



Original article

Accessibility of urban parks for older adults in post-industrial cities: the case of Sosnowiec, Poland

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ABSTRACT

Population ageing increases the need for urban environments that support safe everyday physical activity, social interaction, and quality of life. This article assesses the network-based accessibility of designated urban parks for older adults in the post-industrial city of Sosnowiec. The study used registry data on residents aged 60 and over and park data from the Database of Topographic Objects (BDOT10k), supplemented and validated with OpenStreetMap (OSM). Accessibility was modelled as walking time along the pedestrian network. Three cumulative thresholds were analysed: 5, 10, and 15 minutes, corresponding to approximately 250, 500, and 750 m. Of 55,748 older adults, 19.28% were located within the 5-minute catchment of at least one park, 39.10% within the 10-minute catchment, and 56.86% within the 15-minute catchment. These results indicate limited coverage by designated parks under the adopted thresholds, and the coverage estimate was strongly dependent on the threshold selected. Park-level Gini coefficients of 0.461–0.486 and top-three shares of 39.8–41.5% show that exclusively assigned accessible residents were concentrated among a small number of parks. The findings support a dual planning strategy: maintaining highly accessible parks while developing smaller, proximate recreational spaces and reducing pedestrian barriers in underserved areas.

KEY WORDS: age-friendly planning; pedestrian networks; spatial inequality; Gini coefficient; network analysis

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1. Introduction

Population ageing is one of the most important challenges facing contemporary developed societies. This process results primarily from increasing life expectancy and persistently low fertility rates [STATISTICS POLAND [GUS], 2023a]. In Poland, the proportion of people aged 60 and over has been steadily increasing, creating a growing need to adapt different spheres of public life, including spatial policy, to the needs of these older adults.

This phenomenon is particularly visible in post-industrial cities, which, following the political transformation and economic restructuring, began to experience new development challenges, especially depopulation linked to the outmigration of younger people to larger educational and economic centres. As a result, cities such as Sosnowiec, Poland, whose development was based for decades on heavy industry, have experienced both a decline in the total population and a growing share of older residents. This means that an ageing community now functions

in an urban space designed under very different conditions and for very different needs.

In the context of older adults' quality of life, access to safe, attractive, and functional recreational spaces is especially important. Regular outdoor activity can support physical functioning, psychological well-being, and social interaction in later life. Urban parks provide settings for walking and social contact; research indicates that they can facilitate social interaction and cohesion (PETERS ET AL., 2010) and contribute to older adults' well-being (FINLAY ET AL., 2015).

The aim of this article was to assess the network-based accessibility of designated urban parks for older adults in Sosnowiec and to examine how exclusively assigned accessible residents are distributed across individual parks under three cumulative walking-time thresholds. The analysis is intended to provide evidence relevant to urban policy, particularly the siting of smaller recreational spaces and the reduction of pedestrian barriers. More broadly, the study responds to growing interest in the role of urban green space in supporting health, social interaction, and quality of life.

Accordingly, the study addressed three research questions: (1) What proportion of Sosnowiec residents aged 60 and over live within 5-, 10-, and 15-minute network-based walking catchments of a designated urban park? (2) How concentrated is the exclusively assigned accessible population across the 22 parks? (3) How sensitive are city-wide coverage and park-level distributions to the threshold adopted? The study used an integrated methodological framework combining address-based demographic data, pedestrian-network analysis, exclusive nearest-park allocation, and park-level concentration measures in a post-industrial urban context.

2. Literature review

Polish and international research indicates that maintaining quality of life in an ageing society requires residential environments that support everyday activity. Urban parks can form an important component of health-promoting infrastructure, but their presence on a city map does not by itself ensure functional accessibility. Studies involving older adults and people with mobility difficulties emphasise the importance of route quality, amenities, maintenance, and perceived safety (WOJNOWSKA-HECIAK ET AL., 2022; KIMIC & POLKO, 2022).

Post-industrial cities in the Upper Silesian conurbation often contain fragmented urban structures

shaped by former industrial land, railway corridors, and major roads (SŁODCZYK, 2003; RUNGE ET AL., 2011; KRZYSZTOFIK ET AL., 2022). Such features can interrupt pedestrian continuity and complicate access to green areas. Urban shrinkage may also be accompanied by underinvestment in public infrastructure, although the condition of pavements, park paths, and local amenities was not directly assessed in the present study (RUNGE ET AL., 2011).

KRZYSZTOFIK ET AL. (2022) examined perceptions of urban forests in Sosnowiec and showed that residents value forests on post-mining land as recreational spaces. Research in spatial planning also suggests that universal design in Poland often remains more a policy aspiration than a consistently implemented standard (ŻÓŁKOWSKA, 2016). For older adults, access to a park may therefore be limited not only by distance, but also by the quality and usability of the route and the destination.

