HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES

THESES OF Ph.D DISSERTATION

CHARACTERISTICS, EFFECTS AND MITIGATION OF URBAN HEAT ISLAND IN DEVELOPING URBAN REGIONS

DOI: 10.54598/001070

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BUDAPEST, 2021

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1. BACKGROUND AND OBJECTIVES

From the "United Nations Convention on Climate Change" in 1992 to the Kyoto Protocol in 1997, and from the "Bali Roadmap" to the Copenhagen World Climate Conference in 2007, the world's attention on global warming had been growing. As one of the urban issues, the proportion and intensity of urban heat island (UHI) are also rising, which is closely related to the accelerating urbanization process in the world. Urban heat islands have resulted a series of problems on the quality of life of urban residents, urban climate, urban ecological environment, etc., most of which are negative. The urban high temperature formed by urban heat island will also increase energy consumption in summer, increase pollutants and greenhouse gas emissions seriously threaten the ecological environment and sustainable development of the city. With the global warming, the problem of the heat island effect will become more prominent and serious. Therefore, research on strategies and measures that can slow down and reduce the urban heat island effect is of great significance for improving the urban thermal environment, improving the city's livability, and realizing the sustainable development of the city.

China has a unique model of urbanization and economic growth compared to the western countries (in the US and the EU) because of the rapid growth and rapid expansion of urbanization. Therefore, the Chinese cities provide a suitable and interesting examples to study the dynamics of UHI in developing cities. In 2018, the Chinese government put forward a national strategy - “Park city” to build a newly formed urban planning model in order to make cities more ecological. “The expectation of a city is like a grand park so that when people go outside the door, they feel being in a park”. This is the vision of “Park City.”

How to achieve this goal in the future development of the cities in modern civilization? Furthermore, how to avoid the problems with the next phase of urbanization in a developing country like China, which has a high population density and urban agglomeration level? Quite many urban issues should be draw attention, especially for urban planners, landscape architects, and decision-makers.

This dissertation focuses on the UHI characteristics and UHI-related mitigation factors. Systematic research from urban scale to micro-scale, horizontal and vertical dimension was applied to investigate UHI to reduce UHI impacts and give a proposal to future urban planning and landscape design. The goal of the dissertation can be categorized into four parts below:

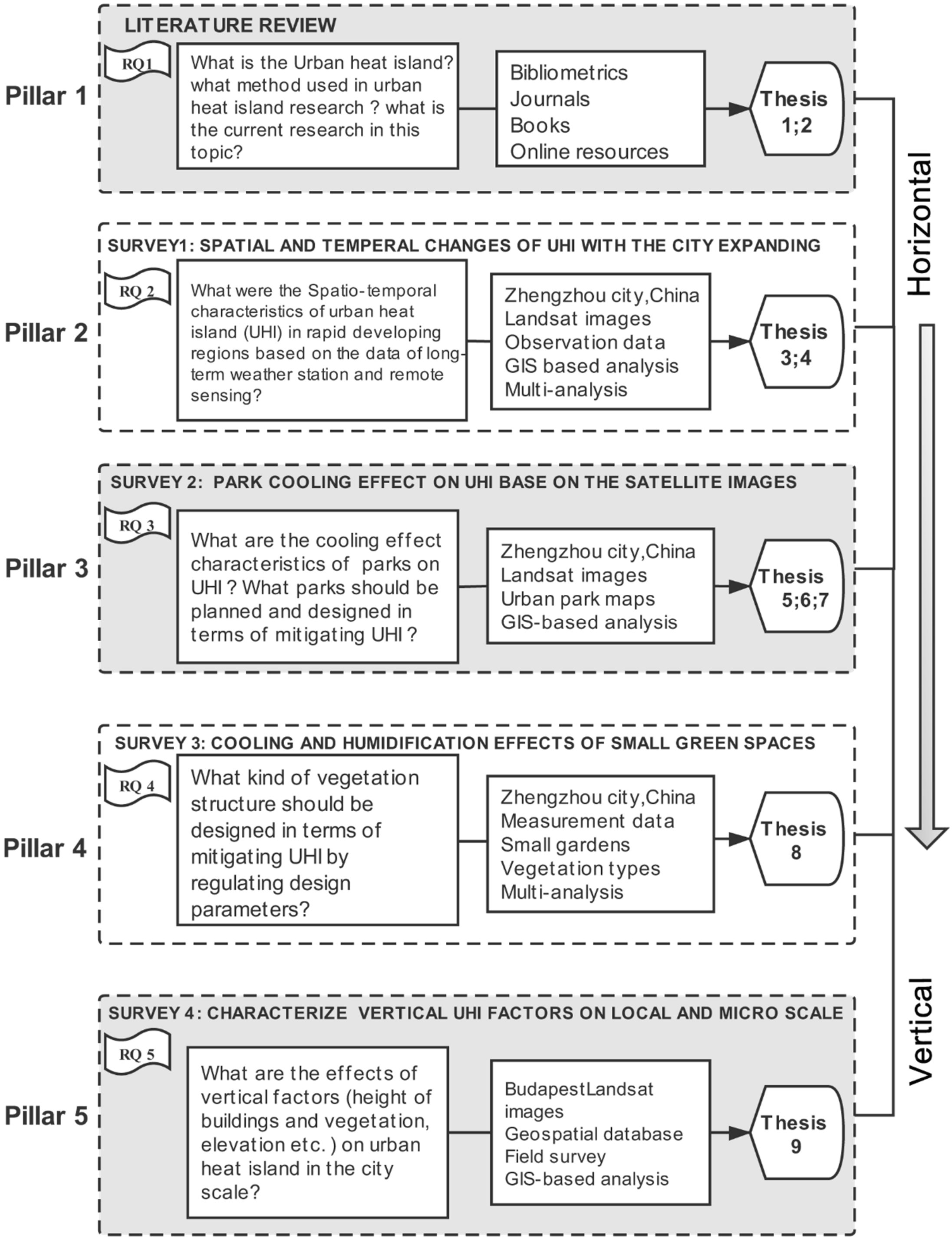
--**On an urban scale**, to explore the spatial-temporal UHI change and its impact factors on rapidly urbanized city. Simultaneous goal is to examine the different effects of the urbanization process under the new urban development context in recent years.

--**On a local scale**, to explore optimal park type, size, shape, properties and characters of urban parks for the mitigation strategies of UHI.

--**On a micro-scale**, to investigate the impacts and mitigation of vegetation coverage types small green space on UHI.

--**On the vertical dimension**, to investigate the impacts of elevation and slope orientation on UHI and explore the impact vegetation height and buildings' height and factors on UHI.

The dissetation aims to use a practical approach, which can deliver valuable results for practical urban planning and landscape architecture as well.



Structure of PhD research

2. MATERIALS AND METHODS

The materials and methods of the dissertation according to the objectives and suitable study areas. The study areas vary from the urban spatial level (urban scale) to the lower spatial level (micro-scale). The dissertation materials could be categorized into four types (Table 1): observation databases, geospatial data, statistical data and survey data.

Table 1: Materials and Database

Type	**Pilot 1- Zhengzhou**	**Pilot 2-Budapest**
Meteorological data	Long-term observation data, Air temperature (day, night, season, year) 1981-2019	Air temperature
Geospatial data	Landsat images, Google Earth Maps, derived maps	Landsat images, DSM [1], DEM [2], derived maps and databases
Field survey data	Air temperature; relative humidity, wind, canopy density, leaf area index, leaf angle.	On site photo, surface temperature,
Other additional statistical data	Urban development indicators: Population and population density, urbanization rate, GDP,	

I selected two pilot cities (Zhengzhou, in China, and Budapest, in Hungary) based on my research questions and goals, related to available dataset, field work experience and field survey options. On the local scale and micro-scale, I chose parks, small green spaces, vegetation coverage types, and I used specific vertical aspects to analyze the correlation among these and urban heat island characteristics.
Accordingly, I used various methods in the different research scales. My methods were obtained both from the literature review and practical test and then, I had combined them into a comprehensive approach to adapt my research objectives. Geospatial data such as aerial photographs, satellite image mapping, and analysis were based on the GIS technique. For field measurement and survey, the research was supported by the field-related thermal images. Afterward, statistical methods such as two-factor analysis and multivariate correlation analysis are used to study the relationship between urban heat island and influencing factors.

