

# A GIS-based assessment of different income groups' access to multiple types of green areas in Budapest, Hungary

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## ABSTRACT

A growing body of literature demonstrates that the accessibility of urban green spaces may differ across ethnic, minority, racial, and socioeconomic groups. In post-socialist Central and Eastern European (CEE) countries, income has become the most critical factor influencing where people may reside in a city, as well as to the extent to which they can access city services. This paper investigates socioeconomic disparities in access to green areas in Budapest, Hungary, taking multiple types of green areas into account, such as urban green spaces (e.g., urban parks and gardens), urban forests, and residential greenery (e.g., private gardens and street trees). People's incomes were considered a proxy measure for socioeconomic status, and the spatial distribution of green areas were analyzed with geographic information system (GIS) tools. The results show that the advantage of wealthier people in terms of urban green space provision is not so pronounced, which is the outcome of a multi-layered historical urban development. However, considering the accessibility of urban forests and residential greenery, high-income people are in a more favorable position than those from other socioeconomic groups. In addition, geography seems to be a crucial constraint for high- and upper-middle income inner-city residents to access urban forests and residential greenery, indicating that factors outside of socioeconomic status influence access to green areas. Future planning policies should attempt to alleviate inequalities in green area provision; however, some inherited and recent issues may jeopardize municipalities' ability to achieve this goal.

## 1. Introduction

One of the essential elements of modern urban planning set by the manifesto of *La charte d'Athènes* is the easy accessibility to Green (Space and Sun) for all residents, regardless of their income and wealth (Corbusier et al., 1943). However, a growing body of literature demonstrates that, across the globe, the accessibility to urban green spaces increasingly differs across socioeconomic groups (Boone et al., 2009; Csomós et al., 2021; Fernandez et al., 2019; In Oh et al., 2020; Suárez et al., 2020; Verheij & Corrêa Nunes, 2021; Wolch et al., 2005, 2014; Yuzhen et al., 2021). Income is often the most influential factor affecting the accessibility of urban green spaces, with the wealthy being, in many cases, privileged. At the same time, racial and ethnic minorities, migrants, homeless people (Iglesias-Pascual et al., 2023), and some other vulnerable groups (e.g., elderly, children, and people with disabilities) often find themselves in a desperate situation considering urban green

space availability and accessibility, which raises concerns over environmental justice (see, for example, Kim et al., 2022; Reyes et al., 2014; Roe et al., 2016; Thomas et al., 2022; Vaz et al., 2017; Venter, Shackleton, et al., 2020; Wen et al., 2013; Wen et al., 2020).

Studying the accessibility of green spaces for different socioeconomic groups has only recently gained attention among researchers and policymakers in the post-socialist countries of CEE (see, for example, Biernacka et al., 2022; Kabisch & Haase, 2014; Kolcsár et al., 2022; Kronenberg et al., 2020; Łaszkiwicz et al., 2018; 2021). Research has demonstrated that post-socialist cities offer unequal opportunities for people of different age, sex, and occupation regarding the availability and accessibility of green spaces (see, for example, Biernacka et al., 2022; Csomós et al., 2020; Csomós et al., 2021; Harper et al., 2009; Kolcsár et al., 2022). However, in most cases, socioeconomic status has been identified as the only factor explaining this uneven accessibility (Farkas et al., 2022; Kronenberg et al., 2020). This paper seeks to show

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that spatial inequalities in the availability and accessibility of urban green spaces can also be interpreted as the legacy of past planning regimes that have privileged different social classes when creating new urban green spaces, eventually resulting in an uneven distribution of such amenities across the city. Therefore, this paper hypothesizes that wealthier citizens are not always favored regarding this availability and accessibility, and some other factors should also be considered to explain and understand the current pattern of urban green space distribution in post-socialist cities. To test our hypothesis, we take Budapest, Hungary's capital city, as a case study.

Budapest is one of the most economically thriving cities of post-socialist CEE and has undergone profound socioeconomic and spatial transformations since the collapse of state-socialism in 1989/90 (Egedy et al., 2017). As an outcome of the country's transition from a centrally planned to a market economy (and similar to other countries in the region), income inequalities started to increase (Marciniczak et al., 2012, 2015; Rose & Viju, 2014), and the gap between rich and poor within society has widened (Kovács, 2012). While in the socialist era, the state made great efforts to reduce the level of segregation through homogenization and egalitarianism in the housing and labor market, the neoliberal regime and its urban planning system have intensified spatial inequalities since the early 1990s (Kovács, 2020; Sager, 2011).

People who have succeeded in taking advantage of the privatization or had sufficient capital to start a business were able to move to newly-built upmarket housing encircling the inner-city, or to residential parks in the outskirts. Due to large-scale urban regeneration programs, some parts of the inner-city have undergone significant social and physical transformations (Kovács et al., 2013), and have witnessed an influx of well-educated, higher-income citizens. Local governments have also fostered gentrification in these neighborhoods by revitalizing public spaces, including parks and other green infrastructure. At the same time, low-income people and those who benefitted least, or even lost out, from the economic restructuring (e.g., blue collar workers, and retired people) have found themselves in the city's least desirable neighborhoods, such as low-quality prefab housing estates (Benkó, 2015) and segregated neighborhoods embedded in former industrial districts.

The current distribution of green areas in Budapest and inequalities in green space provision are rooted in a multi-layered historical development, where three entirely different planning regimes have played a role over the last 150 years. As one of the youngest capital cities in Europe, Budapest was officially established only in 1873, through the unification of three independent towns: Buda, Pest, and Óbuda (Enyedi & Szirmai, 1992). Before 1945, urban planning focused on developing high-density inner-city quarters consisting of four- and five-story tenement blocks. The densely-built central city was surrounded by low-rise poor quality dormitory settlements. The ecological structure of Budapest followed European traditions: elite groups occupied the core, whereas working class people lived in the periphery (see, for example, Harris, 2003; Reick, 2019; Stovall, 2018). Residents' social status gradually diminished from the city center to the outskirts. Urban planning practiced in the pre-socialist period aimed to satisfy the needs of the elite class through the development of city parks, public gardens, and other recreational areas close to the city-center (Enyedi & Szirmai, 1992). The supply of such amenities in the low-status outskirts was not among the planning priorities.

