THE ROLE OF CITY-LEVEL GREEN SPACE FACILITIES IN MUNICIPAL CLIMATE REGULATION THROUGH THE EXAMPLE OF KECSKEMÉT

A VÁROSI SZINTŰ ZÖLDFELÜLETI LÉTESÍTMÉNYEK SZEREPE A TELEPÜLÉSI KLÍMA-SZABÁLYOZÁSBAN KECSKEMÉT PÉLDÁJÁN KERESZTÜL

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ABSTRACT:

Based on the individual reports on climate change (VAHAVA, WMO-CCI/CLIVAR, IPCC, etc.) and the regional assessments of the second National Climate Change Strategy on climate vulnerability, it can be stated that Kecskemét and its region is one of the most exposed to the effects of climate change and drought. Currently, the issue of green spaces, green space management, CO_2 absorption and water management are very important in the city. We hypothesise that the existence of urban green infrastructure can play a serious role in the regulation of urban climate, it can alleviate today's extreme weather conditions. We intend to substantiate this suggestion based on analyses of high-density areas and other built-up fabrics delimited by us across the settlement in an urban structure band ("Green Corridor").

Keywords: climate adaptation, Kecskemét, temperature reduction, public welfare green spaces, forest area, green corridor

INTRODUCTION

One of the most important problems of the 21st century is mitigating the effects of climate change. Climate change (climate change) is a permanent and significant change in the Earth's climate, generated by natural or anthropogenic processes, mainly due to an increase in the quantity of greenhouse gas emissions. In Hungary, the average temperature is expected to rise, reaching 20 ° C in almost all seasons for the period between 2021 and 2050, and may exceed 4 ° C in the summer months by the end of the century (NÉS 2). In the light of climate change, in the case of Kecskemét, it is necessary to develop proposals on the problems of drought and drought, extreme rainfall, stubble and forest fires, and heatwaves. The municipal green infrastructure network is suitable and can provide a framework for dealing with individual factors in a modern and natural way. After all, green infrastructure, as a strategically designed network of natural and semi-natural areas, as well as other areas covered with vegetation and having an ecological function, is able to provide a wide range of ecosystem services thanks to conscious planning and management. In the case of Kecskemét, the services of the ecosystem regulating and maintaining green infrastructure would prevail markedly.

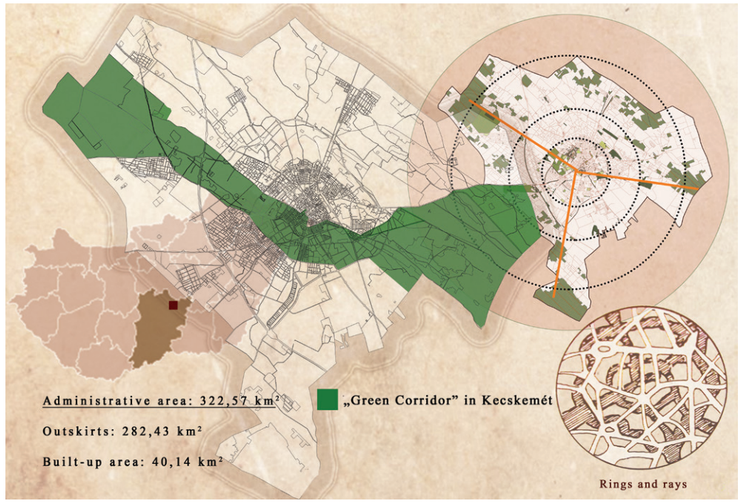

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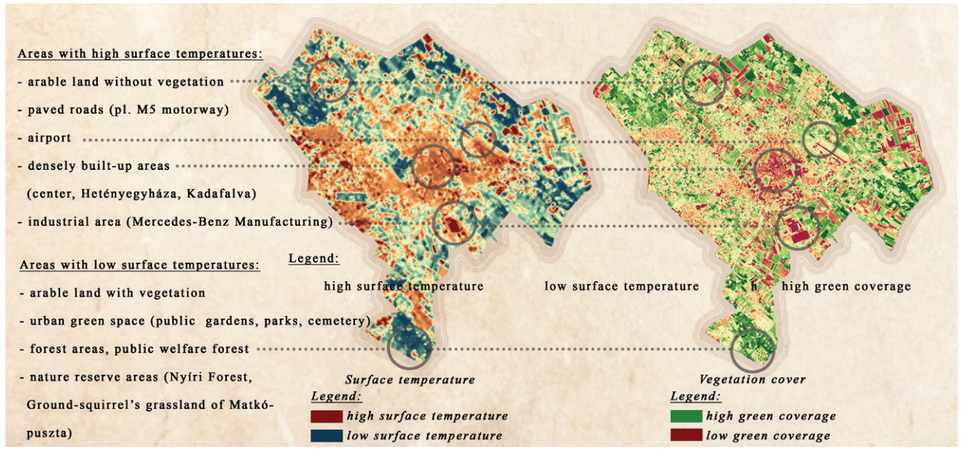
Fig. 1: Location and city structure of Kecskemét (SELF-EDITED FIGURE 2020)

The forecasted climate changes will harm the agricultural, water management, production safety, energy, green space management and human health situation of Kecskemét, as well as on the long-term viability of the city. However, the root of the problems for the city is twofold. In Kecskemét, not only global climatic and environmental changes are causing difficulties, but also the negative anthropogenic effects generated during today's economic development (increasing energy use, air pollution, illegal groundwater abstraction, decreasing green spaces, changing rainwater infiltration conditions, rapid derivation, etc.). Landscape changes caused by indirect or direct human activity have an impact on the well-being of the individual and society. Kecskemét's green spaces are in combination of rings and rays (Figure 1).

