A KECSKEMÉTI FŐTÉR KLÍMAADAPTÁCIÓS SZEMPONTÚ ELEMZÉSE

CLIMATE ADAPTATION ANALYSIS OF THE MAIN SQUARE IN KECSKEMÉT

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ABSZTRAKT

Kecskemét városfejlődése során egy sűrű beépítésű központi városmag alakult ki alacsony zöldfelületi intenzitással, ezért a belterületi zöldfelületi rendszerben jelentős szerepet tölt be a városközponti gyalogos téregyüttes. A kecskeméti Főtér eredetileg a kereskedelmi utak találkozásában kialakult, történelmi jelentőségű piactér rendezésével és körbeépítéséve (Füzi & Walter, 2005), majd 1976-ban gyalogos zónává való átalakításával (Gutai, 2005) és a 2000-es évek elején zajló rekonstrukcióval (Építészműhely Tervező, Beruházó és Szolgáltató Kft., 1994) nyerte el mai formáját. A fásított és burkolt, köztéri alkotásokkal, vízarchitektúra elemekkel, variábilis építészeti megjelenésű térfalakkal határolt, intenzíven fenntartott és nívós megjelenésű köztér együttes, nemcsak egy reprezentatív városi szabadtér, de jelentős növényállománya miatt klímakondicionálás szempontjából is meghatározó zöldfelületi-rendszer alkotó elem. Kutatásunk során célunk Kecskemét főterére vonatkoztatható környezeti- és klíma- kockázatok megismerése volt. Ehhez olyan módszertant dolgoztunk ki, melynek alapját azok az építészeti és tájépítészeti elemek összegyűjtése képezte, melyek hatással vannak a lokálklíma alakítására, így a humánkomfortra is.

Kulcssszavak: Kecskemét, főtér, klímaváltozás, klímaadaptáció, városi hősziget, zöld infrastruktúra, városfásítás, lombkorona-borítottság ⦿

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ABSTRACT

Over the course of Kecskemét's urban development, a densely built-up central core with low green space intensity has developed; the pedestrian square complex in the city centre therefore plays an important role in the inner city's green space system. Kecskemét's Main Square (Főtér) was originally formed by the reorganisation and enclosure of the historically significant market square at the junction of the commercial roads (Füzi & Walter, 2005). It was pedestrianised in 1976 (Gutai, 2005) and then reconstructed in the early 2000s (Építészműhely Tervező, Beruházó és Szolgáltató Kft., 1994). With its intensively maintained and sophisticated appearance, this public space is not only a representative urban open space, but also, given its significant plant population, a key element of the green space system in terms of climate conditioning; it is bordered by wooded and paved public spaces, water architecture elements and square walls with variable architectural designs. The aim of our research was to understand the environmental and climate risks related to Kecskemét's Main Square. For this purpose, we developed a methodology based on the collection of architectural and landscape elements that have an impact on the local climate, including human comfort.

Keywords: Kecskemét, main square, climate change, climate adaptation, urban heat island, green infrastructure, urban afforestation, canopy cover

INTRODUCTION

Kecskemét and its region is one of the most exposed areas in Hungary to the impacts of climate change and droughts (23/2018. (X. 31.)) OGY Határozat a 2018–2030 Közötti Időszakra Vonatkozó, 2050-Ig Tartó Időszakra Kitekintést Nyújtó Második Nemzeti Éghajlatváltozási Stratégiáról, 2018). Local adaptation options for drought, extreme precipitation and heat waves need to be developed and implemented. A network of municipal green infrastructure can provide a suitable and natural framework for addressing each of these factors in a modern and natural way. In an urban context, local adaptation to the negative impacts of climate change is mainly focused on mitigating the urban heat island effect and protecting against high levels of warming, with urban planning and architecture based on ecological and climate-friendly design methods as central elements.

There is a significant lack of green space in Kecskemét's city centre (Kecskeméti Városfejlesztő Kft., 2023). Over the course of the city's development, the historic centre has evolved to exhibit characteristics of both a town and a country town. The presence of framed or enclosed buildings with semi-enclosed courtyards and a built-up area that occupies 40-60% of the small plot area is typical (Kecskemét Megyei Jogú Város Önkormányzata, 2017). The emphasis on green space within the urban fabric is conspicuously absent, and the city centre is devoid of any substantial public green spaces with a minimum area of 3-5 hectares, nor does it have an urban-level public park. Consequently, the development of new multifunctional public parks and public gardens is unfeasible. With its arboreal elements, the Main Square has therefore emerged as a pivotal component of the urban green infrastructure. The Main Square not only connects the mosaic of green spaces in the central inner area – such as Széchenyi Square, Katona József Square and Kodály Zoltán Square – but is also an integral part of the network of roadside green spaces and tree-lined streets (Kecskemét Megyei Jogú Város Önkormányzata, 2017).

Responding to the challenges of climate change, improving the microclimate and climate-friendly development of the Main Square (Kossuth Square, Szabadság Square, Lestár Square) is an urgent task. In order to lay the foundations for climate-smart planning, we aim to identify environmental and climate risks and conduct vulnerability assessments for Kecskemét's Main Square. In our research, we will investigate the current microclimate of Kecskemét's Main Square and the main factors influencing it from the perspective of public space development solutions typical for a climate-friendly city (e.g. use of permeable and high-albedo pavements, humidification, quantitative and qualitative improvement of green spaces, shading, ventilation, sustainable operation solutions). For the climate adaptation analysis of Kecskemét's Main Square, our aim was to develop a methodology that can be applied primarily to the climate analysis of the selected public space in the city, in addition to exploring the general characteristics of the given open space.

MATERIAL AND METHODS

A number of studies have demonstrated that the perception of outdoor human comfort is directly influenced by microclimatic factors, including humidity, air temperature, air movement, surface temperature and radiation.

