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THE ROLE AND IMPORTANCE OF WATER BODIES FOR THE STRUCTURE AND FUNCTIONS OF URBAN OXYGENATING SURFACES. CASE STUDY: SOUTH-WEST OLTENIA DEVELOPMENT REGION, ROMANIA

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Abstract

As part of the urban environment, urban water bodies, lakes and rivers consist in oxygenating surfaces that support and simplify the functions of the urban landscape. Our research, undertaken for the first time in Romania, aims to establish the place and role of lacustrine water bodies and the manner we define the structure and functions of urban oxygenating surfaces, for the quality of natural capital and urban biodiversity. We used cartographic sources which we corroborated with field data in order to calculate quantitative indicators. We obtained a hierarchy of existent urban lakes in cities located in the South-West Oltenia Development Region. Also, to highlight the importance and role of urban lakes in the structure and ecological, social and economic functions of oxygenating surfaces, we calculated a series of indicators: the surface share of urban lakes to the administrative-territorial unit and oxygenating surfaces; the lakes' surface per capita and per administrative-territorial unit population; the distance between urban lakes and residential areas, the centrality level of lakes within a city; the level of accessibility; the share of urban lakes within the constructed surface; the social diversity on the proximity of urban lakes (number and type of housing – private, collective; number of schools, kindergartens or cultural institutions) and sensitive urban areas. We also established a hierarchy of the analyzed cities by the way urban lakes are valued (for recreation, water sports, sport fishing, water transportation or educational activities). Our main results consist in an extensive database that will help decision-makers implement solutions for a better urban planning and manage the natural capital in a sustainable way. Our study will be continued and improved with results on the topo-phobia and topo-philia of urban oxygenated surfaces and urban lakes. We also consider important to establish the role of water bodies as ecological corridors, for increasing urban biodiversity.

Keywords: urban oxygenating surfaces, urban lakes, sustainable cities, South-West Oltenia Development Region, Romania

1 INTRODUCTION

Urban oxygenating surfaces have been poorly studies in the field of geographical sciences in Romania, evading their assessment of structure and functionality in relation health and quality of living of inhabitants in urban environments.

The literature does not provide a dogmatic definition of *urban oxygenating surfaces*, but it can be explained by an association of green-blue urban areas with a role in improving the quality of urban life, human health (Niță, 2016) and the overall urban environment (Badiu, et al., 2016). Under this category, based on structural, functional and aesthetic aspects, all elements of natural and semi-natural landscapes should be included (Demuzere et al., 2014) such as urban lakes, urban rivers, urban parks, forested areas, public and private gardens, sports areas, street trees and riparian vegetation. *Urban lakes*, as a category of oxygenating surfaces, have a role in ensuring urban biodiversity and support for physical and cultural activities (CCMESI, 2018). The capacity of urban lakes in regulating climate, improving the air quality and water as a source (CCMESI, 2018) is conditioned by the process of implementing legislative measures directed towards proper ecological conditions (Directive 2000/60/EEC). Otherwise, *urban lakes* could be transformed in vectors that can disseminate different problems, such as: invasive species, pests, health

hazards and loss of aesthetic quality (Kuznyetsov, 2006). In this context, it is necessary to improve the knowledge on *urban lakes*, on their role as an oxygenating surface in the urban environment (Miller and Small, 2003), and also on the relation with other blue-green areas.

South-West Oltenia Development Region (SW Oltenia DR) is located in south-west of Romania and it includes 5 counties (*Dolj, Gorj, Olt, Vâlcea and Mehedinți*), with a total area of 29.212 km2, which is approximately *12.2%* of Romania's territory. The regions includes *40* urban areas divided by their importance in 3 categories, according to *Law no. 351/2001* on the approval of the *Landscaping National Plan – Section IV – Settlements network* (Figure 1). Of these, only *21 urban areas have aquatic surfaces* that are strongly related to the physical characteristics of the cities and the degree of human intervention. The aim of this study is to highlight the role of *urban lakes* in the structure and functionality of urban oxygenating surfaces, as a premise of sustainable development.