In Kecskemét, the duplicated urban development problems of the city is examines in the research of Hoyk – Kanalas – Farkas – Szemenyei titled Környezeti kihívások a városfejlesztésben Kecskemét példáján (Hoyk et al., 2019). They are looking for the answer to the question of whether Kecskemét can fulfill its commitments despite the growing environmental problems due to the city's economic transformation, the lack of a comprehensive strategy and operational action plan, the uncertainty of resources for certain interventions and the negative attitude of society? Their hypotheses include the deterioration of air quality in Kecskemét and its link to economic development, the appearance of the urban heat island effect, and the reality that the change in the quantity and quality of urban green spaces in Kecskemét is negative. The typical settlement environment processes of the last decade are presented divided into five chapters and topics: water management and precipitation, transport and air quality, the emergence of urban heat island. The article concluded that Kecskemét can only comply with EU regulations and fulfill its obligations if serious steps are taken in the field of environmental protection, a marked part of which is environmentally conscious urban development and the improvement of urban green infrastructure. The study proves that in the last few years the urban heat island phenomenon is



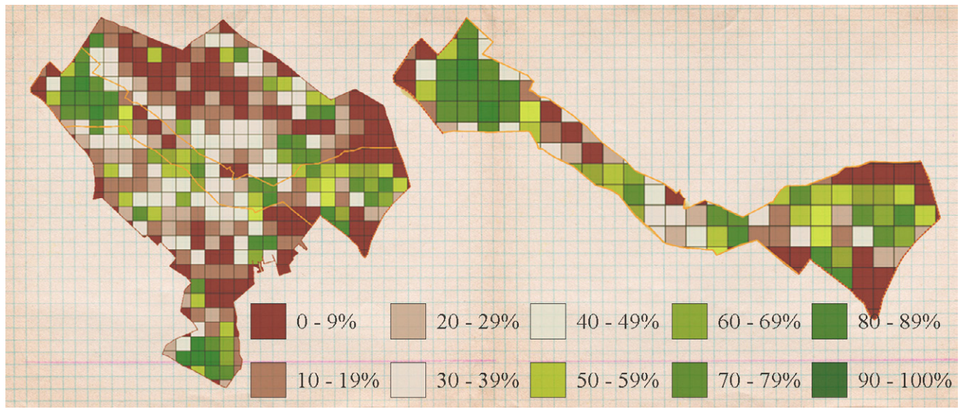


Fig. 2: Relationship between surface temperature and vegetation cover via the example of Kecskemét (self-edited figure 2020, based on Landsat satellite images)

Fig. 3: Vegetation cover ratio per square kilometer (self-edited figure based on self-calculation, wich has been created using the ecosystem map of Hungary (project kehop-430-vekop-15-2016-00001, ministry of agriculture, 2019) 2020).

becoming more and more apparent in Kecskemét as well, the intensity of which increases in proportion to the size and population of urban areas, appearing on cloudless, windless nights in the inner parts of the settlement. Based on the data of August 2018, it can be realized that there was a difference of up to 4-5° C (17-2° C) between the outer areas of Kecskemét and the night temperature of the city center.

Comparing the maps showing the surface temperature and vegetation cover made from Kecskemét, it can be stated that there are microclimatic differences and the existence of a relation between vegetation cover and green areas (Figure 2). It can be clearly seen in the figure that the areas with high surface temperatures are those parts of settlements or smaller parts of the landscape where the vegetation cover is already low (paved roads, densely built-up urban environment, industrial areas, military airport) or intermittent (uncovered arable land). In contrast, it can be observed that in areas with high vegetation cover (more extensive green areas at the city level, forest areas) – due to the shading and evaporating effect of vegetation – the surface temperature is much lower (Bounoua et al., 2000).

MATERIALS AND METHODS

The “Green Corridor” of Kecskemét is the NW-SE oriented structural strip of the administrative area of Kecskemét from the administrative border to the administrative border, within the territory of which there are a large number and density of green-sized units with different purposes and primary functions, mainly in urban areas, the main cocept was to string them along the Csukásér main canal randomly or formed according to conscious design. The climate control role of green spaces in this delimited part of the settlement was examined by analyzing several parameters. A 1 km x 1 km grid was projected onto the settlement, and we calculated the quotient of the areas covered with vegetation and the base area (ratio of vegetation cover per square kilometre) based on the National Ecosystem Map of Hungary (Agrárminisztérium 2019) (Figure 3).