Figure 1: The most important factors influencing the current microclimate of Kecskemét's Main Square
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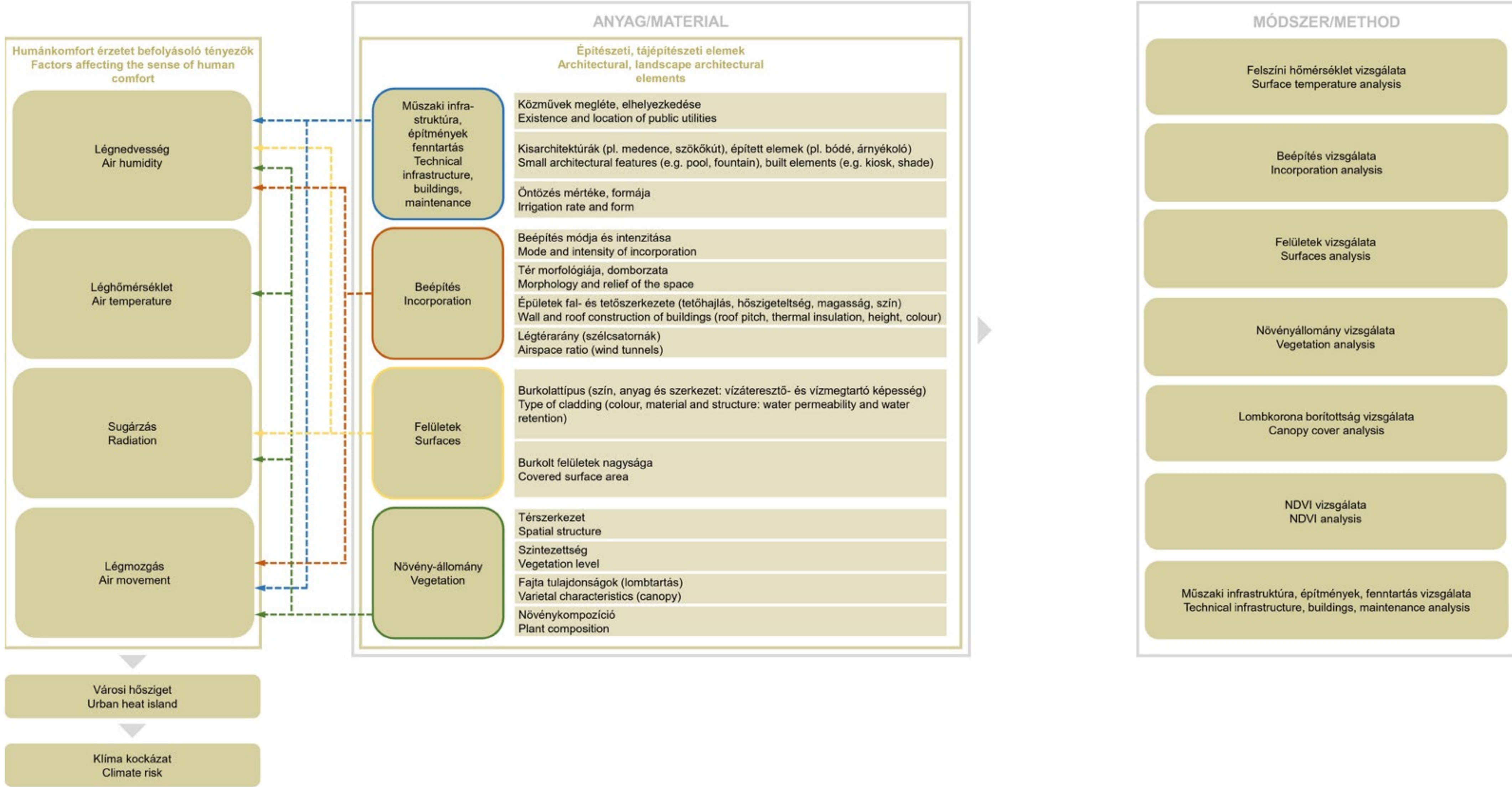


These factors are, in turn, strongly influenced by the space's physical/biophysical quantitative and qualitative characteristics (Dadvand et al., 2016; Ekkel & De Vries, 2017; Gill et al., 2007; Ren et al., 2023; Yang, 2009).

The microclimate of an urban open space is determined by geography, environmental conditions and urban and spatial structure, but can be further modified by other anthropogenic interventions (Unger et al., 2012).

In developing the methodology, we collected the architectural and landscape elements (e.g. buildings, surfaces, vegetation, technical infrastructure) that have the greatest impact on human comfort in Kecskemét's Main Square (Figure 1). To investigate the urban heat island (UHI) phenomenon, Landsat 9 and Sentinel-2 satellite data (EarthExplorer, n. d.; Planet Labs: Satellite Imagery & Earth Data Analytics, n.d.), Land Surface Temperature (LST) were calculated following the methodology of Malik & Kalotra (2024) (Abhishek & Gaurav, 2024). UHI was calculated from LST using the formula UHI= (LST-LSTave)/LSTscattering.

For the analysis of the built environment, we used QGIS software to determine the percentage of building coverage of the surrounding parcels. Surface quality was analysed based on field maps, orthophotos and field observations, while technical infrastructure was analysed based on utility maps to identify stormwater management and new green space opportunities.

The intensity of green areas was assessed using zonal statistics, while canopy cover was assessed using aerial photographs and field surveys. NDVI was calculated using Sentinel-2 data (22.08.2023) and thermal infrared data was obtained using the Landsat 9 satellite (20.08.2023). Microclimatic, ecological and compositional analyses of the vegetation were also carried out.

RESULTS

Kecskemét belongs to Hungary's temperate, warm-dry climate zone, with an aridity index of 1.22-1.35 (Kecskeméti Városfejlesztő Kft., 2023; Magyar Meteorológiai Szolgáltató Nonprofit Zrt, n.d.). It has relatively low (average of 520 mm over many years, about 300 mm in the growing season) and unevenly distributed rainfall (Dövényi, 2010; Hoyk et al., 2019). Characterised by a flat landscape and good ventilation, the prevailing wind direction is W, NW, NE, and the average wind speed 2.5-3.0 m/s (Kecskeméti Városfejlesztő Kft., 2023). According to the National Meteorological Service, mean annual temperatures rose by approximately 3.5°C from 1991 to 2019, which is significantly higher than the global average, while climate models predict a slight decrease in precipitation in the future (Hoyk & Kanalas, 2020).