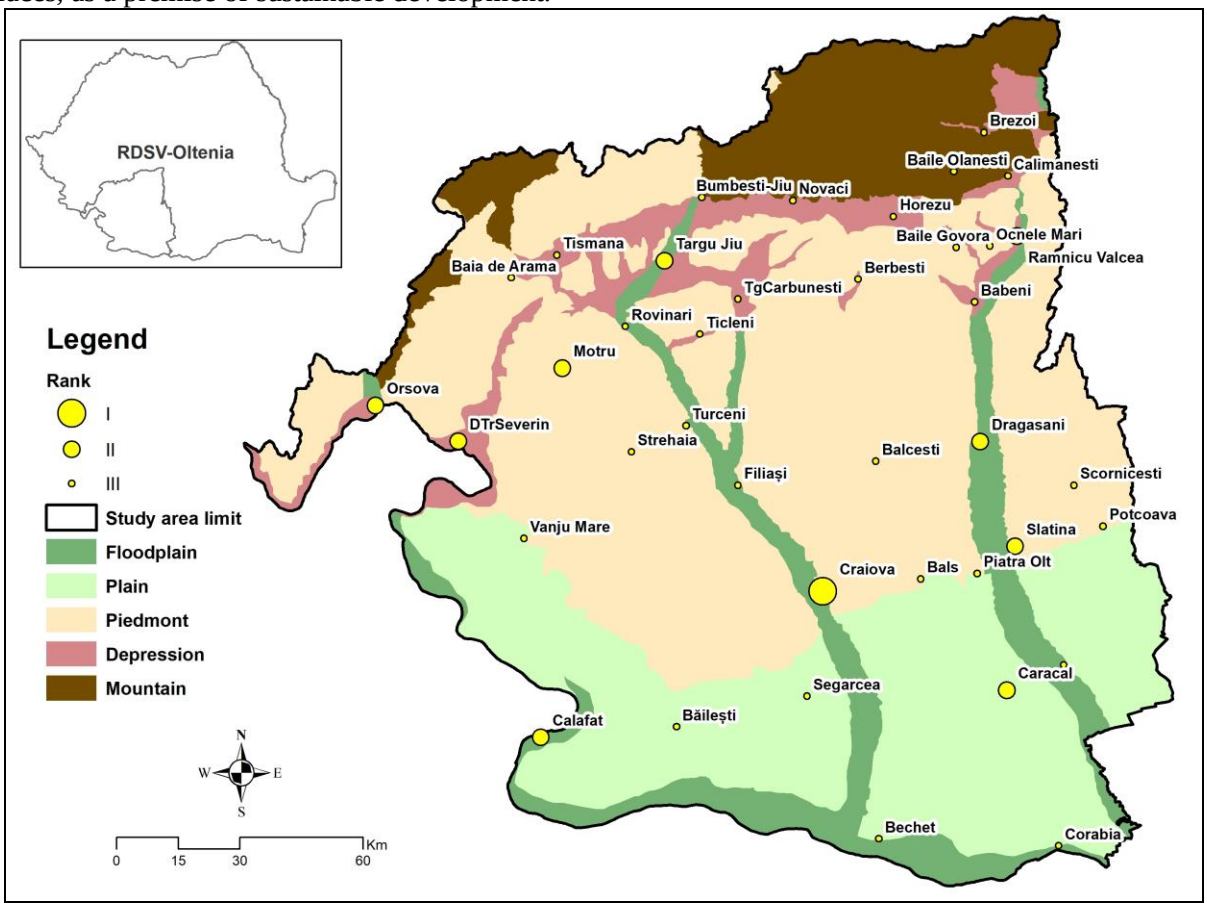

Figure 1. Cities located in South-West Oltenia Development Region

2 METHODS

In order to evaluate the impact of urban lakes for the quality of life of urban inhabitants, we used cartographic data (2008 aerial images, general and zonal urban plans) and GIS methods. Firstly, we identified all existent *urban lakes* in major cities from South-West Oltenia Development Region and we validated our results with general and zonal urban plans and filed observations. Moreover, we used the *Tempo Online* statistical database (*National Institute of Statistics*) to extract information and calculate a series of indicators: *lakes' surface per administrative unit and oxygenating surface, lakes' surface per number of inhabitants and artificial surface*. We also evaluated the degree of accessibility, the distance from the city center and the main functions of urban lakes.