During state-socialism (1946–1990), urban planning primarily focused on finding the best locations for factories and adjoining mass housing complexes built to accommodate tens of thousands of workers (Ouredníček & Kopecká, 2023; Sailer-Fliege, 1999). These multi-story housing estates were equipped with sizeable, but poor-quality, green spaces (Benkó, 2015). The upswing of the urban periphery was accompanied by the neglect and gradual decline of inner districts. In the inner-city, not only the built environment, but also public open spaces (including urban green spaces) became deteriorated. At the time of state-socialism, the maintenance of existing urban green spaces and the creation of new ones were not highly prioritized, but were rather

occasional, leading to a shortage of adequate green areas.

After the collapse of state-socialism in 1989/90, in line with the advent of free-market capitalism and the privatization of land, suburbanization suddenly began to intensify (Brown & Schafft, 2002; García-Ayllon, 2018; Kovács & Tosics, 2014). Housing preferences quickly changed, with single-family homes in suburban locations becoming the dream of many (Kok & Kovács, 1999). Consequently, many households left the city, and the population of Budapest dropped from 2 million to 1.7 million between 1990 and 2010. Among the triggering factors of suburbanization, the lack of adequate urban green spaces and other recreational opportunities in the central city undoubtedly played a role (Kovács & Tosics, 2014). The municipal government of Budapest has realized the problem and has launched a long-term urban development strategy entitled Budapest 2030 (BVFT Ltd., 2013). The strategy notes that the per capita urban green space for recreational purposes is considered low in Budapest (i.e., 5 m<sup>2</sup> per capita) and proposes (BVFT Ltd., 2013: 107) that “New green areas for public purposes (city parks, public parks, public gardens) should be established in unsupplied quarters and in the inner-city lacking in green areas.” While the strategy contains some vague references about where the “unsupplied quarters” are, no evidence is provided about the spatial inequalities of the city's green space provision.

Since previous planning systems have tended to prioritize different socioeconomic groups when creating new urban green spaces (i.e., the elite in the pre-World War II period, the working-class during state-socialism, and high-income groups recently), the contemporary distribution of urban green spaces in Budapest is the outcome of this versatile development. In addition, when assessing the inequalities of the city's green area provision, we considered not only urban green spaces (i.e., parks and gardens) in the analysis, but also urban forests (i.e., forests lying within the city's administrative boundaries), and residential greenery (e.g., private gardens and street trees). We deemed including urban forests into the analysis important because recreational forests may provide equal benefits for visitors as urban green spaces located in the urban fabric, whereas residential greenery provides on-site and local access to nature.

Therefore, using the broad definition of green areas (i.e., urban green spaces, urban forests, and residential greenery), this paper aims to provide a deeper understanding of the inequalities in the availability of green spaces and their accessibility for different socioeconomic groups.

The main objectives of the paper are as follows.

- 1) To map and assess the availability of different types of green areas (including urban green spaces, urban forests, and residential greenery) for different socioeconomic groups in Budapest.
- 2) To explore the relationship between people's income (taken as a proxy for socioeconomic status) and accessibility of green areas.
- 3) To measure differences regarding the potential use of green areas by different socioeconomic groups.

This paper is structured as follows: in the following section, we briefly introduce the research design, describing the study area and research methods. Then, we present the main findings of the research. This is followed by the discussion of the results and, finally, the presentation of the conclusions.

## 2. Data and methods

### 2.1. Data sources

For the analysis, data were sourced from GeoX Ltd., Urban Atlas 2018, Hungary's Ecosystem Basemap, Budapest's zoning plan, and the nationally designated area's database by the European Environmental Agency. In the following, we provide a detailed description of the data used for the analysis:

*Residential area types and net income data:* GeoX Ltd. is a private

company that provides various types of GIS databases, including 100 × 100m vector grid geometry databases of building zone types and socioeconomic data (<https://geox.hu/en/business-solutions/business-database/100x100-geo-demographic-map/>). GeoX Ltd. calculates the net income per capita for each populated 100 × 100m grid cell on a yearly basis. The grid level data is derived from municipal level income data and external variables, such as real estate prices, housing types, and household age structure. Accordingly, we obtained a net income database of 23,459 inhabited grid cells in Budapest.

**Income classes:** In spatial research, income quintiles are commonly used to explore socioeconomic disparities (see, for example, Garrett et al., 2020; Iglesias et al., 2019; Jonker et al., 2014). We classified the 23,459 inhabited grid cells into 5 income classes based on data provided by GeoX Ltd. The income classes are as follows: 1) low-income class: 2482–3779 EUR net per capita income/year (4696 grid cells); 2) lower middle-income class: 3780–4116 EUR net per capita income/year (4720 grid cells); 3) middle-income class: 4117–4584 EUR net per capita income/year (4689 grid cells); 4) upper middle-income class: 4585–5334 EUR net per capita income/year (4687 grid cells); and 5) high-income class: 5335–10,518 net per capita income/year (4667 grid cells).

**Urban green spaces and urban forests:** Urban Atlas 2018 is provided by Copernicus Land Monitoring Service. Urban Atlas gives detailed land cover/land use maps for 788 Functional Urban Areas across Europe, in addition to street tree maps, building block height measurements, and population estimates. In this analysis, we considered two land use/land cover categories, indicated by codes “14100” (green urban areas) and “31000” (forests) in Urban Atlas ([https://land.copernicus.eu/en/technical-library/urban\\_atlas\\_2012\\_2018\\_mapping\\_guide/@download/file](https://land.copernicus.eu/en/technical-library/urban_atlas_2012_2018_mapping_guide/@download/file)). After retrieving data from Urban Atlas, we merged green urban areas lying within 10 m from each other to avoid over fragmentation. Finally, our database contained 457 urban green spaces in Budapest.

**Residential greenery:** We used Hungary’s Ecosystem Basemap to determine the proportion of residential greenery for 100 × 100m grid cells. The Ecosystem Basemap provides complete coverage of urban ecosystems (<http://alapterkep.termesztet.hu/>).

**Nature conservation areas and protected forests:** The European Environmental Agency provides a database of nationally designated areas (version 20) for the year 2022, which is the official source of protected area information from the 38 European member countries to the World Database of Protected Areas. Data of nationally designated areas are freely available in the European Environmental Agency’s Datahub (<https://www.eea.europa.eu/en/datahub/datahubitem-view/f60cec02-6494-4d08-b12d-17a37012cb28>).