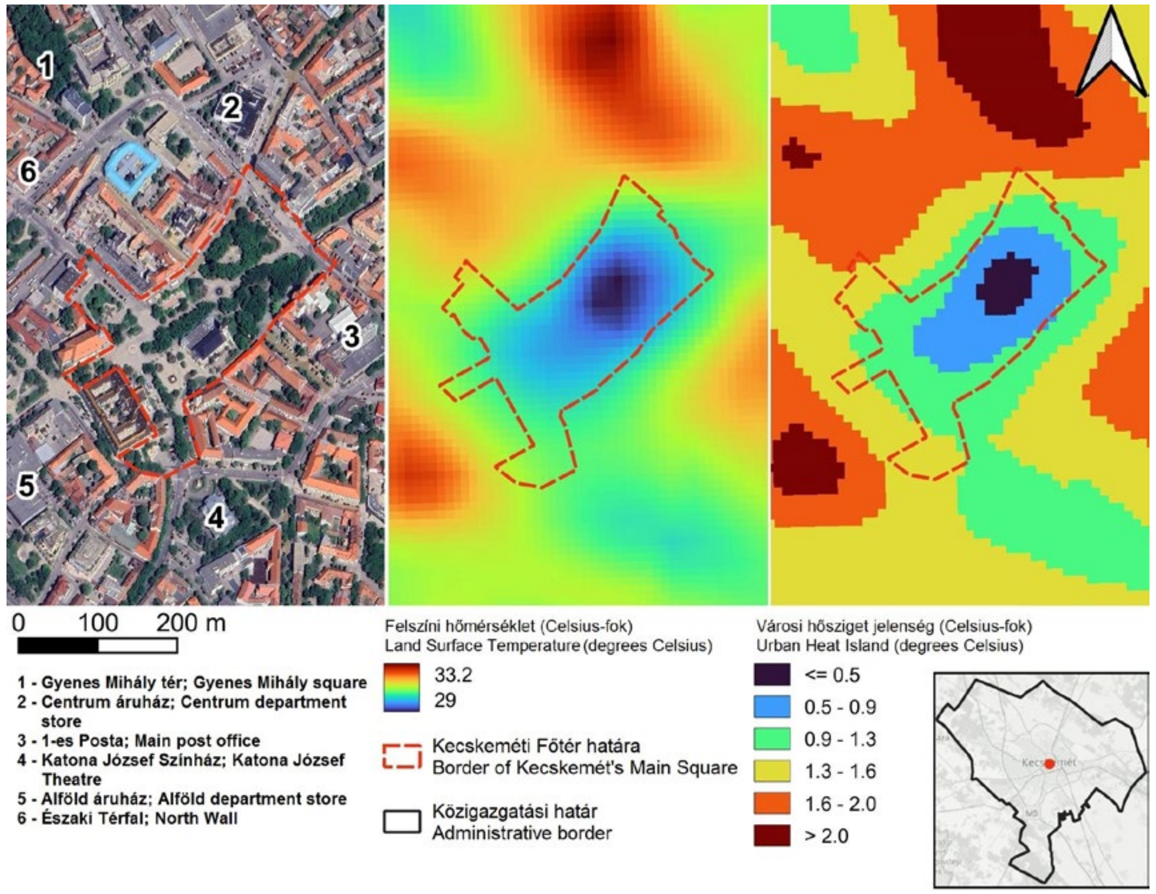
In addition to the geographical location and the environmental conditions, the following findings were made by subject area, and examine the most significant factors influencing the current microclimate of Kecskemét's Main Square and its fluctuations.