Table 1: Land uses of the "Green Corridor" (self-edited table based on own calculations 2020)

Name	Area (ha)
settlement structure, built with multi-storey houses without gardens	45,20
built-in structure with familyhauses with garden	199,06
industrial and commercial facilities	362,82
agricultural facilities	46,85
educational and health facilities	98,33
special technical facilities	48,17
road network and connecting areas	590,80
railway network and connecting areas	27,72
solid waste landfills	28,47
construction sites	48,16
parks	3,36
cemeteries	14,07
sports facilities	28,29
leisure areas	118,93
large field fields	1543,70
small field fields	1544.56
wine - growing areas	50,91
fruit tree plantations	66,71
intensive pastures and degraded grasslands without bushes and trees	68,39
intensive pastures and degraded grasslands with bushes and trees	34,23
complex cultivation structure with buildings	596,05
homesteads	49,05
agricultural areas with arable land and significant vegetation	60,08
deciduous forest plantations	1831,88
coniferous plantations	262,16
natural lawn without trees and shrubs	523,76
natural lawn with trees and shrubs	13,57
young forests	215,22
spontaneous scrub areas	75,78
nurseries, forest nursery	6,94
channels	18,82
artificial lakes, reservoirs	75,23
fishponds	9,26

Regarding the land use of the sample area, it can be stated from the first table that the characteristics of the market town characteristic of the whole of Kecskemét can be discovered in the examined landscape part, the dominant surface cover is provided by small and large fields. Cereals (wheat, rye, barley, maize), tubers (potatoes), fodder crops (silage maize, alfalfa and industrial crops (sunflowers, rape)) are grown on the land. In the southern part of the "Green Corridor", large-scale industrial and commercial areas can be observed with built-up developments. - and in suburban residential areas, which in two cases (Rendőrfalu, Szent László város) are wedged into the industrial fabric as a result of specific urban development.

Our evaluation is divided into three parts, first, we evaluated the “Green Corridor” according to different factors. In the second part of our evaluation, we analyzed the cardinal green areas of the “Green Corridor” in terms of quantity and quality, which play a role in regulating the urban climate and meeting the recreational needs of the population outdoors. The population satisfaction survey was conducted in the form of an online questionnaire as the third block of the evaluation.

To determine the optimal and critical area units of the “Green Corridor”, we first divided the sample area into twenty-four different parts of the settlement based on the typical construction method, the current structural plan and construction zones of Kecskemét,

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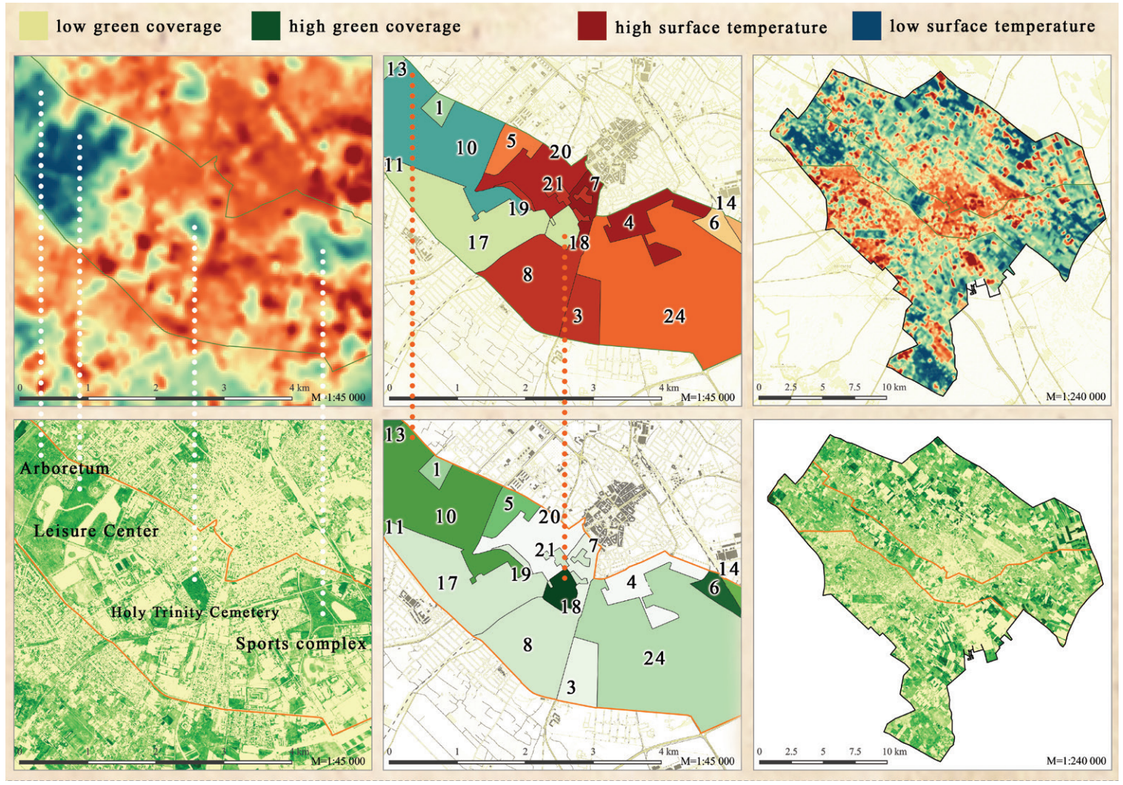
Fig. 4: Relationship between surface temperature and vegetation cover by sub-area (SELF-EDITED FIGURE BASED ON SELF-CALCULATION 2020)



