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MEASURING DISTRIBUTION AND DERIVED INEQUALITIES IN ACCESSING URBAN GREEN SPACES WITHIN IAŞI CITY (ROMANIA)

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Abstract: The present study aims to identify inequalities concerning accessibility to urban green spaces within Iași city. In order to reach this purpose, the used methodology included walking time distance-based indicators, as well as demographic-load based indicators. The accessibility was assessed by means of Closest Facility and Service Area tools in ArcGIS for Desktop 10.1, while the demographic load was calculated by different specific indicators, based on the total area, pedestrian area and the number of benches for each urban green space. The results highlighted a great deficit in parks for the Iași city, as 25 % of the population is located at more than 12 minutes walking time distance from an urban green space and, at the same time, according to the calculated optimal demographic load, only 5% of the city population can be hosted by the existent parks. These mean values also contain important disparities, as the central and northern part of the city is by far more advantaged than the peripheral neighborhoods.

Key words: intra-city green spaces, accessibility, demographic load, urban inequalities, GIS

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INTRODUCTION

Urban green space represents a major concern of the present urban planners, as it is more and more commonly agreed that there is a strong connection between the derived benefits and the appropriation of the urban green space by the inhabitants. Frequency and duration of visits to green areas are key factors of obtaining health benefits related to physical outdoor activities and many studies focused on the relationship between the availability of close-to-home green spaces and the frequency of participation in outdoor activities (Neuvonen, 2007; Gobster, 2005), as well as on the links between pooreraccess to green space and higherrates of obesity (Ellaway, 2005), higher mortality risks (Mitchell, 2008), poorer self-perceived health (Maas, 2006) and lower levels of psychological well-being (Xiaolu, 2012).

Among the various types of green spaces within cities situated all over the world (Dai, 2011), the present study concerns urban green spaces (UGS) falling into the definition of intra-city green

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spaces composed by a natural or planted vegetal cover and a built-up setting consisting in adequate facilities for recreational, cultural, educational and sports activities of the population (Muja, 1984).

Accessibility to urban green spaces, as well as to other urban facilities was assessed by means of different methods in a large number of studies. The simplest method is represented by the Euclidian or buffer distance, but as the configuration of road network may differ totally from the straight line directions, this method is considered to have a low level of accuracy and certainty. Several studies concerning accessibility to urban green spaces demonstrated that buffer zones based on Euclidian distance overestimate theserviced population (O'Neill, 1992; Javed, 2013). More accurate are the models based on network distance (Al-Ballaa, 2012; Javed, 2013), e.g. by creating a Closest Facility or Service Area layer in ArcGIS for Desktop, based on a network dataset (Nicoară, 2011). Further analyses are centered upon spatial interaction models, which take into consideration origin and destination properties – emissivity and attractiveness – and friction factors, mainly represented by distance (Goodchild, 2009). The aim of the present study focuses on assessing the accessibility to urban green spaces in Iași and highlighting the derived inequalities within the city. Two types of disparities will be analyzed: location-based ones – consisting in walking time distance to the nearest urban green spaces, assessed by means of Network Analyst extension from Esri ArcGIS 10.1 software and demographic load-based disparities, calculated using several indicators, among which we proposed a formulae for Optimal Demographic Load.

MATERIALS AND METHODS

Study area

Iași city, the fourth largest in Romania - 290 422 inhabitants (Central comission for population census, 2012) and the most important city in the Eastern part of Romania is characterized by a lack of urban green spaces, more than 70% of population being included, from this point of view, into critical areas (Roșu & Oiște, 2013).