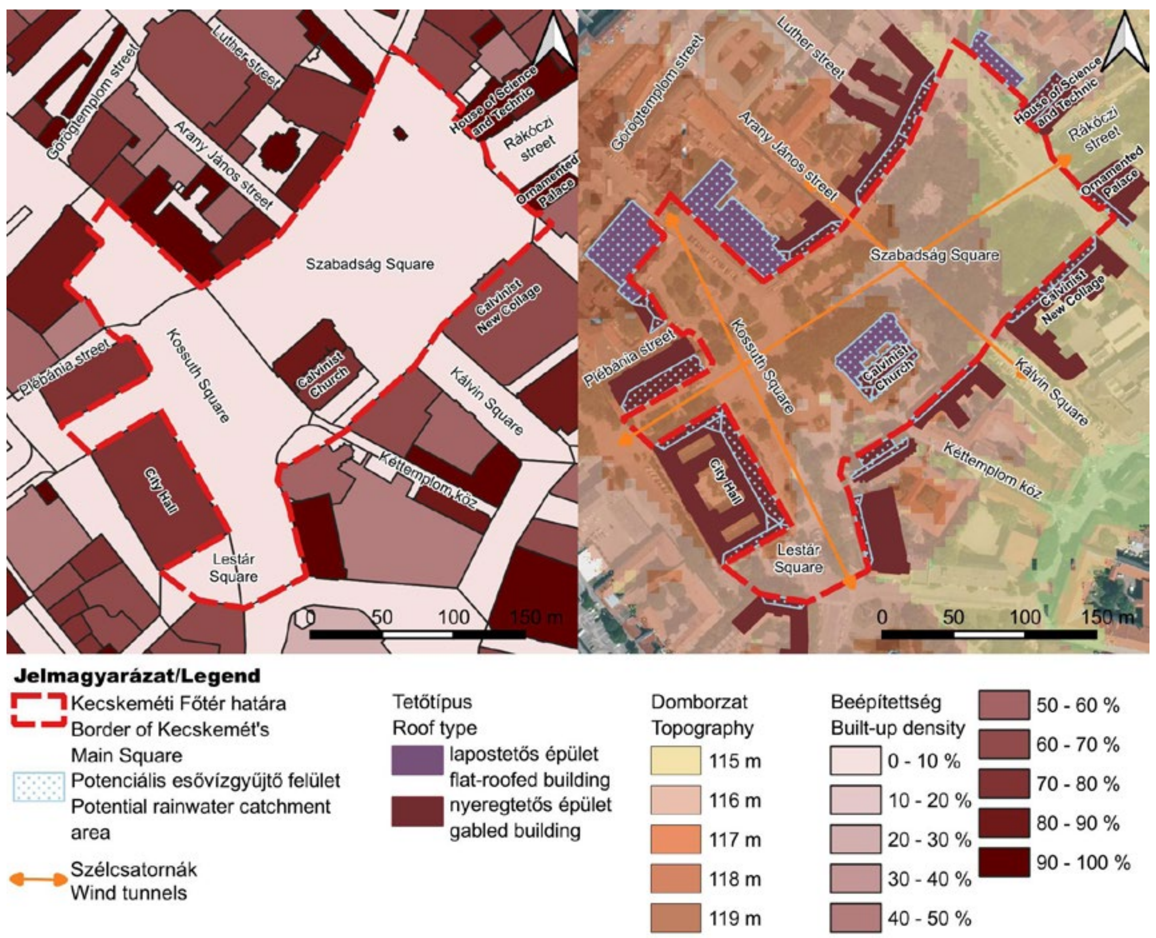
Land surface temperature

Based on the surface temperature image of Kecskemét's Main Square (Figure 2), it can be concluded that the Main Square is a cool (blue) zone within the urban area, with a surface temperature of 29-30°C, and the areas in the NE part of the Main Square, which are typically characterised by multi-level vegetation, have a surface temperature 3-4°C lower than their surroundings. In the wider area around the Main Square, differences of up to 4°C can be observed within a few hundred metres. In the built-up and paved areas of the city centre, such as the Centrum department store, the area around the market, the Alföld department store, the Dobó Street car park, the North Wall and Piaristák Square, temperatures range from 30°C to 33.2°C, while public gardens and parks such as Gyenes Mihály Square and the area around the Katona József Theatre also have multi-level vegetation, resulting in a temperaturedrop of 2-3 °C.

Analysis of built area

The Main Square is a morphologically enclosed complex of gently sloping squares surrounded by walls, divided by extensions and connecting streets. The square covers a total area of the square is 5 hectares, with the NW and SE walls averaging 280 m apart and the NE and SW walls 150 m apart. The layout of the square is similar to a rectangle with long sides of proportionate length, divided and completed by the block-like buildings (Reformed Church, Great Church, Town Hall) and the spaces between them. The typical built-up area of the blocks is relatively high for a city centre, averaging 60-90%, and the unbuilt parts of the site are mostly paved (Figure 3). A favourable air-space ratio is also provided by a typical number of 1-6 storeys and an average building height of 4-18 m, with the exception of the tower-like buildings and





◂◂**Figure 2:** Surface temperature image of Kecskemét's Main Square and urban heat island phenomenon
SELF-EDITED FIGURE BASED ON GOOGLE SATELLITE IMAGE TAKEN ON 20.08.2023 (GOOGLE, 2015)

◂◂**Figure 3:** The extent of the built-up area of the Main Square and its surroundings, the topography of the square and the roof structure of the buildings bordering the square walls and located in the square
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Figure 4: Percentage of surface qualities in the Main Square
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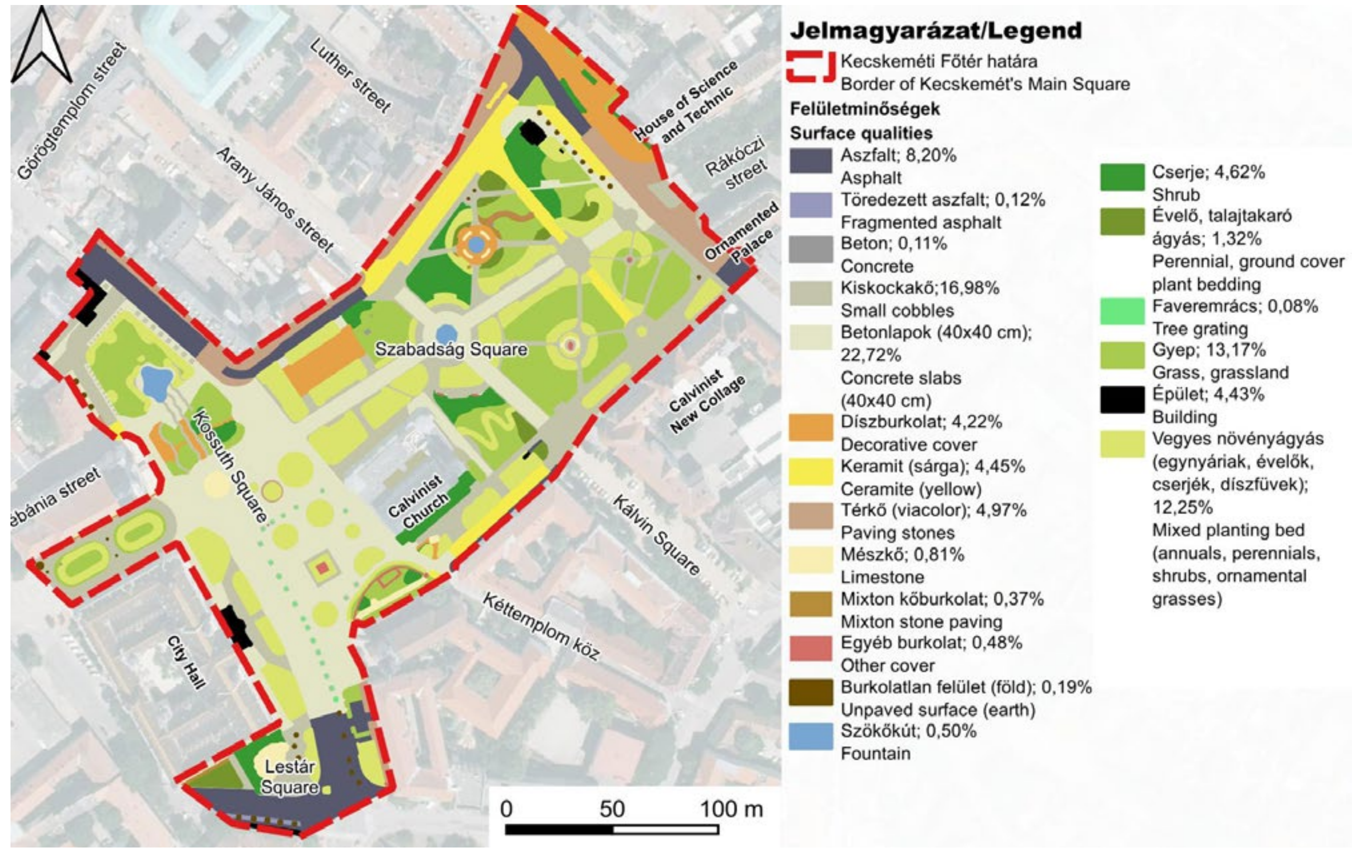