and the typical land use. Territorial units of different characters can be observed to have a kind of symmetry. If we take the urban core of the metropolitan construction method as an axis of symmetry, it can be stated that in the north-eastern and south-eastern parts of the "Green Corridor" there are territorial units with the same characteristics. (forest areas, large-scale arable lands, farmland outskirts, suburban gardens, industrial and institutional areas, large-scale recreational areas, small-town residential areas).

Each block was assessed based on three interacting subjects, according to factors related to urban structure, green infrastructure and biodiversity (degree of built-up, green space supply, biological activity value, etc.) by setting up a unique scoring system. In most cases, scoring was done on a six-point scale based on percentages relative to the size of each territorial unit as well as figures with scores rising from zero to five. In terms of the urban climate and green infrastructure, I rated the positive features and values with a higher score, while the negative ones with a lower score. Our assessment aims to point out at the level of these territorial units how much the urban green infrastructure has an impact on the urban climate, the most climatologically critical and the most ecologically disadvantaged areas due to the lack of green spaces and underdevelopment of the network.

Urban green infrastructure is one of the main pillars of urban climate adaptation, the most significant source of regulatory and sustainable ecosystem services. Factors related to the large-scale evaluation of green infrastructure were the ratio of the basic elements of green infrastructure, the average value of the NDVI vegetation index, the value of biological activity per hectare and the analysis of surface natural and artificial water surfaces inseparably connected to the green infrastructure network.

It can be stated that in Kecskemét the structural elements of the green area system on the outskirts are the connected forest blocks, the forest blocks with a mosaic location, the grassland management areas, the vineyards and fruit fields, the gardens and the arable lands. Inland, non-public forests, public forests, public parks, other public gardens, residential green spaces, and residential gardens can be separated as green space units. Territorial units of different characters were classified based on whether they were located outdoors or indoors, and then the system components listed above were detailed according to zones and green infrastructure type. In the case of territorial units that contain both outdoor and indoor landscape details, the elements belonging to each type were counted only once, this phenomenon was mainly realized in the calculation of the proportion of forest areas (public welfare, economic, protection). The size of the buildings located in the area as well as the traffic areas was subtracted from the area of each construction zone, as these items are not included in the green area ratio. The size of the structural elements of the green space system was summed for each structural unit of a different character, then divided by the extent of the units and the percentage obtained was scored according to the classes of the evaluation method.

When comparing the proportions of green areas, the unusual phenomenon can be found first, in the case of the "Urban Forests" area, the amount of green area is extremely low, although this should not be the case due to the name of the area. The cause of the anomaly, the calculation based on the zoning classification, this landscape part includes a water management area, the southwestern branch of the Csukás-éri main canal and afforestation along the canal. In the present case, the proportion of water management areas and water areas was not included in the basic elements of green infrastructure but was classified in a separate point, so in the case of the territorial unit, the "lost" points are rebuilt in the other category. Based on the calculation, it can be stated that the proportion of green infrastructure elements is extremely low in the case of inner-city units (urban residential areas and institutional areas).

The extent of water management areas and water surfaces is the highest in the case of "Urban Forests" and the "Széktó Nature Reserve Recreation Area", which includes the urban stormwater storage system (96.43%, 50.69%). On the other hand, only the open water surfaces of the stormwater reservoir can be classified as significant evaporating surfaces, and with the forest details framing the lakes, its significance is also outstanding from an urban ecological point of view.

In the case of each territorial unit, the 9/2007. (IV. 3.) ÖTM (Ministry of Local Government and Regional Development) decree, we also calculated the biological activity value to keep the values before the changes and proposals at the level, and for improvement. The calculation was made based on the value indicators according to the annexe of the decree (the value of the biological activity of different surface qualities) and the product of the extent of each land use surface. The values obtained were summed and then divided by the size of the territorial unit to obtain an average biological activity value per hectare. Nature conservation, recreation and forest area units have the highest biological activity value per hectare due to the high value and significant extent of forest areas, large-scale sports areas, water management areas, and urban-level green space facilities. Based on the average biological activity value, the lowest scores were given to residential, institutional and industrial areas in the inner area, and to monocultural agricultural areas in the outer area, which also have a low biological activity value.

