Research Journal of Agricultural Science, 57 (3), 2025; ISSN: 2668-926X

http://doi.org/10.59463/RJAS.2025.3.27

HIDDEN CLIMATE HEROES: ASSESSING CARBON SEQUESTRATION AND ECOSYSTEM SERVICES OF URBAN PARKS IN BUDAPEST

Absatu JALLOH[1], Stephanie ACHEAMPONG[1], Liliana TÖRÖK[1], Zs. TÖRÖK[1]

[1]John Wesley Theological College, Department Environmental Security, Budapest, Danko Street, No. 11, 1086, Hungary

Corresponding author: torokliliana@yahoo.com

Abstract. *Everyone knows urban parks are valuable, contributing to both public health and biodiversity. Still, pinning down their exact environmental benefits in concrete numbers is often a challenge, especially in dense cityscapes where every square meter is contested. Our study tackled this by assessing the ecosystem services of eight parks in Budapest's District VIII. Using the i-Tree Canopy tool, a standardized method for urban forest analysis, we quantified key metrics like carbon storage, annual carbon sequestration, air pollutant removal, and storm water runoff reduction. The results were clear: together, these parks store around 909 tons of carbon in their biomass and pull down another 36 tons every year, acting as vital, local carbon sinks. The heavy lifting is done by the larger parks, particularly Orczy tér and II. János Pál pápa tér, a direct result of their size and mature tree cover. In economic terms, these benefits are significant, totalling more than €450,000 each year, a figure that underscores their immense public value. Just as important, smaller neighbourhood spots like Mátyás tér provide tangible local perks, proving that green spaces of all sizes are vital to the city's health and resilience. The data makes a strong case for protecting and expanding Budapest's parks, framing such policy not as a cost but as a practical move for building a greener, more climate-ready future.*

Keywords: urban parks, i-Tree Canopy, carbon sequestration, air pollution benefits

INTRODUCTION

Urban parks are integral to the environmental, social, and economic fabric of cities, delivering crucial ecosystem services that enhance the well-being and health of urban communities. These services include air purification, carbon storage, management of urban heat and stormwater, and the provision of cultural and recreational spaces (RAZZAGHIAN & RAHNAMA, 2012; KONDO ET AL., 2018). In densely populated cities, these green spaces are vital for maintaining ecological balance and improving environmental quality. However, rapid urbanization in Europe since the turn of the twenty-first century has placed significant strain on urban green infrastructure, a trend particularly evident in the Hungarian capital, Budapest. While renowned for its historic architecture and the Danube River, Budapest grapples with the pressures of a large population, expanding infrastructure, traffic congestion, and air pollution in its inner districts, making the city's urban parks invaluable ecological assets.

The conflict between historical urbanism and modern-day environmental pressures is well-illustrated in Budapest's District VIII, Józsefváros. Once a working-class area, the district has undergone selective gentrification and large-scale renewal efforts. It hosts numerous parks including Horváth Mihály, II. János Pál pápa, Golgota, Mátyás, Teleki, Kálvária, Ludovika, and Orczy which are the focus of this work. These parks, though varying in size, design, and use, are exposed to significant environmental risks such as stormwater floods aggravated by climate change, soil pollution from historical land-use, urban heat-island effects caused by vast impermeable surfaces, and traffic-related air pollution (CSOMÓS ET AL., 2023).

While it is established that urban green areas function as ecological buffers by moderating temperature, absorbing pollutants, and storing carbon (BOWLER ET AL., 2010; KONIJNENDIJK et al., 2013), quantifying these benefits in small or mid-sized urban parks remains a challenge, and their localized environmental contributions are often overlooked (HAASE ET AL., 2014). Addressing this gap, this study aims to evaluate the carbon sequestration and related ecosystem services provided by the eight selected parks in District VIII. By combining in-situ observations with the visual interpretation capabilities of the i-Tree Canopy tool, this research will estimate the parks' ability to store carbon, remove air pollutants, and retain stormwater, while also assessing the monetary value of these benefits.

