ASSESSING PEDESTRIAN ACCESSIBILITY TO GREEN SPACE USING GIS*

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Abstract

This paper aims at comparing the parameter of green space per capita currently requested by the Romanian legislation to accessible green space per capita. The comparison is undertaken through a Geographic Information System methodology that uses publicly available data to evaluate actual population numbers with pedestrian access to parks and green squares. Using the city of Timișoara as a case study, population is divided into three main groups according to neighborhood type in order to investigate the urban planning implications of residential typologies in relation to green space. Two scenarios are compared, namely the existing situation which describes access to municipally-administered parks and squares and the possible situation where both existing and informal green spaces are considered. The main findings show that, at present, only a quarter of the city's population benefits from proper access, yet by developing all residual green areas this proportion could be raised to over 40%. However, the current parameter of square meters per person requested by the Romanian legislation proves to be insufficient in indicating green space accessibility because of the uneven distribution of population and green areas across the city.

Keywords: accessibility, GIS, urban parks, network analysis, QOL.

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1. Introduction

Quality of life (QOL) has been the subject of a great amount of literature since 1933, when researchers first began to pay attention to it (Bălţătescu, 2000). Although the topic has been studied for more than half a century, recent years have shown an increased scholarly interest in matters of QOL, as well as in individual well-being and happiness, both considered to be related concepts that are useful in trying to define QOL (European Environment Agency, 2009; Doi *et al.*, 2008).

At present, it seems that QOL has a multidimensional nature that makes it more of a multilevel concept (Doi *et al.*, 2008). In trying to rationalize QOL, researchers have found two different approaches: objective and subjective. Aside from their reference field, another essential difference between the objective and subjective measures of QOL is expressed by the method of data collection taken into consideration: objective measurement is based on secondary analysis of data such as that derived from official statistical collections, whereas subjective measurement is based on primary data collected through sample surveys (Marans and Stimson, 2011).

Several researchers believe that QOL is equal with the satisfaction one gets from surrounding human and physical conditions (Beck, 2009). This idea can be traced in the way objective indicators used for the quantitative measurement of QOL are classified. These indicators are physical and social. Within the physical indicators there are two different categories: man-made, like roads or density, and natural physical indicators, like parks or other kinds of open spaces. Referring to the importance of the above-mentioned indicators, Perloff (1969) states that the QOL of people who live in urban communities is very much shaped by the interrelationship between natural and man-made environments. The same study acknowledges that the QOL of all people who are clustering into urban communities is clearly influenced by what happens to both the natural and the man-made environments in direct interrelationship with each other.

Researchers have been concerned with issues in dealing with the relationship between QOL and quality of space, such as the quality of the environment (Doi *et al.*, 2008; Makra and Sümeghy, 2007), where the term environment covers built, natural and socio-cultural dimensions. Quality of urban life is a natural consequence of the way people interact with the urban environment (Nasution and Zahrah, 2012). Thus, environmental quality becomes a fundamental building block of social well-being and UQOL (European Environment Agency, 2009) which raises concern surrounding environmental elements like housing, transportation, air quality and public green space as important determinants of QOL (Makra and Sümeghy, 2007).

Public open space (POS) is a significant element which contributes to QOL (Nasution and Zahrah, 2012). The use of POS depends on its design, meaning that only high quality parks and urban public spaces that are well designed and managed will promote QOL (Beck, 2009). However, before discussing quality of design, an essential aspect of POS usage is accessibility.

Accessibility is one of the main indicators of QOL (Dave, 2011). Even if, when talking about accessibility as a general concept, the importance of physical distance is sometimes diminished because of technological development (Talen, 2002), that can-

not be said about pedestrian accessibility (Morar and Bertolini, 2012). Environmental and urban amenities are strongly related to community quality, personal activities of citizens, satisfaction and physical health. Moreover, researchers assert the dependency of physical health on the use of these amenities (Marans and Stimson, 2011). Therefore, quality green space is a community asset that could ensure the health of citizens. For this to happen, it is essential to have well-designed green spaces within reach of the population, encouraging a high level of walking and active use (Giles-Corti *et al.*, 2005).According to facts, when regarding green space availability, distance becomes very important for attractiveness. For example, the study of Stigsdotter *et al.* (2010) showed that respondents who have the nearest green space at more than 1 km distance from where they live are more stressed than those who live less than 300 m from the nearest green space. By investigating the associations between green space and health, health-related quality of life and stress, the study finally showed the importance of green spaces in stress management and as parts of healthy environments. Besides the increased personal comfort of people with good access, the field literature proves its importance for the urban environment, ranging over several subjects:

- Lowering noise and CO_2 pollution levels (De Ridder *et al.*, 2004);
- Serving for social interaction, sports and cultural events (Oh and Jeong, 2007; Giles-Corti *et al.*, 2005);
- Positively influencing the physical state of the population (Kuo and Sullivan, 2001; Maas *et al.*, 2006); and
- Improving urban aesthetics in city centers, resulting in expanding the economic sphere (Colesca and Alpopi, 2011).