To determine and evaluate the intensity of the green spaces per unit area, we calculated the average NDVI vegetation index indicating the presence, health and vitality of the biomass based on the orthophoto of Kecskemét made in the summer of 2019 using GIS programs (ArcMAP, QGIS). Adjusting the spectral channels resulted in an image file from the orthophoto where the values of each pixel were between –1 and +1. Above 0.5, extensive vegetation cover can be observed by remote sensing. The values of the NDVI points were averaged on the

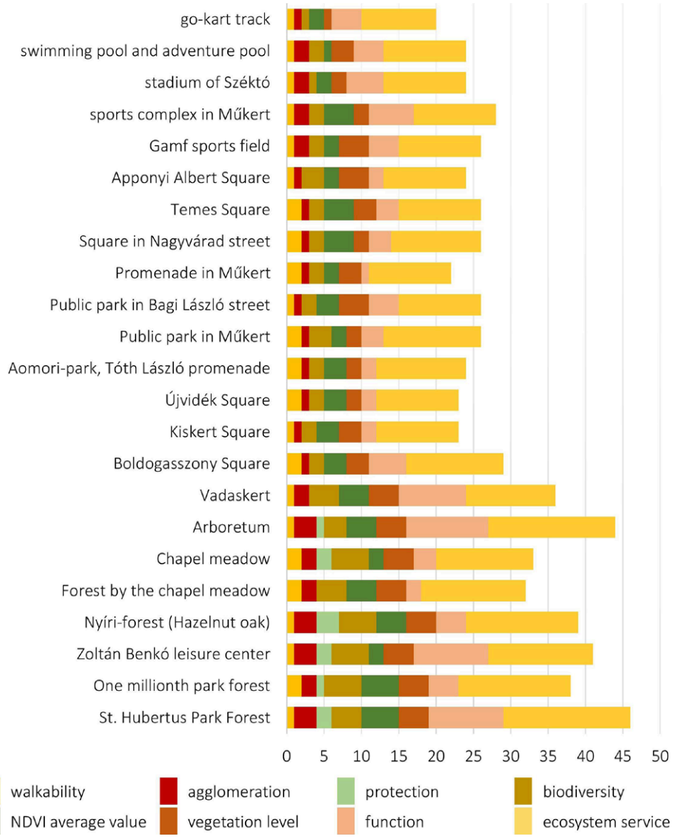
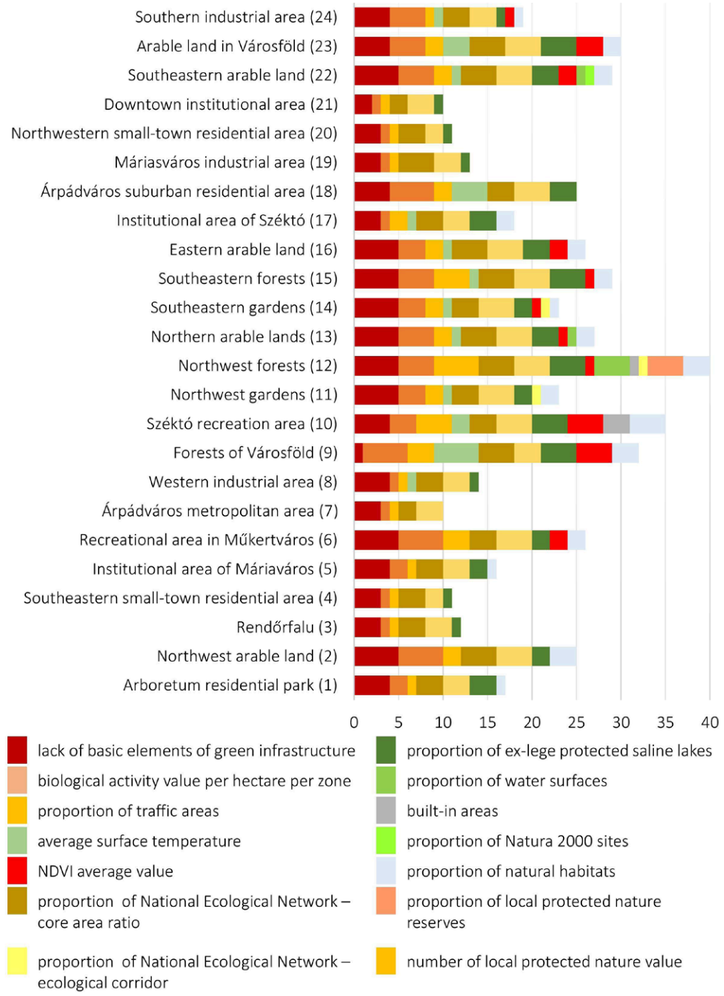


Fig. 5: Aggregation of points for the main elements of the green public infrastructure of the "Green Corridor" by category (SELF-EDITED DIAGRAM BASED ON SELF-CALCULATION 2020)

Fig. 6: Aggregation of points given for territorial units of different characters by category (SELF-EDITED DIAGRAM BASED ON SELF-CALCULATION 2020)



patches of the separate territorial units, and zone statistics were performed, during which a numerical value coherent with the extent of the territorial unit was obtained, and then scored.

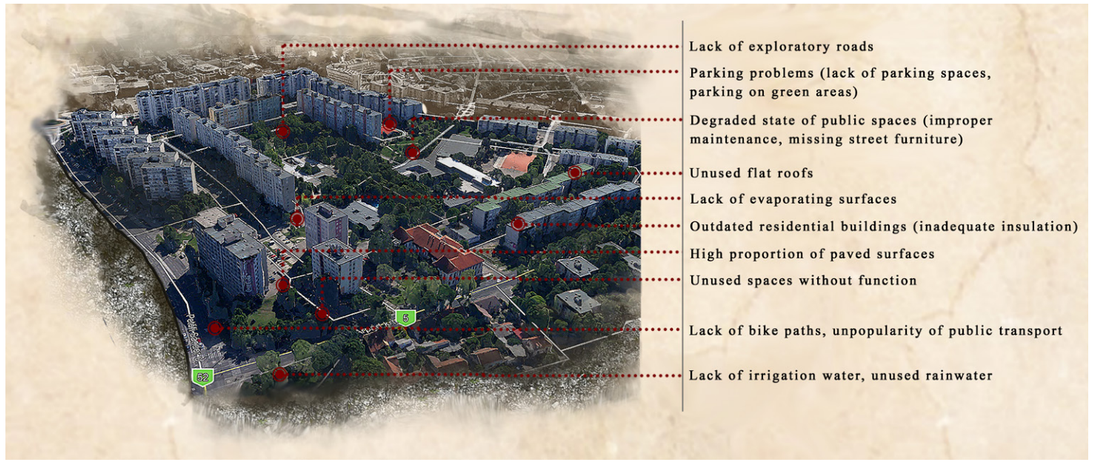
Surface temperature changes per unit area were similarly monitored by average per zone. Comparing the vegetation intensity map of Kecskemét NDVI with the map showing the surface temperature values, it can be stated that the areas with high vegetation coverage (Arboretum, Leisure Center, Trinity Cemetery, BÁCSVÍZ Zrt., Széktói Stadion, Műkerti sports field, Deer-park) play the role of green infrastructure in urban climate regulation. At the same time, based on the comparison, it can be stated that the effect of urban heat island can only be effectively reduced by a minimum of 11 hectares of contiguous green space (the Holy Trinity Cemetery area); The NDVI and temperature average values of the areas of different character also show that the blocks with low NDVI value and the area units with high surface average temperature are also at the same time (e.g. "Árpádváros metropolitan residential area") (Figure 4).

During the evaluation of the main elements of the "green corridor" green public infrastructure, we selected the modules intended for public use from the examined green areas (cadastre), so the Kecskemét population visits them with a high degree of regularity, more than one function and free or time and money.

The analysis was carried out in a simplified version based on the Methodological Guide for the Preparation of an Action Plan for the Development and Maintenance of Green Infrastructure, compiled by the Department of Spatial Planning and Settlement of the Deputy State Secretariat for Architecture and Construction, focusing on the most informative aspects. Due to the length of the article, the topics presented in the methodological guide were not fully elaborated, therefore the elements were analyzed based on eight parameters: walkability, biodiversity, NDVI average, plant level and planting mode, catchment area, function provided, nature conservation concern and ecosystem service.

In terms of accessibility, mainly temporal (Arboretum, St. Hubertus Park Forest) and monetary (Swimming Pool and Adventure Bath, Go-Kart Track, Deer-park) restrictions, or a combination of these (Zoltán Benkó Leisure Center) are relevant. Completely free access areas are smaller public spaces, promenades. The availability of the green infrastructure elements was assessed to the size of the elements, the areas within 300 meters can be reached within a 5-minute walk. At the same time, items with a larger area received higher scores because the population visits it more often and more willingly, making it harder for actual congestion or congestion to develop in their area.

In the case of the NDVI average value, it can be said that St. Hubertus Park Forest, Arboretum and One Million Memorial Forest have the highest values, while Go-Kart Track has the lowest value, as there is the only grassland among the paved trails. The classification of the



biodiversity of each green area was based on the number of species of soft and woody plants, the diversity of habitats for larger elements, and the number of species and distribution of flood species as a negative factor. Closely related to this evaluation factor are the plant level of the given area (grass level, ground cover vegetation, shrub level, deciduous crown level) and the planting method. It can be stated that in most cases the majority of the tree stand is of different ages, has a mixed variety composition (at the same time a maximum of 3 varieties) and is extremely different in its state of health and appearance. The older stock is typically in poor health, drastically truncated, and in the case of housing estate public parks, vegetation is beginning to age. A tree with reduced viability will be more susceptible to parasitic infections and less resistant to environmental stress, so it will not perform its protective and regulatory functions properly. Furthermore, only green surfaces with good canopy cover can significantly reduce surface warming.

The elements of the green infrastructure network are the sources of different ecosystem services, the possible ecosystem services were evaluated with an additional 1-1 point for each green area, we were distinguished based on the table of the methodological guide. Based on the overall scores, it can be concluded that most ecosystem services are provided by St. Hubertus Park Forest as well as the Arboretum. Also in the survey of green areas by function, each different function in an area received an extra 1 point. Eligible features include significant vegetation, water architecture, and water surface, seating and seating, playground, dog runner, outdoor fitness track or equipment, sports field or treadmill, catering unit, event space events, barbecue or barbecue garden, memorial space, sculptures, works of art education and research, gene pool conservation. The promenades and the smaller stretches are extremely poor in function (Kiskert square, Újvidék square, Apponyi Albert square), their construction is incomplete. The Arboretum, the Szent Hubertus Park Forest and the Zoltán Benkó Leisure Center have the most functions.

In the case of the NDVI average, it can be said that St. Hubertus Park Forest, Arboretum and One Million Memorial Forest have the highest values, while Go-Kart Track has the lowest value, as there is the only grassland among the paved trails. The nature conservation impact of the "Hazelnut Oak Park" is the highest, as it is located in the Natura 2000 protected Nyíri Forest, it is a nature protection area under local protection, and it can be classified as an ecological core area (Figure 5). Arboretum and One Million Memorial Forest are not under nature protection. There are some reason to take them under neture protection such as conditional potential and lot of valuable, old, good conditioned trees. However, only the

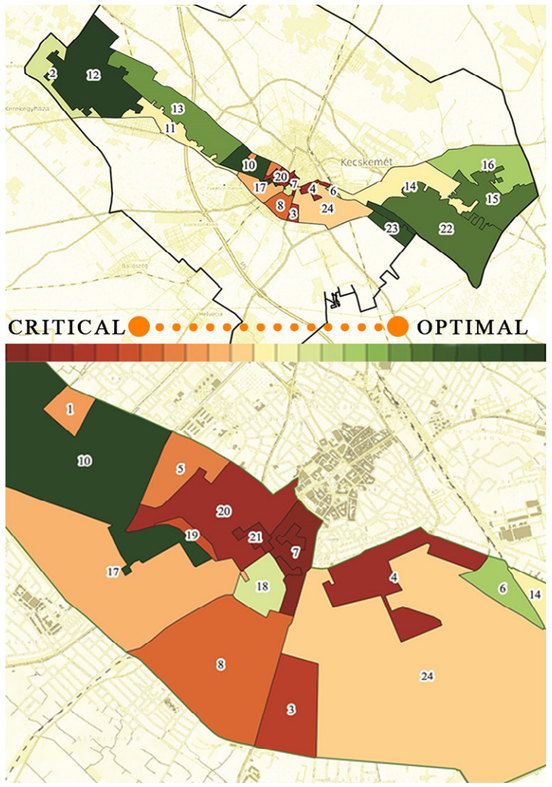


Fig. 7: The "Árpádváros metropolitan residential area" and it's land use conflicts in the (SELF-EDITED FIGURE 2020)

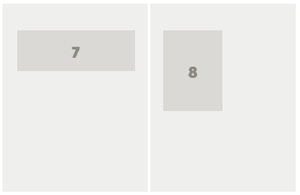


Fig. 8: Optimal and critical area units of the "Green Corridor" (SELF-EDITED FIGURE BASED ON SELF-CALCULATION 2020)

One Million Memorial Forest is on the list of proposed areas of nature protection area under local protection (Kecskemét Municipal decree 16/2017. (IX.21.))

RESULTS

Based on the established methodologies and the performed analyzes (Figure 6), it turns out that the most critical blocks of the "Green Corridor" in terms of green infrastructure, urban structure and biodiversity (marked with burgundy in the sixth figure) are the "Árpádváros metropolitan residential area" (Figure 7), the ", The north-western and south-eastern suburban residential areas and the" Police Village "district due to the high percentage of built-up, low green space indicators, lack of urban ecosystems and evaporative surfaces.

The territorial units with the highest scores are located on the outskirts (blocks marked in dark green), typically include some extensive forest area, and have very little coverage by buildings and transport surfaces. The "Széktó Nature Reserve and Recreation Area" also received a high score, where, in addition to the diverse wooded stands (Arboretum), the artificial stormwater storage system also has a significant climate control function (Figure 8). In the case of Kecskemét, this reinforces the peculiar reality of landscape architecture that the characteristic landscaping activities of anthropogenic origin also have positive outcomes in the perspective of fifty years.

In the course of some of the objects of the green space system, we can state that the maintenance of the inner green spaces leaves a lot to be discarded, which is reflected in the neglect of the parks and the great damage to the vegetation. The supply of public parks in Kecskemét, the proportion of green space per capita in the case of residential areas is critical, it does not reach a third of the proposed norm (3 m² / person). The extent of green space owned by the municipality decreased by more than 30% between 2009 and 2017 (KMJV-KP) (Figure 9).

The partial results of the population questionnaire also show that 37.1% of the respondents are dissatisfied with the number of green areas in Kecskemét, and there is also a great demand for the establishment of new green areas. At present, residents prefer to visit large-scale green space facilities located on the edge of downtown areas due to their functional economy and adequate species and vitality of vegetation.

