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Urban Green Infrastructure for Shrinking City: Case Study - City of Osijek

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Abstract. Urban planning of contemporary city is challenged to ensure a quality environment, inclusive green infrastructure towards sustainable urban development. Recent studies of urban green infrastructure consider green areas in cities in the context of different cultures, different social and economic circumstances, as well as diverse urban trends. Changes of the green urban infrastructure in Eastern European cities have been endangered by construction abuse but also by changes caused by urban shrinking or urban sprawl. The aim of the paper was to provide a framework that enables creating a data base of urban green infrastructure regarding its functions for the shrinking city. The framework was created for several urban levels starting from the whole city area, urban district, urban neighbourhood and the green element. Three objectives were set in the paper: a) to review the existing classifications, typologies and functions of green infrastructure b) to provide a proposal for an analytical framework for multilevel classification of urban green infrastructure and c) to analyse green infrastructure of the city of Osijek, eastern Croatia, according to city plans and documents. For the Osijek case study, the population density, the share of green infrastructure was presented for the whole area of the city and at the level of the city districts. The most populated and the least populated district were further examined according to the neighbourhood morphology and green functions. Lack of the classification of urban green infrastructure for the neighbourhood level was elaborated and a framework was proposed.

1. Introduction

Green infrastructure has an increasing importance within the ecosystem and biodiversity protection regarding the city environment. Benefits of green areas in cities such as economic, ecological and social are perceived as contributes to the quality of life and health [1-4]. Research results on green infrastructure are not agreed on effects. There are examples that indicate benefits of green city areas as having positive effect for the wider city area while at the same time cause negative effect in the focus area [5]. Criticism also occurs in the interpretation of the green infrastructure impact to the social functions in the city [6].

The definitions of green infrastructure are changing over time and the accent has been changed from the natural asset to functional, social, cultural and economic content. Different definitions of green areas are presented depending on the area for which they are observed, the tradition of spatial planning, social circumstances, technological achievements and culture of the area. Green areas include several performances - open spaces, natural areas, forests and parks; green streets, squares and public spaces; sustainable drainage systems, cycling and hiking trails within urban environments; to green roofs, walls and facades depending on the scale and typology they are envisaged.

Green spaces have a special definition if considered in urban environments. The definitions include several constructs that include greenery: green infrastructure, green areas, green spaces. The authors [7]. define green infrastructure as a "connected network of natural ecosystems and other open spaces that preserves the values and functions of natural ecosystems, keeps the air and water clean and provides a



wide range of contributes to people and nature." [7]. In the introduction of the 2012 Environmental Practice Journal, authors [8] added the concept of infrastructure to the term green, according to the statement that "infrastructure requires maintenance" [8]. By joining the term "infrastructure", green areas started to be observed as areas that have their social and economic value as well as claims and become active land in urban space. Further definitions included the technology that creates and maintains green areas [9]. Recent definitions of green infrastructure integrate the functional and service determinants, so the definitions that do not rely merely on natural features are even more pronounced [6, 10]. The documents provided by the European Commission [11] confirm this definition by statement that green areas are „a strategically planned network of natural and semi-natural areas is planned and managed with other environmental phenomena in order to provide numerous ecosystem services.”

The aim of the paper is to provide a framework for the green infrastructure inventorying and valorising, according to the literature that explains the definition, classification and typology of green infrastructure. Three goals are set: a) to review the existing classifications of green infrastructure across spatial levels b) to provide a proposal for an analytical framework for multilevel classification of urban green infrastructure and c) to analyse green infrastructure of the city of Osijek, eastern Croatia, according to the city plans and documents.

2. Global urban trends

The latest documents [12] indicate that 54.5% of the world's population lives in the cities, pointing to both, the increase of area covered by cities and number of cities. Expansion by urbanization has the most intensively marked Asian and African cities. As a global trend, the opposite trend is also identified - shrinking of the cities which is caused by a natural disaster (flood, tsunamis), economic crisis and a low population growth. Quality environment and inclusive greenery in line with urban changes that take place in urban tissue should be insured for the planning of the cities, being a great challenge.

2.1. Shrinking city and green infrastructure

Perceived process of decline in activities and population in the cities initiated theories and researches about the causes and consequences managing this process. The debate has renamed the decline into shrinking within the discussion about the development paradigm - the USA faces shrinking despite development trends, while the European space is marked by overall decline - economic, inhabitants and total activity decline. Shrinking was observed in the context of suburbanization and urban sprawl, and pointed to the differences in change in the cities of Europe and USA [13, 4]. The author [15] differentiates shrinking within Europe by identifying regions of similar features: post socialist countries, Northern Europe and Southern Europe, each one with its common general causes of shrinking.

