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The availability of green spaces for different socio-economic groups in cities: a case study of Budapest, Hungary

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ABSTRACT

The provision of urban green spaces (UGS) within a reasonable walking distance/time for each resident has become a major challenge of urban planning. We provide a novel method to map the availability of UGS for different socio-economic groups in cities using a demand–supply composite index (DSCI). Budapest, the capital city of Hungary, has been chosen to test how the DSCI works. The results show significant differences in the availability of UGS for people living in different neighborhood types. Furthermore, findings reveal that regardless of which type of residential area is considered, young and middle-aged people with higher per capita income are more likely to access UGS. As the demographic and socio-economic structure of the population is continuously changing in the different neighborhood types and so is the demand for UGS, urban planners should carefully monitor societal changes and elaborate interventions to help improve the availability and accessibility of UGS.

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Urban green spaces; availability; walking distance; demand and supply; urban planning; Budapest

1. Introduction

Urban green spaces (UGSs) are recognized as the main suppliers of ecosystem services in cities contributing to the well-being of residents, improving air quality, reducing noise, and regulating urban climate (La Rosa et al., 2018). However, green spaces are very unevenly distributed in urban space (Csomós et al., 2020; Łaskiewicz et al., 2021). Therefore, one of the most important challenges of contemporary urban planning is how to provide equal opportunities for residents (Dai, 2011; La Rosa et al., 2018) and reduce the relative disparities in the availability and accessibility to UGSs. Consequently, the accessibility-planning paradigm has gained widespread attention among urban planners and policymakers in the United States and countries of the European Union in recent years (Arranz-López et al., 2021; EC–UN–Habitat, 2016; Poelman, 2016). There are a variety of approaches in the literature on how to measure the accessibility of UGSs. Perhaps the most generally used model is the fixed distance approach, i.e. the distance to the closest green space using simple Euclidean distance or walking time (Reyes et al., 2014). However, looking at national and local planning guidelines we find that the recommended walking distance/time for UGS

accessibility varies from country to country, sometimes even from city to city (Biernacka & Kronenberg, 2018; Zepp et al., 2020). In a growing body of literature, the recommended walking distance ranges between 300 and 1600 meters (i.e. 4- and 20-minute walking time, respectively) (see, for example, Barbosa et al., 2007; Boone et al., 2009; De Sousa Silva et al., 2018; Dempsey et al., 2018; Kaczynski et al., 2009; Schipperijn et al., 2010; Smoyer-Tomic et al., 2004).

When evaluating the spatial access to green spaces, an accessibility measure considering supplies and demands as well as their interactions is desired (Dai, 2011). This paper moves beyond the conventional methods that focus on investigating UGS accessibility from a single angle and introduces a demand–supply composite index (DSCI) that considers multiple indicators (Csomós et al., 2021). The novelty of the method is that it can be used to measure and compare the accessibility of UGS for different socio-economic groups of residents and in a wide circle of cities. The main aim of this paper is to test the effectiveness of the DSCI in a mapping exercise through the example of Budapest, the capital city of Hungary. On the basis of the research findings, we formulate some

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recommendations for urban planners at the end of the paper to help achieve a more balanced and socially just UGS system in the city.

2. Demand and supply models in the study of accessibility to ecosystem services and green spaces in cities

In recent years, several studies have focused on measuring and assessing the demand and supply of ecosystem services in cities. To map the spatial pattern of cultural ecosystem services in Shanghai, [Bing et al. \(2021\)](#) used a set of cultural ecosystem service indicators to assess supply and demand. Authors compared the difference of normalized demand level and supply capacity by grids. In their study focusing on Dresden and Heidelberg, [Krellenberg et al. \(2021\)](#) developed an indicator-based assessment of cultural ecosystem services. They used a two-step approach by linking green space criteria with recreational activities (demand-side) based on a series of surveys and conducting a spatial mapping of urban green spaces based on activity-driven indicators (supply-side). [Lee and Hong \(2013\)](#) investigated spatial disparity between the supply of neighborhood parks (service areas) and the demand from residents. In the study, the spatial disparity is defined as the spatial mismatch between supply and demand levels of park services in a geographic unit (e.g. 100×100 m square grid).