For the GIS analysis and mapping, we used ESRI’s ArcGIS 10.8.

## 2.2. Study area

With approximately 1.64 million inhabitants and a total area of 525 square kilometers, Budapest is one of the most populous cities and a major economic and cultural hub in the post-socialist CEE region (Keresztély & Scott, 2012). Budapest’s physical layout is relatively simple: the Danube River divides the city into two parts. The western Buda side is characterized by a hilly topography, whereas the eastern Pest side is a plain area, allowing the city to increase its urban fabric toward the east and southeast.

### 2.2.1. The distribution of the population by residential area types

Budapest’s inhabited area can essentially be classified into four main residential area types: 1) the inner-city, with many historical buildings, high built-up ratios, and high population density; 2) the socialist housing estates, containing 5–10-storey prefabricated buildings (built predominantly in the 1970s and ‘80s) and 2–4-storey brick buildings (built in the 1950s and ‘60s); 3) the areas of greenbelt condos enriched with a

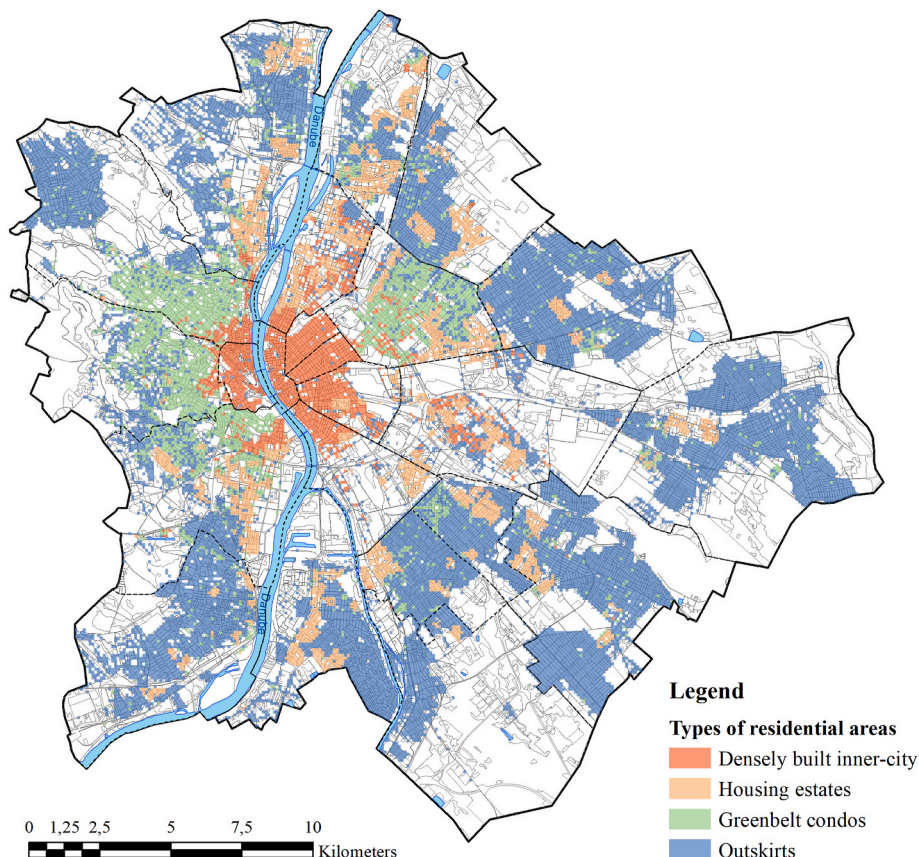


Fig. 1. Classification of Budapest’s inhabited areas into residential area types.

high proportion of residential greenery; and 4) the outskirts occupied by single-family houses with private gardens (Fig. 1).

As shown in Table 1, the most populous residential area type contains the large-scale housing estates, providing homes to over a third of Budapest's population (36.4%). This residential area type has the highest population density (Benkő, 2015). In contrast, the average population density in the outskirts is extremely low, although these residential areas host the second largest group of people in the city. Overall, the outskirts encompass an area almost five times greater than that of the housing estates and occupy 63.6% of Budapest's total inhabited area.

The greenbelt condos and the outskirts can be characterized by the highest proportion of children. We assume that this pattern is partly due to the Family Housing Allowance program introduced by the Hungarian government in 2015, aiming to provide financial aid and low interest loans for young families having (or planning to have) three children, thus allowing them to build a new family house or purchase an apartment in a newly built condominium. The proportion of children and the elderly is the lowest in the inner-city, suggesting that this residential zone hosts the highest proportion of working-age people. Since the early 1990s, some inner-city neighborhoods have been affected by large-scale regeneration projects and subsequent gentrification (Csanádi et al., 2011; Kovács, 2009; Kovács et al., 2013; Kubeš & Kovács, 2020), which serves to explain the current demographic structure and the high proportion of people with tertiary education (Table 1).

#### 2.2.2. Distribution of Budapest's population by income class

We considered income as a proxy for socioeconomic status. Based on net per capita income, we classified Budapest's population into five income classes. As shown in Table 2, the majority (65.5%) of Budapest's population belongs to one of the middle-income class categories, whereas the proportions of the low- and high-income classes are much smaller (13.4% and 21.1%, respectively). The proportions of children and the elderly are the highest in the high-income class. However, no significant differences in age structure could be detected across the income classes.

The number of people per household is the highest in areas occupied by the low-income class (2.7), and the lowest in high-income areas (2.1).

However, the differences are significant when considering people's education by income class: while over 50.3% of people belonging to the high-income class have tertiary education, this share is only 20.4% for the low-income class.

As Fig. 2 shows, the spatial distribution of income groups reveals a marked spatial pattern. High- and upper middle-income people mainly reside in the inner-city, on the Buda side, and in a zone stretching between the inner-city and the north-eastern edge. Low- and lower middle-income people tend to concentrate on the Pest side, primarily on the city's southern, south-eastern, eastern, and north-eastern parts. However, these residential zones also contain some enclaves of more affluent groups.