Green infrastructure research in cities looks at the development of a green structure in the context of different cultures, different social and economic circumstances, as well as different processes in the city. Recent studies presented by [6] critically view case studies of green infrastructure in existing urban centres, in the context of their inclusiveness and social function and space manipulation by discussing the role of green infrastructure. An example of a revitalized area of the High Line Park, New York, USA, illustrates the process of manipulating with green areas as revitalized space became the cause of negative urban change, gentrification. At the same time, they identify processes in eastern European cities through examples of Poland and Bulgaria, where green infrastructure is threatened due to "construction terrorism" [6]. Green infrastructure can also unavoidably affect life in the city and need to be carefully looked at, while goals have to be communicated transparently. The authors emphasize the importance of reflecting on the type of green infrastructure that is developing and this will be one of the aspects of our research on the example of Osijek, eastern Croatia.

2.2. Green Infrastructure typology classification

According to document of the research project GREEN SURGE [17] *A typology of urban green spaces, ecosystem provisioning services and demands* the urban green spaces (UGS) are divided into forty-four types of green urban spaces. European Union countries use this comprehensive classification. The typology is based on a two-stage level. In the first level, eight topics define the general feature of green infrastructure in relation to activity and position, while in the second level it is divided in more detailed according to morphology, and somewhere a social role (e.g. urban, historical park etc.). Although

integrated in typology, this classification is based on the analysis of physical and land use properties of green spaces.

Author [18] has presented two systems that categorize green spaces in the United Kingdom. In the first system, according to the National Land Use Database (NLUD), the green spaces are divided according to the functional division based on the way the land is used. The green spaces are further systematized according to the activities. Besides the first system (the way the land is used), according to the Royal Commission for Environmental Pollution (RCEP) system, green spaces are classified into informal and formal groups based on the way of managing. The informal group represents open strategic spaces such as national parks, large natural areas, green spaces with informal recreation and the green corridors.

2.3. City data and data on green areas

Urban Audit is the most comprehensive project that collects data on European cities. The city is defined by its morphological delineation, according to urban land use classes which intersects with the city delineation defined by Urban Audit. Most of the data are collected at the core city level and additionally to establish data base for the urban-rural linkage, data was collected for the functional urban area extending beyond the core city. Three input data sets are used for the level of the core city Urban Audit statistical data for the Functional Urban Area, Urban Atlas for the same scale level and Urban Morphological Zones defined by DG Regio [19]. The Urban Atlas is providing a pan-European comparable land use and land cover data for Large Urban Zones (2006) with more than 100.000 inhabitants as defined by the Urban Audit. In the Urban Atlas, 21 thematic classes, including diverse urban pattern, transportation, industrial and environmental classes, are distinguished (European Commission, 2011). As for the green spaces several indicators can be extracted from these data sources (Table 1).

Table 1. Sources and data categories for the green surface at the functional urban area and city level

Source	Data categories
Urban Audit – Functional Urban Area	Share of land (%): Green urban areas and sports and leisure facilities Share of land (%): Agricultural areas Share of land (%): Natural areas
	Green areas and sports facilities satisfaction
Urban Atlas (2012) – Functional Urban Area	Land without current use Green urban areas Sports and leisure facilities Arable land (annual crops) Permanent crops Pastures Complex and mixed cultivation patterns Orchards Forests Herbaceous vegetation associations Open spaces with little or no vegetation Wetlands Water
	Green urban areas Sports and leisure facilities Agricultural Areas Forests and semi-natural areas Wetlands Water
UMZ (Corine Land Cover) The Core City	Green parts of buildings Private, commercial, industrial, institutional UGS and UGS connected to grey infrastructure Riverbank green area Parks and recreation Allotments and community gardens Agricultural land Natural, semi-natural and feral areas Blue spaces

Linked to Urban Atlas and CLC, project Green Surge proposed detailed typology classification for the Urban Green Infrastructure (UGI) city level. The list contains forty-four (44) urban green spaces (UGS) - systematically grouped into eight categories according to the GREEN SURGE project (Tab.1). Further division can be directed by tools for registering and monitoring area, like Geographical Information System (GIS) that collects information as features (collections or points, lines, and polygons) attributes and imagery.