[Cortinovis and Geneletti \(2020\)](#) developed a performance-based planning approach built around the assessment of ecosystem service supply and demand, using several ecosystem supply indicators and integrated ecosystem demand maps. They also developed a scoring system that, based on the values of the indicators in the maps, assesses the ecosystem-based actions implemented in each urban transformation. The study of [Larondelle and Lauf \(2016\)](#) introduced a scheme to assess the demand and supply of urban ecosystem services and derived respective budgets by using detailed environmental, urban structural, and socio-economic data. They used multiple ecosystem service demand and supply indicators that were combined into single measures. Then they mapped the normalized ecosystem services demand and supply, and the normalized net ecosystem service supply on the neighborhood level. [Herrerros-Cantis and McPhearson \(2021\)](#) quantified the relative mismatch between supply and demand of ecosystem services across New York City, identifying spatial hot- and coldspots of supply-demand mismatch. They defined demand for ecosystem service as a need for risk reduction whereas the supply indicators were derived from such ecosystem services as the local temperature regulation, runoff mitigation, and air purification.

[Luo and Li \(2021\)](#) proposed a multi-criteria approach to quantify the imbalance and spatial

patterns of ecosystem supply and demand in Chongqing. The authors introduced the nighttime light data to identify the demand of ecosystem services, whereas, for supply indicators, some regularly used indicators were chosen (e.g. water regulation, and water and air purification). The city's districts were classified into four categories in terms of the supply-demand relationship (i.e. high supply – high demand, high supply – low demand, low supply – high demand, low supply – low demand). This approach has also influenced the methodological considerations of this paper.

Common in the above studies is that they have investigated the demand and supply in the context of ecosystem services, yet few studies have sought to measure the spatial aspects of the demand and supply of UGSs. [Xing et al. \(2018\)](#) employed integrated approaches to analyze the spatio-temporal disparities between demand and supply of park green spaces of two traffic modes in 500×500 meters grid scale in the center of Wuhan. The authors used a Gaussian-based 2SFCA method to analyze the spatial accessibility of park green spaces. [Liu et al. \(2020\)](#) proposed a comprehensive framework of recreation service supply and demand assessment. In their work, supply is measured by available UGSs within a certain radius around a residence, whereas demand is characterized by UGS area required by the population for recreation.

In these works, the supply side is generally represented by different types of ecosystem service indicators, or the area of available UGSs, whereas on the demand side, indicators such as population, population density, or income per capita are considered. In this research, we selected some of the demand and supply indicators introduced by previous studies and considered some new ones that better fit our social geographic approach.

3. Study area

This paper uses Budapest, the capital city of Hungary as a case study area. With a population of ca. 1.7 million, Budapest is a major city in post-socialist Central and Eastern Europe. The historical core of the city has evolved gradually for several hundred years. However, after the communist takeover in 1948, the city became subject to a large-scale state-driven industrialization process that gave significant impetus to transforming the urban landscape. At the edge of the compact city, new housing estates were erected containing high-rise prefab buildings surrounded by green areas. Providing home to one-third of the city's population these housing estates have gradually become the landmarks of Budapest, just like in other state-socialist cities in the region. At the same time, the outskirts were almost completely neglected, which led to the uncontrolled development of these

areas. After the collapse of state-socialism, central planning was abolished, urban planning and management was transformed in a quasi-neoliberal manner. Consequently, urban space became impacted by the interest of private developers who only considered the creation of UGS if they increased the market value of the newly developed housing. After the early years of the transition, in Hungary both the central and local governments introduced strict regulations regarding the use of urban space, and in the last decade, the development of UGSs has become a primary urban planning objective.

4. Data and methods

The application of the DSCI requires a database of UGSs, for which we used the Urban Atlas 2018 dataset of Budapest. This contains 700 polygons classified as ‘green urban area’ (land cover category 14100) in the territory of the city. We adopted the data content of the Urban Atlas 2018 as the basis of our analysis, but we attempted to reduce the level of fragmentation caused by roads, promenades, and other artificial surfaces. After conducting distance analysis, we merged the polygons by applying the Aggregate Polygons function in the ArcGIS Cartography Toolbox when two neighboring green areas were not more than 10 meters apart. As a result, we created 457 UGS.