parts of the site, and the distance between the walls. The Main Square and the surrounding blocks are all listed buildings, the vast majority of which date from the second half of the 19th century and the first half of the 20th century, with the exception of a few buildings (Erdélyi & Sallay, 2023). The load-bearing structure of the buildings is masonry brick, with thick boundary walls, and all buildings are painted in light.

Analysis of paved area and horizontal surfaces

71% of the Main Square's total area is paved and 29% is covered by vegetation. The study area contains a wide variety of pavements, with the highest proportion of paved surfaces for pedestrian traffic at 53% (25,952 m²). These areas are characterised by prefabricated precast paving, consisting of small and large precast concrete slabs in light grey or dark grey, yellow precast ceramic paving, light grey, dark grey or brick red basalt paving, and light grey Viacolor slabs (Figure 4). Apart from the paving stones and ceramic tiles, all the tiles listed are designed with rigid bases. In addition, a number of other paved surfaces appear: the local collector roads and the car park in Lestár Square are paved with asphalt, while the partial public space renovations in spring 2024 will include stabilised gravel paving around a bicycle storage area and a fountain. As the pavements in the Main Square are typically in light pastel colours, they are highly reflective and therefore significantly improve the microclimate.

Analysis of infrastructure and other built elements

The Main Square is fully served by a public utility network, with a larger un-serviced area around the Kossuth statue and the water fountains, and in the eastern corner of Szabadság Square (Figure 5). The main square is adorned with three water fountains (two of which are also located in Szabadság Square), covering a total area of 284.4 m². In terms of microclimate, it is important to note that a water spray gate is also in operation in Kossuth Square in summer.

In 2018, a total of 555.9 mm of precipitation fell in and around the Main Square. The driest months were April (4 mm) and November (9.8 mm), while the wettest months were June (133.5 mm) and August (52.4 mm) (*Netatmo Kültéri Mérőállomás Csapadék Adatai,* 2024). As the drainage system in the Main Square is well established and most of the pavements have a rigid base, rainwater falling on the pavement surface is optimally discharged to green areas due to the slope of the pavement, and in the worst case to the closed stormwater drainage system. In the case of the paving stones and ceramics and Mixton stone paving, rainwater seeps directly into the lower layers of the soil, so the water that seeps through the paving into the soil can be absorbed by the surrounding vegetation.

Analysis of vegetation

The Main Square in Kecskemét has a green area ratio of 29%, with a vegetated area of 14,500 m². In addition to their positive impact, green spaces also have a significant economic value, with an estimated total value of woody species of HUF 1.4 billion (Hoyk et al., 2019).

Canopy cover is a key criteria for assessing the conditioning effects of trees. In 2024, the canopy cover over the Main Square, which has a total area of 50,000 m², was 25,226 m², resulting in a canopy cover value of 52% (Figure 6). From a planning viewpoint, canopy cover of 25-30% is considered ideal for open spaces, while 40-60% is considered ideal for parks (Tóth et al., 2024; Városklíma Műhely, 2012).

In Szabadság Square, trees with a large canopy, such as Japanese pagoda tree and pedunculate oak, have a prominent climatic effect, while in Kossuth Square, less shade-tolerant trees, such as the maidenhair tree and Turkish hazel, have a more moderate effect (Szabó, 2023; Tóth, 2022). Among the younger trees, American tulip trees, dawn redwoods and Atlas cedars can cause significant microclimatic changes over the long term.

The NDVI vegetation index shows an average vegetation intensity of 0.22. The "Címerdomb", the Kossuth statue and the City Hall have low intensity due to the dominance of pavement, while the landscaped areas show medium to high values. These spatial differences reflect the traces of the 1976 restructuring.

In addition to trees, shrub and grassland taxa in the Main Square play an important role as conditioning surfaces. For shrubs, an important aspect is that nearly ⅔ of the taxa are evergreen or semi-evergreen, so unlike trees, at this level we can conclude that they can exert beneficial effects such as mulching, water retention, evapotranspiration and shading throughout the year. Szabadság Square is mainly dominated by broadleaved evergreens and larger, almost woody deciduous taxa, but in terms of shade, it is also important to highlight the *Wisteria sinensis,* which to a large extent determines the square's appearance and microclimatic conditions. Kossuth Square is also dominated by evergreens and pines.

Besides the intensively maintained ornamental grasslands, perennial beds are mainly composed of shade-rich groundcover taxa, while mixed beds are created by combining a wide range of plant species – shrubs, groundcover, flowering perennials and grasses – contributing to the biodiversity and sustainability of the space.