An important line of research concerns the subjective perception of urban parks by older adults and people with mobility limitations. WOJNOWSKA-HECIAK ET AL. (2022) identified the importance of benches, footpath surface quality, public toilets, shade, and manageable changes in elevation. Perceived safety is another key factor shaping the attractiveness of green areas and a willingness to use them for recreation (KIMIC & POLKO, 2022). The international literature commonly situates older adults' access to green spaces within the age-friendly-cities framework (WHO, 2007). KAPLAN & KAPLAN (1989) argued that contact with natural environments can support well-being and everyday functioning. Proposed mechanisms include stress reduction and the beneficial effects of contact with nature (ULRICH & ADDOMS, 1981), as well as attention restoration (KAPLAN, 1980; 1981). Research on the built environment also shows that accessibility and environmental attractiveness can support physical activity (SALLIS ET AL., 1997; 1998).

The availability and perceived accessibility of green spaces influence leisure decisions among older park users (GODBEY & BLAZEY, 1983). Nature-based recreation and park use have also been associated with mood, stress reduction, and psycho-physiological well-being (MORE & PAYNE, 1978; HULL & MICHAEL, 1995; ORSEGA-SMITH ET AL., 2004), while leisure-based coping has been linked to well-being more generally (IWASAKI & MANNELL, 2000; PONDÉ & SANTANA, 2000).

WHO guidelines (2007) identify accessibility, along with quality, and safety of outdoor spaces as important conditions for active ageing. VAN CAUWENBERG ET AL. (2018) reported positive associations between walking

opportunities, landscape aesthetics, and access to public transport. Environmental gerontology emphasises the fit between personal capacities and environmental demands (LAWTON, 1982), while qualitative studies show that seating, shade, route quality, quietness, and other micro-scale features shape older adults' experiences of outdoor spaces (FINLAY ET AL., 2015; WOJNOWSKA-HECIAK ET AL., 2022). Park amenities, maintenance, and incivilities can influence use and perceived attractiveness (BEDIMO-RUNG ET AL., 2005). GILES-CORTI ET AL. (2005) further demonstrated the importance of distance, attractiveness, and size for the use of public open space.

Beyond physical design, the social composition and management of parks can shape whether different groups feel welcome (GOBSTER, 1998). Perceived security also varies between user groups and is influenced by park conditions and management (KIMIC & POLKO, 2025). Park programming is associated with greater use and physical activity (COHEN ET AL., 2016), group-based outdoor programmes can benefit older adults with walking difficulties (KOKORELIAS ET AL., 2025), and intergenerational design can support interaction across age groups (NELISCHER & LOUKAITOU-SIDERIS, 2023).

3. The concept of human-scale urbanism

Research on older adults' access to urban recreational spaces can be situated within the concept of human-scale urbanism (GEHL, 2010). This approach assumes that urban design should be informed by observations of actual user behaviour and should account for the physical and psychological needs of different groups of residents, particularly older adults. In practice, this entails creating spaces that are accessible, green, safe, and welcoming, and that support everyday physical activity and social interaction. In the present study, human-scale urbanism serves as an interpretive framework for translating the accessibility results into planning recommendations; it is not tested as a separate empirical construct.

4. Materials and methods

The study was conducted in accordance with the principles of research integrity and applicable personal-data-protection regulations (ALLEA, 2023; Regulation [EU] 2016/679, GDPR). Registry data on the residential locations of older adults in 2024 were provided by the Central IT Centre (Centralny

Ośrodek Informatyki, COI) under controlled-access conditions. No address points or individual-level microdata are reported; the article presents only aggregated city-level and park-level results, thereby reducing the risk of re-identification.

Spatial layers were obtained from the Database of Topographic Objects (BDOT10k; status as of 20 December 2025) and OpenStreetMap (OSM). OSM data for Sosnowiec were downloaded from Geofabrik and processed into GIS vector layers. The analyses were conducted in the PL-1992 coordinate reference system (EPSG:2180) in ArcGIS Pro (Esri, Redlands, CA, USA) with the Network Analyst extension. The pedestrian network was built from road and pedestrian-path layers. Walking time was calculated from segment length using an assumed speed of 3.1 km/h, and the network allowed movement only along links accessible to pedestrians, excluding expressways, motorways, and other inaccessible segments.

Parks were defined on the basis of BDOT classes corresponding to designated park areas. Non-park green areas, such as forests and natural areas, were excluded from the analysis in order to maintain comparability and the functional consistency of the recreational sites examined. Ultimately, 22 urban parks were included in the analysis. Park entrance points were identified on the basis of OSM and orthophotos, and where entrances were not clearly represented, the points where the park boundary met the pedestrian network were used as an approximation of access.

In the park-level analysis and in the calculation of the Gini coefficient, an exclusive allocation rule was applied. This meant that each person who had access to more than one park within a given threshold was assigned only to the park for which the network walking time was shortest. As a result, the counts assigned to individual parks were not inflated by overlapping catchment areas, and their sum corresponded to the number of older adults with access to at least one park.