**Table 1**  
Indicators of the population by residential area types in Budapest.

	Population	Number of households	Population density (people/km <sup>2</sup> )	Tertiary education ratio (% of the class's population)	Population ages 0–18 (% of the class's population)	Population ages 63 and above (% of the class's population)
Inner-city	364,323	184,488	17,575	40.4	14.7	22.7
Outskirts	473,207	152,269	3174	29.2	19.8	23.4
Housing estates	598,810	271,614	19,354	25.3	15.2	25.5
Greenbelt condos	208,356	93,001	6157	47.5	19.5	26.7
<i>Total/Average</i>	<i>1,644,696</i>	<i>701,372</i>	<i>7011</i>	<i>32.6</i>	<i>17.0</i>	<i>24.4</i>

### 3. Results

#### 3.1. Mapping the availability of urban green spaces

As a first step of the analysis, we wanted to demonstrate which socioeconomic groups have better access to urban green spaces (i.e., public parks and public gardens) in Budapest. For this purpose, we mapped urban green spaces' catchment areas using an isodistance approach. To define a catchment area, we chose a 500-m walking distance, which corresponds to approximately 10-min walking time and is frequently used in similar research to map urban green space accessibility (see, for example, Chen & Chang, 2015; De Sousa Silva et al., 2018; Wüstemann et al., 2017).

As per Fig. 3, urban green spaces' catchment areas cover a significant part of Budapest's inhabited areas. It can also be observed that residential areas with no access to urban green spaces within a 500-m walking distance are mostly located with the city's fringes. These unsupplied areas are home to 14.8% of Budapest's population, meaning that 85.2% of residents have relatively good access to urban green spaces (Table 3).

Many studies have demonstrated that there is a relationship between income and urban green space availability: those with higher incomes tend to have more urban green spaces within a reasonable walking distance (see, for example, Astell-Burt et al., 2014; Csomós et al., 2021; Evans & Kantrowitz, 2002; Talen, 1997). Table 3 shows that, in Budapest, high-income people indeed live closer to urban green spaces than their low-income counterparts, but the difference between the average distances they need to walk to the nearest urban green space is not significant (less than 10%).

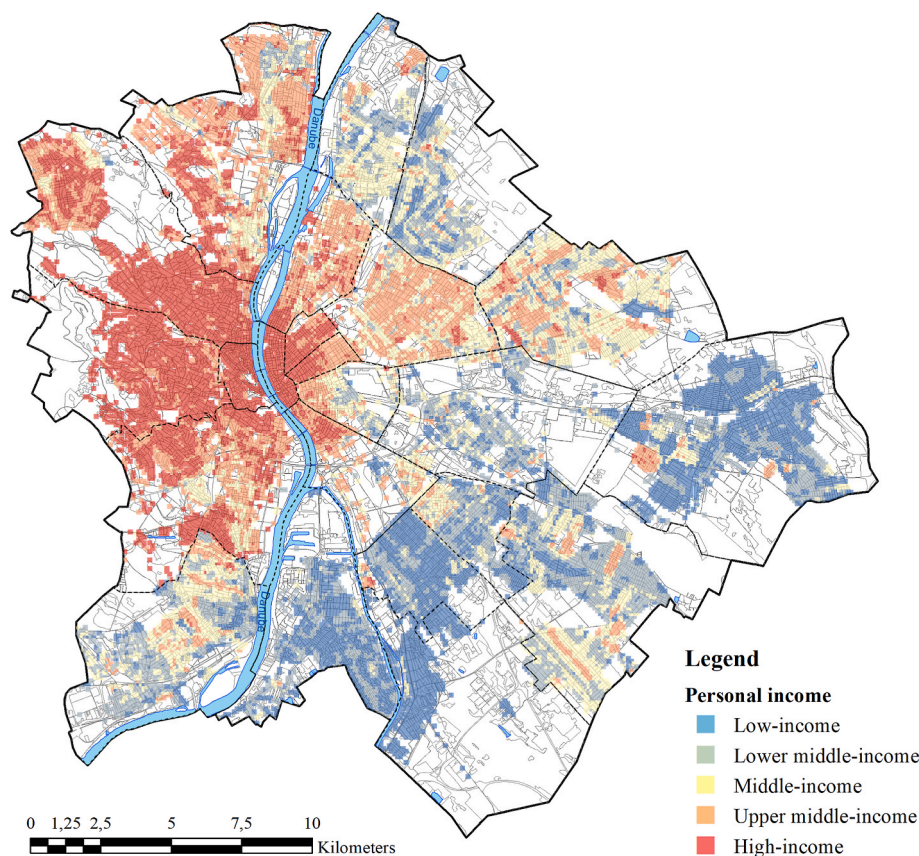
Further analyzing Table 3, the proportion of individuals lacking access to urban green spaces within a reasonable walking distance is only 9.8% in the high-income class, while this share exceeds 20% for low-income individuals (the average for other groups is approximately 15%). It is worth noting that over 240,000 residents who reside outside this 500-m accessibility zone must, on average, walk an additional 575 m to reach the nearest park. These findings may raise concerns about environmental justice. However, compared to the proportion of people with easy access to urban green spaces, inequalities in accessibility do not appear to be a critical issue in Budapest. This conclusion is further supported by the fact that the lack of convenient access to urban green spaces also impacts a significant number of high-income residents.

#### 3.2. Mapping the availability of urban forests

To refine the overall picture on the accessibility of green areas in Budapest, urban forests were also considered as a second step of the analysis. Urban forests are located within the city's administrative boundary, typically in outer urban areas adjacent to the city's built-up area. In most cases (except for those privately owned), they are maintained by the municipality or a state forestry company. To explore socioeconomic disparities in the accessibility of urban forests, catchment areas using 500-m walking distances were mapped, as in the case of urban green spaces. The results confirm that those living in the outskirts or in the greenbelt condos on the Buda side have much better access to

**Table 2**  
Distribution of Budapest's population by income class.

Income classes	Population	Number of households	Tertiary education ratio (% of the class's population)	Population ages 0–18 (% of the class's population)	Population ages 63 and above (% of the class's population)
Low	220,426	80,983	20.4	17.0	24.5
Lower middle	322,480	127,543	21.8	16.7	24.2
Middle	371,512	157,332	27.4	16.7	24.7
Upper middle	383,779	172,871	37.6	16.9	23.7
High	346,499	162,643	50.3	17.6	25.3
<b>Total</b>	<b>1,644,696</b>	<b>701,372</b>	<b>32.6</b>	<b>17.0</b>	<b>24.4</b>



**Fig. 2.** The spatial pattern of income classes in Budapest.

urban forests than residents of the compact inner-city and housing estates (see Figs. 4 and 1).