3 RESULTS AND DISCUSSION

We identified a number of *76 urban lakes* in the analyzed cities: Craiova, Târgu Jiu, Slatina, Drobeta Turnu-Severin and Râmnicu Vâlcea (Table 1) with a *surface* situated between *80 m²* and *236,728 m²*.

Table 1. The surface and distribution of *urban lakes* in cities of South-West Oltenia Development Region

City	Number of urban lakes	Lowest surface (m^2)	Highest surface (m^2)
Craiova	26	80	37,749
Târgu Jiu	14	372	19,521
Slatina	15	909	91,691
Râmnicu Vâlcea	17	231	236,728
Drobeta Turnu Severin	4	1,585	5,953

Source: GIS measurements after aerial images, 2008

The issue of establishing a minimum threshold at which a surface water may be considered a Lake has been addressed in numerous specialty papers (Kalff, 2001; Alsdorf et. al., 2003; Lehner and Döll, 2004), where researchers mention the value of 1 km^2. Downing et al. (2006) specifies that this approach is inefficient in the context of using aerial images to identify and map *urban lakes*, regardless of surface. The total surface of urban lakes however is relevant in relation to the characteristic of the city. Thus, to highlight the benefits of urban lakes for the urban environment, we assessed the ratio between the total area of lakes and the administrative-territorial unit surface, as a percentage value (Table 2).

Table 2. Ratio of the total area of urban lakes per administrative unit surface

City	Urban lakes area (m^2)	Administrative unit area (m^2)	Ratio (%)
Craiova	259,530	77,973,196	0.33
Târgu Jiu	62,009	24,530,475	0.25
Slatina	199,967	18,809,897	1.06
Râmnicu Vâlcea	354,616	14,792,000	2.39
Drobeta Turnu Severin	14,439	19,266,094	0.074

Source: GIS measurements after aerial images, 2008

The data in Table 2 shows that the highest value is obtained for Râmnicu Valcea, where urban lakes occupy a *2.39%* of the total area of the city, fact can be explained on one side by the low surface of the built-up are, but also by the reasonable size of urban aquatic areas.

The lakes were established together with the works for damming on Olt River. At the opposite side, the percentage of urban lakes in Drobeta Turnu-Severin has a value of only *0.074%* and it can be correlated with the proximity of this city with the Danube River, thus compensating for the need to establish artificial urban lakes. The calculated indicator mentioned before was also used to rank the cities based on their aquatic resources (the ratio between the total area of lakes and the administrative-territorial unit surface) but without considering the direct beneficiaries. Thus, we also calculated the surface of urban lakes per inhabitant (Table 3), evaluating, in this manner, the impact of aquatic surfaces on the quality of life and on the consumption pattern (Ciocănea, 2017).

Table 3. Surface of urban lakes per inhabitant

City	Urban lakes area (m^2)	Number of inhabitants	Surface of urban lakes per inhabitant (m2/loc.)
Craiova	259,530	311,988	0.83
Târgu Jiu	62,009	97,558	0.63
Slatina	199,967	88,168	2.26
Râmnicu Vâlcea	354,616	119,564	2.96
Drobeta Turnu Severin	14,439	115,611	0.12

Source: National Insitute of Statistics, accessed May 2018; aerial images, 2008

The number of inhabitants was obtained from the *Tempo Online* statistical database and the values vary between *0.12* and *2.96 surface of urban lakes/inhabitant*. The lowest value is characteristic for Drobeta Turnu-Severin and it can be explained by the high number of inhabitants, mainly determined by the influx of migrants that enter the South-West part of Romania or move from the rural areas to the city. Moreover, Danube River already provides space for cultural, educational and economic activities in Drobeta Turnu-Severin so the local authorities did not establish new aquatic areas.