The research procedure comprised several stages. First, the number and spatial distribution of older adults living in Sosnowiec in 2024 were determined. Next, urban parks were identified, and network accessibility was calculated as walking time along the street and pedestrian network, with mapped barriers and crossings incorporated where represented in the network. Three cumulative time thresholds were adopted: 5, 10, and 15 minutes. At a walking speed of 3.1 km/h, these correspond to approximately 258, 517, and 775 m, respectively; throughout this

article they are presented in rounded form as approximately 250, 500, and 750 m (RUDZKI & NAWRAT-SZOŁTYSIK, 2016). The number of older adults within the catchment of at least one park, as well as outside all park catchments, was then calculated.

Sosnowiec was selected as a relevant example of a large post-industrial city in southern Poland. Its urban structure reflects the long-term effects of industrialisation and economic restructuring, including extensive post-mining and post-industrial areas that influence the continuity of the urban fabric and the configuration of pedestrian connections (GMINA SOSNOWIEC, 2025).

The Gini coefficient was used to describe the concentration of exclusively assigned accessible residents across the 22 parks. The units of this calculation were therefore parks ($n = 22$), not individual residents, and the coefficient should be interpreted as a park-level concentration measure rather than as a person-level measure of inequality in access. The Friedman test was used to summarise the sensitivity of park-level counts to the three dependent, cumulative thresholds, followed by Wilcoxon signed-rank comparisons with Holm adjustment. For the pairwise comparisons, effect size was calculated as $r = |Z|/\sqrt{n}$, where $n = 22$ paired parks. Because wider catchments necessarily include narrower catchments, these tests are treated as descriptive sensitivity diagnostics rather than independent evidence that the thresholds themselves cause differences in accessibility. In accordance with the Act of 11 September 2015 on Older Persons, an older adult was defined as a person aged 60 years or over.

5. Study area

5.1. Demographic situation

Poland and Sosnowiec are experiencing persistent depopulation, low fertility, and progressive population ageing. In Sosnowiec, these processes have been reinforced by industrial restructuring and unfavourable migration trends. Demographic projections indicate that ageing and population decline will continue, increasing the importance of adapting local services and public space to the needs of older residents (STATISTICS POLAND [GUS], 2023a, b; SITEK ET AL., 2025; WOJTOŃ, 2010).

Population ageing in Poland is advancing rapidly. In 2024, people of post-working age accounted for 23.8% of the population, compared with 16.8% in 2010 (STATISTICS POLAND [GUS], 2026). At the end of 2024,

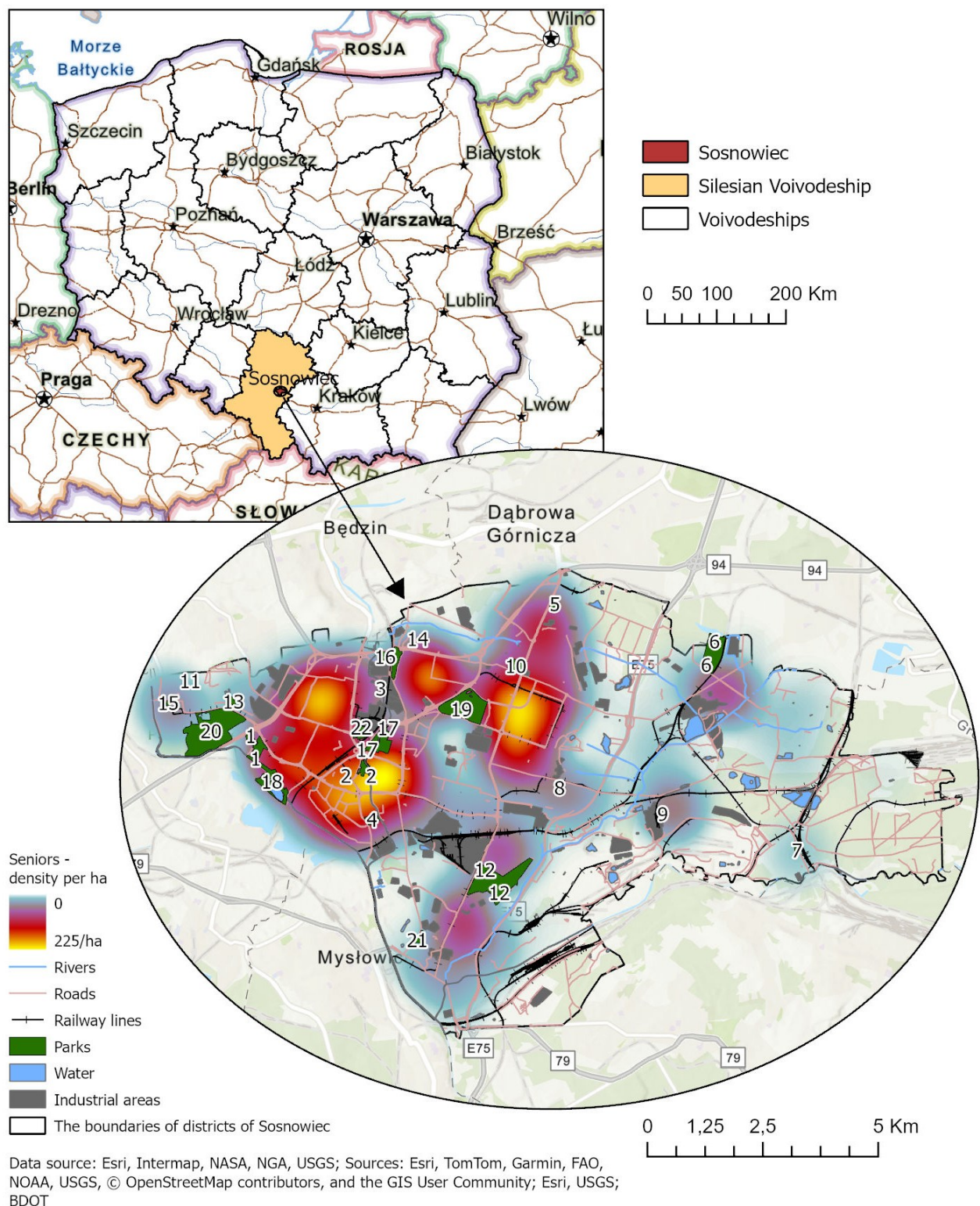
Poland had approximately 37.5 million residents (STATISTICS POLAND [GUS], 2026). GUS projections indicate that Poland's population may decline to 30.4 million by 2060 in the main scenario and to 26.7 million in the low scenario, while demographic dependency is expected to increase (STATISTICS POLAND [GUS], 2023a, b).