As Table 4 shows, more low- and lower middle-income people have access to urban forests within 500 m than high- and upper middle-income people. For example, 22.5% of low-income residents have easy access to urban forests compared to high-income people, of whom only 13.3% can access an urban forest within 500 m. Moreover, upper middle-income people are in the worst position in terms of urban forest availability, as 89.9% cannot find an urban forest within a reasonable walking distance. Additionally, the nearest urban forest lies approximately 1.2 km from low-income people on average compared to high-income people, for whom the nearest urban forest is almost 2 km away.

However, if quality aspects are included in the analysis, the picture becomes clearer. As shown in Fig. 4, protected urban forests, part of a nature conservation area, are located predominantly on the Buda side of the city. These are high-quality and well-maintained urban forests with the primary goal of being recreational spaces for residents, and they deliver high-level cultural ecosystem services (Buzási & Jäger, 2020). In contrast, other urban forests serve different purposes, such as protecting

residential areas against air and noise pollution from highway and railway traffic, providing lumber for construction, and firewood for heating. Table 5 shows that only a handful of low- and lower middle-income people live near protected urban forests, while over 9% of high-income people (i.e., the elite of Budapest's population) reside in such areas. Since protected urban forests are located almost exclusively on the Buda side (Buzási & Jäger, 2020), it is unsurprising that low- and lower middle-income people, mostly living on the Pest side, face distances of approximately 10 km to reach a high-quality urban forest. This distance remains under 3 km on average for high-income people, which seems relatively small, considering that a significant share of them reside in the inner-city.

In conclusion, the availability of urban forests is determined by the basic geographical features of the city: because urban forests are located adjacent to the city's peripheral residential areas, residents of those areas have the best access to such amenities. In addition, a significant proportion of high- and upper middle-income people, primarily younger adults, tend to reside in gentrifying inner-city neighborhoods that are cut off from forests, while low-income and marginalized people are often

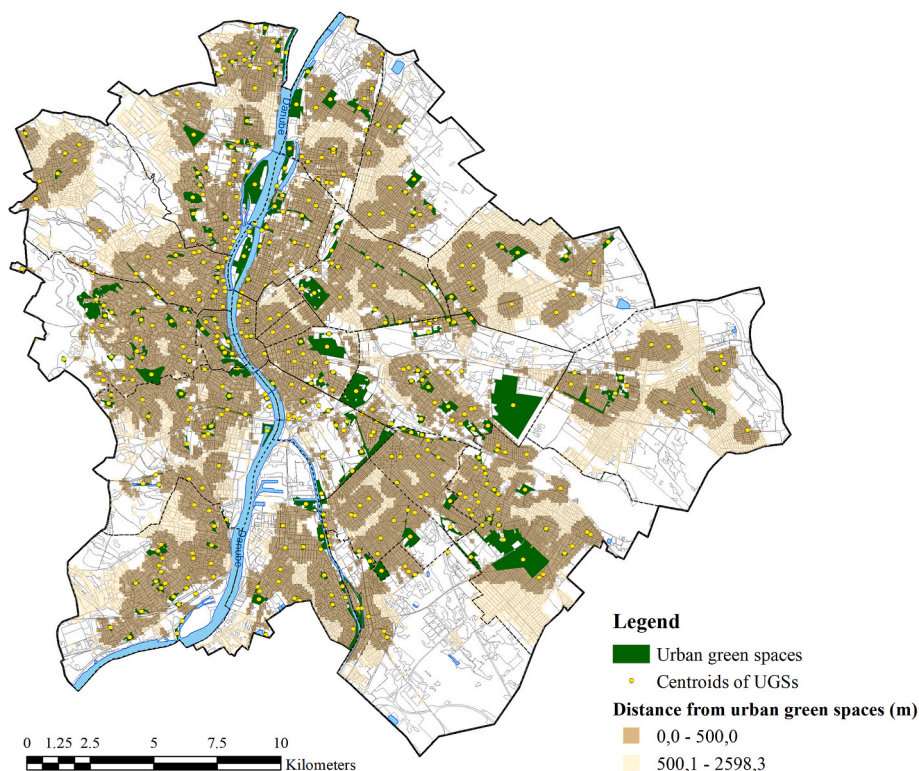


Fig. 3. Mapping urban green spaces' catchment areas based on a 500-m walking distance in Budapest.

Table 3

Population with and without access to urban green spaces within 500 m by income class.

Income classes	Access to UGSs within 500 m			No access to UGSs within 500 m		
	Population	Proportion of people in the income class (%)	Average distance from the nearest UGS (m)	Population	Proportion of people in the income class (%)	Average distance from the nearest UGS (m)
Low	176,318	80.0	228	44,108	20.0	827
Lower middle	275,879	85.6	225	46,601	14.5	858
Middle	310,046	83.5	227	61,466	16.5	812
Upper middle	372,241	85.5	235	63,143	14.5	755
High	266,087	90.2	208	28,807	9.8	745
Total/ Average	1,400,571	85.2	225	244,125	14.8	806

edged out of the inner-city to peripheral neighborhoods, where the urban forests of a lower quality are also located (Kovács et al., 2013; Kubeš & Kovács, 2020). Therefore, when considering quality aspects by including the protected urban forests into the analysis, the favorable position of high-income people on the Buda compared to any other residents in the city becomes obvious.

### 3.3. Mapping the availability of residential greenery

As the third step of the analysis, we explored the availability of residential greenery for different socioeconomic groups. Residential greenery is defined as green patches around buildings that cannot be classified as urban green spaces (i.e., public parks and gardens) nor urban forests. They are usually small-scale, fragmented green surfaces (e.g., street trees and walking paths), often in private or semi-private use (e.g., private gardens and backyards). Nevertheless, these green areas play an important role in improving urban residents' health and well-being, as well as the ecosystem services the city provides (Schmid & Säumel, 2021). Therefore, residential greenery should also be considered so as to obtain a more complex picture of green area availability.

The average proportion of residential greenery in Budapest is 31.6%, meaning that almost one-third of a 100 × 100m grid of inhabited area is covered by greenery. This value is lower for people residing within a 500-m walking distance than for those who have no access to urban green spaces within such a perimeter. Therefore, the higher availability of residential greenery for people living away from other forms of urban green spaces could be classed as a form of compensation for their disadvantageous circumstances. However, this compensation is not equal. As Table 6 shows, residential greenery is more available for high- than low-income residents.

From Table 7 and Fig. 5, it also becomes clear that high-income people do not equally benefit from the high proportion of residential greenery in Budapest either. Those residing in villas and greenbelt condos in the more affluent quarters of the Buda side enjoy a much higher proportion of residential greenery than their high-income peers in the inner-city (55.4 and 43.2 vs. 7.8%). The proportion of residential greenery is the lowest for upper middle-income people living in the inner-city (5.8%). Indeed, for them, the average distance from the nearest urban green space is higher than for any other income classes (over 280 m in the inner city). This means that upper-middle income

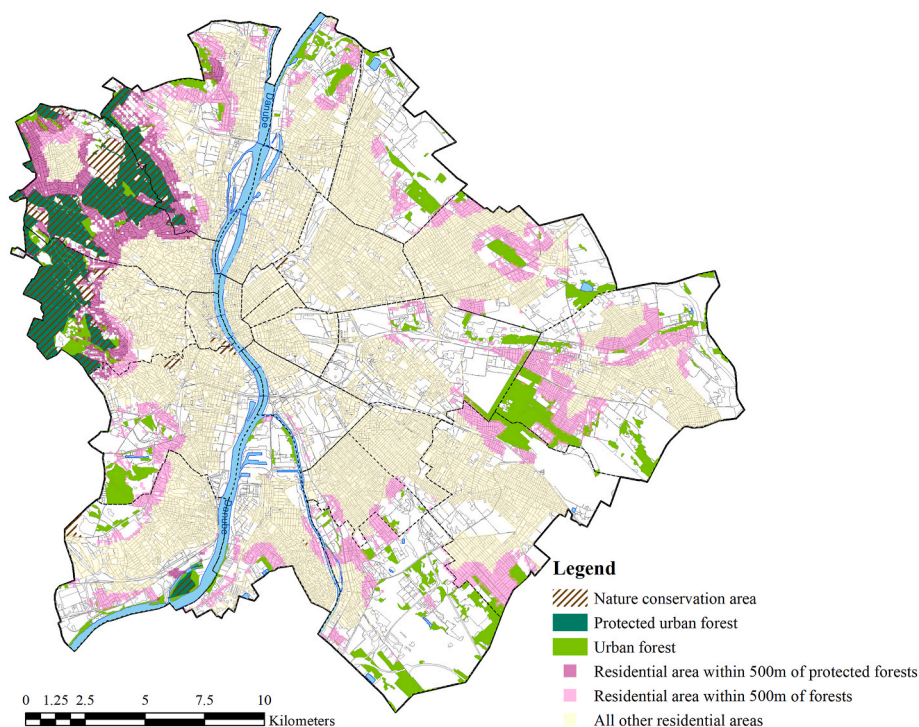


Fig. 4. Mapping urban forests and protected urban forests' catchment areas based on 500-m walking distances in Budapest.

**Table 4**  
Population with and without access to urban forests within 500 m by income class.

Income classes	Access to urban forests within 500 m			No access to urban forests within 500 m		
	Population	Proportion of people in the income class (%)	Average distance from the nearest urban forest (m)	Population	Proportion of people in the income class (%)	Average distance from the nearest urban forest (m)
Low	49,603	22.5	239	170,823	77.5	1207
Lower middle	54,697	17.0	248	267,783	83.0	1389
Middle	55,198	14.9	254	316,314	85.1	1519
Upper middle	43,966	10.1	195	391,418	89.9	1934
High	39,126	13.3	180	255,768	86.7	2018
Total/ Average	242,590	14.8	221	1,402,106	85.3	1607

**Table 5**  
Population with and without access to protected urban forests within 500 m by income class.

Income classes	Access to protected urban forests within 500 m			No access to protected urban forests within 500 m		
	Population	Proportion of people in the income class (%)	Average distance from the nearest protected urban forest (m)	Population	Proportion of people in the income class (%)	Average distance from the nearest protected urban forest (m)
Low	78	0.04	281	220,348	99.96	10,706
Lower middle	134	0.04	355	322,346	99.96	9281
Middle	1558	0.42	281	369,954	99.58	8175
Upper middle	15,113	3.47	203	420,271	96.53	5614
High	26,631	9.03	192	268,263	90.97	2721
Total/ Average	43,514	2.65	202	1,601,182	97.35	8175

people in the inner-city are in a less favorable position in terms of access to urban green spaces than low-income people.

In the inner-city, the proportion of residential greenery for low-income people is unexpectedly high: 23.7% (i.e., three times higher than for high-income people). However, we must note that very few low-income people live in the inner-city, whereas upper middle- and high-

income people account for 87% of inner-city residents.

The smallest differences in terms of both the proportion of residential greenery and the average distance to urban green spaces across income groups can be observed in large housing estates built in the state-socialist period. Since masses of people live together in these residential areas in spatially concentrated high-rise buildings surrounded by

**Table 6**  
The proportion of residential greenery in Budapest by income class.

Income classes	Proportion of residential greenery (%)	Proportion of residential greenery for those having access to urban green spaces in 500 m (%)	Proportion of residential greenery for those having no access to urban green spaces in 500 m (%)
Low	28.7	25.8	36.0
Lower middle	29.5	26.8	36.6
Middle	30.5	28.7	34.8
Upper middle	31.4	29.2	39.2
High	39.0	36.9	49.5
Average	31.6	29.4	38.0

**Table 7**  
Residential greenery by income class and residential area type.

Income class	Inner-city (high built-up ratio)	Outskirts	Housing estates	Greenbelt condos
	Residential greenery (%)			
Low	23.7	29.6	20.6	25.4
Lower middle	12.9	31.9	24.3	20.3
Middle	9.0	35.4	22.4	22.9
Upper middle	5.8	43.8	24.1	25.0
High	7.8	55.4	17.8	43.2
Total/Average	7.7	36.4	23.0	32.7