For Râmnicu Vâlcea we obtained a value of over *1 m^2 of urban lake surface per inhabitant*, as a result of it's proximity to Olt River. This aspect favored the development of aquatic surfaces as a result of frequent flooding in natural depressions.

The dynamic and increase of artificial surfaces at the expense of natural areas, has a negative impact on the capacity of climate regulation provided by aquatic surfaces in cities. For an objective

understanding of the relation of aquatic and built-up surfaces, we have calculated the ratio of the two types of environments (Table 4).

Table 4. Ratio of urban lakes area per build-up surfaces

City	Urban lakes area	Build-up area	Ratio urban lakes area per build-up surfaces (%)
Craiova	259,530	14,575,275	1.78
Târgu Jiu	62,009	5,023,030	1.23
Slatina	199,967	4,037,237	4.95
Râmnicu Vâlcea	354,616	2,810,501	9.41
Drobeta Turnu Severin	14,439	4,570,405	0.31

Source: GIS measurements after aerial images, 2008

A low value of indicator of urban lakes area per build-up surfaces reflects the degree of artificial areas in the urban environment and is considered a factor of urban pathology. Drobeta Turnu-Severin and Râmnicu Vâlcea are differentiated by the lowest (*0.31%*) and highest values (*9.41%*) of the indicator. The results can be explained by the geographic position of the city of Drobeta Turnu-Severin, between the Danube River and Carpathian Mountains, which favored a concentration of grey infrastructure and artificial uses on a small area. The high degree of artificial lands associated with small aquatic surfaces explains the low value of *0.31%*. We also analyzed the level of accessibility, which is characterized by the distance between *urban lakes* and residential areas and the frequency of visitors. Taking into account that the 5 cities have a different spatial structure, are located in different geomorphological areas, established in several historical periods and have their specific socio-economic context, we used an accessibility analysis that evaluates the distance between the city centre and urban lakes. We used Google Maps to calculate the road distance between the central areas and each of the 76 urban lakes we identified (Table 5). Our results show that, for Craiova, the mean distance is higher, which can be explained by the high area of the city and by the divergent locations of urban lakes within the city. The mean distance for Slatina (1.83 km) is an important indicator for ecological and cultural benefits provided by urban lakes.

Table 5. Accessibility level of analyzed urban lakes

City	Mean distance between urban lakes and central areas (city hall) - km
Craiova	4.4
Târgu Jiu	2.75
Slatina	1.83
Râmnicu Vâlcea	3.52
Drobeta Turnu Severin	3.17

Source: GIS measurements after aerial images, 2008

We also analyzed the accessibility of urban lakes from a time point of view and we calculated the minimum time required to travel between the city hall in Craiova and largest 5 urban lakes (Table 6).

Table 6. Accessibility of urban lakes in Craiova, by time

Urban lake	Minimum time required to travel (minutes)
Craioviței 5 wetland	43
Pușcăriei wetland	80
Hanul Doctorului Lake	66
Great Lake (Nicolae Romanescu Park)	34
Tanchiștilor Lake	64

Source: GIS measurements after aerial images, 2008

Our results show that Great Lake from *Nicolae Romanescu Park* (Figure 2) is located near the central area of Craiova and the time required to reach the urban lake is *34 minutes*, in comparison with *80 minutes* needed to reach *Pușcăriei wetland*, situated in the south-east part of the city, serving the inhabitants of Craiovița Nouă, George Enescu and Brestei neighborhoods. We also analyzed the types of land use situated in a buffer of 300 m around the 5 aquatic surfaces (Table 7).