The proposed DSCI method integrates various indicators reflecting potential demand and relative supply concerning green spaces (Table 1). The paper follows previous examples from the literature, where the supply of and demand for parks and ecosystem services were statistically examined (Fernández-Álvarez, 2017; Herreros-Cantis & McPhearson, 2021; Larondelle & Lauf, 2016; Rigolon et al., 2018). To obtain information on the socio-economic characteristics of the population (e.g. age, and per capita income), we used the 100 × 100 database of Geox Ltd., which is a vector grid geometry with a 100 meters grid size, and all subsequent calculations were

performed on these grids or their centroids in ArcGIS and MS Excel. Because similar socioeconomic data are available at the level of census tracts (e.g. Rigolon et al., 2018, 2020), blocks (Pearsall & Eller, 2020) and planning units (Zhang et al., 2021) in many cities around the world, the replication of the proposed method seems to be relatively easy.

While data on the population, age structure, and per capita income were readily available in the 100 × 100 database for the demand index, we had to calculate the total area of green surfaces for the cells. We used the Ecosystem Map of Hungary (EMH) (20 meters resolution raster) for this purpose (with the Tabulate Area tool of Spatial Analyst Tools in ArcGIS) and this data represents the general exposure to green in the residential area.

In the case of the supply index, the three indicators were calculated for each cell by using the Near and Buffer functions of Analysis Tools in ArcGIS. We used variable buffer sizes depending on the area of UGSs, which means that we applied 300 meters buffer zone under 4 hectares, 600 meters buffer zone between 4 and 10 hectares, and 900 meters buffer zone above 10 hectares (see, for example, Chen & Chang, 2015; Grunewald et al., 2017; Schipperijn et al., 2010). Then we counted the UGSs’ buffer zones on each cell’s centroid and summed the area of the respective UGSs to determine the number of available UGSs and per capita area of UGSs for each cell.

In the next step, we exported all data to MS Excel where we normalized the indicators with MIN–MAX normalization. This allowed us to combine indicators with different units of measurement and different scales. The v_i is the normalized value of the indicator between the 0.0-1.0 range, v_i is the value of the indicator in an individual grid, \min_v and \max_v are the minimum and maximum values of that indicator:

$$v_i = \frac{v_i - \min_v}{\max_v - \min_v}$$

Table 1. The description of demand and supply variables constituting the DSCI.

| | Indicator name | The rationale for the variable | Data source |
|---------------------|---|---|---|
| Demand index | Population in 100 × 100 m grids | Basis of demand for UGSs | 100 × 100 database of Geox Ltd. |
| | Population under the age of 18 in 100 × 100 m grids | Priority/sensitive group of UGS users | 100 × 100 database of Geox Ltd. |
| | Population above the age of 63 in 100 × 100 m grids | Priority/sensitive group of UGS users | 100 × 100 database of Geox Ltd. |
| | Per capita income (HUF) in 100 × 100 m grids | Indicator of socio-economic status | 100 × 100 database of Geox Ltd. |
| | Total area of green surfaces in 100 × 100 m grids | Measures the general exposure to green in the residential environment | Own calculation based on the Ecosystem Map of Hungary |
| Supply index | Indicator name | | Data source |
| | Distance of the nearest UGS in m for 100 × 100 m grids | Measures UGS accessibility | Own calculation |
| | Number of UGSs within 300 m/600 m/900 m for 100 × 100 m grids | Measures UGS accessibility | Own calculation |
| | Per capita area of UGSs (sqm/person) 100 × 100 m grids | Measures UGS availability | Own calculation |

In the case of ‘per capita income’, ‘total area of green surfaces’, and ‘distance of the nearest UGS’ we used the inverse formula:

$$v_i = \frac{\max_v - v_i}{\max_v - \min_v}$$

The data of the two indices were classified independently into three classes (low supply/demand, average supply/demand, and high supply/demand) in ArcGIS with Quantile classification. Then a composite index was created which resulted in nine classes. Finally, we merged the nine classes into five main classes (Figure 1): (1) HSS – high supply surplus (i.e. low demand and high supply), (2) HDS – high demand surplus (i.e. high demand and low supply), (3) MSS – moderate supply surplus (i.e. average demand and high supply, and low demand and average supply), (4) MDS – moderate demand surplus (i.e. average demand and low supply, and high demand and average supply), and (5) BDS – balanced demand and supply (i.e. average demand and average supply, low demand and low supply, high demand, and high supply).