[1] Digital Surface Model (DSM) represents the elevations of the reflective surfaces of trees, buildings, and other features elevated above the "Bare Earth". For Budapest, I used the normalized Digital Surface Model (20m resolution with height of landscape elements (buildings, vegetation) above ground level). Source: Lechner Institution in Hungary.
[2] Digital elevation model (DEM) is a 3D computer graphics representation of elevation data to represent terrain.

3. NEW SCIENTIFIC RESULTS (THESES)

Thesis 1: Identification of an efficient method for land surface temperature retrieval and mapping.

Based on the scientific literature and a large amount of image process practice, I identified two important land surface temperature (LST) methods: Image-based Method LST retrieval methods and average LST mapping, which could improve the accuracy and efficiency of UHI heat island research.

a) I identified and tested five land surface temperature (LST) **retrieval methods**[3] based on satellite image LST calculations. I found **Image-based Method** could be widely used and is suitable for satellite images **in case no atmospheric data available**. It is especially true for the early history of satellite imagery (1980-ies, 90-ies). However, the accuracy of the Image-based Method is lower than the method with atmospheric data correction.

b) I identified the **average LST map** is a higher accuracy method to represent the surface temperature in a particular study area than using a single LST map, which calculates the average LST value from several LST maps. This average LST method minimizes the impacts of:

   - short-period land cover changes, such as the vegetation changes by seasonal harvest in the agricultural area.
   - temporary land-use types (e.g. floods, fire, organized events, construction sites).
   - changes in green infrastructure/elements over time, especially short-term leaf changes in green spaces or individual plants due to maintenance, e.g. lawns, shrubs, fast-growing plants, canopy cut, trimming, etc.
   - meteorological conditions, such as clouds, wind, etc.

[3] Five retrieval algorithms: Plank function, Radiative Transfer Equation (RTE); Single Channel Algorithm (SCA); Mono-Window algorithm (MWA); Image-based Method (IBM).

Thesis 2: Determination of urban heat island's research trend currently.

Based on the literature review and scientific analysis from urban heat island publications, I identified the research trends of urban heat island studies currently.

Using the **bibliometric method**, I analyzed **7808 publications** from the Web of Science in urban heat island (UHI) studies from **1975 to 2020**. I defined the growth tendency in the number of UHI related publications and I summarized the general results (method trends, research direction) on urban heat island studies.

a) **Urban heat island problems are increasing all over world.** The number of the research publications number was multiplied decade by decade. From 1990 to 2000 this number became **four times** bigger (from 65 to 257 publications); then from 2000 to 2010, the UHI researches increased **five times** more (from 257 to 1157), finally, from 2010 to 2020, the numbers **increased almost six times** more (1157 to 5985).

b) The main trend is the adaptation to the changing urban heat environment currently. Research trends from the publications based on keywords: from 1975 to 2012 period; the main topic was vegetation and UHI; UHI model; temperature measurement; from 2013 to 2020; the main topics were: Urban heat island and its impacts, **adaptation and mitigation**.

Thesis 3: Determination of the relation between urban climate warming and urbanization process in Zhengzhou city

I identified the relationship between urban climate warming and the urbanization process. I have determined that urban growth (e.g.: built-up area density increase, impervious surface sprawl) significantly contributes to the urban heat compared to its rural surroundings by the analyzed long-term meteorological data.