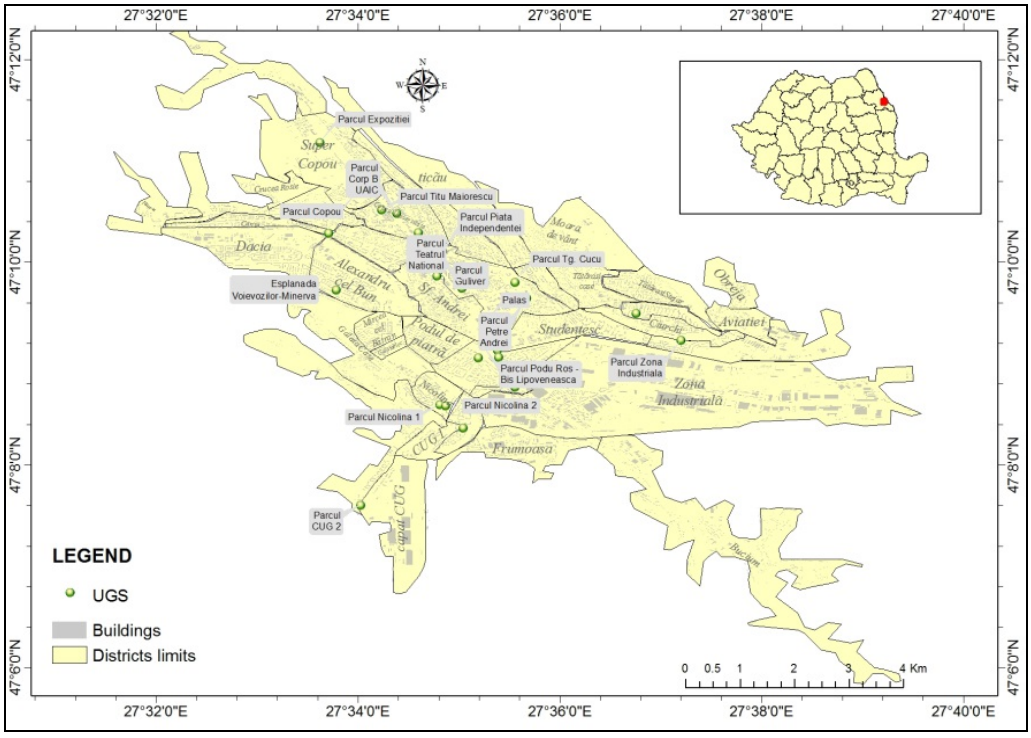

Figure 1. Positions of urban green spaces in Iași City

Urban green spaces hold a long tradition in Iaşi development, the oldest parks being enhanced in 1833 (Copou Park). Since then, authorities developed 26 urban green spaces (figure 1), the latest (Palas park) being arranged in 2012 and considered a landmark of the city due to its centrality, facilities and advertising. Most of the urban green spaces are located throughout the central part (where the cultural, educational and social life take place) of the city, while the populated districts (former industrial districts from the south and south-western parts) face a lack of easy access to urban green spaces. Therefore, analyzing evenness of accessibility to parks is a demand that inquires different types of spatial data which were collected and analyzed as following:

Data collection

The present study was conducted by means of three thematic spatial data: urban green spaces, Population Addresses and Road Network (table 1). Urban green spaces data, acquired by fieldwork and validated by Google Earth comparison, included the polygon geometry of each urban green space in Iaşi City, accompanied by the following attributes: total area, pedestrian area, number of benches. Population Addresses, represented as point feature class included the number of inhabitants per address according to Census 2012; also, Road Network was provided by Open Street Map 2013 and corrected by field observations.

Table 1. Input data

Urban green space		Population adresses		Road network	
(Polygon feature class)		(Point feature class)		(Line feature class)	
Attribbutes	Data source	Attribbutes	Data source	Attribbutes	Data source
Total area	Google Earth	Number of inhabitans	Census 2012 INS	Length	Open street Map 2013
Pedestrian area	Google Earth + Fieldwork				
Number of benches	Fieldwork				