We consider the DSCI to be a decision-support tool for urban planning. The DSCI shows the neighborhoods and districts that have balanced demand-supply, deficit, and surplus in the green infrastructure serving the citizens, irrespective of the general green space provision of the city. In addition to a pure service approach, its elements also integrate environmental justice aspects, so its application goes beyond just addressing technical-infrastructure challenges (Fernández-Álvarez, 2017; Herreros-Cantis & McPhearson, 2021; Rigolon et al., 2018). In addition, the results can be compared with data from other

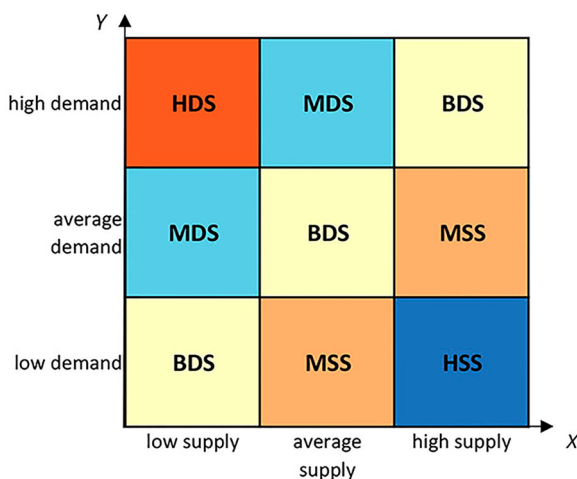


Figure 1. The 3 × 3 matrix graph of the DSCI classes' composition. A 3 × 3 matrix graph in a coordinate system, where the x-axis shows the UGS supply in three categories (low, average, high) and the y-axis shows the UGS demand in three categories (low, average, high). The intersections of categories give the DSCI classes which are indicated in the matrix by the color scheme from the main map and their class names.

sectors/institutions (e.g. education, elderly care, tourism), allowing further conclusions to be drawn for city management and smart-city operations (Benkő et al., 2021; Egedy & Ságvári, 2021).

5. Results

5.1. Main types of residential areas in Budapest

The inhabited area of Budapest contains 23,459 grid cells of 100 × 100 meters. The densely built inner-city accounts for 8.84% of the city's inhabited area. Old tenement buildings with high population density (175.75 people/grid cell on average) characterize the urban landscape of the inner-city. Figure 2 shows that on the Buda side, west of the Danube, the inner-city is surrounded by a broad zone of greenbelt condos, whereas this type of residential area occurs on the Pest side only in smaller patches and loosely connected to the inner-city. The building density of the area of greenbelt condos is lower than that of the inner-city, just like the population density (61.57 people/grid cell on average). The area of greenbelt condos occupies 14.43% of Budapest's inhabited area. Towards the edge of the city, both the average building heights and the building density decrease. The outskirts cover 63.55% of Budapest's area and contain 28.77% of the total population, suggesting that the population density of the outskirts is relatively low (31.74 people/grid cell on average). The outskirts are typically built-up by single-family houses with gardens of various size. Finally, high-rise housing estates containing mostly prefab buildings account for 13.19% of Budapest's inhabited area, concentrating 36.41% of the population. They were built during state-socialism mainly on agricultural and natural land outside the compact city. In the meantime, most housing estates have been surrounded by single-family houses resulting in a mixed urban landscape appearance. The housing estates grid cells contain 193.54 people on average, thus, the population density is the highest in this residential area.