This investigation aligns with the European Green Deal's call for nature-based climate solutions and seeks to provide data-driven insights for sustainable urban planning in rapidly urbanizing contexts**.**

MATERIAL AND METHODS

Study Area

This study investigated the ecosystem service advantages of urban parks in District VIII (Józsefváros), a densely populated and historically significant central district of Budapest, Hungary. Like many cities, Józsefváros has issues with air pollution, the urban heat island effect, and managing stormwater. It also depends on its green spaces to improve people's health and the environment (CSOMÓS ET AL., 2023). We chose eight urban parks on purpose to study because they have different sizes, types of plants, and urban settings. Orczy tér (10.2 ha), Ludoviká tér (1.5 ha), Kálvária tér (0.9 ha), II János Pál pápa tér (4.6 ha), Teleki László tér (1.1 ha), Golgota tér (0.7 ha), Horváth Mihály tér (0.8 ha), and Mátyás tér (0.6 ha).

The Google Earth Pro (2025 satellite images) was used to determine the exact borders and total area of each park. We painstakingly drew the outline of each park's border and then found the area of the polygon that came out of it. This area was the starting point for the tests that came after. The parks we chose are good for comparing how well they do ecologically because they are very different in size, structure, and the kinds of plants that grow there.

Study Design

This study employed a quantitative and geographic analysis methodology, integrating targeted field observations with an extensive satellite-based assessment utilising the i-Tree Canopy v7.1 software tool (USDA Forest Service).

The initial phase of this study involved "in situ" observation (tree counts). Field data collection occurred concurrently with the complete foliation phase of deciduous trees in Budapest from March to May 2025.

The second phase was corroborated and supplemented with the canopy coverage data from the i-Tree Canopy analysis (https://canopy.itreetools.org). This foundational analysis performed using i-Tree Canopy's used random sampling on 2025 satellite imagery, that allowed as to quantify the structural makeup of each park, providing essential context for understanding their ecological functions.

The land cover in each park was split into six main groups: tree canopy, grass and shrubs, impervious surfaces (like roads, pavements, and buildings), bare soil, water bodies, and other surfaces (like permeable playgrounds and unpaved walks). To ensure that the data was statistically representative, each park had 500 random points chosen.

Research Journal of Agricultural Science, 57 (3), 2025; ISSN: 2668-926X
http://doi.org/10.59463/RJAS.2025.3.27

Data analysis

The primary analysis relied on high-resolution 2023 satellite imagery from Google Earth.

The analysis focused on quantifying specific critical environmental factors and their associated economic values, as estimated by i-Tree Canopy's internal models: Five major air pollutants were taken into consideration: carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone (O_3), and particulate matter ($PM_{2.5}$ and PM_{10}), as well as annual carbon sequestration (metric tons/year) carbon storage (metric tons) and water retention capacity (Avoided Storm water Runoff (m^3)).

i-Tree Canopy that was also built-in as an algorithm valuation made possible to evaluate how much money (in euros) the ecosystem services that each park provides (NOWAK ET AL., 2006).

RESULTS AND DISCUSSION

The benefits offered by the investigated parks are tied directly to their scale and character (TYRVÄINEN ET AL., 2005) and the ecosystem services of urban parks in District VIII (Józsefváros), a densely populated and historically significant central district of Budapest, Hungary.

The i-Tree Canopy analysis showed larger parks (Orczy tér, II. János Pál pápa tér) have over 40% tree canopy, while smaller ones (Mátyás tér, Horváth Mihály tér) have under 20%. This directly links vegetation structure to ecosystem service delivery. These findings align with broader urban studies on how park design influences canopy cover, carbon capacity, and microclimate regulation (HAASE ET AL., 2014; OTHMAN & FADZIL, 2019), reinforcing the critical environmental benefits of urban green spaces in Józsefváros.

The results of the primary objective made it easier to see how the canopy was built (table 1) The estimated tree counts varied significantly across the study parks, directly influencing their potential for ecosystem service provision

Table 1

The distribution of trees by parks (field observation)

PARK	Oczy tér	Ludoviká tér	Kálvária tér	II. János Pál pápa tér	Teleki tér	Golgota tér	Horváth Mihály tér	Mátyás tér
Estimated trees	320	210	80	280	120	170	75	70

The field investigation confirmed that the biggest and most important park for the urban environment in Józsefváros is Orczy tér, which is 10.2 hectares. It is a multi-use space that includes not only mature trees but also extensive open lawns, a large pond, and university buildings, which results in a lower overall tree density compared to other parks. Orczy tér (10.2 ha) is vital for air purification and carbon sequestration for the district.