CONCLUSIONS

Only green surface elements with a well-closing canopy cover of more than 11 hectares can play a significant role in the regulation of the urban climate and the reduction of the urban heat island. Such extensive green space elements in Kecskemét are city-level green space institutions and forest areas. City-level green space institutions (located within

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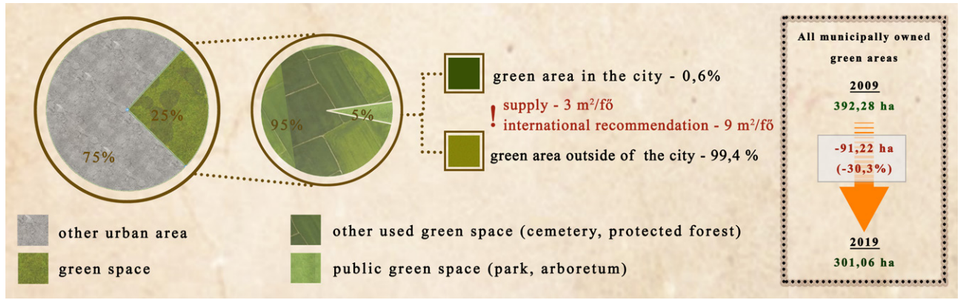
Fig. 9: The green area of Kecskemét (SELF-EDITED FIGURE 2020)



the "Green Corridor" area) include the Arboretum, the Chapel Meadow, the Zoltán Benkó Leisure Center, the One Million Park Forest, the Nyíri Forest, the Széktó Stadium, the Swimming Pool and Adventure Bath, the Deer-park, the Art Park the Trinity Cemetery can be named.

For the time being, the set-up method is similar to Kecskemét and can be applied to the large city of the Great Plain (Szeged, Debrecen, Békéscsaba, Hódmezővásárhely). For cities with other natural features and sizes, additional indicators should be included in the evaluation.

K. Vijayaraghavan also states in his article on the various benefits of green roofs that not only green roofs but also other components of urban green infrastructure, a country with different climatic conditions and architectural characteristics should carry out various specialized local research to plan as well as possible (Vijayaraghavan, 2016). The same assumption holds at the municipal level. In the case of settlements with more marked topographic conditions or natural stagnant and running water (eg Keszthely, Pécs Eger, Győr) these climate control objects should also be covered. The delimitation of territorial units of different character would be expedient only in the case of larger cities with diverse construction zones, it would be less relevant in the case of villages. The study of the climate regulatory impact of municipal green infrastructure can be incorporated into the documentation of environmental protection programs, energy and climate action plans to localize and establish development proposals. To the best of our knowledge, the next EU budget cycle will provide significant resources for urban green infrastructure planning, for which a similar type of urban ecological research is necessary. Regarding the further development of the evaluation, it can be stated that in our work we deal only with the surface-like elements, not with the role and evaluation of the linear elements providing networking (tree rows, shrub strips, canal afforestation, etc.) and the fragmentation of each green surface. Sustainability is optimally ensured if there are as many and as wide objects as possible between each of the extensive green space elements and if the airflow is generated through these flow corridors. Not only in the case of the built urban environment, but also at the landscape and sub-regional level, it is necessary to analyze the minds of ensuring "green flow" (game crossings, landscape crossings, green crossings).

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Kecskemét Town Municipality's 16/2017. (IX.21.) municipal decree about Kecskemét Town's settlementscape protection

ÖSSZEFOGLALÓ

A VÁROSI SZINTŰ ZÖLDFELÜLETI LÉTESÍTMÉNYEK SZEREPE A TELEPÜLÉSI KLÍMA-SZABÁLYOZÁSBAN KECSKEMÉT PÉLDÁJÁN KERESZTÜL

Kecskemét és térsége a klímaváltozás és szárazodás hatásainak országos viszonylatában az egyik leginkább kitett területe. Jelenleg nagyon fontos a városban a zöldfelületek kérdése, a zöldfelület-gazdálkodás, a CO_2 elnyeletés, illetve a vízgazdálkodás tárgyköre. Kutatásunk a városi zöldinfrastrukrúra települési klímaszabályozó hatásának bebizonyítására fókuszál, valamint a kecskeméti zöldfelületi rendszer hiányosságait, a lakossági elégedetlenség okait tárja fel. Hipotézisünk, hogy a városi zöldinfrastruktúra megléte komoly szerepet játszhat települési klímaszabályozásában, napjaink szélsőséges időjárási viszonyait enyhíteni képes. Ezt a felvetést egy általunk lehatárolt, a településen átívelő, magas zöldfelületi intenzitású területekből és egyéb beépített szövetből városszerkezeti sávban („Zöld Folyosó") végzett elemzések alapján igazoltuk. Értékelésünk során a „Zöld Folyosót" huszonnégy eltérő karakterű részre bontottuk a beépítés jellemző módját, Kecskemét jelenkori szerkezeti tervét és a jellemző területhasználatot alapul véve. Az egyes blokkokat városszerkezethez, zöldinfrastruktúrához és biodiverzitáshoz köthető faktorok szerint értékeltük (beépítettség mértéke, zöldfelületi ellátottság, biológiai aktivitásérték stb.) egyéni pontozásos rendszert felállítva. Értékelésünk célja volt ezen területegységek szintjén rámutatni arra, hogy a települési zöld infrastruktúra mekkora hatással bír a városklímára, illetve a zöldfelületek hiánya és a hálózat alulfejlettsége miatt melyek klimatológiailag a legkritikusabb és településökológiailag a leghátrányosabb területek.