5.2. Spatial distribution of different socio-economic groups

The socio-economic status of households is measured in this study by income as a proxy indicator (Figure 3). People with the highest per capita income live in Budapest in the inner-city and the Buda Hills in the west. These areas have traditionally been the strongholds of upper-middle class, and recent developments reinforced the old pattern. Since the collapse of the communist regime the inner-city of Budapest has experienced a significant urban renewal and upgrading and a concomitant population change (Kovács et al., 2013). During the gentrification process, well-

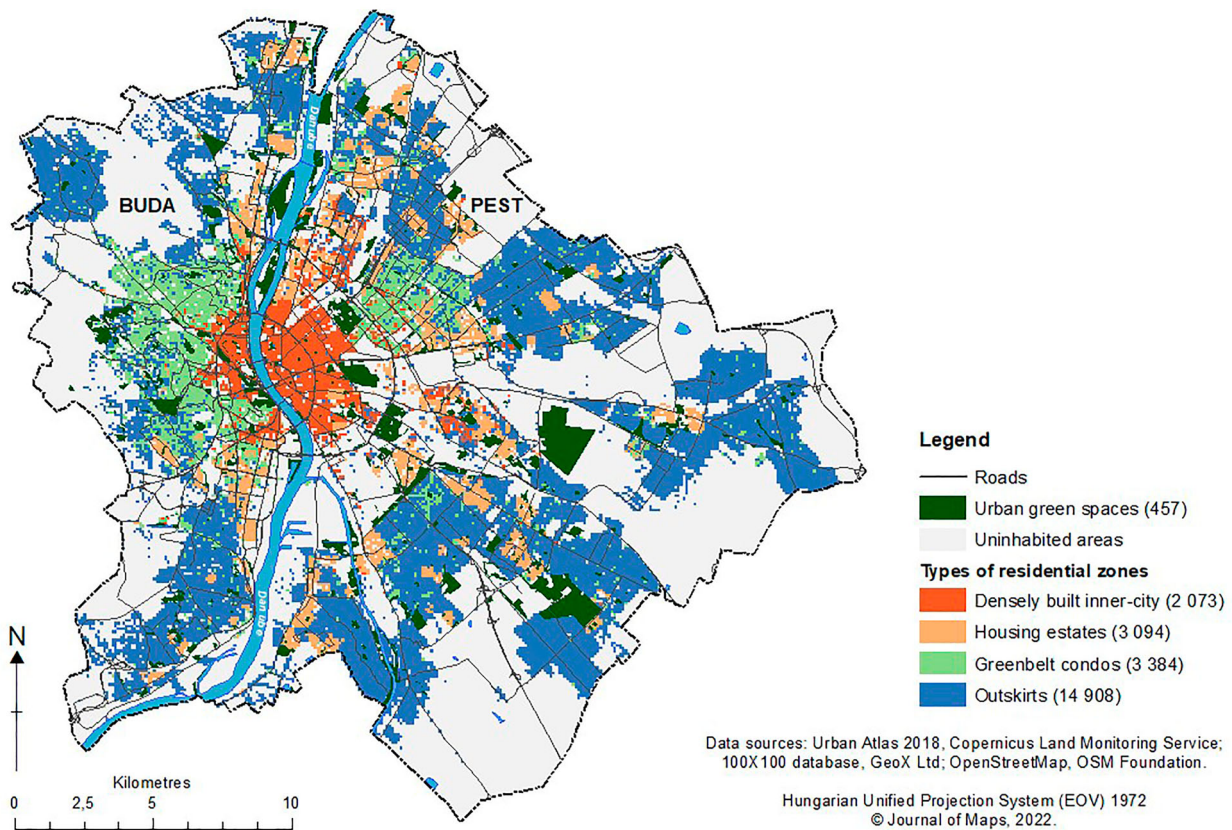


Figure 2. The classification of Budapest’s inhabited area into different residential area types. Map of residential zone types in Budapest. On both banks of the Danube, a densely built inner city is located, surrounded by areas of greenbelt condos, and the outskirts on the edge of the city. High-rise housing estates are located randomly citywide.