Ludoviká tér (1.5 ha) is next to Orczy Park, being part of an old city complex–has similarly aids microclimate stability and offers recreation with its blend of trees and paths.

Neighborhood parks like Kálvária tér also provide essential localized services such as supports biodiversity and relaxation

II. János Pál pápa tér (4.6 ha) significantly improves air quality and temperature regulation (WÁGNER G. 2021).

http://doi.org/10.59463/RJAS.2025.3.27

Teleki László tér (1.1 hectares) has recently been redesigned to include organised grass, flower gardens, and young trees. It helps people in the area get to know each other and cool down urban heat islands (BODROGI E., 2019; WÁGNER G., 2022).

Smaller parks like Golgota tér (0.7 ha) enhance aesthetics and cooling, Horváth Mihály tér (0.8 ha) provides crucial shade and air purification (BUDAPEST100), and Mátyás tér (0.6 ha) contributes to urban cooling and biodiversity. Despite their size those parks help keep the city cool and supports biodiversity.

District VIII's green infrastructure that includes these eight parks are very important, because they make the air cleaner, help plants store carbon, and make ecosystems more resilient in many ways.

The results of the second objective (figure 1) accurately quantify the extent of each type of land cover within the selected parks and subsequently evaluate their efficacy in delivering essential ecosystem services. The i-Tree Canopy results show clear variation in land-cover composition among the eight studied parks in District VIII.

II. János Pál pápa tér and Ludoviká tér recorded the greatest share of tree and shrub cover, corresponding with their higher tree counts (280 and 210 trees, respectively).

Golgota tér and Kálvária tér also displayed substantial vegetation dominated by trees and grass surfaces.

In contrast, Horváth Mihály tér and Mátyás tér were characterized by extensive impervious areas mainly roads and paved walkways which limited overall canopy density and carbon sequestration potential.

Teleki tér exhibited a moderate balance of vegetated and paved zones, while Orczy tér, though lacking precise data, appeared well covered with trees and grass based on satellite imagery.

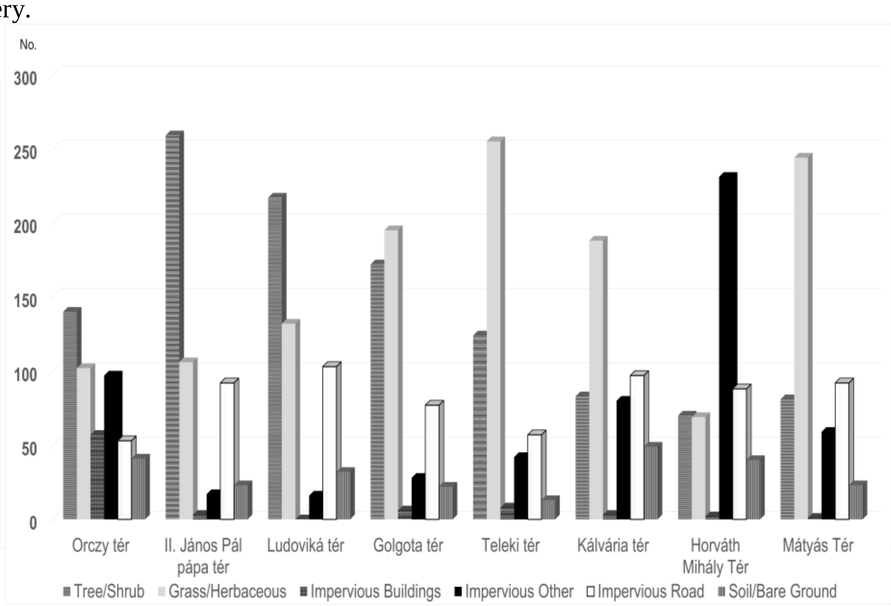

Figure 1. Number of sample points recorded in i-Tree Canopy

These land-cover variations directly influence each park’s ability to capture carbon, reduce surface temperature, and manage runoff in the dense urban environment.