Despite global warming makes the temperature increasing both in urban and rural areas, the **temperature rising** in the urban areas is more predominant due to the **urbanization process**. The urbanization process contributes to urban warming and the urban heat island effect. **China has a specific high speed of urbanization** growth even more intensive than other Western countries (in the US and the EU). From this perspective, I analyzed the dynamics of the urban and rural air temperature in Zhengzhou city over the **last 38 years (1981-2019)**. During the study period, urbanization made a significant warming rate of about **+0.67℃ per decade** on average in the city. This **warming rate** is about **0.43℃ per decade, higher** on average than the adjacent **rural area.** It is about **2.2 times bigger (+1.96℃)** than the average **global land temperature increase magnitude (+0.9℃) in the last 40 years**, indicating that **urbanization has a significant contribution to global warming**.

Thesis 4: Determination of optimizing methods for assessing surface urban heat islands and its characteristics of the city with high urbanization rate.

I have applied two methods to assess the surface urban heat island based on satellite images from 1989 to 2019. Based on the two Surface Urban Heat Island Intensity (SUHII) and Urban Heat Island Ratio Index (URI) method[4], I identified surface urban heat island change characteristics in the rapidly urbanizing city of Zhengzhou. I have evaluated the impact of urban construction guided by ecological concept on the urban heat island effect, and I have found:

a) The **increase of urban green infrastructure significantly reduces the urban heat island aggregation**. Especially the increase of green infrastructure in the central urban area can mitigate the heat island effect. The increase of blue and green infrastructure in the central urban area of Zhengzhou from 2009 to 2019 has reduced the average surface heat island intensity in summer by 1.3℃.

b) **The green infrastructure development concept for urban development is crucial and successful from urban climate aspects.** It is due to the implementation of the ecological city construction plan from 2009 to 2019 in Zhengzhou: improving the structure of **green space network**, building **urban water system**, thus greatly increasing the coverage rate of **blue-green infrastructure** in the urban area, the urban heat island effect was mitigated.

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[4] Two methods:
1) **Surface Urban Heat Island Intensity (SUHII)**, which is expressed by calculating the difference between the average surface temperature of built-up areas and non-built-up areas according to the land use classification. This method provides a way to assess the surface urban heat island and the evaluation and comparison of the surface urban heat island intensity.
2) **Urban heat island Ratio Index (URI)** is an indicator that shows the spatial ratio (%) of the highest temperature category. The index classifies land, based on surface temperature to 5 categories (driven by standard deviation). First the surface temperature is categorized based on standard deviation, then the territorial ratio of the highest-temperature zone is calculated. This method can be used to compare the surface heat island intensity of different time periods.

Thesis 5: Identification of cooling characteristics of park type.

I identified the relation between park types, Land Surface Temperature, and Park Cooling Intensity in Zhengzhou city, which can guide future urban park planning from the perspective of urban heat island mitigation.

Based on **five park types**[5] **and 123 sample parks** investigation in the study area (Zhengzhou city). I have determined the relationship between **park types** and park **surface temperature** and park **cooling intensit**y (PCI). Among the selected five park types **(urban park, theme park, street park, linear park, urban square)**[6], I identified that:

a) **The theme park** has the lowest surface temperature, and **its average cooling intensity is the highest.** For instance, the average surface temperature of the theme park category is 2.14℃ lower than the average temperature of Zhengzhou city. The cooling effect of this category is the strongest, as its average park cooling intensity reached 2.76 ℃.

b) **The urban square type** has the highest surface temperature.

c) **The linear park** type has the lowest park cooling intensity[7](0.64℃).

According to my results, I recommend **considering park types** in dealing with urban heat island problems in the future, not only the construction of more parks and green spaces.

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5 Five park types: Urban park, theme park, street park, linear park, urban square, which based on《Standard for Classification of Urban Green Space》CJdJ/T85-2017 in China.

6 Urban park (e.g. City park, District park); Theme park (e.g. Botanical garden, Zoo); Street park (e.g. Pocket park, community park); Linear park (e.g. Riverside park, roadside park); Urban square (e.g. Parks with square).

7 Zhengzhou's linear parks mostly located beside the channels and rivers.

Thesis 6: Identification of spectral index-based method to quantify the factors and assess park cooling effect.

I built a spectral index-based method to assess the relationship between park surface temperature and park coverage characteristics (vegetation cover, water surface, and impervious surface). The spectral indices can provide a comprehensive and fast character quantification of urban parks. This help to recognize the urban park plan and design parameters to modify the park surface temperature.