Data analysis

Data analysis focused on two main types of measures for inequalities: accessibility-based ones, assessed by Closest Facility Tool (figure 2) and Service Area Tool (figure 3) and demographic load-based, measured by means of several indicators: Urban green space Global Density (GD), urban green space Recommended Demographic Load (RDL), urban green space Effective Density (ED), urban green space Optimal Demographic Load (ODL). Accessibility was measured in walking-time distance, calculated using thelow pace walking speed of 3.5 km/h, obtained by adapting the average pedestrian walking speed of 4.5 km/h (Aspelin, 2005) to the urban conditions, represented by different barriers and obstacles. Following the principle of the least effort, the present study uniforms all urban green spaces to the same standard, without considering differences in attractiveness; in a geographical manner, minimizing the effort means usually minimizing the distance and mobility (Goodall, 1987). Starting from this principle, each inhabitant is supposed to use minimum distance and energy for reaching the nearest urban green spaces. Using Closest Facility Tool, we determined the walking-time distance from each address to the nearest urban green spaces (figure 2). Concurrently, walkability area delineates 10 - 12 minutes as the maximum distance that a person is supposed totravel for reaching the desired destination (UGS). Further away from this limit, the interaction probability between inhabitants and urban green spaces decreases. Accordingly, we calculated the demographic load within 12 minutes Service Area for each urban green space (figure 3).

At the same time, Demographic load indicators were calculated in two different manners: GD (Global Density) and RDL (Recommended Demographic Load) were calculated based on the total area while ED (Effective Density) and ODL (Optimal Demographic Load) were calculated based on the effective pedestrian spaces availability (pedestrian area and number of benches). The

two densities (GD and ED) were directly derived from the demographic load within the service area for each urban green space and the respective total and pedestrian area.