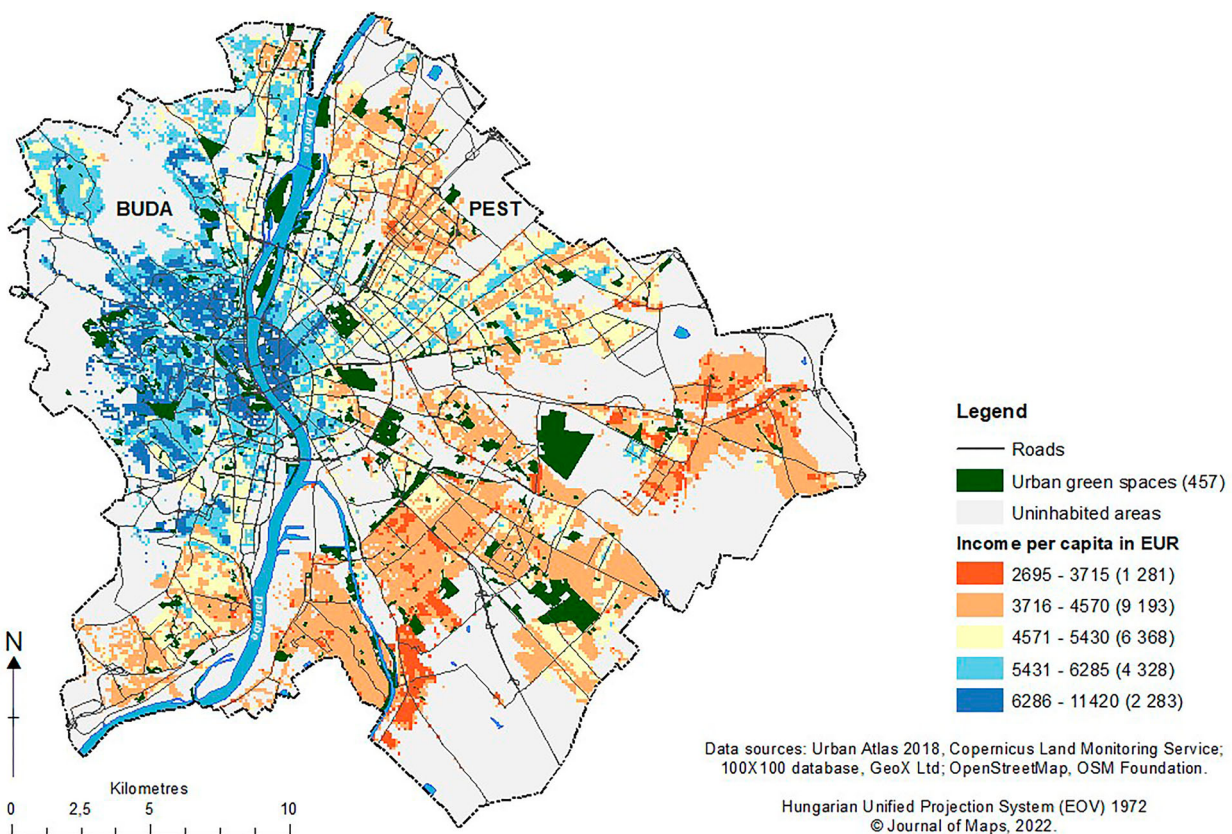


Figure 3. The classification of Budapest’s population based on per capita income. Map of per capita income distribution in Budapest. The most affluent people are located in the inner city, the area of greenbelt condos and the outskirts on the Buda side. These areas, primarily on the Pest side are surrounded by middle-income households. On the Pest side of the city, the outskirts contain mostly low-income people and some segregated areas.

educated higher-income groups and students replaced low-status elderly people (Fabula et al., 2021). The share of children is lowest in the inner-city, whereas the proportion of people with tertiary education second highest which also reinforce the transition (Table 2).

The area of greenbelt condos can be divided into two parts according to per capita income. On the Buda side (West of the Danube), the greenbelt condos concentrate high-status people with higher income levels, whereas the Pest side in the east is rather home to middle-income families. Massive population change is also typical of the greenbelt condos. On the one hand, this residential area contains the highest proportion of elderly people (i.e. aged 63+), and on the other hand, it is also home to the second-highest proportion of children (0–18 years old).

The outskirts show a dual character in terms of the social status of people. On the Buda side, the outskirts offer upmarket housing for the most affluent people. As Table 2 demonstrates, the outskirts host the highest proportion of children and the proportion of people with a higher education is the second lowest in the city.

Finally, housing estates suffer from declining prestige, certain dilapidation, and socio-economic challenges such as the rapid ageing of the population, the outflow of younger and better-off families, and the increasing concentration of low-status residents.