This extensive canopy is indicative of a mature, well-established arboreal structure, which aligns with its status as a significant ecological asset within the district. Its diverse composition, including 38.1% grass and shrubs and 0.7% water bodies, further supports both ecological function and recreational opportunities, distinguishing it from the more compact green spaces.

The i-Tree Canopy graph shows clear differences in land-cover types among the eight parks. II. János Pál pápa tér and Kálvária tér have the highest tree and shrub cover, indicating strong potential for carbon capture and cooling effects. Ludoviká tér and Golgota tér display balanced vegetation, while Horváth Mihály tér and Mátyás tér contain mostly impervious surfaces, which reduce ecological functions. Teleki tér shows moderate vegetation, and Orczy tér also appears well-vegetated also. Overall, parks with more trees provide greater environmental benefits than those dominated by paved areas.

The estimation of air pollutants (table 2) showed how well plants can filter out gas pollutants and block particles, which makes the air cleaner.

Table 2.

The quantity (kg) of pollutants retained by the parks in District VIII, Budapest

	Orczy	II. János Pál pápa	Ludoviká	Golgota	Teleki	Kálvária	Horváth Mihály	Mátyás
CO	24.29	9.7	4.88	2.25	0.86	0.89	0.23	0.32
NO_2	208.4	83.23	41.89	19.29	7.34	7.60	2.00	2.76
SO_2	754.42	301.31	151.65	69.84	26.58	27.52	7.25	9.98
O_3	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00
$PM_{2.5}$	12.25	4.89	2.46	1.13	0.43	0.45	0.12	0.16
PM_{10}	73.35	29.3	14.75	6.76	2.59	2.68	0.71	0.97

***NOTE**: CO – carbon monoxide; NO_2 – nitrogen dioxide; SO_2 – sulfur dioxide; O_3 – ozone; $PM_{2.5}$ – fine particulate matter; PM_{10} – coarse particulate matter.*

The results show that parks with dense tree coverage, such as II. János Pál pápa tér and Ludoviká tér, were more effective in capturing air pollutants. Smaller green areas like Horváth Mihály tér and Mátyás tér removed lower quantities but still improved neighbourhood air quality. Overall, the data indicate that both large and small parks play a vital role in filtering harmful substances, including carbon monoxide (CO) and nitrogen dioxide (NO_2), from the city’s atmosphere.

The i-Tree Canopy model help as to identified significant removal of air pollutants including carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and fine particulate matter ($PM_{2.5}$). The larger parks removed higher pollutant loads, a direct function of their greater leaf surface area available for deposition and absorption. Similar results have been seen by Baró et al. (2014) in Barcelona, showing that urban green infrastructure provides a measurable improvement in air quality. The removal of fine particulate matter ($PM_{2.5}$) is especially critical, given its known connections to serious health problems (POPE III & DOCKERY, 2006). Even the smallest parks can create pockets of cleaner air, a vital service in dense neighbourhoods (VIIPPOLA ET AL., 2024).

The park's plants and permeable surfaces could hold a lot of water (table 3) because a large tree canopy can catch rain, maintain a healthy evapotranspiration environment, and better soil penetration of the water that can allow a better recharge of the groundwater system, as well as helping to keep stormwater from running off and make it easier for city drainage systems to handle.

Parks with higher vegetation and permeable soil, such as II. János Pál pápa tér and Ludoviká tér, recorded greater water retention through infiltration and transpiration.

Parks with more vegetation and permeable surfaces, particularly II. János Pál pápa tér and Ludovika tér, demonstrated higher water retention. This is achieved through rainfall interception by the canopy and infiltration into the soil, which reduces the volume and velocity of stormwater runoff. Conversely, compact parks with more paved areas showed higher runoff potential. This supports extensive research highlighting the role of UGI in mitigating urban flood risk and reducing the strain on conventional "grey" infrastructure like sewer systems (BERLAND ET AL., 2017; LIVESLEY ET AL., 2016).