Based on the satellite images, I used three spectral indices: **Fractional Vegetation Cover (FVC), Normalized Difference Water Index (NDWI), and Normalized Difference Impervious Surface Index (NDISI)** to represent the park characteristics. With the analysis of 123 sample parks in Zhengzhou city. I have found that Fractional Vegetation Cover (FVC) and Normalized Difference Water Index (NDWI) **play a negative role** in park surface temperature, indicating that more **vegetation cover makes parks cooler**, and more water surface also **cools down the park**. On the contrary, the Normalized Difference Impervious Surface Index (NDISI) has a **positive effect** on park LST.

From the regression model between LST and NDISI, the coefficient of determination (R^2) reached 0.926, revealing that the impervious surfaces significantly impact park temperature in Zhengzhou. The **impervious surface is the main contributor** to the warm heat conditions of parks. In conclusion, **water and vegetation positively impact the park's cooling role** in Zhengzhou, while the impervious surface increases the park's warmth. Therefore, it is recommended to add more parks (green spaces) within a densely built up district with high impervious surface ratio, such as built-up areas (transport lines and stations, commercials, business districts, residential areas etc.).

Thesis 7: Determination of the park characteristics on mitigating urban heat island.

I determined the correlation between park characteristics and the park cooling effect, and I proved that those park metrics have significance in park design. This way I quantified the planning and design parameters of the urban park to regulate the surface temperature.

Based on the **satellite images** and the analysis of **123 sample parks** in Zhengzhou city, I have examined special **park characteristics** that impact the **park cooling effect**. I used **four park metrics (Size; Fractal dimension; Perimeter area ratio, Shape index[8])** to investigate the park cooling effect's **mechanism**. In case of increasing park (or green space) cooling effect, I have determined the following common strategies:

a) **The park size and perimeter-area ratio play a more critical role than other patch metrics in parks.**
b) **Large-size parks have a higher cooling effect**. I have found that parks with a size larger than 15 hectares have significant cooling intensity (average PCI 2.23℃).
c) **Based on the above results, large urban parks** should be planned**.**
d) **Based on the above results,** following urban heat mitigation aspects, **fewer curving boundaries** and **fewer waving edges could be recommended** in urban and landscape design to reach stronger cooling effect.

Regarding the common features above, my results can give guidance to urban landscape planners and designers.

[8] Fractal Dimension Index reflects the extent of shape complexity across a range of spatial scales (Lei et al. 2012);
Perimeter-Area Ratio equals the ratio of the patch perimeter (m) to area (m^2) (Lei et al. 2012);
Shape index provides a standardized measure of total edge or edge density that adjusts for the size of the landscape (Lei et al. 2012).

Thesis 8: Determination of vegetation structure factors on mitigating thermal effect.

Determination of the cooling and humidification effects of different coverage types in green spaces. I have determined the best vegetation structure type (tree-shrub-grass)[9] in terms of mitigating the thermal effect.

By selecting four green spaces in a university campus as sample plots, using **meteorological data** to analyze spatial and temporal characteristics of the green spaces, I have compared the effects of **four coverage types (impervious surface; shrub-grass; tree-grass; tree-shrub-grass)** on microclimate. I have analyzed the **four impact factors (Canopy Density, Leaf Area Index, Photosynthetically Active Radiation, Mean Leaf Angle)** of the green space.

I have determined the relationship between temperature and humidity and surface cover types of green space:

a) **Multiple vegetation layers** (tree-shrub-grass) have higher cooling and humidification effect than the types with fewer layers (e.g. shrub-grass).

b) **Tree** is the key factor that contributes to the cooling and humidification of the environment.

c) **Trees with a dense canopy and more leaves** are **cooler and more humid**.

d) **Trees with smaller leaf angles**[10]contribute to **cooler and more humid** green space.

The results can guide green space management and future landscape design, The green space design applying multiple vegetation layers, can better regulate the urban heat environment, and improve human thermal comfort.