Different space levels propose information collection for different purposes. Main goals can be envisaged to be a support for strategic management, policy planning and policy conduction, efficient zoning and providing sustainable and good quality environment at all city levels – from the whole area to the street level and even type of plant.

3. Methods

3.1. Case study – the city of Osijek, Croatia

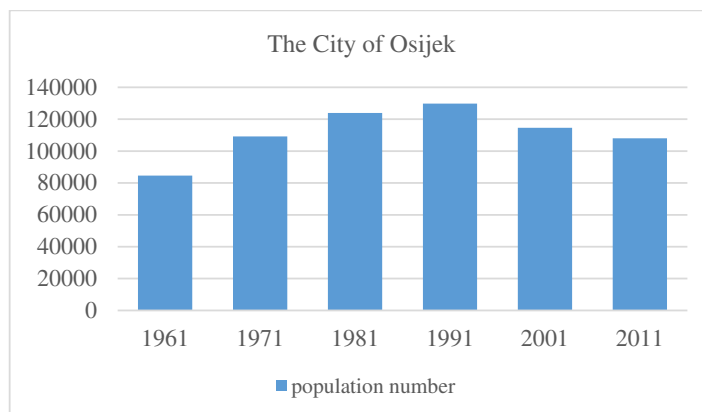


Figure 1. Population number in the Municipality of Osijek 1961-2011, [19]

Osijek is a city in eastern Croatia, located along the right bank of the Drava river. It is the largest city in Slavonia, the fourth largest city in Croatia, as well as the industrial, administrative, law, cultural and centre of the Osijek Baranja County. According to the Population Census in 2001, The Municipality of Osijek had 114.616 inhabitants. Data from Population Census in 2011 detected decrease to 108.048 inhabitants (Croatian Bureau of Statistics, CBS, 2011). The city is going through the process of

shrinking without strategic guidelines to mitigate consequences and include land use management (Figure 1).

4. Results

4.1. Functional Urban Area Osijek

According to the Urban Atlas data about level of Functional Urban Areas in the city of Osijek, in 2012, there were 0.40% green, urban, sports and entertainment surface ration while the ratio of natural spaces was 29.00%. According to CLC data [21] dynamic of changes was almost non existing for the green city area and sports area while land cover for the open space (agricultural and forests) show more dynamic changes (land use change ratio 0,01-0,16).

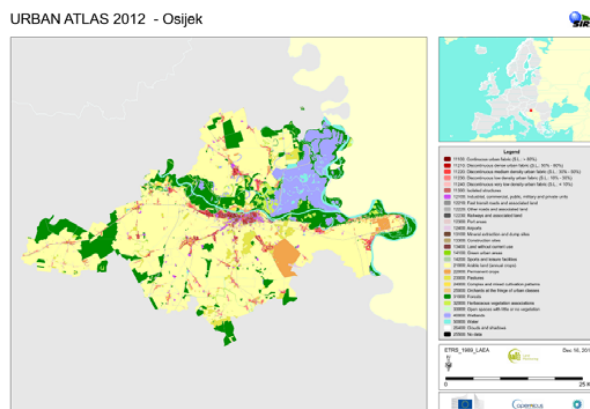


Figure 2. Functional Urban Area of Osijek, Source: Urban Atlas FUA Delivery Report (2012), [22]

4.2. The Core City of Osijek

Historical genesis of the city represents the city of Osijek as a conjunction of eastern, western and a historical city part, connected with green infrastructure and the Drava river. Data on green areas in the city of Osijek were obtained from maintenance plan for the green areas for 2017, which was delivered by the city communal company.

According to the City of Osijek data, green areas are divided into the following categories:

- I. parks, city centre alleys, juniper, roses, playgrounds and hedges
- II. collective housing parks and street alleys
- III. other

The data indicate that more than half of the green areas are sited in street alleys and collective housing neighbourhoods (56.9 %), while parks, city centre alleys, juniper, roses, playgrounds and hedges covers 18.7 % of total green areas. Other land for which we do not find a more detailed categorization is represented by 24.4 %. Categorisation presented by maintenance plan does not relate to social utilization of the green infrastructure and one quarter of green area is not categorized.

4.3. District level

According to the historical development, management framework and distribution of functions, the area of the city, 171 km², is divided into seven city's districts. Data show rather incoherent disposition of city green areas according to the population density (Table 2). Historical part of the city mostly built up in baroque period is surrounded by an open area, originally with military purpose and in 20th century developed as large park area. Low population density districts built up in row housing street pattern are weakest in green infrastructure capacity.