With city populations growing, there is a continuous pressure on urban green spaces that are the only undeveloped areas still available for construction. With the disappearance of these areas, certain population groups (like families with children) are moving out of the city (Tratsaert *apud* Van Herzele and Wiedemann, 2003) contributing to the urban sprawl phenomenon, which represents non-sustainable urban growth. Recent studies have shown that only 'flexible spatial plans and open spaces' could resolve such a problem, especially for small and medium cities (Malayeri, 2010). Urban areas are dynamic systems that need to constantly adapt in order to receive population, rather than lose it, and meet the needs of growing communities.

When talking about QOL in Romania, studies have shown that individuals generally show low scores for life satisfaction index, whilst the perception of satisfaction with life amongst Romanian people is rather negative (Bălţătescu, 2000). At the beginning of the 1990s, Romanian interest towards QOL started to take shape, with the opening of the Romanian Research Institute for Quality of Life and the foundation of the Quality of Life Journal. However, attempts to address the theoretical studies in a practical way are, at this moment, still scarcely noticeable.

This is why increasing green space availability is essential. Both urban sprawl and the increased pressure on green spaces are factors currently affecting Romanian cities. Green spaces being among the first public spaces, their management has always been with the local government. With local administration working under national law,

this article seeks to present differences between the current Romanian legislation and international guidelines. It then shows how these guidelines regarding green space availability can be applied to the Romanian city of Timișoara as a case study.

2. Defining green space availability

When dealing with urban and public green spaces we find slightly different approaches within Romanian and international legislation. Whereas Romanian law defines three main types of green spaces (park, square and forest) and sets the limit of public green space at 26 m^2/person (as will be detailed later), when turning to field literature we find a more complex approach in terms of typology, accessibility and usability of green areas. Accessible green spaces are defined as places available free of cost for the general public and mainly utilized by target users living in the catchment area (Natural England, 2010). As seen in Table 1, different limits apply for different surface sizes. This is because each location is considered useful at a functional scale (a forest laying at the city limit cannot be a substitute for the lack of presence of neighborhood squares).

Table 1: Green space accessibility limits

Source	Green space surface	Maximum distance to residence
Natural England (2010)	2-20 ha	300 m
	20-100 ha	2,000 m
	100-500 ha	5,000 m
	>500 ha	10,000 m
Van Herzele and Wiedemann (2003)	<1 ha	150 m
	1-10 ha	400 m
	10-30 ha	800 m
	30-60 ha	1,600 m
	60-300 ha	3,200 m
	>300 ha	5,000 m
Oh and Jeong (2007)	0.15 – 1 ha	250 m
	1 – 3 ha	500 m
	3 – 10 ha	1,000 m
	>10 ha	No limit specified

Usability has been studied by a series of scholars by following the main idea that people's perception of green space is influenced by certain factors related to the presence of natural and man-made elements, as shown by the literature review presented in Table 2.

Although the World Health Organization (WHO) suggests providing a minimum of 9 m^2 of green space per capita (World Health Organization, 2010), this amount is only suitable if the greenery is reachable (Takano *et al.*, 2002), safe (Frumkin, 2003) and usable (Singh *et al.*, 2010). The ideal amount, according to the same organization, would be 50 m^2. The numbers and attributes mentioned above become relevant when looking at cities around the world and how they deal with urban environmental health and green usage and comparing them to this article's case study, the Romanian city of 303,000 citizens, Timişoara.

Table 2: Green space qualities

Source	Green space attributes
Hillsdon *et al.* (2006)	Size Distance to residential location
Colesca and Alpopi (2011)	Green space location Green space use (leisure and sports) Quality of environment (presence of natural water sources, trees and facilities for pets) Diversity of vegetation
Van Herzele and Wiedemann (2003)	Size Quality of nature Culture and history Quietness Facilities
Hamilton (2011)	Facilities (features) Walkability Hosting events Cleanness
Giles-Corti *et al.* (2005)	Activities Environmental quality Amenities Safety

Table 3: Cities that have close to 26 m^2 /person or higher

City	Population	Green space/capita (m^2)
Rennes	206,604	25.27
Ljubljana	255,115	25.97
Rotterdam	615,752	28.30
Bern	125,681	30.51
Montpellier	255,080	33.00
Berlin	3,501,872	37.84
Dublin	525,383	40.00
Victoria – Gasteiz	242,223	20.00 + reachable green belt >40
Genoa	606,070	49.39
Antwerp	493,517	51.50
Curitiba (Brazil)	1,764,540	52.00
Nantes	283,025	57.00
Alphen van den Rijn	72,674	57.15
Budapest	1,740,041	61.80
Krakow	756,666	65.45
Lodz	750,125	65.60
Warsaw	1,716,855	68.49
Leipzig	535,316	93.65
Helsinki	600,551	102.86
Zurich	376,088	111.91
Marseilles	850,602	118.22
Vienna	1,598,626	125.44
Espoo	250,511	140.00
Edinburgh	477,660	144.59