Similar trends can be observed in Sosnowiec. The report The Demographic Situation of Sosnowiec and GUS Forecasts (Sytuacja demograficzna Sosnowca wraz z prognozą GUS), published in March 2025, documents long-term depopulation (SITEK ET AL., 2025). The city's population peaked at 259,600 in 1987 and subsequently declined to approximately 185,000 in 2024, the lowest level since 1975. Thus, the 2024 population was approximately 71% of the 1987 peak. The average pace of decline has been about 1% per year, with particularly pronounced losses in 1995–1999 and 2020–2024 (SITEK ET AL., 2025).

5.2. Transformations in the industrial sector

Sosnowiec, one of the principal industrial centres of the Zagłębie Dąbrowskie region, underwent a profound economic transformation from the second half of the twentieth century onwards (SOSNOWIEC CITY OFFICE, n.d.; WOJTOŃ, 2010). After the Second World War, the city developed within a centrally planned economy and relied heavily on mining, metallurgy, machinery production, and manufacturing. Major enterprises included the Sosnowiec and Kazimierz-Juliusz hard-coal mines (CIEPIELA, 2006). Industrial growth was accompanied by the expansion of technical and housing infrastructure (URZĄD MIEJSKI W SOSNOWCU, n.d.).

After 1989, privatisation and industrial restructuring accelerated. Many plants reduced production or closed, contributing to employment losses and to a deterioration in the socio-economic situation of part of the population (WOJTOŃ, 2010). At the same time, the city pursued economic diversification, service development, and new investment (URZĄD MIEJSKI W SOSNOWCU, n.d.). The establishment of a subzone of the Katowice Special Economic Zone in 1996 supported investment and employment in sectors including automotive production, electronics, machinery, and logistics (RADA MINISTRÓW, 1996; KATOWICKA SPECJALNA STREFA EKONOMICZNA S.A., n.d.). Nevertheless, the spatial and social effects of deindustrialisation remain an important development challenge (WOJTOŃ, 2010). The location of Sosnowiec and the spatial distribution of the 22 analysed parks are shown in Fig. 1.



Parks: 1- Bioróżnorodności (Fusińskiego/Kresowy); 2- Bulwary Czarnej Przemszy przy ul. Mościckiego; 3- Bulwary Czarnej Przemszy przy ul. Rybnej; 4- Harcerski; 5- Kępa (Zagórze); 6- Kuronia plus Ogród Jordanowski; 7- Maczki; 8- Malczewskiej; 9- Mazura; 10- Mieroszewskich (Dworski); 11- Miłowice (Baczyńskiego); 12- Niwka i Park Leśny Niwka; 13- Ogród zabaw dziecięcych im. Baczyńskiego; 14- Okrzei (Środula); 15- Poniatowskiego; 16- Schoena; 17- Sielecki (Nowa i Stara część); 18- Stawiki – Bulwary Brynicy; 19- Środula; 20- Tysiąclecia; 21- Wygoda – przy ul. Powstańców; 22- Żeromskiego /(Dietla)

Fig. 1. Location of Sosnowiec within Poland and urban parks in Sosnowiec in relation to the spatial concentration of older adults.