In contrast, areas with more pavement, like Mátyás tér, showed increased runoff due to limited soil permeability. This indicates that vegetation density and soil condition strongly influence water balance across the studied parks.

Table 3.

The quantity (kl) of water retained or lost by the parks in District VIII, Budapest

	Orczy	II. János Pál pápa	Ludoviká	Golgota	Teleki	Kálvária	Horváth Mihály	Mátyás
AVRO	160	64	32	15	6	6	2	2
E	6495	2594	1306	601	229	237	62	86
I	6513	2601	1309	603	229	238	62	86
T	4637	1852	932	429	163	169	44	61
PE	23761	9490	4776	2199	837	867	228	314
PET	19239	7684	3867	1781	678	702	184	255

***NOTE**: AVRO – available runoff; E – evaporation; I – infiltration; T – transpiration; PE – potential evaporation; PET – potential evapotranspiration; CO_2 – carbon dioxide.*

In total, the eight parks stored roughly 909 tons of carbon and sequester another 36.2 tons a year. Orczy tér was the leader with nearly 400 tons of stored carbon.

This result, despite its lower tree count, drives home the point that a few large, mature trees are the real carbon storage workhorses in a city (NOWAK AND CRANE, 2002; GILLNER ET AL., 2017).

While smaller parks contributed proportionally lower amounts, their cumulative role remains vital in district-level carbon accounting, a point emphasized by STROHBACH ET AL. (2013) in their study of European cities.

The sequestration potential is tied to canopy health and age, highlighting the importance of long-term park management (DAVIES ET AL., 2011).

The investigation of park carbon sequestration emphasised the role of green spaces in mitigation of the urban heat giving the police maker a guiding line for improving the strategies for reaching the carbon neutrality goals (GAO ET AL. 2023; MYALKOVSKY ET AL. 2023)

The parks together store a large amount of carbon and provide continuous environmental benefits (table 4). II. János Pál pápa tér had the greatest carbon storage, while smaller parks still contributed meaningfully to reducing CO_2 in the atmosphere.

This confirms that all parks, regardless of size, play a role in making the city more sustainable.

Research Journal of Agricultural Science, 57 (3), 2025; ISSN: 2668-926X
http://doi.org/10.59463/RJAS.2025.3.27

Table 4.

The total amount (t) of tree benefits provided by the parks in District VIII, Budapest

	Retained pollutans (t)	Carbon seq. annualy (t)	Carbon stored (t)	CO_2 seq. annualy Equiv. (t)	CO_2 seq. annualy Equiv. (t)
Total	1.918	36.20	908.82	132.69	3332.29

Most of the time, these models give dollar amounts based on the idea of avoided costs (like lower healthcare costs because of cleaner air or delayed investments in grey infrastructure for storm water management) and replacement costs.

The total estimated monetary value of ecosystem services for the eight parks in District VIII (figure 2) show that Orczy tér recorded the highest value (about €250,000), followed by II. János Pál pápa tér and Ludoviká tér, which also showed considerable returns linked to their dense vegetation. Smaller parks such as Golgota tér, Teleki tér, Kálvária tér, Horváth Mihály tér, and Mátyás tér had lower values, consistent with their limited area and tree cover.