Source: Haq, 2011; Vázquez, 2011; Levent and Nijkamp, 2004

Table 4: Cities that have less than 26 m^2/person

City	Population	Green space/capita (m^2)
Buenos Aires	2,891,082	1.90
Tokyo	13,222,760	3.00
Istanbul	13,483,052	5.00
Barcelona	1,621,537	5.60
Malaga	568,305	7.79
Santiago (Chile)	6,026,797	10.00
Sarajevo	321,000	11.00
Toronto	2,615,060	12.60
Salzburg	148,521	13.44
Madrid	3,284,110	14.00
Turin	905,352	19.44
Birmingham	992,400	20.00
New York	8,244,910	23.10

Source: Haq, 2011; Vázquez, 2011; Levent and Nijkamp, 2004

For better relevance to this article's case study, the most important cities to be analyzed are those of medium size (population of 100,000-500,000). Therefore, we can look at the cases of Bern, Edinburgh, Espoo, Leipzig, Montpellier, Zurich (Haq, 2011; Levent and Nijkamp, 2004), Nantes (European Comission, 2012a), Rennes (World Health Organization, 2010) or Victoria-Gasteiz (European Comission, 2012b). It is important however to correlate the green m^2/capita with availability and usability, as mentioned above. The French city of Nantes and the Spanish city of Victoria-Gasteiz, both applicants for the title of European Green Capital (European Comission, 2012b; European Comission, 2012a), have 100% of the population within a 300 m range of open green public zones. Furthermore, both have transformed their green belts into usable public green space by making them accessible. In the case of Nantes this was made possible by creating a network of green areas through the so-called 'coulées vertes' (green corridors). In Victoria-Gasteiz accessibility is resolved by interconnecting parks and plazas through boulevards and avenues and by improving bicycle lanes, pedestrian streets and public transportation. Certain cities, like Espoo (Finland), have made use of their natural surroundings throughout their historic growth and development (Haq, 2011), turning natural landscape into urban green space. There are also cases where the amount of urban green space is below the Romanian 26 m^2-law-set quota, but above the limit set by the WHO, like in the cases of Salzburg and Sarajevo. However, the green spaces of these examples are highly accessible and usable by a large percentage of their population (Levent and Nijkamp, 2004).

As awareness of people's need of urban green increases (Takano *et al.*, 2002; Frumkin, 2003), we can see not only changes in international legislation, such as increasing the green space/capita, but also campaigns and various initiatives by international organizations. For example, Rennes has been part of the WHO European Healthy Cities Network for twenty years and developed a strong focus on town planning and health (Takano *et al.*, 2002). Furthermore, it has increased its green areas ten-fold, providing not only parks, gardens and 'green corners' but also eight sites with 772 plots for com-

munal family gardening. We can see such initiatives towards increasing green areas or at least awareness of their necessity in Romania as well, but so far at a much smaller scale, namely through private companies, as well as NGOs (Marinescu, 2012; Gavrilescu, 2011), who have developed plans for introducing more parks or have actually built them in cities throughout the country.

However, such initiatives are not as strongly encouraged by Romanian legislation as in other European countries. As we have seen in several of the cases presented above (Victoria-Gasteiz, Rennes, Nantes etc.), the amount and type of interventions in urban spaces, although made through the efforts of international organizations or local administrations, imply acceptance and support from a national level, as most of them are made in order to meet the legislative norms regarding accessibility, usability or catchment area attributes. Romanian legislation, on the other hand, makes no reference regarding such attributes, regulating only the type and the size. According to the Romanian legislation (Law no. 24/2007), there are several types of urban green spaces, which are divided into three main groups: recreation, aesthetics and protection of infrastructure. Hence, looking at green spaces used for recreation, besides thematic parks like museums and sport facilities, we identify three main types, which are:

- The park, defined as a green area of a minimum of one hectare destined for sport and leisure activities;
- The square, defined as a green area smaller than one hectare; and
- The forest, which is an afforested piece of land used for leisure activities (Law no. 24/2007).

Besides measures for maintaining and conserving these areas, the Romanian legislation sets the limit for urban green space at 26 m^2/person, to be fulfilled by all Romanian cities by 31st December 2013 (Government Ordinance no. 114/2007). Furthermore, it gives provisions related to the percentage of green areas to be assured from building land. Construction is generally decided by the Zonal Urban Plan (Order no. 1549/2008 of the Ministry of Development, Public Works and Housing). However, since the Zonal Urban Plan is controlled by private entities, it often comes to represent the interests of these entities instead of representing the interests of the people. Although it goes through committee approval, these committees only have the power to verify compliance with the law, not to provide guidelines to change the Zonal Urban Plan in the interest of the city. Thus, in the case of green spaces, it comes to a 'derogative urban planning' (Decision no. 525/1996 republished), meaning the use of existing urban tissue for private purposes due to incomplete legislation on accessibility. Although public consultation is mandatory when making decisions regarding the environment and green spaces (Law no. 265/2006, art. 1), it is not a common practice in Romanian culture, so its effectiveness is minor. However, with Romania joining the European Union, the authorities are required to report to the European Commission how environmental regulations are applied and whether they are satisfied. If the regulations are not met, the same law (Law no. 265/2006) specifies that NGOs can institute legal proceedings after consultation with the National Environmental Guard.

After examining the Romanian legislation, it appears that Romanian authorities resort to various means of classifying green spaces to increase green space index/capita, in order to meet European standards. Thus, by including areas inadequately classified as green spaces and which are not intended/designed for leisure or recreation (Law no. 24/2007 art. 3 and 4), such as cemeteries or greenhouses (agricultural areas within city limits), authorities are being absolved of the responsibility to correct the current situation regarding insufficient green spaces. As a result, the index of green spaces in Romanian cities is increased by taking advantage of the loopholes in the formulation of the laws but many of these areas are not accessible to the public.

Amongst the 24 Romanian cities with over 100,000 citizens containing 38.8% of the country's urban population, there are only six cities which have an amount of green space close both to European and Romanian regulations (Redacția Ziarului 'Unirea', 2011), with 20 to 23 m^2 per capita. Cases that register values between 2.4 and 17.85 m^2 per capita can also be found as in the case of cities like Galaţi or Bacău (Chiriac *et al.*, 2009).

Table 5: Romanian cities with green space between 20 and 26 m^2/capita

City	Population (2002)	Green space/capita (m^2)
Iasi	301,955	20.60
Oradea	206,527	24.30
Pitesti	168,756	22.81
Satu Mare	115,344	22.99
Sibiu	155,045	24.60
Suceava	106,138	20.31

Source: Chiriac *et al.*, 2009

The situation is quite similar amongst the 81 towns with a population ranging between 20,000 and 100,000 citizens, which contain 27.6% of the Romanian urban population. Among these, only 12 present more than 20 m^2 of green space per capita, out of which five have more than 26 m^2 per capita (Odorheiu Secuiesc, Voluntari, Carei, Drăgăşani and Buhuşi) (Chiriac *et al.*, 2009).

It is observable that not only do most Romanian cities have less green space than specified within the legislation but also that the country's law permits the inadequate cataloguing of green spaces, advantaging private entrepreneurs and real estate development to the disadvantage of QOL. Thus, comparing Romanian and international legislation, there are differences in approach, as Romanian law regulates only type, protection measures and surface per capita but, as demonstrated above, accessibility and usability are highly necessary in order to have a suitable public green area. These two qualities are related to particular attributes, some of which have been mentioned in Tables 1 and 2. As presented before, these particular attributes of each park or square, generally meaning size and facilities offered, define a specific catchment area (service area). In the examples of other European cities, we have seen that urban planning of public green spaces takes into account not only the amount of necessary green

zones but also how these green zones relate to their catchment areas so that these are distributed and cover the entire city. Therefore, looking at the three types of green spaces specified by Romanian legislation, we will try to see how their service area is related to the city's built typology, investigating relationships between state-planned residential and green areas.

3. Description of case study

For our case study we have chosen the city of Timișoara, the fourth largest Romanian city, with a population of over 300,000 inhabitants. We made this choice because Timișoara has a history of concern for green spaces that extends back to the Austrian dominance, these being observable in early cartographic representations (Ancuța and Mușulescu, 2012). As a result of the political, economic and cultural history the city passed through, green spaces were introduced in the planning period that followed the 1716 transition from the Ottoman to Habsburg Monarchy (Opriș, 1987). At that time, green spaces were private or semi-private, mainly because they were being laid out around high-class private residences. Also, there were tree alignments bordering the main avenues and a forest, protecting the city from the surrounding swamps' foul air. Greenery was thus used for aesthetic and hygienic purposes; furthermore, since the settlement was located within wetlands, it also served a role in preventing periodic flooding (Mușulescu, 2008). In the mid-eighteenth century Timișoara was a fortified citadel with only one 0.4 ha park inside its walls. But in the larger context of the urban system there were 13.80 ha for a total of 5,600 inhabitants, which meant 24.64 m^2 of green space per capita (Grand Principality of Transylvania, 1772).

In the nineteenth century the city passed to Hungarian administration which demolished the entrenchments in order to develop the city towards the surrounding villages. The resulting belt, consisting of 1.5 km of empty space around the former citadel, was occupied mainly by parks (Ancuța and Mușulescu, 2012). Therefore, at the end of the century plans show a total of 47.37 ha of green spaces for 44,809 inhabitants, which meant 10.57 m^2 per capita (Lajos, 1893). Their main role was protection against industrial polluted air and high summer temperatures.

Since 1918 Timișoara has been under Romanian administration. The 1940 plan reveals that the city had only 51.77 ha of existing green spaces for approximately 100,000 inhabitants (91,580 in 1930 and 111,987 in 1948) and a ratio of 5.17 m^2 per capita. This is the most critical situation in the history of the city. The plan proposed another 47.10 ha of new parks and public gardens (Udrea-Stoia, 1940), out of which only 9.11 ha were laid out. In this period, the recreational role of the green spaces became important, as seen from their design aesthetics. The 1970 plan was proposed during the communist era. The total surface of green spaces grew up to 153.34 ha for approximately 200,000 inhabitants, resulting in an average of approximately 7.66 m^2 per capita (Radoslav, 1970).

Each of these historical periods is characterized by a building typology which has left its mark on Timișoara's character. From the Austro-Hungarian dominance

Timișoara inherited a total area of 530 ha of eighteenth- and nineteenth-century densely built neighborhoods. Apartment building complexes of four to ten storeys, built between the 1960s and the 1990s, make up about 440 ha of the city. The rest of the built surface is occupied by single family housing, which is the only typology still in expansion today (Suditu *et al.*, 2010) because of the city's current evolution that is characterized by urban sprawl (occupying agricultural land between its current built limits and its surrounding villages at a very low population density). This means that the surrounding villages will soon be 'swallowed' by the main body, decreasing today's net residential area density of 126.37 people/ha (Halcrow Romania S.R.L., 2011), and resulting in an unplanned green space network.

We have seen that green space per capita has fluctuated throughout the city's history, reaching today's 16 m^2/person (Miron, 2012; Luca and Gaman, 2009), which is a parameter calculated by dividing the sum of all urban green space defined by Romanian legislation (including grassed verges along streets) by the total city population.

In this study we want to see if accessible green space has any correlation to the current parameter and, by looking at these three state-regulated typologies, we want to find out what types of population have good access to green spaces. The article aims at defining a clearer picture of the effects different types of planning has had on green areas. At the same time, it seeks to offer a working methodology for other cities for evaluating objective green space pedestrian accessibility. To reach these goals we make use of GIS technology and publicly available data.

In summary, after having presented the importance of green spaces and discussed how their availability should be considered, the methodology will show the preparation of datasets (population, street network and green space locations). Results will compare the accessibility of Timișoara's existing parks and green squares to accessibility to all city green spaces that may be used for leisure proposes. The discussion will investigate planning implications based on population numbers and the conclusion will summarize the paper's main findings.

4. Methodology

Kwan (1998) suggests three steps in assessing accessibility, namely: specifying a set of destinations (urban green spaces), deciding the physical separation model and choosing a reference location. Many researchers use straight-line distances in accessibility studies, resulting in a high degree of error because of network distances which are actually used in practice (El-Geneidy and Levinson, 2006). This is why we chose to use the physical separation model ESRI's ArcGIS 10 software with the Network Analyst extension, which allows the computing of network distances. As reference locations we chose residences populated with inhabitants, as described in the following section.

4.1. Data sources and data construction

The data used in this study is publicly available, as shown in Table 6.

Table 6: Data sources

Data	Type	Source
Timișoara street network	Line	OSM (2012)
Timișoara street network dataset	Network dataset	Peters (2011)
Green areas	Polygon	National Agency for Cadaster and Land Registration (2012)
Timișoara cadastral plan	Polygon	Planwerk S.R.L. and Vitamin Architects S.R.L. (2011)
Population density	Polygon	S.C. Veltona S.R.L. (2011b)

We began by extracting the road data from Open Street Map and transforming it into a pedestrian routing network using the application created by Peters (2011). However, this operation can also be undertaken in ArcGIS using the new network dataset command. Studies show that walking speed ranges from 4.5 km/h (Widjajanti, 1995) to 5 km/h (Chartered Institution of Highways and Transportation, 2000; Widjajanti, 2000). This is why we chose the average speed of 4.8 km/h, used by common online applications like Google Maps and Bing Maps.

Green areas and houses were digitized based on aerial imagery and the plans used for supporting Timișoara's new master plan (Planwerk S.R.L. and Vitamin Architects S.R.L., 2011). Other maps used in the study by Radoslav *et al.* (2010) were used to accurately identify all green spaces.

For assessing green space accessibility we have used the limits suggested by Van Herzele and Wiedemann (2003) for two reasons: the detailed scale of analysis and the close match between indicated surfaces and Timișoara's green space profiles (all city parks and green squares are under 10 ha). A similar approach was used by Comber *et al.* (2008) in determining accessibility for different ethnic and religious groups. Because our method looks solely at pedestrian access, results show a more detailed perspective which offers insight on planning implications.

Population numbers were obtained from road traffic zone data (S.C. Veltona S.R.L., 2011a) resulting in density areas. Buildings representing residences were digitized on each density area based on detailed block level data provided by Timișoara's Densification Study (CCDDT, 2009). Population was then distributed into each residence according to building footprint size. This procedure follows the same principles used by Ural *et al.* (2011) who distributed population according to building volume extracted from color infrared aerial imagery. Not being able to make use of such imagery, we consider our approach extremely useful for cities where data availability is limited. Finally, houses were turned into centroids (ESRI, 2012) which became destinations for the Origin-Destination Cost Matrix function of Network Analyst. This procedure of population mapping allowed us to distribute publicly available population numbers into individual residences. So, instead of using an analysis which calculates proportions from density area intersected by buffers along the streets, as seen in the work of Pulugurtha and Sambhara (2011), we were able to perform an analysis at address lev-

el, eliminating errors caused by homogeneity in the distribution of population across a density area (Harris and Longley, 2000; Chang and Liao, 2011).

4.2. Methodological implementation of the GIS model

After the population was distributed into houses, we mapped the contours of all green areas that could be used for leisure purposes. These resulted in two layers: existing and informal green areas. We considered existing parks the ones maintained by the municipality and called 'informal green areas' other grassed surfaces characterized by unrestricted access but without the minimum endowment of benches and footpaths. The state of each site was checked through on-site survey and its GIS contour was then constructed based on aerial imagery (National Agency for Cadaster and Land Registration, 2012).

To get a better understanding of the city's planning situation, we mapped three types of built areas, namely sites with collective housing, historical neighborhoods and neighborhoods with houses built through individual means which we called single family housing. The building typology may vary within these three residential types, as seen below:

- Collective housing may vary in height and flat type according to the decade it was built in (see Radoslav *et al.*, 2010);
- Historical neighborhoods may vary from a row housing typology to single houses and shared flats in mansions;
- Single family houses may vary in height and parcel type.

That is why we have considered them from a planning point of view, namely state-built, Austro-Hungarian legacy and built by single citizens or families. We have seen in the case study description that green space played a different role in each of these planning periods. However, the physical relationship still remains because of the historical continuity.

5. Results

Figure 1 shows pedestrian accessibility to existing parks and green squares. Buildings are represented by centroids with the three hatches (dots, stripes and blank) indicating built typology. The service area is computed through the shortest network path method (represented by the dark fill), offering a more precise analysis as opposed to airline distances.

Figure 2 shows all green areas with their accessibility radius. We chose to undertake this analysis to show the maximum potential of the city and compare the resulting numbers to both the current situation and to the situation as expressed by Romanian green space legislation. There are two main differences to the present situation. These differences are the urban forest to the North and a substantial number of green squares under 1 ha (123 compared to the existing 41) appearing across the city. According to the study by Van Herzele and Wiedemann (2003), the 800 m range was used for the larger green areas to the North-East, considering the contour as starting point.

Figure 1: Accessibility to existing green spaces

Figure 2: Accessibility to existing and informal green spaces

Results are presented in absolute numbers and summarized in Table 7. Due to the fact that the population used in the study by S.C. Veltona S.R.L. (2011a) was in the metropolitan region of Timișoara, we considered the total city population as indicated by the census' preliminary report from the Romanian National Institute of Statistics (2012).

Table 7: Results

ID	Type of data	Quantities	Differences in percentages to total population
A	Total population	303,708	100%
B	Population in collective housing	151,183	49% of total population
C	Population in historical neighborhoods	39,117	12% of total population
D	Population in single-family housing	113,408	39% of total population
E	Population with good access to existing green spaces	80,217	26% of total population
F	Population in collective housing with good access to existing green spaces	46,169	15% (58% of pop. in row E)
G	Population in historical neighborhoods with good access to existing green spaces	15,322	5% (19% of pop. in row E)
H	Population in single-family housing with good access to existing green spaces	18,726	6% (23% of pop. in row E)
I	Population with good access to all green spaces	135,981	45% of total population
J	Population in collective housing with good access to all green spaces	79,688	26% (59% of pop. in row I)
K	Population in historical neighborhoods with good access to all green spaces	18,188	6% (13% of pop. in row I)
L	Population in single-family housing with good access to all green spaces	38,105	13% (28% of pop. in row I)

6. Discussion

Results are divided into three groups, namely general data about total population living in the three types of residential neighborhoods (A-D), results extracted from the analysis of the current situation (rows E-H and Figure 1) and results showing access to all green spaces (rows I-L and Figure 2).

First of all we note that almost half of the city's population lives in collective housing, meaning that parks or green squares placed in these neighborhoods are more efficient in terms of served population. Historical neighborhoods are split into four main groups, three of them (Iozefin, Cetate and Fabric) along the Bega water channel and one to the North-West (Mehala). The first three are characterized by a densely built environment with a medium height of two to three stories and approximate population density of 110 people/ha. The one to the North-East is similar in density to the single housing average, inheriting of a village-type land-use pattern. The largest part of the built environment is represented by houses erected generally between the 1950s and the 1990s, many of which were built on parcels of land initially dimensioned for agriculture.

Analyzing the planning reasons for the current situation, we note that less than one third of people living in collective houses have good access to green spaces (40,000

from a total of 150,000). The explanation is that these residential developments were commissioned by the state during the socialist period (between the 1960s and 1990s) when cities were seen as the main points of modernization. This is why a rapid expansion of cities was called for, following the principles of economic efficiency through agglomeration and leading to the development of large compact urban areas. We only see one main large park to the South in the middle of a residential complex because in this type of planning green spaces were treated like surfaces for filling gaps needed to provide appropriate lighting to the apartment buildings. Our on-site survey has shown that some are cared for by locals because of the need to compensate for the small balcony surface and lack of personal outdoor space. With locals creating direct exits at the ground level and small fences, these spaces are turned from public to private or semi-private. We see here why the municipality's role is so important in ensuring free access to all citizens to state-owned public spaces.

A higher proportion of people living in historical neighborhoods have good access (15,000 from 39,000 shown in row C), mainly because of the distribution of Timișoara's main parks and historical neighborhoods along the Bega water channel. The presence of the water channel has actually helped these parks resist residential development plans during the last 50 years but the neighboring low density areas leave them underused during weekdays.

The rest of the population remains mostly without proper access because of two main reasons: planning strategy and city expansion. With state interest during the socialist period concentrated on tall residential buildings, workplaces and transportation, private investments in housing were allowed but not thoroughly planned. Planning was merely reduced to efficient distribution of parcels of roughly 500 m^2 along 3rd level streets connected to the main circulation arteries. In this type of planning, green squares seldom appeared, usually around small technical facilities or at street corners where the organic shape of the street network did not allow for the laying out of a residential parcel. The second reason for the absence of green spaces is the surrounding villages which were swallowed by the city body. Their long and narrow agricultural parcels still constitute a land-use problem (Radoslav *et al.*, 2010) because they were not planned to accommodate urban facilities and do not allow street access to new constructions which can only develop on a perpendicular direction to the street.

Row E in Table 4 summarizes the existing situation, showing that a total of 26% of the city population has good pedestrian access to green spaces, although the service area covers less than a quarter of the city surface. This means that our approach shows more accurate results than simply estimating access by service area covering residential land, as seen in Cucu *et al.* (2011). This result also allows us to estimate green space per capita, which reaches an average of 11 m^2/person for the 90 ha of parks and squares present in the model.

If we look at the 76% of the population with poor access, we are able to say that this situation should be improved. Figure 2 shows a possible improvement, namely through the simple development of unused green spaces.

Rows E to L present access to existing and informal green areas and show a fundamental rise to 44% of the population with proper access. This is due to the substantial influence played by the small green areas under 1 ha and the large urban forest to the North-East. Again, service area covers a lesser proportion of the city surface than the population ratio meaning that redevelopment of green spaces within apartment building complexes is the key to increasing overall access. With green areas within the city reaching 158 ha in the GIS model, we can estimate a ratio of 12 m^2/person as the currently available.

The number of people with good access living in historical neighborhoods only increases by 3000 (row K compared to row G) in respect to the existing situation. The densely built form did not leave any unused territory, this increase coming mainly from peripheral informal green spaces.

The greatest increase is seen in single family housing neighborhoods, with more than double the population gaining good access (row L compared to row H); the reason being the large service area of the forest and the above mentioned 'residual' spaces which only need a minimal investment to become functional.

7. Suggestions

After analyzing the current and the possible situation of green spaces in Timișoara, we find that several recommendations referring to informal green space can be made for the future development of the city, implying both short- and long-term actions. Following other European urban examples, we recommend functionalizing the informal green spaces and creating a mesh of interconnected public green spaces. The GIS system can be applied in this case not only in analysis but also in determining the adequate zones for creating green corridors, as seen in the examples of Nantes and Victoria–Gasteiz. This can be applied further into seeking places with the potential of becoming 'flexible spatial plans' within the urban area, thus setting the path for a healthy future development of the city.

GIS can also help in determining redundant former industrial areas with the potential for becoming public green spaces. At the moment, there are several industrial platforms interpolating between residential and green areas and acting as barriers between the two. We recommend a step-by-step removal of the industrial areas from within the city and re-functionalizing the sites. The GIS system can be used to determine which platforms need to be transformed by testing which industrial areas are surrounded by very high density, thus having the highest potential of a large catchment area. By this, we aim to ensure high accessibility levels or, in case this is impossible, to find optimal linkage paths around them.