ASSESSMENT AND SUGGESTIONS

The analysis of canopy cover, vegetation and surface temperature confirms that medium to high canopy cover and multi-level vegetation is effective in mitigating the urban heat island phenomenon. In the Main Square, the surface temperatures are highest in the most covered, uncanopied areas, while open spaces and ventilation corridors, such as the passageways along Rákóczi Street and Deák Ferenc Square, provide wind channels and significantly mitigate the heat island effect. The roof area of the buildings around the square, covering 12,463 m², also allows for rainwater harvesting, while the light wall surfaces have a positive effect on long-wave radiation, reducing air temperatures.

With only 9.85% of the pavements in the Main Square being permeable and the rest being concrete-based, climate-adaptive retrofitting would involve replacing a large proportion of non-permeable pavements with green surfaces or permeable materials, which would better support local stormwater management and recycling. The vegetation is rich in taxa, but the planting of mature tree species and species with inappropriate environmental needs, such as the American tulip tree and Turkish hazel, should be avoided in the future.

Figure 5: Public utility access to the Main Square
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Figure 6: Canopy cover analysis of the Main Square in Kecskemét
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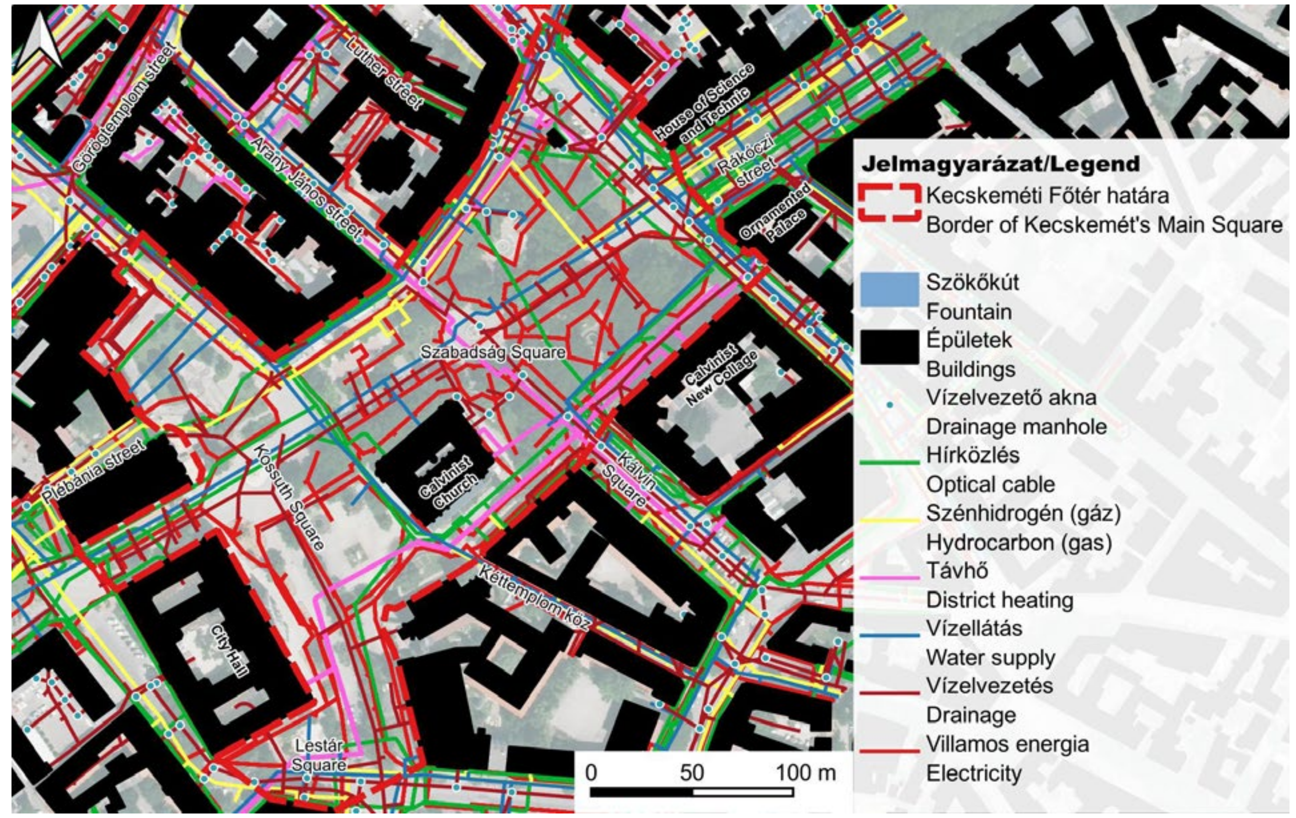