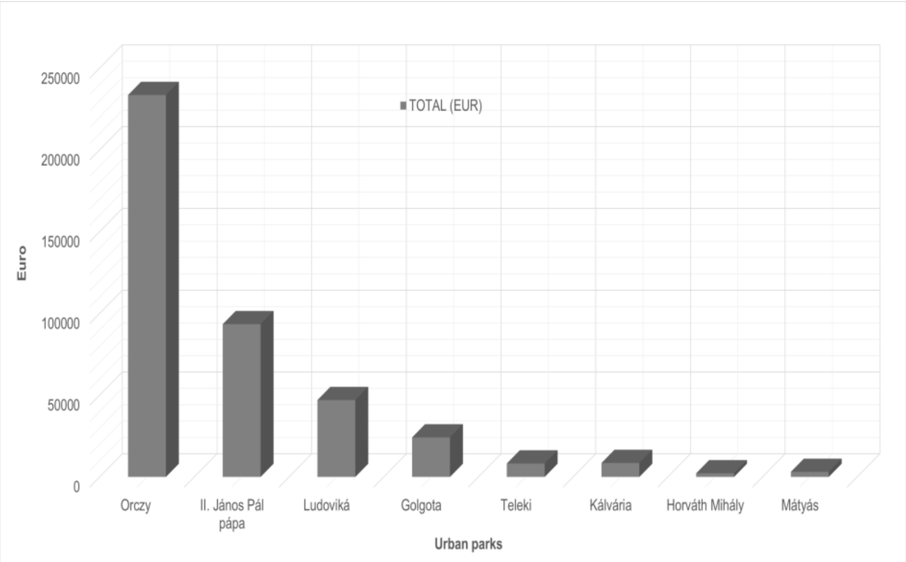

Figure 2. Comparative analysis of the benefits in terms of monetary value (Euro)

Overall, the results show that larger parks generate greater total benefits, while smaller ones still provide important local environmental value within the urban landscape.

These figures, derived from the social cost of carbon and avoided health and infrastructure costs, provide a powerful economic argument for investing in parks. By translating environmental benefits into monetary terms, policymakers can better justify budgets for park maintenance and creation. This aligns with previously proposed valuation methodologies (PUKOWIEC-KURDA, 2022; GÓMEZ-BAGGETHUN & BARTON, 2013). The main argument being that such quantification is essential for integrating nature-based solutions into urban policy. (PUKOWIEC-KURDA, 2022; GÓMEZ-BAGGETHUN & BARTON, 2013)

Orczy tér, the largest park by a wide margin, doesn't actually have the most trees. It has fewer than the much smaller Ludovika tér and II. János Pál pápa tér. Yet, as we'll see, Orczy tér delivers the greatest ecosystem benefits. This points to a critical conclusion: the park's ecological power comes from the quality of its trees their size, age, and maturity not just the quantity. It’s a clear reminder that preserving large, old trees is essential for getting the most out of urban green spaces (NOWAK AND CRANE, 2002).

CONCLUSIONS

The comprehensive comparative analysis performed across the eight parks showed how variations in park size, vegetation density, and specific land cover compositions influence their overall ecological performance and the magnitude of the ecosystem services they provide. The results of this study give us a strong scientific basis for understanding and promoting the environmental benefits of urban parks in relation to sustainable urban growth in Budapest.

The environmental contributions of the eight urban parks in Budapest’s District VIII by using the i-Tree Canopy method showed that all parks, whether large or small, play an important part in improving the city’s environmental quality. Bigger green areas, such as II. János Pál pápa tér and Ludoviká tér, recorded higher levels of carbon storage and pollutant removal because of their dense vegetation. Smaller parks, including Mátyás tér and Horváth Mihály tér, also provided meaningful benefits by offering cooler microclimates, shade, and cleaner air for surrounding communities.

The analysis revealed that tree number, canopy size, and soil characteristics are key factors determining how much ecosystem service each park can provide. Parks with more trees and vegetation showed better performance in carbon capture, air purification, and water regulation. These outcomes emphasize the need to maintain and expand both large and small green spaces to promote a sustainable and balanced urban environment.

To further improve these functions, the city should prioritize planting more trees, reducing paved areas, and using native plant species that are well adapted to local conditions. Strengthening and protecting urban vegetation in this way will help Budapest lessen the effects of climate change, enhance residents’ health, and create a greener, more comfortable city for future generations.

Acknowledgements

The authors are grateful for the support received from students at John Wesley Theological College, Budapest who made a significant contribution to the field investigations. We would like to thank all of them for their effort and help in quantifying trees in the parks that are the subject of this study.