Table 2. Green surface per inhabitant and per household in the City of Osijek

City district	Green surface (m ²)	Population number in 2011 (inh)	House number in 2011 (no)	Population ratio per green surface (m ² /inh)	Housing ratio per green surface (m ² /no)
Lower Town	163.337	11.776	4.703	14	35
Fortress	403.775	7.476	3.332	54	121
Upper Town	400.804	16.392	7.187	24	56
Retfala	170.310	13.258	5.169	13	33
Industrial District	211.960	12.110	4.415	18	48
Jug II	267.318	13.035	5.334	21	50
New Town	385.922	12.498	4.900	31	79
Total	2.003.426	86.545	35.040	23	57





Figure 3. Overview of green area typology per city district, Osijek

According to the population data from the last Population Census in Croatia in 2011, the Down Town district had the highest population density (6,453.54 inh/km²) and household density (2,829.53 no/km²), while the area of the Industrial District had the lowest population density (1,794.07 inh/km²) and the density of households (654.07 no/km²). The district Upper Town that is set up centrally to the city geometry and is predominantly built up area of diverse urban building typology, ranging from low residential density and low buildings to high residential density and high buildings. The Upper City district is also the part of the city where are main public services and business building typology located. Overall low density observed for the area of the Industrial District can be partially explained with large unbuilt part of the south-western part of the city. If data on population density within city districts is linked with the share of green areas it is evident that Upper Town and the area of Fortress district has the largest area covered by green infrastructure while Industrial district that has the smallest green area share (211,960 m²).

Population density data as well as household density in the context of share of green areas may indicate gaps in the quality of the environment. Useful data to improve the management of green areas is also the diversity of typology of green areas within the city district. Green typology applied at this level do not consequently follow any of the concepts – land use, functions, social functions, activities or way of managing green area.

4.4. The green infrastructure elements

The Green Cadaster of Osijek, includes six basic categories of green areas which are classified into GIS elements - surfaces, lines and point objects associated with attributed information (for example: plant species, condition, type of bench, condition, required activities, etc.) (Figure 4).

Categories are distributed as follows:

- fountains
- tree: name, diameter, damage, height, slope, protection category, address
- bench: kind, state, street
- bushes: name, age, damage, protection category, address
- playground: function



Figure 4. The Green Cadastre of Osijek (GIS tool)

5. Discussion and conclusion

Osijek city space is reviewed through a series of spatial frameworks. The data is collected at EU level from a common database that allows comparison of similar spatial phenomena. Urban Audit and Urban Atlas Projects allow comparison of data for City Core and Functional Urban Area level data that match administrative boundaries and are extremely suitable for management and strategic plans. In order to manage city space more efficiently, the classification should be integrated vertically through spatial levels (Table 3).

Table 3. Matrix of linked information to the Green Infrastructure

Spatial Level	Functions	Activities	Management	Attributes
FUA				
Core City				
City Districts				
Neighbourhoods				
Green Elements				

This paper researches green infrastructure classifications from the FUA level to the level of the green infrastructure element on the example of the city of Osijek. Monitoring the changes in green areas for the city of Osijek at FUA and Municipality has shown that this land use does not change and is quite static in time. The negative dynamics of demographic and economic trends can be characterized as shrinkage, so land use management should follow other changes in response to the expected threats.

According to the data, density of green areas for the City of Osijek is 23,1 m²/inhabitant which can be assessed as high density. The World Health Organization (WHO) has suggested that every city should have a minimum of 9 square meters of green space per person. Vienna is a leading European capital with 51% of the city covered by green area while there are 120 square meters of green space for every inhabitant. This data helped to set up goals for the Vienna city projects to green up courtyards and façades, as well as planting new avenue trees.

The categorization used for different levels of the Core City of Osijek is robust and does not sufficiently share details on green infrastructure functions. Further, classification is not vertically integrated with the district level to provide efficient maintenance. Data provided by the Green cadastre, GIS tool of Osijek green infrastructure, enable a dynamic review and data base rich with information that can contribute to the efficient management and maintenance of the green infrastructure of the city. It should also provide classes of green elements that could be linked to upper levels.

The categorization presented by the Green Surge project offers a clear structure that would give a better comparison of greenery by city districts. The results of the analysis clearly indicate that the space allocated to the city districts of Osijek is intensely covered by green areas, suggesting the need for proper categorization for more efficient management.

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