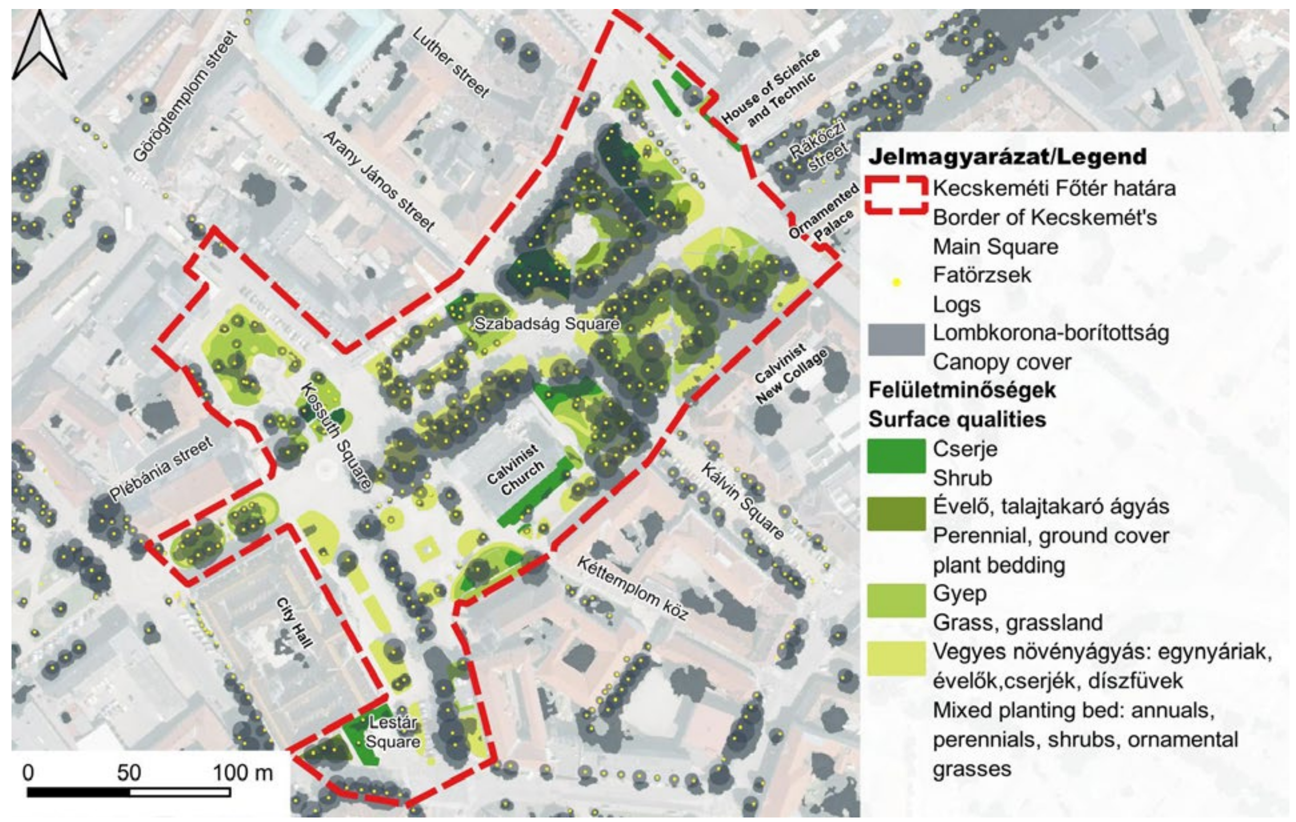
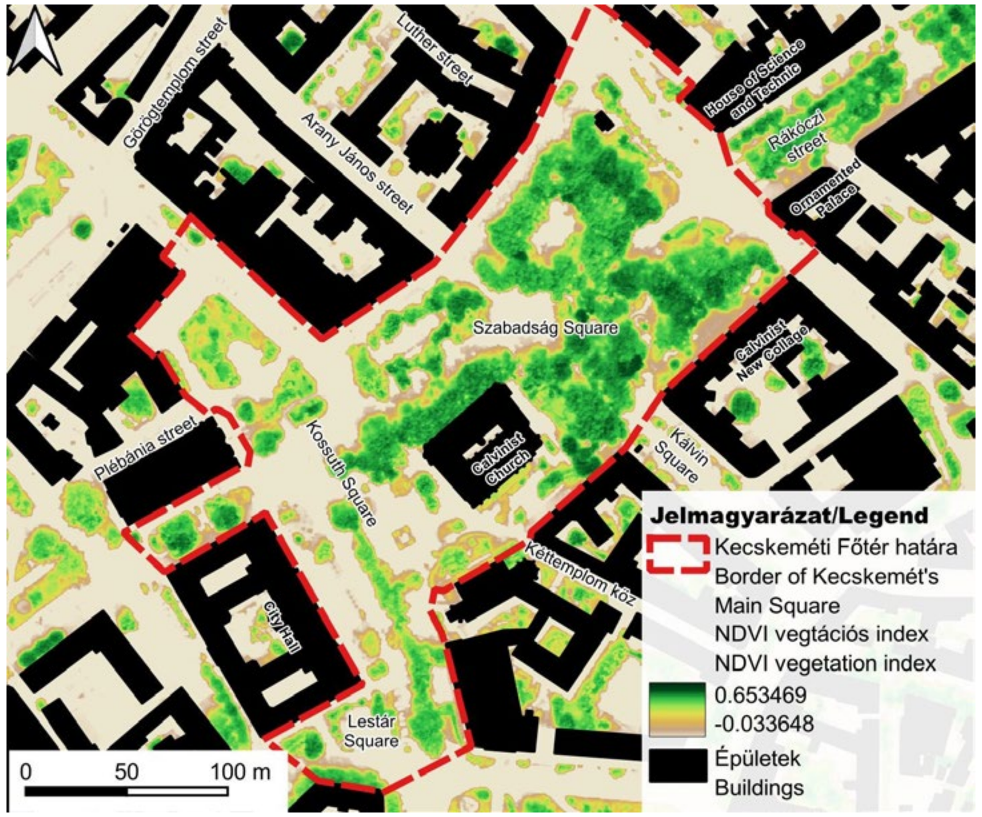


Figure 7: NDVI vegetation index for the Main Square and its surroundings
OWN EDITED FIGURE FOR THE 2023 FOLIAGE PERIOD, BASED ON AN ORTHOPHOTO AT 0.4 M/PIXEL FIELD RESOLUTION



In the short term, the most important measures are to improve green space indicators and to protect and care for the trees in a professional way. In particular, older trees in poor health, such as common hackberry, Japanese ash and columnar black poplar, really need replacing. In the medium term, creating conditions for adequate stormwater management and evapotranspiration will become a priority, for example with the installation of water gateways, creating water surfaces, installing rain gardens or creating groundwater reservoirs. Reducing paved surfaces and increasing green areas are also essential to improving microclimatic conditions.

