualization and considerations for maximizing healthy development." *Health Education & Behavior* **34** (6): 846-63.
Parlamentul României (1991). Legea fondului funciar nr 18/1991. Monitorul Oficial al României din 20 februarie 1991.
Perera, N. G. R., et al. (2016). "A "Local Climate Zone" based approach to urban planning in Colombo, Sri Lanka." *Urban Climate*.
Puertas, O. L., et al. (2014). "Assesing spatial dynamics of urban growth using an integrated land use model. Application in Santiago Metropolitan Area, 2010-2045." *Land Use Policy* **38**: 415-25.
Pulighe, G., et al. (2016). "Insights and opportunities from mapping ecosystem services of urban green spaces and potentials in planning." *Ecosystem Services* **22**: 1-10.
Rees, W. E. (1997). "Urban ecosystems: the human dimension." *Urban Ecosystems* **1**(1): 63-75.
Renn, O., et al. (2013). "A Framework of Adaptive Risk Governance for Urban Planning." *Sustainability* **5**(5): 2036-59.
Rocha, S. M., et al. (2015). Mapping and assessment of urban ecosystems and their services, Joint Research Centre.
Saghin, I., et al. (2012). *Perception of the Industrial Areas Conversion in Romanian Cities-Indicator of Human Settlements Sustainability*. 48th ISOCARP Congress, Perm, Russia.
Saltelli, A., et al. (2008). *Global sensitivity analysis. The Primer*, John Wiley & Sons.
Salvati, L. (2014). "Land availability vs conversion bz use type: A new approach for land take monitoring." *Ecological Indicators* **36**: 221-3.
Saura, S., et al. (2009). "Conefor Sensinode 2.2: a software package for quantifying the importance of habitat patches for landscape connectivity." *Environmental Modelling & Software* **24**(1): 135-9.
Schäffler, A., et al. (2013). "Valuing green infrastructure in an urban environment under pressure — The Johannesburg case." *Ecological Economics* **86**: 246-57.
Shin, H., et al. (2017). "Participatory governance and trans-sectoral mobilities: The new dynamics of adaptive preferences in the case of transport planning in Seoul, South Korea." *Cities* **65**: 87-93.
Stanilov, K. (2007). Urban development policies in Central and Eastern Europe during the transition period and their impact on urban form. *The Post-Socialist City*, Springer: 347-59.
Stojanovic, M., et al. (2014). "The scenario method in urban planning." *Facta universitatis - series: Architecture and Civil Engineering* **12**(1): 81-95.
Suditu, B., et al. (2010). "Urban sprawl characteristics and typologies in Romania." *Human Geographies–Journal of Studies and Research in Human Geography* **4**(2): 79-87v.
Sukhdev, P. (2010). The economics of ecosystems and biodiversity. Berlin.
Susca, T., et al. (2011). "Positive effects of vegetation: Urban heat island and green roofs." *159*: 2119-26.
Swanwick, C., et al. (2003). "Nature, role and value of green space in towns and cities: An overview." *Built Environment* **29**(2): 94-106.
Takano, T., et al. (2002). "Urban residential environments and senior citizens' longevity in mega-city areas: the importance of walkable green space." *Journal of Epidemiology & Community Health* **56**: 913–6.
Taylor, P. D., et al. (1993). "Connectivity is a vital element of landscape structure." *Oikos* **68**: 571-3.
Tzoulas, K., et al. (2010). "Peoples' use of, and concerns about, green space networks: A case study of Birchwood, Warrington New Town, UK." *Urban Forestry & Urban Greening* **9**(2): 121-8.
Urban, D., et al. (2001). "Landscape connectivity: a graph-theoretic perspective." *Ecology* **82**(5): 1205-18.

Van de Voorde, T., et al. (2008). "Comparing Different Approaches for Mapping Urban Vegetation Cover from Landsat ETM+ Data: A Case Study on Brussels." *Sensors (Basel)* **8**(6): 3880-902.
Van Herzele, A., et al. (2003). "A monitoring tool for the provision of accessible and attractive urban green spaces." *Landscape and Urban Planning* **63**(2): 109-26.
Vandermeulen, V., et al. (2011). "The use of economic valuation to create public support for green infrastructure investments in urban areas." *Landscape and Urban Planning* **103**(2): 198-206.
Wolch, J. R., et al. (2014). "Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'." *Landscape and Urban Planning*.
Yang, J., et al. (2008). "Quantifying air pollution removal by green roofs in Chicago." *Atmospheric environment* **42**(31): 7266-73.
Young, R., et al. (2014). "A comprehensive typology for mainstreaming urban green infrastructure." *Journal of Hydrology* **519**: 2571-83.