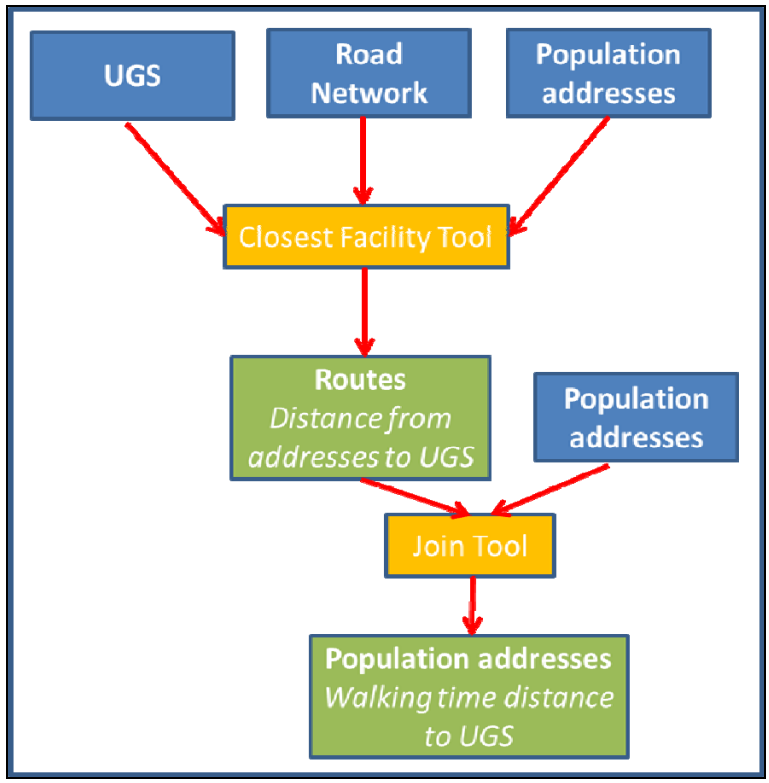

Figure 2. Workflow performed for highlighting accessibility to urban green space

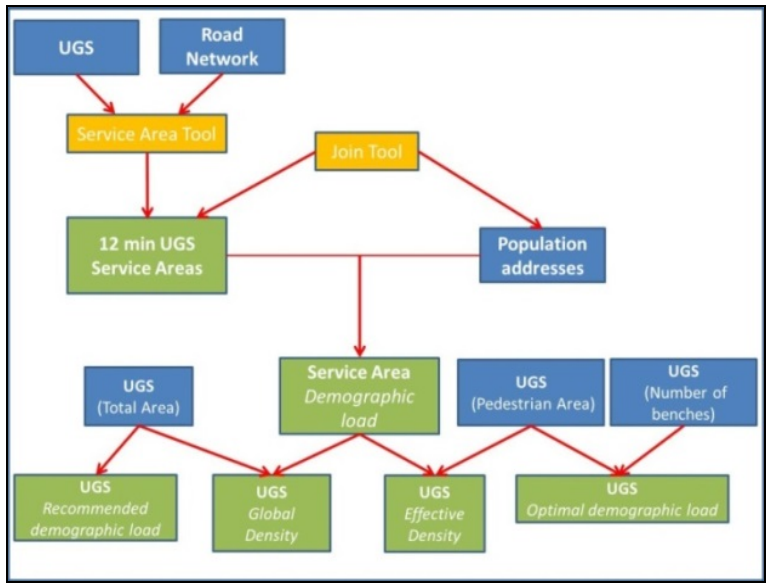

Figure 3. Workflow performed to delimit Service Areas and to calculate demographic load indicators

The RDL indicator was calculated considering the required of area of urban green space per inhabitant (5 m²) (Cândea et al., 2006). By analyzing the values of this indicator and their distribution, we stated the hypothesis that a more detailed indicator should be employed in order to estimate the optimal demographic load of a urban green space; hence, we took into consideration two variables - pedestrian area and number of benches - and created the following ODL indicator:

$$ODL = \frac{PA}{10} + 2 \times N_B,$$

Where: ODL – optimal demographic load (number of inhabitants), PA – pedestrian area (m^2), N_B – number of benches. This formula is based on the assumptions that an area of 10 m² per inhabitant represents the limit between social and public space (whereby actions such as social interaction or relaxation can take place) and that each bench can host maximum two persons, in order to avoid overcrowding (Hall, 1969).

RESULTS

In this section, the above mentioned proposed methodology was applied to the 26 urban green space identified inIaşi city in order to analyze different levels of accessibility and their optimal demographic capacity according to different standards. The results are divided into 3 main parts, each one presenting a separate analysis for highlighting the main aim of this paper:

Closest facility

Population and urban green space locations inside of Iaşi city do not respect an even distribution, as they are concentrated across the central and north-western parts of the city, while the highest population densities are recorded in peripheral, former industrial neighborhoods. The industrialization policies played a major role in the structure of the urban territory by means of the large industrial platforms arranged in the southern and eastern part of Iaşi city accompanied by the working-classdistricts endowed with basic socio-economic utilities necessary to the rural population attracted by the Iaşi factories (Stoleriu, 2004). The northern part of the city is the most privileged, cumulating the largest number of urban green space as a result of the reduced interventions of the communist urban planning.

For highlighting different levels of accessibility, several time-distance break values had been used (figure 4):

- 5 minutes to closest urban green space represents the optimal time distance; 23.8 % of total population is located within this distance;
- 5 to 10 minutes to closest facility (urban green space) is considered an average travelling distance and 36.9 % of total population is included in this category;
- 10 to 20 minutes time distance leads to a significant decrease in the probability of interaction between inhabitants and the closest urban green space; within this distance, 31.4 % of total population is included;
- more than 20 minutes represents abarrier for interaction; these inhabitants (7.33 %) are constraint to use other means of transport for accessing this facility or to find other types of recreational activities.

The central districts are favored by this distribution; they offer high accessibility (up to 10 minutes) for their entire population and alsoalternative, due to the high density of urban green space. At the same time, peripheral urban green space overlap the neighborhood centers, representing the social open space for the community. Esplanada Minerva, Esplanada Oancea, Nicolina 1 and 2 or Parcul Poştei P.R. induced the occurrence of these community centers due to their social role ofestablishing recognition and developing relationships (Kazmierczak, 2013). Nevertheless, only a reduced percent of thepopulation of these districts is included within the10 minutes break value, the greatest part of the population of these districts encountering a low level of accessibility.