SUMMARY

Kecskemét's Main Square has a significant positive impact on the microclimate of the surrounding buildings and blocks, but in light of climate change, it needs to be developed in a climate-friendly manner to further enhance its role. In order to preserve the city's long-term livability, architectural and public space solutions typical of climate-friendly cities should be prioritised. Although the transformation of the Main Square has often been driven by economic or technical considerations or architectural prestige, it is now time to focus on environmental considerations. Although no major redevelopment is foreseen, measures to improve human comfort need to be developed to integrate building, façade design, stormwater management, green spaces and paving in the square. In addition to examining the most important factors affecting the Main Square's microclimate, more precise climatic analyses, such as an LCZ assessment method and seasonal air temperature and humidity measurements, are needed. ◉

Abhishek, A. M., & Gaurav, G. K. (2024). Land Surface Temperature and Urban Heat Island: A Case Study of Faridabad City using RS and GIS techniques. International Journal For Multidisciplinary Research, 6(1), 11865. https://doi.org/10.36948/ijfmr.2024.v06i01.11865

Csizmadia, D. (2022). Klímaadaptív gyepgazdálkodás a városban. 4D Tájépítészeti És Kertművészeti Folyóirat, 90–91. https://doi.org/10.36249/62.8

Dadvand, P., Bartoll, X., Basagaña, X., Dalmau-Bueno, A., Martinez, D., Ambros, A., Cirach, M., Triguero-Mas, M., Gascon, M., Borrell, C., & Nieuwenhuijsen, M. J. (2016). Green spaces and General Health: Roles of mental health status, social support, and physical activity. Environment International, 91, 161–167. https://doi.org/10.1016/j.envint.2016.02.029

Dövényi, Z. (2010). Magyarország kistájainak katasztere—Dövényi Zoltán—Régikönyvek webáruház. MTA Földrajztudományi Kutatóintézet. https://www.regikonyvek.hu/kiadas/magyarorszag-kistajainak-katasztere-2010-mta-foldrajztudomanyi-kutatointezet

EarthExplorer. (2025). https://earthexplorer.usgs.gov/

Ekkel, E. D., & De Vries, S. (2017). Nearby green space and human health: Evaluating accessibility metrics. Landscape and Urban Planning, 157, 214–220. https://doi.org/10.1016/j.landurbplan.2016.06.008

Építészműhely Tervező, Beruházó és Szolgáltató Kft. (1994). Előkészítés-vizsgálat és programjavaslat a Kecskemét, Főtér és környezete tervfelülvizsgálathoz, valamint új rendezési tervéhez.

Erdélyi, R., & Sallay, Á. (2023). A kecskeméti főtér fejlődéstörténete és zöldinfrastruktúra szerepének változása. 4D Tájépítészeti És Kertművészeti Folyóirat, 72–87. https://doi.org/10.36249/4d.67.4129

Füzi, L., & Walter, P. (2005). Kecskemét Fő tere: Vallomás a városról. Kecskeméti Lapok Kiadói Kft.

Gill, S. E., Handley, J. F., Ennos, A. R., & Pauleit, S. (2007). Adapting Cities for Climate Change: The Role of the Green Infrastructure. Built Environment, 33(1), 115–133. https://doi.org/10.2148/benv.33.1.115

Google. (2015). Google Satellite műholdfelvétel ©2015 Google, (2023). https://www.google.at/permissions/geoguidelines/attr-guide.html

Gutai, M. (2005). Kortárs építészek Kecskemétről. Kecskeméti Monográfia,. https://moly.hu/konyvek/gutai-matyas-kortars-epiteszek-kecskemetrol

Hoyk, E., & Kanalas, I. (2020). Kecskemét klímaváltozási kihívásai és alkalmazkodási lehetősége. 7–8, 148–165.

Hoyk, E., Kanalas, I., & Farkas, J. Z. (2019). Környezeti kihívások a városfejlesztésben Kecskemét példáján. IN: Farkas J. Zs., Kovács AD, Perger É., Lennert J., Hoyk E., Gémes T.(Szerk.): Alföldi Kaleidoszkóp: A Magyar Vidék a XXI. Században: Tanulmányok a, 70, 133–146.

Kecskeméti Városfejlesztő Kft. (2023). Kecskemét Megyei Jogú Város Megalapozó Vizsgálat. I. kötet.

Magyar Meteorológiai Szolgáltató Nonprofit Zrt. (n.d.). Meteorológiai Adattár. Retrieved 20 January 2025, from https://odp.met.hu/climate/

Netatmo kültéri mérőállomás csapadék adatai (Hoyk Edit). (2024). [Dataset].

Planet Labs: Satellite Imagery & Earth Data Analytics. (2025). https://www.planet.com/?utm_source=google&utm_campaign=evr-brand&utm_content=pros-leads-brandsearch-0124&utm_medium=paid-search&gad_source=1&gclid=CjoKCQiAhbi8BhDIARIsAJLOlueaxRgpI7haSjc75mszkgpkxoJaPr7hazt9eNlguhWkKI5RGIh4cKoaArE-EALw_wcB

Ren, J., Shi, K., Li, Z., Kong, X., & Zhou, H. (2023). A Review on the Impacts of Urban Heat Islands on Outdoor Thermal Comfort. Buildings, 13(6), 1368. https://doi.org/10.3390/buildings13061368

Szabó, K. (2023). Klímafák és városfásítás. Starkiss Kft., Budapest

Tóth, B. (2022). Kertművészeti fejlesztési lehetőségek a Budai Arborétumban. Magyar Agrár- és Élettudományi Egyetem.

Tóth, B., Doma-Tarcsányi, J., & Szabó, K. (2024). A telepítési sűrűség és a lombkorona-borítottság vizsgálata budapesti szabadtereken: Esettanulmányok 1. rész – Móricz Zsigmond körtér. 4D Tájépítészeti És Kertművészeti Folyóirat, 70, 14–31. https://doi.org/10.36249/4d.70.4728

Unger, J., Sümeghy, Z., Kántor, N., & Gulyás, Á. (2012). Kisléptékű környezeti klimatológia. JATEPress. https://moly.hu/konyvek/unger-janos-sumeghy-zoltan-kantor-noemi-gulyas-agnes-kislepteku-kornyezeti-klimatologia

Városklíma Műhely. (2012). Városklíma Kalauz. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/http://urban-path.hu/~tgal/pdf/Varosklima%20kalauz.pdf

Yang, J. (2009). Assessing the Impact of Climate Change on Urban Tree Species Selection: A Case Study in Philadelphia. Journal of Forestry, 107, 364–372.