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[9] Among four types of coverage: Impervious surface; Shrub-grass; Tree-grass; Tree-shrub-grass.

[10] Refers to the angle between the leaves and the horizontal direction, thus small leaf angle means near horizontal leaves.

Thesis 9: Determination of vertical vegetation factors on mitigating urban heat island.

I identified those vegetation height-related factors that influence surface urban heat island. The high vegetation area is cooler than low vegetation area, and forest type green areas are cooler than grass type area and woody type areas.

Based on my research, I have determined those vegetation height-related factors that could be used to modify urban heat island problems as below:

a) **The high vegetation is cooler than low vegetation**. I found that areas covered by higher vegetation (trees, woodlands, etc.), had lower temperature (26.31℃) than areas covered by lower vegetation (e.g. shrublands, transitional vegetation (28.38℃)) or areas with low vegetation (e.g. grassland (29.35℃)) in the 10 sample areas (3023 points) of Budapest (2015). For every 2.5 m increase in vegetation height, the average temperature decreases by 0.45℃.

b) The **broadleaved vegetation areas**[11] **(average height**[12] **is 8.83m) are cooler than woody feature**[13] **areas (average height is 4.83m**[14]**) and grassland.** The average temperature of **broadleaved vegetation areas** is about 3.04 ℃ lower than the average temperature of grassland.

The above factors could be considered from the perspective of urban heat mitigation.

[11] The forest product allows to get as close as possible to the FAO (2000a) forest definition. Forest includes natural forests and forest plantations. It refers to land with a tree canopy cover of more than 10 percent and area of more than 0.5 ha. Forests are determined both by the resence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 m. (Sourse: Copernicus)
[12] The average height was extracted from DSM products of Budapest which obtained in 2015 by using the forest type layer from Copernicus.
[13] Woody area are exclusively covered by ligneous vegetation (woody plants) and comprise linear hedges and tree rows along field boundaries, riparian and roadside vegetation, as well as scattered patches of trees and scrubs, but will not be differentiated into trees, hedges, bushes and scrub.
[14] The average height was extracted from DSM products of Budapest which obtained in 2015 by using the forest type layer from Copernicus.

4. CONCLUSION AND RECOMMENDATIONS

This dissertation seeks answers to questions about the **characteristics** of urban heat islands and mitigation **measures**:

First, by reviewing the historical development of urban heat island research, deepen the understanding of the existing problems and challenges in the existing urban heat island effect research practice. Based on literature research and method practice, to find a suitable method for studying the urban heat island effect. Prepare for a comprehensive assessment of the heat island effect and subsequent research.

According to my research goals and research questions, my dissertation could be divided into **four main scales**. The research was separated from large to small scale, **from urban scale, local scale, and finally to micro-scale and additionally considers vertical factors:**

1) I analyzed the characteristics of the heat island in the urban scale to determine the **characteristics of the urban heat island and the cooling factors**;

2) I studied the cooling effect of green space with urban parks as the object, analyze the **influencing factors** and characteristics of the **park cooling effect**;

3) I took the small green space as an example, analyze the effect of the internal **vegetation structure** of the green space on **temperature and humidity**.

4) Finally, I checked the effect of specific **vertical factors of heat island**. The dissertation studies the heat island from the **horizontally** (surface temperature, etc.) and conducts a supplementary study of the heat island from the **vertical direction** (vegetation height, elevation, etc.).

My study can provide a **methodological reference** for a comprehensive and integrated **assessment** of urban heat islands and a **quantitative guide** for future urban planning, urban vegetation design, park design, and plant community design from a landscape planning and design perspective, the planner and designer can follow the recommendations:

- Regulate the urban planning model, implement more **sustainable urban planning and renewal concepts**, increase the proportion and coverage of urban green space;
- Plan a complete water system network, more reasonable layout of the urban water

system network system; based on the **blue-green infrastructure system effect** to mitigate urban heat island effect.