BIBLIOGRAPHY

BARÓ, F., CHAPARRO, L., GÓMEZ-BAGGETHUN, E., LANGEMEYER, J., NOWAK, D. J., & TERRADAS, J., 2014 - Contribution of ecosystem services to air quality and climate change mitigation policies in the city of Barcelona. Ambio, 43(4), 466–479. https://doi.org/10.1007/s13280-014-0507-x

BERLAND, A., SHIFLETT, S. A., SHUSTER, W. D., GARMESTANI, A. S., GODDARD, H. C., HERRMANN, D. L., & HOPTON, M. E., 2017 - The role of trees in urban stormwater management. Landscape and Urban Planning, 162, 167–177. https://doi.org/10.1016/j.landurbplan.2017.02.007

BODROGI, E., 2019, July 28 - A Teleki tér sokkal jobb, mint gondolnád! [The Teleki Square is much better than you think!]. NLC. https://nlc.hu/utazas/20190728/teleki-ter-jozsefvaros-piac-budapest/, accessed on 04.2025

BOWLER, D. E., BUYUNG-ALI, L., KNIGHT, T. M., & PULLIN, A. S., 2010 - Urban greening to cool towns and cities: A systematic review of the empirical evidence. Landscape and Urban Planning, 97(3), 147–155. https://doi.org/10.1016/j.landurbplan.2010.05.006

BUDAPEST100, 2018 - Horváth Mihály tér lakóházközterület-Megszólított ház [Horváth Mihály Square residential area-Addressed house]. https://budapest100.hu/house/horvath-mihaly-ter/, accessed on 04.2025

CSOMÓS, G., FARKAS, J. Z., SZABÓ, B., BERTUS, Z., & KOVÁCS, Z., 2023 - Exploring the use and perceptions of inner-city small urban parks: A case study of Budapest, Hungary. Urban Forestry & Urban Greening, 86, 128003. https://doi.org/10.1016/j.ufug.2023.128003

DAVIES, Z. G., EDMONDSON, J. L., HEINEMEYER, A., LEAKE, J. R., & GASTON, K. J., 2011 - Mapping an urban ecosystem service: Quantifying above-ground carbon storage at a city-wide scale. Journal of Applied Ecology, 48(5), 1125–1134. https://doi.org/10.1111/j.1365-2664.2011.02021.x

ESCOBEDO, F. J., KROEGER, T., & WAGNER, J. E., 2011 - Urban forests and pollution mitigation: Analyzing ecosystem services and disservices. Environmental Pollution, 159(8-9), 2078–2087. https://doi.org/10.1016/j.envpol.2011.05.022

GAO, J., HAN, H., & GE, S., 2023 - Carbon-saving potential of urban parks in the Central Plains city: A high spatial resolution study using a forest city, Shangqiu, China, as a lens. Land, 12(7), 1383. https://doi.org/10.3390/land12071383

GILLNER, S., BRÄUNIGER, C., HOFMANN, M., & ROLOFF, A., 2017 - The carbon storage of urban trees: A case study of a German city. Urban Forestry & Urban Greening, 25, 1-10. https://doi.org/10.1016/j.ufug.2017.04.009

GÓMEZ-BAGGETHUN, E., & BARTON, D. N., 2013 - Classifying and valuing ecosystem services for urban planning. Ecological Economics, 86, 235–245. https://doi.org/10.1016/j.ecolecon.2012.08.019

HAASE, D., LARONDELLE, N., ANDERSSON, E., ARTMANN, M., BORGSTRÖM, S., BREUSTE, J., & KABISCH, N., 2014 - A quantitative review of urban ecosystem service assessments: Concepts, models, and implementation. Ambio, 43(4), 413–433. https://doi.org/10.1007/s13280-014-0504-0

i-Tree Tools. (n.d.). i-Tree Canopy v7.1. U.S. Forest Service. Retrieved October 30, 2024, from https://canopy.itreetools.org/

KONDO, M. C., FLUEHR, J. M., MCKEON, T., BRANAS, C. C., 2018 - Urban green space and its impact on human health. International Journal of Environmental Research and Public Health, 15(3), 445. https://doi.org/10.3390/ijerph15030445

KONIJNENDIJK, C. C., ANNERSTEDT, M., NIELSEN, A. B.,MARUTHAVEERAN, S., 2013 - Benefits of urban parks–A systematic review. University of Copenhagen & Swedish University of Agricultural Sciences.