5.3. Parks in Sosnowiec

Parks are important components of urban green infrastructure. In addition to their recreational, health-related, and social functions (BREUSTE ET AL., 2013; CHIESURA, 2004; BOŻĘTKA, 2008), they play ecological roles by supporting biodiversity, ecological connectivity, and ecosystem services (SZUMACHER, 2005, 2011; NIEMELÄ ET AL., 2010; RAHMONOV ET AL., 2019). Parks can also contribute to urban-climate regulation (WÓJCICKA, 1971) and support psychological restoration, social integration, and physical activity (LIS, 2004; COHEN ET AL., 2010; KONIJNENDIJK ET AL., 2013). Parks in Sosnowiec vary in age and origin. Some were established on reclaimed post-mining land (CEMPULIK & HOLEKSA, 2008), which gives them particular ecological and recreational significance and may require attention to habitat condition and soil contamination (RAHMONOV ET AL., 2024).

6. Results

6.1. Scale of park accessibility in relation to the older adult population

In 2024, 55,748 older adults lived in Sosnowiec, according to the COI registry data used in the study. Relating network-accessibility results to this population makes it possible to estimate the share of older adults whose registered residence lies within a given walking-time catchment. This indicator measures potential spatial coverage; it does not measure actual park use.

The analysis identified 10,751 people within the 5-minute catchment of at least one park, 21,800 within the 10-minute catchment, and 31,701 within the 15-minute catchment. At the assumed walking speed, these thresholds correspond to approximately 250, 500, and 750 m when expressed as rounded distances. Relative to the total older adult population, the respective shares were 19.28%, 39.10%, and 56.86%. Expanding the threshold from 5 to 15 minutes increased the covered population by 20,950 people and 37.58 percentage points (equivalent to a 194.9% relative increase from the 5-minute value). The 15-minute count was 2.95 times the 5-minute count, demonstrating the sensitivity of the coverage estimate to the selected threshold (Fig. 2; Table 1).

In post-industrial cities such as Sosnowiec, this is of particular importance. The spatial structure shaped by former industrial development is often

highly fragmented, cut through by railway and road infrastructure, and includes areas of limited pedestrian permeability. In practice, even a short distance may therefore imply a much higher access cost for an older person than geometric distance alone would suggest.

The distribution of the number of older adults located within the catchment areas of individual parks was also examined in order to determine whether the system functions evenly or relies on a few dominant sites. The distribution was clearly right-skewed at all three thresholds. For the 5-, 10-, and 15-minute thresholds, the means were 488.68, 990.91, and 1,440.95, respectively, whereas the medians were lower: 323.5, 819.0, and 1,277.5. The coefficients of variation were 1.05, 1.00, and 0.96; skewness was 2.38, 2.16, and 1.73; and excess kurtosis was 7.31, 4.85, and 3.13. These values confirm the presence of extreme observations and strong differentiation between parks, although relative dispersion and asymmetry decrease as the walking threshold increases. This means that a small number of parks have very large demographic catchment areas, whereas many others include only small numbers of older adults.

The mean park-level count is therefore not representative of the distribution as a whole. Among the parks listed in Table 1, Bulwary Czarnej Przemszy przy ul. Mościckiego had the largest exclusively assigned catchment at all three thresholds (2,320 / 4,102 / 5,444), followed by Środula (1,153 / 3,383 / 4,673). The park with the third-largest count varied by threshold: Sielecki (nowa i stara część) at 5 minutes (924), Harcerski at 10 minutes (1,555), and Niwka i Park Leśny Niwka at 15 minutes (2,499). These are official Polish park names listed in Table 1: 'Bulwary Czarnej Przemszy' means 'Black Przemsza Boulevards', 'przy ul. Mościckiego' means 'at Mościckiego Street', 'nowa i stara część' means 'new and old sections', and 'Park Leśny' means 'Forest Park'. These dominant catchments can mask low coverage in other parts of Sosnowiec when only city-wide totals are considered.

6.2. Concentration of accessibility across parks

In this study, the Gini coefficient is used to describe concentration across parks, measured as the number of accessible older residents exclusively assigned to each park.

The Gini coefficient was calculated from the 22 park-level counts produced by the exclusive allocation

procedure ($n = 22$ parks). The resulting values were 0.486 at 5 minutes, 0.461 at 10 minutes, and 0.469 at 15 minutes. These values indicate a marked concentration of the exclusively assigned accessible population among parks. The decrease from 5 to 10 minutes suggests a modest equalisation of park

catchments, whereas the slight increase at 15 minutes shows that concentration does not decline monotonically as the threshold expands. The coefficient does not represent inequality among all 55,748 older residents, because residents outside every catchment are not analytical units in this calculation.