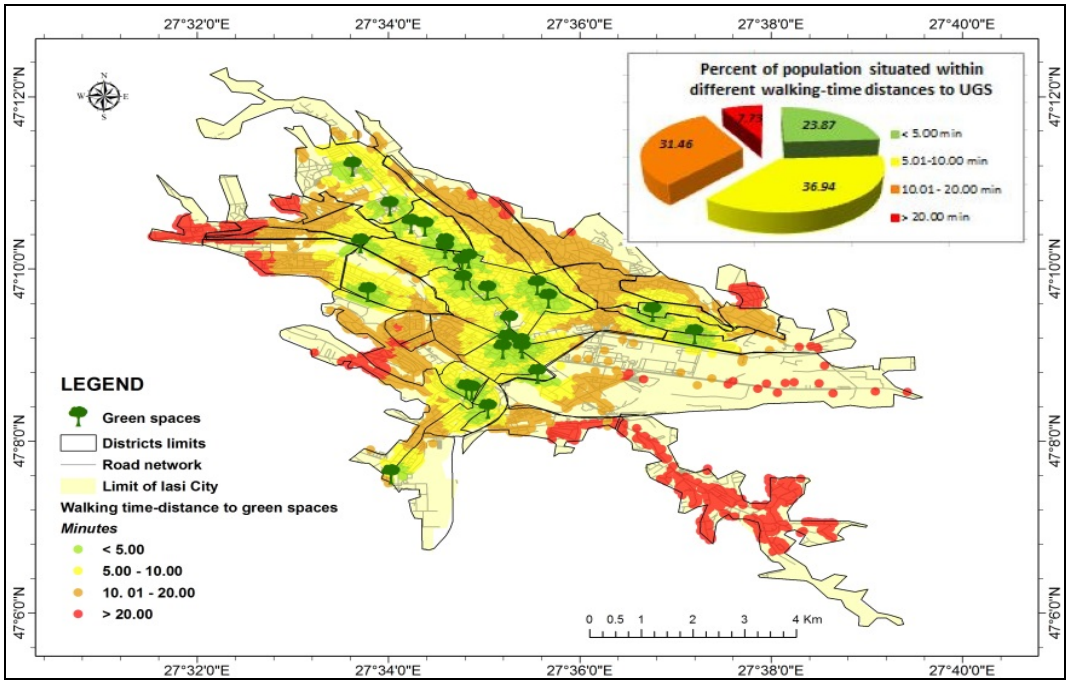

Figure 1. Time distance to closest urban green space in Iași City

The most deprived inhabitants are located in Dacia and Păcurari (former industrial districts), located outside of 20 minutes time-distance. This highlights the theory that planning urban green space in industrial districts had been excluded from urbanism planes during the communist period (Stoleriu, 2008). At the same time, peripheral neighborhoods such as Galata Case, Bucium, Obreja, Țicăuface low accessibility too, asthey are characterized byindividual households, belonging to urban sprawl-emerged districts (Suditu, 2010; Cîmpianu, 2013), low population density and intricate street texture, adapted to local topography (Barbu, 1987).

Service area within 12 minutes

For each urban green space, a service area was developed, whereby the inhabitants can access the referred urban green space within the 12 minutes walking time-distance barrier. In this case, the 26 resulted service areasdo not cover the entire population of the city; 25 % of the population is situated outside the 12 minutes-limit. The highest density of population situated outside Service Areas is on the westernpart of Iași (Păcurari-Dacia districts) where thereis a lack of accessibility to urban green space. Also, population located in Galata Case and Zona Industrială is outside of the service areas limits. Other neighborhoods, such as Țicău or Bucium can be considered as transition areas from urban to rural typology, the existence of urban green space being replaced by forests, croplands or pastures.

Analyzing service area revealsoppositedemographic dimensions and, at the same time opposite features:

- central urban green space with different total areas, tend to form small service areas for proximate population – resulting small population loads (situation which is confirmed by field observations). These urban green space are characterized by quietness, cleanness, safety feelings, benefitingfrom social and personal space, basic pedestrian facilities (benches, play ground sand pavilions), cultural and social facilities (nearby museums, gardens). These characteristics are highly connected to mental and physical health benefits (McCornack, 2010).