LEE, A. C. K., JORDAN, H. C., & HORSLEY, J., 2015 - Value of urban green spaces in promoting health and wellbeing. Risk Management and Healthcare Policy, 8, 131–137. https://doi.org/10.2147/RMHP.S63407

LIVESLEY, S. J., MCPHERSON, E. G., CALFAPIETRA, C., 2016 - The urban forest and ecosystem services: Impacts on urban water, soils, and biodiversity. In The Urban Forest (pp. 49-69). Springer, Cham.

Myalkovsky, R., Plahtiy, D., Bezvikonnyi, P., Horodyska, O., & Nebaba, K., 2023 - Urban parks as an important component of environmental infrastructure: Biodiversity conservation and recreational opportunities. Ukrainian Journal of Forest and Wood Science, 14(4), 57-72. https://doi.org/10.31548/forest/4.2023.57

NOWAK, D. J., & CRANE, D. E., 2002 - Carbon storage and sequestration by urban trees in the USA. Environmental Pollution, 116(3), 381–389. https://doi.org/10.1016/S0269-7491(01)00214-7

NOWAK, D. J., CRANE, D. E., & STEVENS, J. C., 2006 - Air pollution removal by urban trees and shrubs in the United States. Urban Forestry & Urban Greening, 4(3-4), 115–123. https://doi.org/10.1016/j.ufug.2006.01.007

OTHMAN, R., & FADZIL, A. M., 2019 - Carbon sequestration potential of urban parks based on park layout and tree species. International Journal of Engineering and Advanced Technology, 8(5), 263-268.

POPE III, C. A., & DOCKERY, D. W., 2006 - Health effects of fine particulate air pollution: Lines that connect. Journal of the Air & Waste Management Association, 56(6), 709–742. https://doi.org/10.1080/10473289.2006.10464485

PUKOWIEC-KURDA, K., 2022 - The urban ecosystem services index as a new indicator for sustainable planning. Ecological Indicators, 144, 109532. https://doi.org/10.1016/j.ecolind.2022.109532

RAZZAGHIAN, F., & RAHNAMA, M. R., 2012 - Ecological analysis of urban parks (case study: Mashhad Metropolitan). International Journal of Applied, 2(7), 136–142.

STROHBACH, M. W., ARNOLD, E., & HAASE, D., 2012 - The carbon footprint of urban green space—A life cycle approach. Landscape and Urban Planning, 104(2), 220-229. https://doi.org/10.1016/j.landurbplan.2011.10.013

STROHBACH, M. W., HAASE, D., & KABISCH, N., 2013 - Wo wachsen die Bäume in den Himmel? Über die Verteilung von oberirdischem Kohlenstoff in der Stadt [Where do the trees grow to the sky? On the distribution of above-ground carbon in the city]. Forum der Geoökologie, 24(2), 18-23.

TYRVÄINEN, L., PAULEIT, S., SEELAND, K., & DE VRIES, S., 2005 - Benefits of urban green space. In C. C. Konijnendijk, K. Nilsson, T. B. Randrup, & J. Schipperijn (Eds.), Urban forests and trees (pp. 81-114). Springer.

VIIPPOLA, V., YLI-PELKONEN, V., JÄRVI, L., & SETÄLÄ, H., 2024 - Small-scale urban green infrastructure provides significant air quality benefits. Urban Forestry & Urban Greening, 92, 128189. https://doi.org/10.1016/j.ufug.2024.128189

WÁGNER, G., 2021 - Vásárosok, gázosok meg a kazamaták titka – A II. János Pál pápa tér története [Traders, gas workers and the secret of the casemates – The history of Pope John Paul II Square]. We Love Budapest. https://welovebudapest.com/cikk/2021/12/09/latnivalok-es-kultura-vasarosok-gazosok-meg-a-kazamatak-titka-a-ii-janos-pal-papa-ter-tortenete/, accessed on 04. 2025,

WÁGNER G., 2022 - Az öngyilkos, a Tangó meg az Eldorádó Sanyi bácsija – A Teleki tér története IN: We love Budapest, 2022.03.23. accesed on 04. 2025,

i-Tree Canopy, A tree canopy assessment tool, accesse on 04 -05 2025, https://canopy.itreetools.org/