Figure 2. View from Nicolae Romanescu Park (Craiova) **(Photo by Avram M., May 2018)**

Table 7. Land use types situated in the proximity of aquatic surfaces

Urban lake	Percentage of land use (%)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Craioviței 5 wetland	-	-	25.5	13	7.81	7.91	30.7	4.25	-	-	-	-
Great Lake	1.19	74.9	7.02	0.88	1.22	1.16	-	-	10.95	-	-	-
Hanul Doctorului Lake	-	-	6.45	5.59	3.31	-	-	17.49	-	22.9	-	-
Tanchiștilor Lake	-	-	9.35	-	-	2.40	3.95	65.95	-	-	7.38	-
Pușcăriei wetland	-	-	-	11.38	0.67	3.36	2.46	15.51	-	-	-	2.66

Source: GIS measurements after aerial images, 2008

Notes: 1. **Street trees;** 2. **Urban parks;** 3. **Build-up areas;** 4. **Individual residential ares;** 5. **Impermeable surface;** 6. **Road infrastructure;** 7. **Riparian vegetation;** 8. **Agricultural land;** 9. **Cemeteries;** 10. **Urban forests;** 11. **Train infrastructure;** 12. **Public institutions gardens**

Our results show that *Craioviței 5 wetland* is situated in the residential area of Craiova, near individual residential areas with a high number of gardens and a *25.5%* build-up area.

Hanul Doctorului Lake is located at the outskirts of Craiova, aspect confirmed by the high percentage of urban forests and agricultural land in it's proximity. *Tanchiștilor Lake* is located also at the outskirts of the city, near agricultural lands and train infrastructure. *Pușcăriei wetland* is located near individual residential areas and near a maximum security prison. By analyzing the different types of land uses situated in the proximity of aquatic surfaces in Craiova, we can also establish an approximate number of inhabitants that have access to economic, ecologic and cultural benefits (Ionuș et al., 2014).

By analyzing Table 8, we can see that urban lakes are mostly considered places for recreation and educational activities, rather than for using it complementary with specific infrastructure (sports areas, playgrounds, bicycle paths). Also, water transportation with water bicycles or boats represents another way to use aquatic surfaces of urban parks.

Sport fishing is mostly done in urban lakes that are situated at the outskirts of the city, but without specific infrastructure (pontoons or fishing equipment for rent). The analyzed urban lakes are not used as a source for drinking or water sports and the main cause for this are the lack of infrastructure but also the small size of aquatic surfaces.

Table 8. The use of aquatic surfaces in South-West Oltenia Development Region cities

Use of aquatic surfaces	Craiova	Târgu Jiu	Slatina	Râmnicu Vâlcea	Drobeta Turnu Severin
	26 urban lakes, of which	**14 urban lakes, of which**	**15 urban lakes, of which**	**17 urban lakes, of which**	**4 urban lakes, of which**
Recreation	16	7	8	6	1
Watersports	0	0	0	0	0
Sport fishing	7	3	2	4	2
Transportation	2	3	6	2	1

Water of irrigation (on Green spaces)	0	0	0	0	0
Education activities	7	6	6	2	1

Source: GIS measurements after aerial images, 2008

4 CONCLUSIONS

Urban lakes are an important component of the urban environment, with a role in ensuring its sustainability. Our analysis, using different indicators (descriptive, performance and benefits analysis) for the cities in South-West Oltenia Development Region), obtained original results for the Romanian scientific landscape and provides understandable values and tools for local and regional authorities, responsible with the urban planning process. The use of our study is justified by the data resulted from inventorying aquatic surfaces, both from a geographical point of view (number, surfaces, location) and also from a functionality point of view (ecosystem services provided, their impact on the urban environment). Further research should be focused on analyzing the connectivity of urban lakes with other components of oxygenating surfaces and of the urban environment, and highlighting the role of these aquatic surfaces for the sustainability of cities in South-West Oltenia Development Region. Also, we consider that this study should be further continued with an analysis on the potential of increasing aquatic surfaces and improving their multi-functionality. We also emphasize the importance of urban lakes in the context of climate change and we consider that it is relevant for future studies to include an analysis on the topo-philia and topo-phobia related to oxygenating surfaces in residential areas.

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