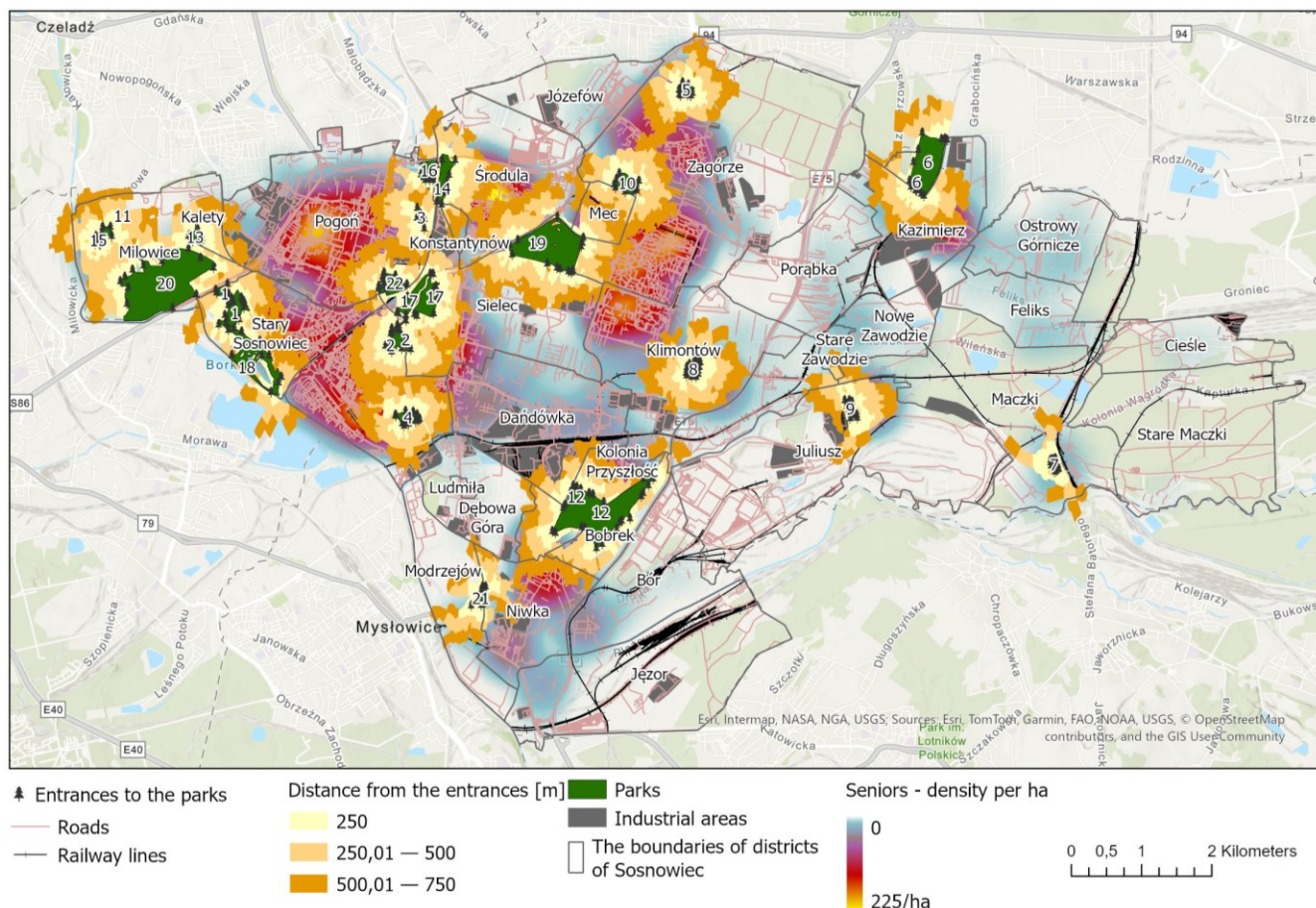


Fig. 2. Spatial density of older adults in Sosnowiec and network-based park catchments (5, 10, and 15 minutes; approximately 250, 500, and 750 m) (Source: Authors' own elaboration)

Table 1. Number of older adults within the 5-, 10-, and 15-minute network catchments of parks in Sosnowiec (Source: Authors' own elaboration)

No.	Park name	Number of older adults		
		5 min (≈250 m)	10 min (≈500 m)	15 min (≈750 m)
1	Bioróżnorodności (Fusińskiego/Kresowy)	140	298	320
2	Bulwary Czarnej Przemszy przy ul. Mościckiego	2,320	4,102	5,444
3	Bulwary Czarnej Przemszy przy ul. Rybnej	124	410	620
4	Harcerski	783	1,555	2,439
5	Kępa (Zagórze)	679	1,063	1,373
6	Kuronia plus Ogród Jordanowski	131	770	1,562
7	Maczki	205	208	208

No.	Park name	Number of older adults		
		5 min (≈250 m)	10 min (≈500 m)	15 min (≈750 m)
8	Malczewskiej	415	991	1,182
9	Mazura	627	1,000	1,118
10	Mieroszewskich (Dworski)	445	868	1,639
11	Milowice (Baczyńskiego)	379	384	384
12	Niwka i Park Leśny Niwka	724	1,419	2,499
13	Ogród zabaw dziecięcych im. Baczyńskiego	268	314	361
14	Okrzei (Środula)	126	975	1,847
15	Poniatowskiego	233	281	281
16	Schoena	15	98	174
17	Sielecki (nowa i stara część)	924	1,446	1,722
18	Stawiki – Bulwary Brynicy	599	894	1,724
19	Środula	1,153	3,383	4,673
20	Tysiąclecia	226	415	417
21	Wygoda – przy ul. Powstańców	54	165	277
22	Żeromskiego (Dietla)	181	761	1,437
Total		10,751	21,800	31,701

To illustrate this concentration, the combined share of the three parks with the largest exclusively assigned catchments was calculated using the total number of accessible, assigned older residents at each threshold as the denominator. The shares were 40.9% at 5 minutes, 41.5% at 10 minutes, and 39.8% at 15 minutes. The three largest catchments were the following parks, identified by their official Polish names as listed in Table 1: Bulwary Czarnej Przemszy przy ul. Mościckiego, Środula, and Sielecki (nowa i stara część) at 5 minutes; Bulwary Czarnej Przemszy przy ul. Mościckiego, Środula, and Harcerski at 10 minutes; and Bulwary Czarnej Przemszy przy ul. Mościckiego, Środula, and Niwka i Park Leśny Niwka at 15 minutes. Thus, about two-fifths of the assigned accessible population was associated with only three parks at each threshold.

The Gini values and top-three shares show an uneven park-level distribution of the assigned accessible population. Some parks function as major nodes, whereas others have comparatively small demographic catchments. The absolute value of the coefficient should not be interpreted through a universal cut-off; its planning relevance arises from the observed concentration and from comparisons

across thresholds. The results support a dual strategy: maintaining the quality, safety, and age-friendly infrastructure of highly accessible parks while improving the network of smaller green spaces and pedestrian connections in areas with limited park coverage.

The persistence of park-level concentration as the threshold expands is consistent with the fragmented spatial structure often observed in post-industrial cities, where post-industrial land, railway lines, and major roads can limit pedestrian continuity. In Sosnowiec, this interpretation should be treated as a planning hypothesis supported by the mapped network pattern rather than as a causal result of the present analysis. Potential interventions include new local green spaces, continuous pedestrian routes, safe crossings, and improved links with public transport.

6.3. Threshold sensitivity analysis

The Friedman test yielded $\chi^2(2) = 42.659$, $p = 5.45 \times 10^{-10}$, with Kendall's $W = 0.970$. These statistics confirm that the park-level counts change consistently as the cumulative catchment is expanded.

However, because the 10-minute catchment contains the 5-minute catchment and the 15-minute catchment contains both, a strong ordered difference is expected by construction. The test is therefore used here to quantify sensitivity to the operational threshold, not to demonstrate an independent causal or behavioural effect.

Wilcoxon signed-rank comparisons with Holm correction were also significant: 5 versus 10 minutes, $p_{\text{Holm}} = 1.43 \times 10^{-6}$; 10 versus 15 minutes, $p_{\text{Holm}} = 1.32 \times 10^{-4}$; and 5 versus 15 minutes, $p_{\text{Holm}} = 1.43 \times 10^{-6}$. The corresponding r values ranged from 0.876 to 0.877. Given the nested design, these large effects primarily describe the mechanical expansion of cumulative catchments. Their substantive implication is that reported coverage depends strongly on the operational accessibility threshold.

7. Discussion

Regarding the first research question, the analysis shows limited network-based coverage by the 22 designated parks. The 5-, 10-, and 15-minute thresholds covered 10,751 older adults (19.28%), 21,800 (39.10%), and 31,701 (56.86%), respectively. At the 15-minute threshold, 24,047 older adults (43.14% of the population aged 60 and over) remained outside all analysed park catchments. Because the study excludes forests, natural areas, and other forms of neighbourhood greenery, this result should be interpreted as limited coverage by designated parks under the adopted method, rather than as a complete measure of access to all urban green space.

The results are broadly consistent with Polish studies showing that short-distance access to larger green spaces may be limited and that network barriers can reduce accessibility relative to straight-line measures (WYSMUŁEK ET AL., 2020). The literature commonly discusses thresholds of approximately 300 – 400 m for nearby green space, while also showing that conclusions depend on the definition, size, and type of green space included (RUBASZEK ET AL., 2023; PRZEWOŹNA ET AL., 2024). The low 5-minute coverage in Sosnowiec is therefore planning-relevant, particularly because mobility constraints make short and barrier-free routes especially important for older adults (WOJNOWSKA-HECIAK ET AL., 2022), but it should not be treated as a breach of a universally binding standard.