5.3. Mapping the availability of UGS by employing the DSCI classification

According to our research, most grid cells belong to the BDS class (8317), followed by the MDS class

(6785). The BDS class concentrates the highest proportion of residents (41.7%) in Budapest, where UGS is available in an acceptable quantity and at a reasonable walking distance. Except for the outskirts, the highest proportions of people live in the BDS class within each residential area type. Investigating the individual residential area types, we found that the proportion of people living in the BDS class is the highest in large housing estates whereas lowest in the greenbelt condos and the outskirts (31.3 and 31.1% of the population, respectively).

In conclusion, according to our calculations, only 9.9% of the population of Budapest lives in districts that are well equipped with UGS, another 41.7% lives in balanced circumstances (the BDS class), whereas 48.4% of people lives in residential areas that provide less favorable conditions regarding the availability of UGS.

The population distributions across various DSCI classes provide us important information on UGS availability in general, but we must dig deeper to provide reasonable findings for local policies. Table 2 shows that in the HSS class, the proportion of children is the highest. However, the HSS class contains as few as 6705 children. In the demand surplus classes, children account for 16–17% of the population (both the HDS and the MDS), which means 133,382 young people. Hence, the astonishing fact is that 47.84% of the children living in Budapest has an inadequate provision of green spaces. With 24.02%, the proportion of children is the highest in the HSS class of the outskirts. This configuration (i.e. HSS class and outskirts) characterizes the Buda side, the most affluent part of Budapest. The outskirts can also be characterized by

Table 2. Summary statistics of different residential area types and DSCI classes.

| | HDS | MDS | BDS | MSS | HSS | Total / Average |
|---|---------|---------|---------|---------|--------|-----------------|
| Population | 279,817 | 516,072 | 685,896 | 131,939 | 30,972 | 1,644,696 |
| Population (% of the total population) | 17.01 | 31.38 | 41.70 | 8.02 | 1.88 | 100 |
| Densely built inner-city | 62,521 | 132,749 | 153,286 | 13,101 | 2,666 | 364,323 |
| Greenbelt condos | 31,900 | 60,871 | 65,232 | 38,570 | 11,783 | 208,356 |
| Outskirts | 105,953 | 159,373 | 147,021 | 47,520 | 13,340 | 473,207 |
| Housing estates | 79,443 | 163,079 | 320,357 | 32,748 | 3,183 | 598,810 |
| Population aged 0–18 (% of the total population) | 16.72 | 16.78 | 16.64 | 18.65 | 21.65 | 16.95 |
| Densely built inner-city | 13.91 | 13.85 | 15.59 | 16.79 | 16.99 | 14.72 |
| Greenbelt condos | 18.51 | 19.24 | 19.28 | 20.41 | 21.41 | 19.48 |
| Outskirts | 18.71 | 19.69 | 19.80 | 20.98 | 24.02 | 19.76 |
| Housing estates | 15.54 | 15.41 | 15.15 | 13.95 | 16.53 | 15.22 |
| Population aged 63 and above (% of the total population) | 23.76 | 23.98 | 24.76 | 25.91 | 24.94 | 24.44 |
| Densely built inner-city | 21.74 | 22.50 | 22.98 | 24.66 | 27.19 | 22.68 |
| Greenbelt condos | 23.79 | 25.50 | 27.84 | 28.69 | 27.73 | 26.69 |
| Outskirts | 23.61 | 23.65 | 23.41 | 22.86 | 21.68 | 23.43 |
| Housing estates | 25.53 | 24.94 | 25.61 | 27.57 | 26.42 | 25.53 |
| Proportion of people having higher education degree (% of the total population) | 27.04 | 31.04 | 33.14 | 39.70 | 47.57 | 33.32 |
| Densely built inner-city | 38.20 | 39.54 | 40.44 | 52.79 | 55.08 | 41.30 |
| Greenbelt condos | 37.54 | 43.42 | 49.05 | 54.22 | 59.93 | 48.67 |
| Outskirts | 23.76 | 28.21 | 30.86 | 34.95 | 42.89 | 30.12 |
| Housing estates | 28.30 | 27.00 | 25.46 | 28.20 | 31.11 | 26.65 |
| Average income per capita in Euros | 4516 | 4762 | 4917 | 5304 | 5799 | 4914 |
| Densely built inner-city | 5628 | 5835 | 5732 | 6440 | 6726 | 5838 |
| Greenbelt condos | 5060 | 5377 | 5706 | 6103 | 6383 | 5713 |
| Outskirts | 4257 | 4507 | 4700 | 4987 | 5536 | 4655 |
| Housing estates | 4685 | 4672 | 4624 | 4794 | 5079 | 4671 |

the highest proportion of children both in the HDS and MDS classes. This latter configuration, however, applies to the outskirts located on the Pest side of the city. Furthermore, most children live in such areas that provide balanced demand and supply in UGS availability.