- Increase the **number and ratio of green spaces** in the city and increase the **tree canopy coverage** in the overall urban planning process.
- Construct **water surface** (e.g. lakes, fountains, channels, reservoirs) and **forest connected** with or integrated with green spaces in urban planning.
- Develop **low-density built-up areas** with a **high rate of green spaces**.
- Increase the **vegetation coverage rate and decrease the impervious surface density** to mitigate the urban heat environment in the newly built towns /districts.
- Increase the number of **theme park types** in the city, increase the **park size** and the **number of compact parks** in a new town/district planning.
- In city planning, **plant species** selection should be based on the local climatic conditions, increasing the multi-layered type of the plant, considering the characteristics of the **leaf area index** and the **leaf angle** of the plant.
- In green space landscape design, conifers should be combined with **broad-leaved trees**, and the tree-shrub-grass compound should be more often applied in design to maximize the cooling and humidification effects of the microclimate.
- Increase **vegetation height, with planting more trees** in the newly built towns /districts regarding mitigating the urban heat island effect. From the aspect of urban heat island effect mitigation, the grasslands are less useful, even if grass is beneficial from social aspects.
- Avoid the introduction of **evergreen trees** as shading elements near the southern side of buildings (in the northern hemisphere), as they provide a cooling effect in winter and block sunshine.
- Urban heat island characteristics of **winter and summer** should be both considered in the future. Some elements show that the summer's advantage is winter's disadvantage. This can be influenced by coloring, choice of built or plant material, shading by built structures (for example: pergola, green wall, green facade) or trees.

5. LIST OF PUBLICATIONS

Journal papers

1. **Huawei Li**, Guifang Wang, Guohang Tian, Sándor Jombach. Mapping and Analyzing the Park Cooling Effect on Urban Heat Island in an Expanding City: A Case Study in Zhengzhou City, China [J]. Land. 2020(2).
2. **Huawei Li**, Handong Meng, Ruizhen He, Yakai Lei, Guohang Tian. Analysis of Cooling and Humidification Effects of Different Coverage Types in Small Green Spaces (SGS) in the Context of Urban Homogenization: A Case of HAU Campus Green Spaces in Summer in Zhengzhou, China [J]. Atmosphere. 2020(8).
3. **Huawei Li**, Wang Guifang; Sándor Jombach. Characteristics of winter urban heat island in Budapest at local and micro-scale [J]. Journal of Environmental Geography. 2020. 13(3–4), 34–43.
4. **Huawei Li,** Wang, Guifang; Tian, Guohang; and Jombach, Sándor (2019) "Mapping and Assessment of the Urban Heat Island in Zhengzhou City," Proceedings of the Fábos Conference on Landscape and Greenway Planning: Vol. 6: Iss. 1, Article 38.
5. Jombach, Sándor; **Huawei Li**; Wang, Guifang; Valánszki, István; and Kovács, Krisztina F. (2019) "Greenway Exploration in the Satellite Jungle: Discovery of Urban and Rural Green Network with Satellite Image Analysis in Hungary," Proceedings of the Fábos Conference on Landscape and Greenway Planning: Vol. 6: Iss. 1, Article 46.
6. Wang, Guifang; **Huawei Li**; Yang, Yang; Jombach, Sándor; and Tian, Guohang (2019) ""City in the park," Greenway Network Concept of High-Density Cities: Adaptation of Singapore Park Connector Network in Chinese Cities," Proceedings of the Fábos Conference on Landscape and Greenway Planning: Vol. 6: Iss. 1, Article 13.
7. DAI Daixin, HOU Zhaowei, **Li Huawei**. Introduction to Landscape Architecture Instructional System of Szent István University in Hungary. Landscape Architecture 26: S2 pp. 89-94. , 6 p. (2019)
8. Guo, Yuchen; Tamás Gál; Guohang Tian; **Li Huawei**; János Unger. Model development for the estimation of urban air temperature based on surface temperature and NDVI – a case study in Szeged. Acta Climatologica. (2020) 54:29-40.
9. Wang, Guifang ; Cushman, Samuel A. ; Wan, Ho Yi ; **Li, Huawei** ; Szabó, Zita ; Ning, Dong Ge ; Jombach, