COULD URBAN GREEN SPACE MANAGEMENT IN MEHEDINŢI COUNTY BE CONDUCTED FOLLOWING GREEN INFRASTRUCTURE PLANNING PRINCIPLES?

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Abstract. Green spaces are a key component of urban green infrastructures (UGI). The principles that define UGI are integration with other urban infrastructures, multifunctionality, connectivity at different spatial scales and from different perspectives. This paper aims to assess the potential of applying the UGI principles taking as case studies the urban green spaces of Mehedinţi County (Drobeta-Turnu Severin, Orşova, Strehaia, Vânju Mare, Baia de Aramă). The analysis was based on data extracted from aerial images that have been used to assess the spatial distribution and structural connectivity of the green areas. The application of 65 questionnaires assessed the perception of the quality of green infrastructures about the urban parks in Drobeta-Turnu Severin and Vânju Mare. Findings show a shortage of green spaces, characteristic of most cities in Romania as well as the relatively low level of connectivity among the green space components. The major findings of the paper show that analysed urban green areas have limited potential to be considered under the concept of urban green infrastructure. Planning, design and management measures have to be promoted in order to increase the diversity of green areas, their accessibility for different users, their connectivity and multifunctionality at local and regional level.

1. INTRODUCTION

Green infrastructure (GI) is an approach in urban nature planning and design, oriented towards ensuring both socio-economic and ecological benefits (Badiu *et al.*, 2019; Forman, 2016; Grădinaru and Hersperger, 2019; Haase *et al*., 2017; Hansen *et al*., 2019). GI consists of natural and semi-natural ecosystems (e.g. forests, grasslands, and wetlands), urban green spaces, aquatic areas and agricultural land which are capable of generating a wide range of ecosystem services (Lafortezza *et al.*, 2013; Pauleit, Ambrose-Oji *et al.*, 2019; Pauleit *et al.*, 2019).

Green infrastructure is a multifunctional system consisting of: (a) *core areas* of major importance for the conservation of biodiversity (e.g. protected natural areas or areas with functional natural ecosystems), (b) *corridors and stepping stones*, which ensure connectivity between elements of the network (watercourses, ponds, windbreaks), (c) *restored habitats*, in particular to improve connectivity and network functions; (d) *artificial components*, made by humans to maintain an optimal level of connectivity and functionality of ecosystems (wildlife crossing, fish ladders, green roofs, green walls, permeable areas); (e) *buffer zones*, which improve the ecological quality and permeability of landscapes (ex-situ wildlife conservation areas, zoos) and (f) *multifunctional areas* with multiple uses but with high compatibility, such as agricultural lands (Iojă *et al.*, 2019; Pauleit, Andersson *et al*., 2019). This multifunctional system is designed and managed to cope with major challenges arising

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from urbanization (Raymond *et al*., 2017), such as increasing social cohesion, urban regeneration, adapting to climate change, and preserving biodiversity (McDonald *et al.*, 2005; Millenium Ecosystem Assesssment, 2005; Pauleit *et al.*, 2019).

Unlike classic approaches in the management of urban green spaces, GI planning is based on several fundamental principles. Agreed upon by several authors are the following principles: (a) *integration of GI elements with other urban infrastructures,* particularly the integration with built spaces; (b) *multifunctionality,* representing the multiple functions provided by GI elements, including multiple ecosystem services; (c) *connectivity,* ensuring links between network elements at different spatial scales and from different perspectives (i.e. humans, species); (d) *multi-scale,* representing the relevance of GI at different spatial scales, starting from individual plots to national level) and (e) *diversity,* meaning the inclusion of all elements potentially generating ecosystem services, regardless of how small they are in area, and how few services they may generate (Lafortezza *et al.*, 2013; Niţă, 2016; Niţă *et al.*, 2018; Pauleit *et al.*, 2019; Grădinaru and Hersperger, 2019).

While connectivity and multifunctionality of GI are the most often adopted principles (Artmann *et al.*, 2019; Badiu *et al.*, 2016; Forman 2016; Grădinaru and Hersperger, 2019; Haase *et al.*, 2014; Hansen *et al.*, 2019; Iojă *et al.*, 2014; James *et al.*, 2009; Lafortezza *et al.*, 2013; McDonald *et al.*, 2020; Niţă, 2016; Niţă *et al.*, 2018), there are still challenges in designing functional infrastructures, particularly in urban contexts. More knowledge is needed to successfully implement the GI principles at local level (Skokanová and Slach, 2020). Furthermore, a better consideration of the local context is necessary for transitioning from green space management to GI planning. For example, Badiu *et al.* (2016) showed the importance of the local context (i.e. historical, environmental) in assessing the necessary quantity of green spaces in Romania. Authors highlighted the need to report information on green spaces` quality, accessibility and attractiveness along with quantitative information. Thus, any locally identified green space deficits must be assessed by considering the demand for ecosystem services (What are the needs of the population in relation to the components of local green infrastructures?) and the regional compensation potential (What proportion of the local deficit can be compensated at regional level?). The availability of green space per capita, accessibility, attractiveness and quality of green space, inter and intra-urban connectivity are GI properties that must be related to the local need and potential for ecosystem services (Iojă *et al.*, 2011).

The purpose of the analysis is to evaluate if urban green areas can be planned by applying the GI principles. To fulfil our aim, we followed the GI principles commonly identified in literature and described in the above paragraphs. The analysis was divided into three objectives, as follows:

(a) assess the potential of urban green areas to be integrated with other urban infrastructure, based off of green areas characteristics and distribution;
(b) evaluate the multifunctionality and diversity of green spaces lending special consideration to their categories and quality;
(c) assess the connectivity of urban green areas and their potential to be considered at multiple scales.

Mehedinţi County was selected to conduct this assessment. Cities in the study area were deeply affected by deindustrialization, decreased attractiveness and unplanned development (Popescu, 2003). The decreasing size of green spaces (e.g. through conversion into built-up areas), the poor vegetation maintenance and the few investments highlighted the existing environmental, social and economic problems. As many other Romanian cities, the cities in the study area have so far adopted a green space management approach instead of designing a functional one (Niţă *et al.*, 2018). The process of urban regeneration would require the development and restoration of green areas as well as a new approach in their planning. Considering that the cities are in the process of developing new urban strategies, we believe our research to be a timely one. Insights developed in this study could support

decision-making for Mehedinţi County and the selected cities in regard to the development of a functional green infrastructure.

2. STUDY AREA

Mehedinţi County is located in the South-West Oltenia Development Region and includes five cities (Drobeta-Turnu Severin, Orşova, Strehaia, Baia de Aramă, Vânju Mare) of sizes ranging from 5,529 inhabitants to 92,617 inhabitants (Fig. 1). The county area covers roughly equal proportions of mountains, hills, and plain areas. Mediterranean influences affect the climate, which benefits from warm and dry summers and moderate and humid winters. On summer days, temperatures frequently surpass 30ºC and torrential rainfall is recorded (Table 1). The population of Mehedinţi County is of 241,262 inhabitants (EUROSTAT 2018), and has a decreasing trend. Of the total population, 46.8% is urban.

The study area allows for an adequate urban and county-scale analysis of urban green infrastructure. The diversity of the biophysical and socio-economic environment at county and urban levels allows an understanding of how to approach the concept of urban green infrastructure in different ecological, social and economic contexts.

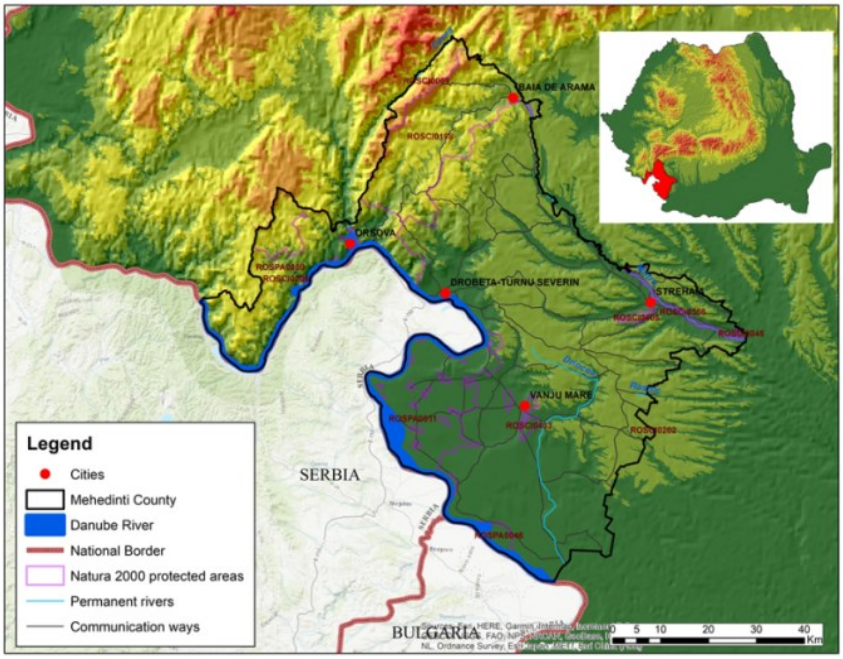

Fig. 1 – The spatial distribution of the selected cities.

Table 1

City description

Cities	Total administrative area (ha)	Geographical location	Number of inhabitants	Founded
Drobeta-Turnu Severin	5471	Danube Floodplain	92,617	272 B.C.
Orşova	5372	Mountainous area	12,233	2nd century B.C.
Strehaia	10864	Piedmont area	10,993	1471
Vânju Mare	9357	Plain area	5,821	1723
Baia de Aramă	9111	Mountainous area	5,529	1851

3. METHODOLOGY

Qualitative and quantitative methods (statistical, empirical, surveys) were used for this research, as presented in the methodology below.

Green areas characteristics (surface, distribution) were assessed spatially and based on official data provided by the National Institute of Statistics (INS, 2018). Data on green space surface extracted from orthophotoplans and maps by the authors were compared with official statistical data. Furthermore, the green space per capita index for each city was compared to the threshold of 26 m^2/inhabitant set by the Environmental Protection Act (OUG 195, 2005).

A spatial analysis was performed to assess the spatial distribution of green spaces, as well as their distribution in respect to other urban infrastructures (i.e. built space, street network). Mapping of the green space was carried out in ArcGis Pro version 2.3.2 (ESRI, 2018) using the OpenStreetMap data, topographic maps and orthophotomaps. Green space categorization follows the Romanian Green Spaces Law (2020) and the study by Badiu *et al*. (2016), where the categories are, respectively, parks, squares, street trees, residential gardens, public institutional gardens, industrial and commercial gardens, cemeteries/graveyards, and sporting grounds. The Tempo Online database of the National Statistical Institute (INS, 2018) was the source for data on population number, land use/land cover surface and urban green spaces surface.

The qualitative assessment of green spaces was conducted through a survey. Sixty-five questionnaires were applied to decision-makers in Mehedinţi County, of which 40 in Drobeta-Turnu Severin and 25 in Vânju Mare. Decision makers held the roles of public institutions employers. The questionnaires were applied face-to-face, sampling being done according to convenience. The period when questionnaires were submitted was between October 2019 and 12–27 May 2020.The questions addressed their perception on the quality of green spaces, the attractiveness factors, the existing challenges and the prospects in terms of the necessary improvements. Statistical data processing was conducted using Microsoft Excel.

Connectivity of urban green spaces was assessed structurally, at two levels: within each city (i.e. urban-level) and in respect to nearby natural and semi-natural areas, Natura 2000 protected areas and forests (i.e. county level). For the connectivity assessment, vector data from digitalization were converted to rasters with a resolution of 5m x 5m. For each city we created two rasters: a) one with spatial data on urban green spaces and b) one with urban green spaces and green areas outside the city limits (i.e. protected areas, forests). Three rasters helped assess the connectivity for the two levels.

Connectivity was assessed using Proximity Index (PROX) and Euclidean Nearest Neighbour (ENN). For the urban-level connectivity assessment, the metrics were calculated for distances of 50m (immediate proximity areas), 300 m (distance corresponding to a time of approximately 5 walking minutes) and 500 m (distance corresponding to a time of approximately 10 walking minutes) (Iojă *et al.*, 2014). The county-level connectivity analysis took into account a distance of 2 km. Fragstats software was used to conduct the assessment (*FRAGSTATS help*, 2015).

4. RESULTS

4.1. Quantitative characteristics of urban spaces

According to the data extracted from the orthophotoplans, the surface of the urban green spaces of Mehedinţi County is 128.46 ha, ranging from 2 ha in Baia de Aramă to 101 ha in Drobeta-Turnu Severin. The share of green spaces in the total administrative territory varies between 0.71% in Strehaia and 4.76% in Vânju Mare. The green space per capita index in all analysed cities is below the

recommended value of 26 m^2/inhabitant. Values calculated in this study show that the index ranges from 3.61 m^2/inhabitant in Baia de Aramă to 22.5 m^2/inhabitant in Vânju Mare (Fig. 2).

There are significant differences between official statistics and those extracted from orthophotoplans on the indicators defining green spaces (Table 2). Values obtained from official statistics are 1.07 to 8.82 times higher than the data extracted from orthophotoplans. After 2007, significant increases in declared urban green spaces of more than 200% were recorded in the cities of Mehedinţi County (excluding Vânju Mare).

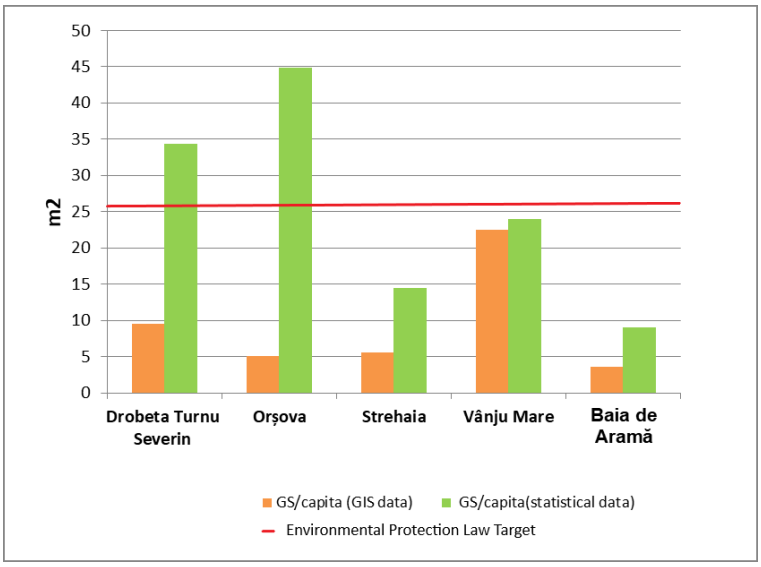

Fig. 2 – Green space per capita in the analysed cities.

The structure of urban green spaces is quite diverse, depending on the importance, the location size of cities, and when they were founded (Fig. 3). Thus, in the municipality of Drobeta-Turnu Severin we identified nine categories of green spaces, while in the other lower-ranking cities we identified between four and six categories. All analysed cities included parks, cemeteries, sporting facilities and street alignments.

Table 2

Quantitative indicators of green infrastructures

Cities	Green space area (ha)		Percentage of green space (%)		Green space/capita (m^2)	
	Mapped by authors	INS, 2018	Mapped by authors	INS, 2018	Mapped by authors	INS, 2018
Drobeta-Turnu Severin	101	364	3,82	13,78	9,55	34,4
Orşova	6,25	55	1,17	10,32	5,10	44,9
Strehaia	6,11	16	0,71	1,86	5,55	14,5
Vânju Mare	13,1	14	4,76	5,09	22,5	24
Baia de Aramă	2	5	0,84	1,07	3,61	9

At county level, the largest share of green spaces is held by parks (33.3%). Their share at urban level is lower in towns (7.6% in Vânju Mare, 12.5% in Baia de Aramă) and higher in medium-sized cities (43.3% in Orşova, 36.6% in Drobeta-Turnu Severin, 29.0% in Strehaia). In terms of area, the

parks occupy an important area only in the municipality of Drobeta-Turnu Severin (37 ha), while in the other cities their areas are quite small (registering a minimum of 0.25 ha in Baia de Aramă). The second category of green spaces according to its percentage at county level is represented by cemeteries (18.9%). At city level, they have the largest share in Strehaia (43.2% of the total area of green spaces) and Baia de Aramă (32.5%). Cemeteries, beyond the green area they include, have little capacity to provide cultural and regulation ecosystem services, due to their medium to high degree of artificialization. Both parks and cemeteries have public access.

In the category of green spaces with limited access, but present in all analysed cities, are sporting facilities. Their register up to 55% of the total green spaces in Baia de Aramă (Table 3).

Table 3

Percentage of each category of urban green areas in Mehedinţi county;
based on authors` calculations

	Drobeta-Turnu Severin	Orşova	Strehaia	Vânju Mare	Baia de Aramă	Country level
Urban forests	11,9	0,0	0,0	0,0	0,0	9,3
Parks	36,6	43,4	29,0	7,6	12,5	33,3
Squares	4,0	1,0	<0,01	<0,01	<0,01	3,2
Sports facilities	5,9	21,6	19,5	11,5	55,0	8,7
Cemeteries	16,8	15,5	43,2	22,7	32,5	18,9
Industrial green spaces	5,0	<0,01	<0,01	<0,01	<0,01	3,9
Institutional gardens	2,0	<0,01	<0,01	<0,01	<0,01	1,6
Residential gardens	7,9	18,1	<0,01	<0,01	<0,01	7,1
Street trees	9,9	0,5	8,3	58,1	<0,01	14,1

Street alignments occur mainly in the proximity of the central area of cities, along the main boulevards and along the streets in collective residential areas. Their share at county level is 14.1% of all green spaces, with the highest values being registered in Vânju Mare (58.1%).

The expansion of the collective residential during the communist period was accompanied by the development of the gardens. This is particularly characteristic for industrial cities such as Drobeta-Turnu Severin (7.9% of all green spaces) and Orşova (18.1%). Urban forests, squares, gardens associated with institutions and industrial spaces have smaller areas, which is also mirrored in the small towns of Mehedinţi County (Figs. 2 and 4).

Table 4

Natural and semi-natural areas in the proximity of the analyzed cities
(INS, 2018)

Cities	**Aquatic surfaces**		**Forests**		**Agricultural land**	
	ha	**%**	**ha**	**%**	**ha**	**%**
Drobeta-Turnu Severin	1160	21,2	2158	39,4	623	11,4
Orşova	760	14,1	2950	54,9	1025	19,1
Baia de Aramă	140	1,5	3382	37,1	4629	50,8
Strehaia	158	1,5	4651	42,8	5317	48,9
Vânju Mare	150	1,6	1579	16,9	6942	74,2

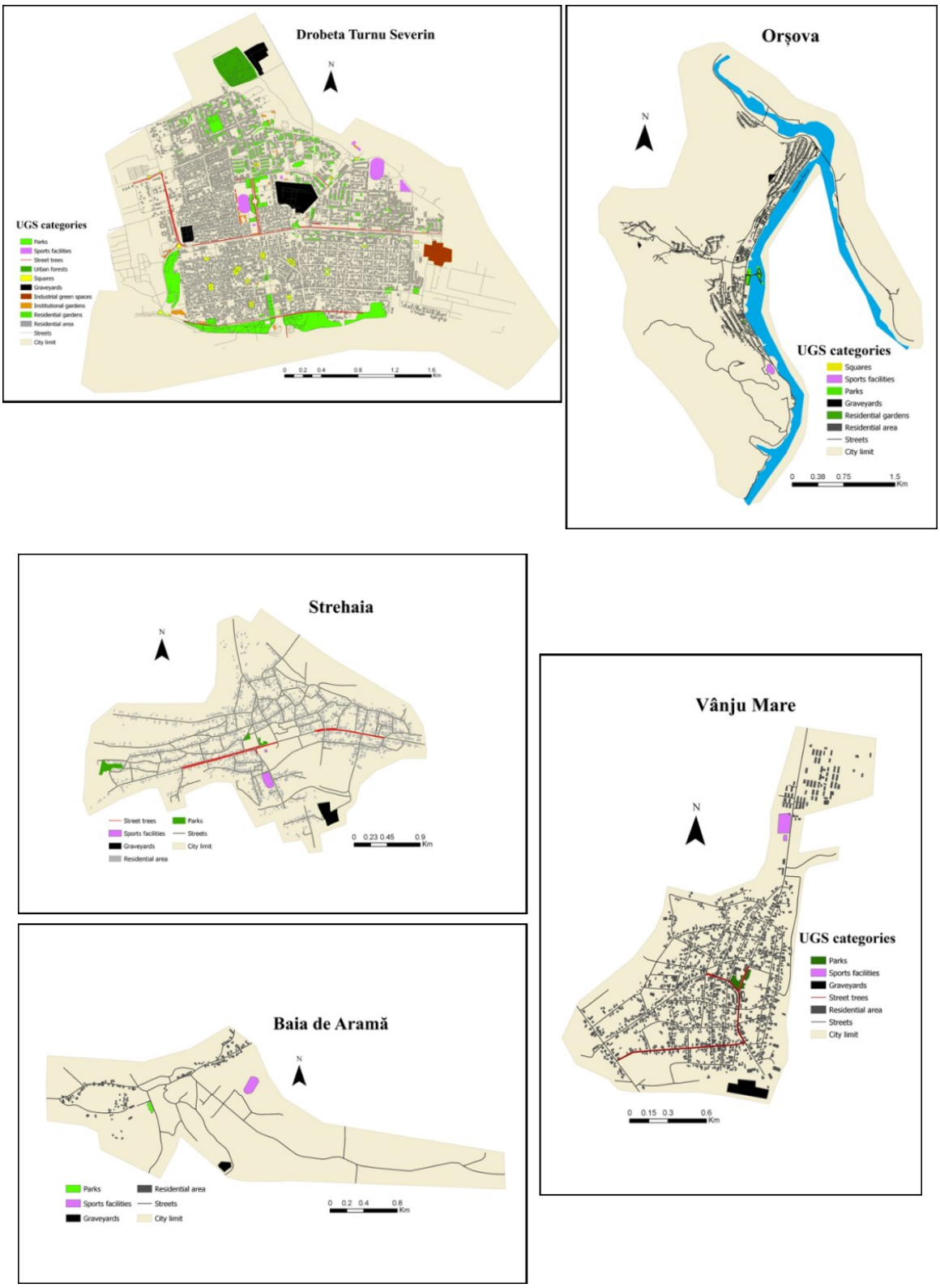

Fig. 3 – Urban green spaces patterns in cities in Mehedinți County.

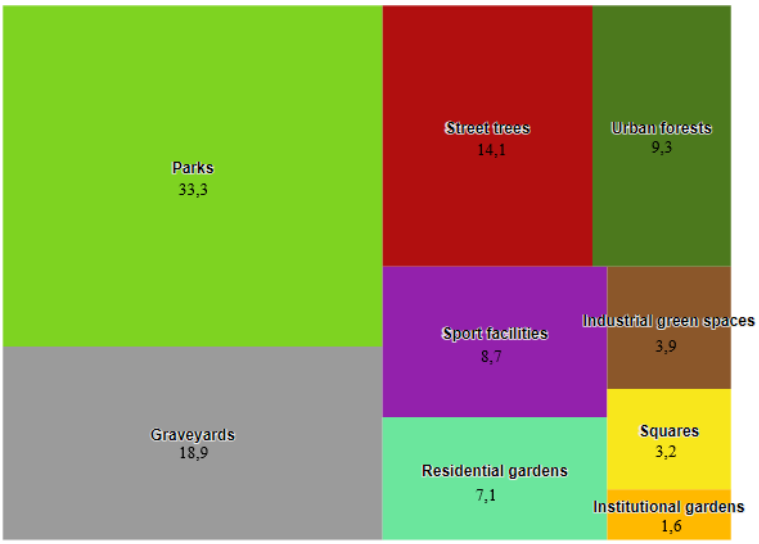

Fig. 4 – The proportion of urban green areas at Mehedinţi county level (in hectares).

4.2. Structural connectivity of urban green spaces

The Proximity indicator, calculated for distances of 50, 300 and 500 meters, records the highest values in Drobeta-Turnu Severin (Table 5), due to the presence of various typologies of urban green areas, such as parks, urban forests, residential gardens (Table 3). The other cities have lower values for this indicator, which shows low connectivity among green space categories.

Table 5

Values of Proximity and Euclidean Nearest Neighbour metrics

Urban-level connectivity					**County level connectivity**
	Proximity Index – PROX			**Euclidean Nearest Neighbour – ENN (m)**	**Proximity Index – PROX**
DISTANCE	50 m	300 m	500 m		2000 m
Drobeta-Turnu Severin	0.00	2.62	3.03	159.85	3.86
Orşova	0.00	0.24	0.24	298.86	41.44
Strehaia	0.00	0.08	0.08	880.19	16.43
Vânju Mare	0.00	0.00	0.00	672.65	1.62
Baia de Aramă	0.00	0.00	0.00	815.28	8.11

The proximity index is zero within the 50-meter distance for all cities because no existing green patches were identified in the established focal distance. Values of the ENN show that the distance between each green patch is significant (an average of 565.3 m), which shows there is a low connectivity at urban level.

The lowest value of the ENN indicator is recorded in Drobeta-Turnu Severin (159.85 m), due to the presence of various categories of green infrastructures, which are arranged randomly within the territory of the city. This higher connectivity is supported particularly by the high number of residential gardens and the small distance among them. Moreover, these green areas contribute to the green urban infrastructure, with the aim of connecting points for the production of a compact area. On the other hand, the town of Vânju Mare is characterized by a high ENN (815.28 meters), caused by the small number of green infrastructure components and the long distances between them. The same goes for the cities of Orşova and Baia de Aramă.

To complement the values obtained by calculating the ENN indicator, the Average Nearest Neighbour function was used in ArcGis Pro, which highlights the distribution characteristics of patches (plots) according to the distance measured between them. In the case of Drobeta-Turnu Severin it showed that urban green areas are clustered because the index value is less than 1. The city of Baia de Aramă has a dispersed distribution of green areas with the value of the index NN > 1.

The connectivity between the urban green areas and the nearby natural areas, showed significant differences depending on the position of the cities. According to the Proximity indicator, higher connectivity is recorded by cities that are located in the plateau and mountain areas, where the degree of afforestation is higher and where the density of protected natural areas is high.

The highest value of the PROX indicator is recorded in the municipality of Orşova (41.44). The same pattern is recorded for Baia de Aramă which overlaps its territory with several protected natural areas, having a high indicator value (8.11). A low PROX value is found in the case of Vânju Mare (1.62), a value determined by the fact that it is located in the lowland area of the county, with considerably smaller forest areas.

4.3. Quality of urban green space

The quality assessment revealed the existence of a satisfactory and good maintenance of existing green areas (Fig. 5), but they are small in size and with few facilities.

Interviewees reported insufficient equipment and inadequate quality of spaces for pedestrians (e.g. alleys) as well as a limited number of relaxation and outdoor activities spaces (e.g. playgrounds, cycle paths). Many respondents argued that most green areas, especially railroad station parks, are insecure for visitors.

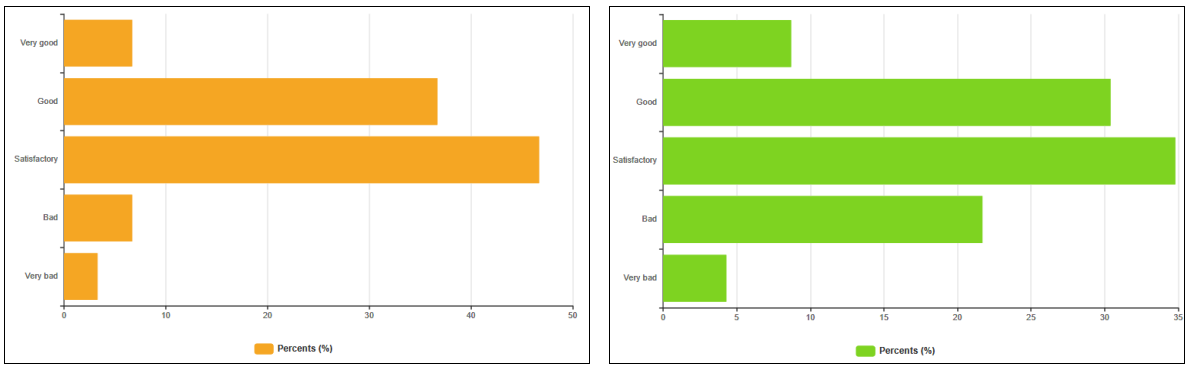

Fig. 5 – Answers given by residents of the cities Drobeta-Turnu Severin (A) and Vânju Mare (B) to the question concerning the maintenance of green infrastructures.

The measures suggested by interviewees relate to greening actions (gathering plant matter, keeping alleys clean), but also actions to improve aesthetics, such as planting and caring for flower beds, tree pruning and creating attractive arrangements for the visitors.

5. DISCUSSION

In this study we evaluated the potential of the green spaces to be considered under the umbrella of the urban green infrastructure concept, using Mehedinţi County as case study. The major findings of the paper show that there is still work to be done to integrate the principles of the urban green infrastructure in the planning, design and management of the green areas in the analysed cities.

The spatial planning discourse about urban green areas has to be transferred from quantitative approaches to more holistic approaches. The quantity of the urban green doesn't point out their real capacity of providing ecosystem services (Badiu *et al.*, 2016; Kabisch and Haase, 2013). We believe that the values for green area per capita in the analysed cities, although they are below the national target of 26 m^2/inhabitant, do not show an environmental crisis at city level. This result is similar to that of Badiu *et al*. (2016) which highlight the need for more diverse indicators when assessing the optimal level of green spaces at urban level. The consequence of the quantity-oriented approach is showed by the differences between data extracted from aerial images and those reported by official statistics (INS, 2018). This demonstrates the lack of realism of the national target, which has led many municipalities to find solutions for the indicator's artificial growth. After this target was set, the approaches frequently used to increase the green areas were the inclusion of forest and aquatic spaces within urban green areas (Grigorescu and Geacu, 2017), as well as zoning changes, such as the return to the green spaces zone of areas that were oriented towards the development of other types of infrastructure. To avoid these situations, green spaces must be of adequate quality, equitably distributed across the territory and must provide the ecosystem services requested by as many residents as possible.