- peripheral urban green space have opposite particularities: high population load inside urban green space (27 000 inhabitants/Esplanada Minerva urban green space) which determines overcrowding, high levels of noise, lack of personal space and other facilities (due to initial narrow plans of urbanism). These problems have negative impacts on health and well-being of the population (stress, obesity, heart diseases, diabetes), on environment (lower air quality, higher air temperatures) or financial aspects (decrease of property value, increase in repulsivity of spaces) (Jong, 2012). It is the example of Octav Băncilă, Esplanada Oancea and Minerva, Țuțora, Podu Roș urban green space which concurrently have the highest density values.

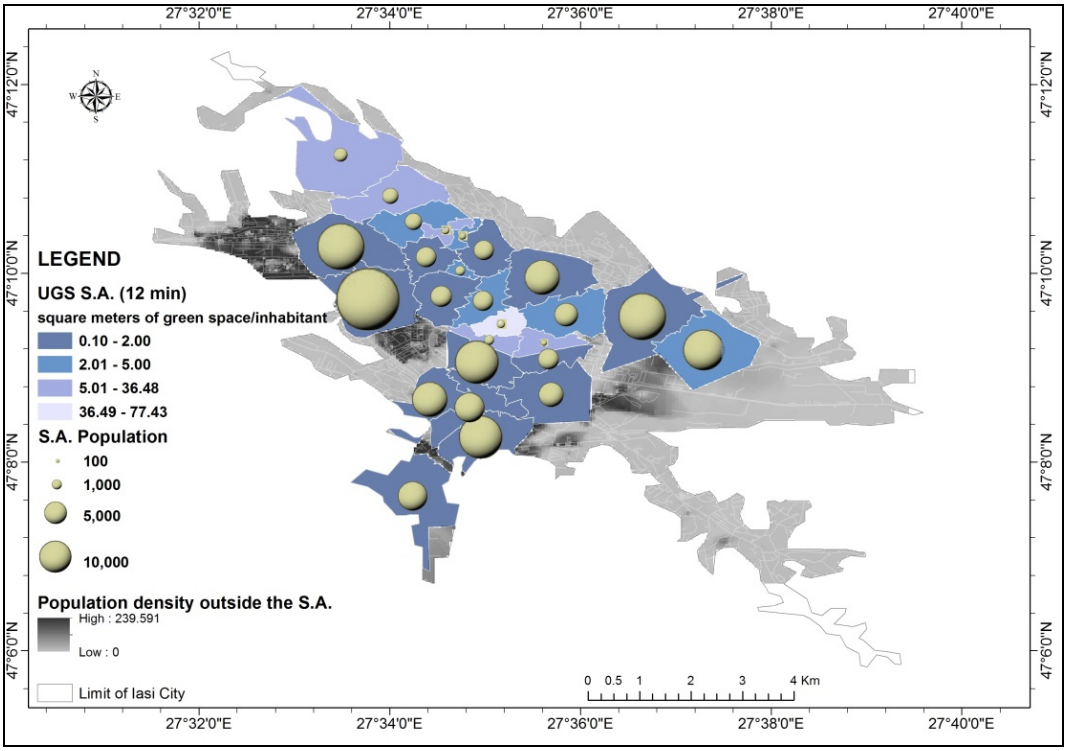

Figure 5. Service area (12 ') for urban green space in Iași city

Demographic load supported by urban green space

Assessing the accessibility to urban green space does not represent an adequately comprehensive manner of highlighting the inequalities within Iași City concerning urban green space; it is highly important to focus equally on stating the demographic load supported by urban green space. In order to measure the demographic load, two main approaches were used: general-density approach – which states that 5 m² of urban green space per inhabitant are necessary and effective-density approach – simulated by us, which takes into consideration only pedestrian area within urban green space (Cândea, 2006). All the primary and derived indicators employed are listed in table 2. These indicators revealed several new inequalities within the city, as a great part of the population situated within walking distance from the urban green space, cannot be housed by the respective urban green space (table 3).