Furthermore, local small-scale agriculture should be encouraged. As mentioned above, collective-building dwellers tend to illegally extend their property with small gardens between the buildings as they feel the need for gardening. Although communal gardening used to be common practice in other Romanian cities, such as Sibiu, a law issued in 2005 put a stop to this practice. We recommend following the example of

Rennes (World Health Organization, 2010), where the local administration provides the citizens with several communal family plots for gardening.

The above recommendations may be applied through policy implementations by the local authorities. Firstly, the city needs to identify all green areas. For this to happen, it is necessary to have a surface, quality and accessibility of green spaces audit (as already requested by Romanian Law no. 24/2007 art. 10) and a green cadastre, as currently undertaken by the administration of the Romanian city of Oradea (S.C. Geodis S.R.L., 2009), is also essential (Ciupa *et al*., 2005). Secondly, the administration should ensure that the law is respected and green spaces are not occupied by other buildings and constructions. Lastly, the administration should encourage both owners within residential areas, as well as owners of private and administrative buildings to manage and create public green spaces around their buildings and/or use accessible green roofs – a solution especially suited for historic neighborhoods where green space is scarce because of traditionally dense urban form. We can see such initiatives already taking place both in Timișoara and in other Romanian cities, such as Alba Iulia (Redacția Ziarului 'Unirea', 2011), Constanţa (Hirsch, 2013), Târgu Mureş (Creţ, 2011) or București (Mitan, 2012). In Timișoara, the case of the 'Bastion' wall can be considered, where the greenery growing on the roof has been kept instead of being removed during the renovation. There are also some proposals for it to be used as a public green space. In Alba Iulia, the bastion and citadel have been converted into public green space.

However, in this particular example, the public green has not been connected to the city's infrastructure and it is not entirely accessible yet. This raises another suggestion for the authorities: interconnecting the public green space network with the public transportation network in order to further ensure accessibility.

These implementations imply both short- and long-term actions. The latter would consist in the purchase by the local administration of hills and unproductive lands around the city in order to include them within the metropolitan area and turn them into public green space. Furthermore, these new green spaces could complete Timișoara's green belt. This action alone is not sufficient, as the green space needs first and foremost to be accessible. Transport routes must be made to link them with other entire city parts, as well as connecting them to the city's green network and pedestrian routes. The GIS method can be helpful in determining the new infrastructure management. Examples from other European cities can be followed, like the case of Victoria-Gasteiz, which uses public-transport infrastructure to access its green belts or the case of Koln (Cologne) which, after having bought the land around the city in 1881, has made it active, accessible and usable (Forrest and Konijnendijk, 2005).

Short-term implementations come to aid the long-term proposals. They imply actually purchasing Timișoara's surrounding land, transforming regular roofs to green ones, turning former industrial parks into active and attractive spaces for leisure activities and using green tiles in parking and pedestrian spots.

8. Conclusions

Romania started the process of joining the European Union in 1995. Hence, the European tendencies and policies on urban planning had to be adopted by local and national authorities as well as the European concerns with issues such as life quality, environmental quality and green areas. However, today, the concern of public administration representatives and local authorities for QOL in Romania is still rather poor.

In this study, we were interested in using the latest technology for analyzing and modelling aspects of QOL in Timișoara as a case study. We believe that, by identifying and solving problems of QOL, like poor pedestrian accessibility in our case, we can interfere in a positive way in matters of urban issues that concern today's modern cities.

This paper has presented a methodology for assessing pedestrian accessibility to urban green space. Besides using service areas according to surface, its value relies on using public data to obtain population addresses, street networks and park locations. This makes it available for all cities or researchers who are not able to access custom GIS datasets.

The results of our study have shown that only 26% of the case study's population has good pedestrian access to green areas cared for by the municipality. It has shown that the city could use unattended green areas, called 'informal' in our study, to raise this percentage to 45%. In both cases green space/capita remains lower than today's 16 m^2/person, meaning that current legislation may offer an accurate picture of the capacity of green space to provide clean air within the city, but tells nothing about its accessibility.

In terms of neighborhood type, our study has shown that the dense urban form of historical neighborhoods reduces the possibility of access to the main parks along the Bega water channel. Single family housing neighborhoods have shown the lowest accessibility levels but the greatest improvement in the case of developing unused green spaces. However, the most important role in the general balance is played by collective housing through the possible use of interstitial green spaces initially planned to separate buildings for the purpose of lighting.

We assert that for maintaining and improving the urban quality of life in Timișoara, as well as in any other city, municipalities should keep track of all available city green spaces and use similar approaches to the one presented in this paper to increase green space per capita, as well as to investigate and enhance accessibility to these spaces. We have seen that pedestrian access to green spaces is considered to be an essential determinant of environmental quality and, moreover, of quality of life which should be one of the main concerns of public policy. Our methodology may be used to support authorities' involvement, which should start from a national level through a survey of the main Romanian cities.

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