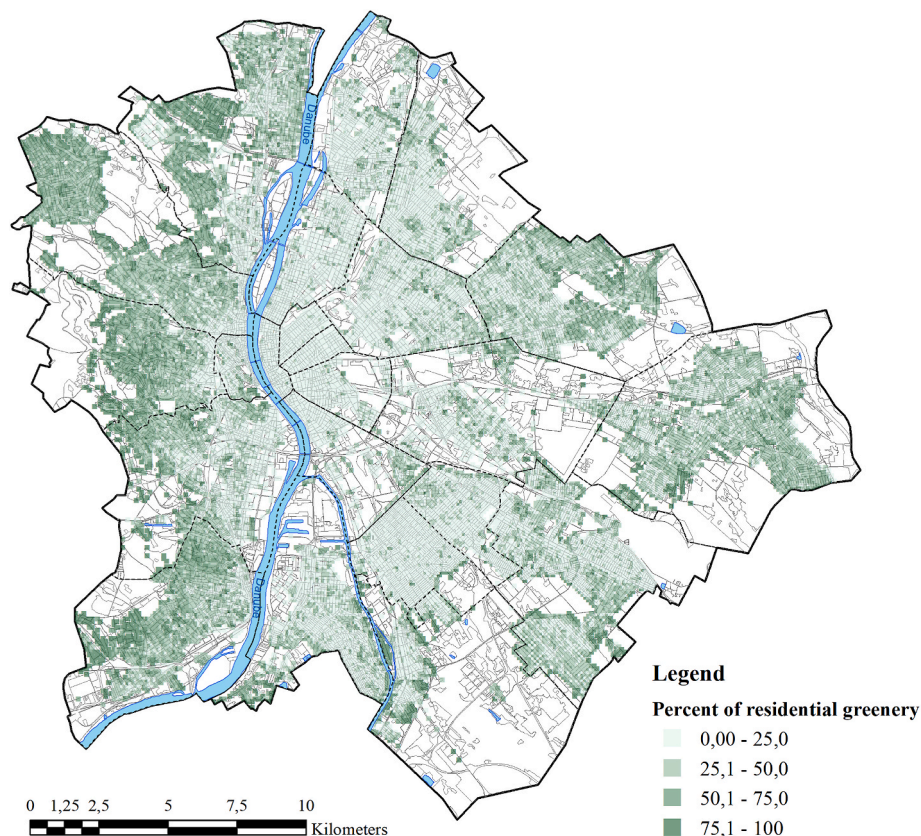
urban green spaces, income has little impact on the access to, and availability of, urban green spaces and residential greenery.

#### 4. Discussion

It has been widely studied that the distribution of environmental goods (e.g., urban green spaces) is often unequal in cities (Schlosberg, 2004; Schweitzer & Stephenson, 2007). For example, in many cases, unprivileged populations, low-income people, and racial, ethnic, and minority groups have disproportionately less access to nature in the city (Pham et al., 2012; Wolch et al., 2014). This might raise environmental justice concerns, considering that urban green spaces and other green areas provide recreational opportunities for inhabitants, positively impacting park users' physical activity and health conditions and contributing to the reduction of chronic diseases and mortality (Bedimo-Rung et al., 2005; Biedenweg et al., 2019; Cohen et al., 2007; Kaczynski & Henderson, 2007). The accessibility of urban green spaces and other green urban areas is often used as a proxy of distributive environmental justice (Kronenberg et al., 2020).

Against the backdrop, this study investigated socioeconomic disparities in the accessibility of multiple types of green areas (i.e., urban green spaces, urban forests, and residential greenery) in Budapest, based on a GIS analysis. Our main goal was to explore whether people's income affects their accessibility to green areas in a post-socialist city, which has developed under various urban planning regimes during the last 150 years. In most CEE countries, income has become the most crucial factor in sorting people across the city (Tammara et al., 2021). This might suggest that wealthier residents have more green areas available to them than their lower-income counterparts (see, for example, Farkas et al., 2022; Kronenberg et al., 2020), but our study demonstrates that the picture is slightly more complicated.

The results show that people with higher incomes are slightly better supplied with *urban green spaces* than low- and lower middle-income



**Fig. 5.** Proportion of residential greenery in Budapest in 100 × 100m grids.

people, but the difference does not seem to be dramatic (5–10%). Nevertheless, it is quite challenging for municipal and district governments to supply low-income people with more urban green spaces due to their owning hardly any tracts of land in the outskirts that could be converted into urban green spaces. In the socialist era, the outskirts evolved under soft planning control, and the local authorities did not prioritize providing local people with such amenities as urban green spaces. In contrast, supplying inner-city neighborhoods with green areas has always been a goal of urban planning because, among other things, the inner-city hosts many public and governmental buildings, and attracts the majority of tourism, so the urban landscape is visible both to decision-makers and visitors. Therefore, inner-city neighborhoods, increasingly occupied by high-income people, are well-equipped with many small and mid-sized urban green spaces (e.g., block parks). Moreover, in the state-socialist era, the newly-erected housing estates accommodating primarily the working class and other low-income groups, were built on large vacant semi-natural and agricultural lands, some of which were later converted into urban green spaces.

Regarding the accessibility to *urban forests*, we can conclude that people living in the outskirts are somewhat compensated for their disadvantageous position in the availability of urban green spaces. Urban forests in Budapest are mostly located in outer urban areas within the city's administrative boundaries, generally adjacent to the outskirts. Since the outskirts are typically occupied by high-income people (on the Buda side) and low-income people (on the Pest side), these groups have the easiest access to urban forests. Based on this pattern, we can conclude that people's access to urban forests is constrained by geography: those living closer to the periphery of the city's built-up areas can find an urban forest closer to their homes. For example, high- and upper-middle income inner-city residents, but also those living in housing estates, cannot access such amenities within a reasonable walking distance. In contrast to urban green spaces, there is an apparent difference between urban forests in terms of quality: protected recreational forests exhibit a much higher quality than any other forests across the city. Our findings show that protected urban forests effectively serve the recreational demands of high-income people (i.e., the elite), while the access to such areas requires a considerable amount of time and effort from people in all other income groups, even from high-income inner-city residents.

Finally, we delved into the availability of *residential greenery* (i.e., private gardens and street trees) for different socioeconomic groups. The results show that, in most cases, a higher share of residential greenery is available for wealthier people than for those from lower-income groups. This pattern could be explained as follows: the more money people earn, the larger plots and richer greenery they can afford. However, we discovered an unexpected deviation from this pattern: in the inner-city, people belonging to lower socioeconomic status have a higher share of residential greenery. This is due to low-income inner-city residents having a tendency to move into previously working-class neighborhoods at the periphery of the inner-city where the primary purpose of greenery (mainly trees and shrubs) is to separate residential areas from adjacent industrial areas and large-scale transportation facilities. Of course, "quality" is not considered the most important determinant of these green areas.