Findings show that the integration of the green areas with other urban infrastructures (first principle of GI) remained at a low level. The level of endowment of parks has remained at an appropriate level only in the central areas of cities, and the consideration of green spaces at the level of other urban functions has remained deficient. Exceptions are only the collective residential spaces, where there is a tendency of area reduction and quality degradation (Grigorescu and Geacu, 2017; Pătroescu *et al.*, 2004; Pătroescu *et al.*, 2012). These problems cannot be solved in the short term by the inclusion of natural or semi-natural surfaces within the urban growth boundaries, but must be the subject of a systematized medium- and long-term approach (Tzoulas *et al.*, 2007).

In our study area, multifunctionalities are low because important categories of green spaces are deficient (parks, street alignments, gardens of public institutions), and others have a slightly too high share (e.g. cemeteries). The low investments in maintaining the green spaces keeps their specific ecosystem services low as well. This requires a stronger orientation towards increasing the multifunctionality of green spaces (Artmann *et al*., 2019; Hansen *et al.*, 2019; Pauleit *et al.*, 2019), avoiding the degradation of their functions.

The structural connectivity of green spaces has significant differences among the analysed cities. Structural connectivity between different categories of green spaces is low, with the exception of Drobeta-Turnu Severin. This highlights the need to increase the area of corridors and stepping stones, such as residential gardens, institutional gardens and street trees (Badiu *et al*., 2019; Niţă *et al*., 2018), considering the entire territory of the settlements.

The structural connectivity of green spaces with other natural and semi-natural ecosystems in the cities' proximity is generally good, highlighting the potential to compensate for green spaces shortage inside the cities, especially in Drobeta-Turnu Severin, Orşova, Strehaia and Baia de Aramă. For these cities, the area occupied by forests and/or aquatic areas of the total territorial administrative unit reaches 38.6% in the town of Baia de Aramă, 44.4% in the city of Strehaia, 60.6% in Drobeta-Turnu Severin, and 69% in Orşova, a large part of these areas being included in protected natural areas. In the cities of Baia de Aramă and Strehaia this is also doubled by a share close to 50% of agricultural ecosystems (Table 5). Thus, the approach of green spaces at different spatial scales allows for an adaptation of the ecosystem services supply, so that it corresponds to the requirements and level of use of the population.

Last but not least, the diversity of the structure of urban green spaces, as well as the regional ecological network, highlights the need for a multilevel approach, in which all components of green infrastructures are important, regardless of the surface, current functions, quality or position.

6. CONCLUSIONS

The paper examines the potential of urban green spaces in Mehedinţi County to be addressed as an urban green infrastructure. The public administrations of small and medium-sized cities view this concept in an ambiguous, complicated form, even if they are aware of the importance of green infrastructure. Green areas planning needs to change the focus of green areas demand and supply from a quantitative approach to the holistic approach. The integration of the green areas with other urban land use will increase their accessibility and attractiveness (Artmann *et al.*, 2019), but also their potential to provide the demanded ecosystem services (Haase *et al.*, 2014) without developing new environmental conflicts (Niţă and Iojă, 2020). Also, considering regional context must become a key step to assess the availability of urban green areas for different stakeholders.

Green areas design must consider connectivity, multifunctionality and integration at different scales. Without these features, it is quite impossible to pass from the green areas approach to an urban green infrastructure.

This study reveals the deficiencies of green space and the lack of important categories of urban green infrastructure faced by cities in Mehedinţi County. Issues are caused by the lack of information of the actors involved, the lack of management regarding existing urban green spaces, and the poor management of the achievement of the targets set by the existing legislation.

The lack of important categories of urban green infrastructure is causing a shortage in connectivity and multifunctionality elements. Residents of these areas need diverse green spaces that offer multiple benefits.

There is a real need for multilevel and integrative management approaches. All urban green infrastructure components must be considered as a whole, and to be managed as a coherent infrastructure. Projects need to find a proper way to improve green areas quality, to connect with local and regional components of green infrastructure and to answer to stakeholders' demands.

Participatory planning can be a way to accelerate the transition to urban green infrastructure (Breuste *et al.*, 2020). Working together can help public administration to find a realistic solution to promote a realistic and efficient approach to UGI.

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