If the general density (GD) is taken into consideration, it can be observed the same pattern: while the urban green space situated in the northern part of the city face larger area of urban green space per inhabitant (Copou, Corp B UAIC, Expoziției), the communist residential complexes situated more peripherally offer less than 1 m² of urban green space per inhabitant (Casa Sindicatelor, CUG 2, Octav Băncilă, Esplanada Oancea, Espalanada Minerva etc.).

Table 2. Indicators used for urban green space demographic load assessment

Indicator abbreviation	Indicator Name	Indicator formulae
SAP	Service Area Population	Total number of inhabitants within 12' from the urban green space
GD	General Density	Total USG Area / SAP
ED	Effective Density	Pedestrian UGS Area / SAP
RDL	Recommended Demographic Load	total UGS Area/5
SPG (RDL)	Served Population Gap according to RDL	(SAP - RDL) x 100/SAP
NA (RDL)	Necessary Area according to RDL	5 x SAP
ODL	Optimal Demographic Load	Total UGS Area/10+2xNumber of benches
SP (ODL)	Served Population according to ODL	Odlx100/SAP

Table 3. Urban green space demographic load

Urban green space	SAP	GD	ED	RDL	SPG	NA	ODL	SP
(Name)	(no.inh.)	(m²/inh)	(m²/inh)	(no. inh)	(RDL)	(m²)	(no. inh.)	(ODL)
					(%)			(%)
P. Octav Bancila Billa	21695	0.17	0.03	734	-96.61	-104801.72	85	0.39
P. Casa Sindicatelor	6004	0.5	0.04	598	-90.05	-27031.25	41	0.68
P. Tg. Cucu	12070	0.61	0.04	1474	-87.79	-52978.26	82	0.68
P. Postei-Podu Ros	18559	0.1	0.05	374	-97.98	-90925.29	134	0.72
P. Biserica Sf. Antonie	18281	0.18	0.05	645	-96.47	-88179.43	131	0.72
P. Tutora	4200	0.36	0.05	306	-92.7	-19469.68	47	1.11
P. CUG 2	8534	0.7	0.15	1200	-85.94	-36673.37	149	1.74
Esp. Minerva	39037	0.44	0.14	3403	-91.28	-178170.5	912	2.34
Esp. Oancea	21930	0.5	0.21	2172	-90.09	-98790.9	538	2.45
P. Nicolina 2	8719	0.83	0.28	1450	-83.37	-36343.79	310	3.56
P. Petre Andrei	5365	3.56	0.38	3820	-28.79	-7723.2	235	4.38
P. Piata Independentei	3926	1.52	0.47	1197	-69.5	-13644.47	208	5.3
P. Nicolina 1	12174	0.89	0.49	2161	-82.25	-50061.2	655	5.38
P. Zona Industriala	16509	3.61	0.57	11934	-27.71	-22874.8	1027	6.22
P. Titu Maiorescu	2850	3.19	0.67	1820	-36.14	-5150.55	238	8.34
P. Voievozilor	4075	0.96	0.17	786	-80.72	-16449.03	416	10.21
P. Guliver	4447	1.78	0.77	1583	-64.4	-14320.6	459	10.31
P. Teatrul National	4046	2.27	0.44	1836	-54.63	-11049.73	418	10.33
P. Muzeul Unirii	953	3.58	1.04	682	-28.45	-1355.6	115	12.07
P. Casa Pogor	589	4.05	1.15	477	-19.02	-560.51	76	12.9
P. Fac. Constructii	383	8.63	1.21	662	72.56	1390.91	64	16.76
P. Bis. Lipoveneasca	944	12.38	2.21	2338	147.62	6970.1	237	25.05
P. Corp B UAIC	632	12.29	2.13	1553	145.76	4605.4	203	32.05
P. Expozitiei	1863	30.86	4.41	11500	517.25	48182.5	1443	77.48
P. Copou	2528	36.48	6.28	18442	629.63	79573.1	2353	93.08
Palas	613	77.43	41.81	9499	1448.54	44429.7	2773	251
Total	220928	1.87	0.45	82647	-62.59	-691402.17	13348	6.04

Several exceptions can also be remarked: Palas – a great recreational site, which is able to host a high demographic load, compared to the population living within its service area; Faculatea de Construcții and Biserica Lipovenească urban green space – form small service areas, theoretically serving a small part of the population, as they are situated in Podu Roș area, where numerous urban green space are available – hence, they face increased availability of urban green space per inhabitant.

The indicators based on the total area too - RDL and SPG (RDL) – emphasize the same aspects as the GD, stating the exact demographic capacity of each of the urban green space. On the one hand, the same urban green space (Copou, Corp B UAIC, Expoziției) are able to host up to six times the population within their service area – this situation characterizes the Copou urban green space. On the other hand, deficits varying from -27.71% to -97.98% are specific for the urban green space situated in highly populated neighborhoods. Palas urban green space is able to receive 14 times the population in its service area, but its great attractiveness polarizes the entire city.

Using the same measure of 5 m² of urban green space per inhabitant, we calculated that 691 402.17 m² are still necessary across the entire city in order to meet this recommendation. In general, effective density (ED) is several times lower than GD, as the pedestrian area in urban green space is more reduced than total area. Palas represents again an exception, as a great part of its area is pedestrian – including the lawn.

According to optimal demographic load designed in the present study, there is no urban green space in Iași city capable of housing the entire population in its service area, excepting Palas, whose situation has already been explained. Copou urban green space has the lowest deficit – 6.92 % of the population, while more than half of the urban green space face a deficit higher than – 90 %. Excepting several urban green space situated in the northernpart of the city, the others can only receive 10-20% of the population within their service area. According to these indicators, inequalities within city were better measured, as well as the overall deficits. At the same time, several particular cases of urban green space can be observed: Fac. de Construcții, P.R. Poștă, Zona Industrială; these parks face a great difference between RDL and ODL, as there is a lack of pedestrian facilities. Consequently, the optimal demographic load of these urban green space is highly diminished compared to their total area, due to the initial unbalanced plans.

DISCUSSIONS AND CONCLUSIONS

The present study revealed increasedinequalities concerning the availability of urban green space within Iași City. The most populated neighborhoods have poor accessibility as well as very reduced urban green space areas, while the central-northern neighborhoods – less populated and hosting commercial, administrative or cultural functions own extended areas of accessible urban green space. At the same time, the overall availability is as serious as the inequalities: 25 % of the population lives at more than 12 minutes walking-time distance from a urban green space, while the demographic load supported by the urban green space is also highly under the actualdemographicweightof the city (the recommended area of 5 m² per inhabitant is not available for 62.59 % of population and the optimal demographic load for urban green space fail to serve 93.96 % of population located inside of service areas). The paper has its limitations, too, as we did not take into consideration the attractiveness of each urban green space, which could be assessed by indicators based on multiple variables, as well as by applying questionnaires. Such an approach would have offered us the possibility to weight the accessibility and the physical demographic load by the attractiveness. At the same time, the Iași City has another important advantage: it is surrounded by substantial forested area, frequently situated near the great residential complexes (Ciric forest for Tătărași, Aviației and Obreja; Cetățuia Forest for CUG 1 and CUG 2; Galata Forest for Nicolina 1, Nicolina 2, Galata and Mircea cel Bătrân etc.). All this sites are not currently adequate for representing functional recreational areas (excepting Ciric Forest), but they represent a potential resource in the context of several environmentally-friendly planning solutions which should be adopted. Still, in the last few years, the increase of the real estate values in the central part of the city

created recreational services at the outskirts of the city: sports-ground, swimming pool and strand (Alexandru cel Bun), hippodrome (Frumoasa), recreation complex (Ciric), (Stoleriu, 2008).

It is highly important to continue scientific inquires by adopting several future directions starting from the present study, such as: proposing geo-design-based solutions for increasing the demographic load of the existing urban green space (for instance, Tătărași urban green space holds a great area not adequately arranged), proposing a set of adequate locations for new urban green space, investigating the possibility of converting parts from the surrounding forests into urban green space.

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