Regarding the second research question, the exclusively assigned accessible population was

concentrated among a limited number of parks. The park-level Gini coefficients ranged from 0.461 to 0.486, and the three largest catchments accounted for 39.8 – 41.5% of all assigned accessible residents. The parks Bulwary Czarnej Przemszy przy ul. Mościckiego and Śródula were among the two largest catchments in every variant. This result concerns concentration among parks, not inequality among individual older residents. It is nevertheless relevant to planning because it identifies a system in which city-wide coverage depends strongly on a small number of sites. Similar spatial concentration can arise from historically shaped urban structure and uneven investment (CHEN ET AL., 2022; WOLCH ET AL., 2014).

The results for Sosnowiec can also be considered in the broader context of post-industrial urban transformation in Poland. A comparative analysis shows that post-industrial cities do not always strengthen green resilience through the systematic development of green spaces and that greenery may be lost to development or economic functions in intensively used areas (STARCZEWSKI ET AL., 2023). The Sosnowiec case illustrates a related planning challenge: the presence of several large and intensively used parks does not automatically produce even access at the district level. This supports action in two directions — maintaining the quality of major parks and developing a denser network of smaller recreational spaces in areas with high concentrations of older residents.

International evidence provides useful context but not a directly comparable benchmark. WÜSTEMANN ET AL. (2017) reported that 92.8% of the population in major German cities had green space within a 500 m Euclidean buffer. Their study covered the general population and a broad category of urban green space derived from the European Urban Atlas, whereas the present study concerns adults aged 60 and over, designated parks only, and network-based walking time. The lower 10-minute coverage observed in Sosnowiec (39.10%) should therefore be discussed as a method- and context-dependent contrast rather than as a direct performance ranking.

Regarding the third research question, city-wide coverage increased by 37.58 percentage points between the 5- and 15-minute thresholds, whereas the Gini coefficient changed only slightly. Expanding the threshold therefore substantially increased the number of residents classified as covered but did not remove park-level concentration. Because the catchments are cumulative, the statistical significance

of the ordered differences is expected; the substantive value of the analysis lies in demonstrating how strongly the diagnosis depends on the operational definition of accessibility.

8. Limitations

Several limitations should be considered. First, the analysis covers 22 designated parks and excludes forests, natural areas, informal green spaces, private greenery, and small neighbourhood green spaces; it therefore does not represent access to all urban nature. Second, residential location within a modelled catchment indicates potential accessibility rather than actual use. The model applies a single walking speed and does not capture individual mobility limitations, slope, pavement condition, signal waiting times, temporary closures, seasonal conditions, perceived safety, or the attractiveness, quality, capacity, and size of individual parks.

Third, park entrances and network links depend on the completeness and temporal consistency of BDOT10k, OSM, and orthophoto interpretation. The demographic data refer to 2024, whereas the BDOT10k layer is dated December 2025, creating a limited temporal mismatch. Fourth, exclusive nearest-park allocation prevents double counting but simplifies real behaviour because residents may choose from several parks. Fifth, the Gini coefficient describes concentration of the assigned accessible population among parks; it does not measure individual accessibility inequality, park quality, or the distribution of residents who remain outside all catchments.

9. Conclusions

The first research question concerned city-wide coverage. The network analysis indicates limited coverage of the older population by the 22 designated parks under the adopted thresholds. The 5-minute catchments included 19.28% of older adults (10,751 people), the 10-minute catchments 39.10% (21,800), and the 15-minute catchments 56.86% (31,701). Consequently, 43.14% of residents aged 60 and over (24,047 people) remained outside all analysed park catchments at 15 minutes. This finding concerns designated parks and potential residential accessibility; it should not be generalised to all forms of urban greenery or actual park use.

The second research question concerned park-level concentration. Gini coefficients of 0.461 – 0.486

and top-three shares of 39.8 – 41.5% show that a small number of parks account for a large part of the covered population. These sites are important nodes in the city's recreational system, but city-wide totals may conceal neighbourhoods with limited access, particularly where linear barriers and fragmented pedestrian connections increase walking costs.

The third research question concerned threshold sensitivity. Coverage increased substantially as the walking-time threshold expanded, while park-level concentration changed only modestly. The Friedman and Wilcoxon statistics quantify this sensitivity, although the ordered differences are expected because the catchments are cumulative.

From an urban-policy perspective, the results support parallel action: maintaining the quality of major parks, supplementing the system with smaller and more proximate recreational spaces, and reducing barriers through continuous pedestrian routes, safe crossings, good surfaces, legible entrances, and universal-design principles. These recommendations are consistent with human-scale urbanism because they prioritise proximate everyday spaces and safe, continuous pedestrian routes. Network-based analysis is useful for diagnosing potential coverage, while park-level concentration measures can identify dependence on a small number of sites. Further research should incorporate park quality, alternative forms of greenery, individual mobility differences, perceived safety, actual use, and multimodal access.

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