Considering the education level and per capita income of people living in different residential areas and DSCI classes, it becomes clear how significantly the socio-economic disparities affect the availability of UGS in Budapest. Except for the housing estates, the proportion of people with higher education degrees increases from the HDS to the HSS classes in each residential area type. This proportion is the highest in the MSS and HSS classes of the inner city and the greenbelt condos. This configuration corresponds with the current trend characterizing cities across Europe (see, for example, [Ali et al., 2020](#); [Oscilowicz et al., 2020](#)): highly skilled and well-educated young people tend to move into some parts of the inner-city and close to UGSs (e.g. pocket parks containing sports facilities), whereas the higher-status young and middle-aged families relocate themselves into greenbelt condos. In general, the less-educated people live in housing estates for which this residential area type provides mostly balanced demand and supply in UGS availability. The outskirts, however, are characterized by the sharpest difference in terms of UGS availability for people living in the HDS/MDS vs. MSS/HSS classes.

Based on [Table 2](#) and the DSCI map, we can also conclude that the city offers better options regarding the availability of UGS for wealthier people. In almost all cases, people's average per capita income increases from the HDS class towards the HSS class. Not surprisingly, the supply surplus classes of the inner city and greenbelt condos concentrate the highest proportions of people with the highest per capita income, suggesting that better-off people can relocate themselves to the vicinity of UGS.

6. Discussion and conclusions

In this paper, we offered a novel methodology to help planning authorities map and interpret the relative availability of green spaces and optimize cities' UGSs more efficiently. The proposed DSCI methodology allowed us to classify the city's inhabited area into five major classes according to the availability of UGSs and identify neighborhoods suffering most from the lack of green spaces and where planning interventions are most needed (i.e. the demand surplus classes should be transformed to be balanced ones, and the balanced status should be maintained). In the following, we briefly summarize our key findings and formulate some policy recommendations:

- (1) We consider the outskirts as being the most problematic areas regarding the availability of UGSs. Currently, most parts of the outskirts belong to the balanced or demand surplus classes, but due to the rapidly changing demography of population in these areas, the demand for UGSs will soon be substantially higher. Therefore, the municipality should consider this problem and adopt new planning approaches and practices, such as greenspace- rather than transport-oriented development strategies ([Bolleter & Ramalho, 2019](#)).
- (2) In many post-socialist cities, inner cities have witnessed rapid gentrification ([Kubeš & Kovács, 2020](#)), rising prestige and population change. In the framework of large-scale state-led regeneration projects, local districts often tended to create pocket parks on the plots of demolished buildings providing better living conditions for new residents, improving the neighborhood's image, and fostering population change. The city has managed to transform the demand surplus into balance in the nearest surroundings of the pocket parks, but demand surplus still characterizes most of the inner-city regarding the availability of UGSs. Therefore, local policies should endeavor to increase the number of pocket parks in the inner-city, and the accessibility of the existing ones simultaneously.
- (3) Finally, a significant part of the large housing estates belongs to the balanced demand–supply class, which means that UGSs are available within a reasonable walking distance for most of their residents. However, urban planners should very carefully monitor the demographic changes of the local population in housing estates. Since the number and share of young families with children is continuously decreasing, and the remaining population shows clear signs of ageing, the ecosystem services of UGSs will require revisions in the future.

Software

ArcGIS 10.6 was used for geoprocessing the spatial datasets and creating the maps.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The Urban Atlas of Budapest for the year 2018 is downloadable after registration from the website of the Copernicus Land Monitoring Service (land.copernicus.eu). The Ecosystem Map of Hungary can be downloaded for research purposes from the project's webpage (<http://alapterkep.termeszem.hu/>). The 100X100 database is a product of Geox Ltd. and can be purchased from the company (see the pricing at the company's website: <http://www.geoindex.hu/tag/100x100-street-index/>)

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