The current pattern of green area distribution in post-socialist cities is the outcome of subsequent planning regimes (Enyedi, 1992; Enyedi & Szirmai, 1992) that preferred different people regarding urban green space provision, depending on the dominant political trend. Accordingly, municipal governments' urban green space developments have targeted different areas of the city, often occupied by people of different socioeconomic status. The quality and layout of these urban green spaces, as well as the diversity of ecosystem services they provided, varied based on the prestige of the surrounding urban fabric and the conceived demands of local people toward such amenities (Buzási & Jäger, 2020). Consequently, the inner-city neighborhoods were supplied with small urban green spaces (Csomós et al., 2023), such as block parks,

providing high aesthetic values. The inner-city and adjacent industrial zones were separated with low-quality greenery that, on the other hand, would not require regular maintenance. In addition, densely-populated housing estates were surrounded by large-scale green spaces offering multifunctional use but low aesthetic values (Kristiánová, 2016; Sailer-Fliege, 1999). Our findings reaffirm that most people in Budapest can find an urban green space within a 500-m walking distance. This is even true of those in the outskirts, whose development has often been overlooked by planners.

Due to people's intra-urban migration having been experienced in post-socialist cities in the last decades (see, for example, Kährlik et al., 2016; Maleszyk & Kędra, 2020; Marcinićzak et al., 2012; Ouređnčėk & Kopecká, 2023; Sýkora, 1999), there may be people in any socioeconomic class with reasonable and less adequate accessibility to urban green spaces; that is, no significant differences can be detected across socioeconomic classes in this regard.

As for the residential greenery, the municipalities have imposed and enforced regulations about the minimum ratio of building plots' greenery cover with varying rigor. Whereas such regulations existed in the socialist era, local authorities did not usually scrutinize whether developers and individuals followed the rules. Since the collapse of the communist regime, both the regulations and their enforcement have become more rigorous and effective. Naturally, high-income people can afford to create larger and more attractive private gardens, whereas private developers occasionally try to manipulate local decision-makers, so that the developments could contain a smaller proportion of greenery ratio than required.

Due to geographic reasons, protected urban forests lie on the city's Buda side (Buzási & Jäger, 2020), and it is unsurprising that the wealthiest people try to relocate themselves to the vicinity of such amenities. Moreover, national parks and state forest companies that maintain protected urban forests sometimes encounter illegal constructions by prominent people, and the razing of buildings is a significant challenge even if a demolition order has been issued by court.

According to Budapest's most recent urban development strategy, *Budapest 2030* (BVFT Ltd., 2013), the municipal government is planning to create several large urban parks around the inner-city to satisfy all residents' needs for urban green spaces. The strategy further proposes that urban green spaces with local significance should be created in the outskirts, which are predominantly inhabited by low-income residents. This strategy looks a step forward toward increasing urban green space supply for not only low-income outskirts residents, but also high-income people in the inner-city.

However, we found three risk factors that may jeopardize the municipal government's goals. First, low-income people have limited power to influence local governments' planning decisions due to their socioeconomic status. Occasionally, local governments run out of money before completing development projects. If urban green space developments targeting low-income people are not prioritized at the outset, they tend not to be completed.

Second, housing estates composed of high-rise prefab buildings in post-socialist cities, including Budapest, face major environmental challenges. When housing estates were built in the state-socialist era, only few people could afford to buy a private car (Péteri, 2009); therefore, equipping housing estates with parking lots was often neglected (the number of private cars per 1000 people in 1970: 23; 1985: 136). However, in recent decades, people's incomes have significantly increased in Hungary (and especially in Budapest), allowing households to own one or more private cars (the number of private cars per 1000 people in 2020: 401). The dramatic increase in car use requires more parking space areas, which is currently unavailable in housing estates. For example, some mayors have recently proposed that public urban green spaces should be converted into parking spaces, which would clearly result in a severe decline in urban green space availability.

Third, lessons learned from the COVID-19 pandemic may affect what green developments municipalities will foreground. During the

lockdowns imposed by governments worldwide to prevent the spread of the virus, the importance of locally-available urban green spaces has become evident, primarily in densely-built inner-city neighborhoods (see, for example, Bereczki et al., 2024; Geng et al., 2021; Liu et al., 2024; Liu & Wang, 2021; Venter, Barton, et al., 2020). For example, inner-city residents with scarce access to residential greenery (e.g., private gardens) experienced a dramatic shortage of urban green spaces during the pandemic. In conclusion, municipalities may consider the supply of inner-city residents with more urban green spaces a top priority, thereby indirectly favoring high-income people over low-income outskirts residents.

## 5. Conclusions

In this paper, we mapped and assessed the extent to which Budapest's inhabitants have access to multiple types of green areas, including urban green spaces, urban forests, and residential greenery. Our main goal was to determine whether disparities in different socioeconomic groups' access to green areas can be revealed in Budapest if considering more than simply urban green spaces. The findings suggest the importance of socioeconomic status to the extent to which one can easily access green areas, but the geographical location within the city is also a decisive factor. We also found that low-income people are in a somewhat disadvantageous position in terms of accessibility to green areas, whereas for more affluent (primarily high-income) residents, their location in the city determines having good access to such amenities. Municipal governments attempt to balance existing differences in the availability and accessibility of urban green spaces, but the decreasing governmental supports and the rise of neoliberal policies serve to hinder their efforts.

The main limitation of our study is that it measures the potential access to green areas rather than their actual use. The latter depends on various factors beyond accessibility, including the quality and quantity of ecosystem services the green areas provide, the built-up ratio of the neighborhood, residents' perceptions of such areas, and their socio-demographic characteristics and lifestyle.

In follow-up research, we plan to apply a new mixed-methods approach based on biophysical parameters and sentiment analysis to measure and compare the quality of green areas, whether urban green spaces or urban forests, which are the most beneficial for human use. This will help us obtain a clearer picture of differences in the availability and accessibility of green areas for different socioeconomic groups.

## CRedit authorship contribution statement

**György Csomós:** Writing – review & editing, Writing – original draft, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Jenő Zsolt Farkas:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Zoltán Kovács:** Writing – review & editing, Writing – original draft, Conceptualization.

## Declaration of competing interest

The authors report there are no competing interests to declare.

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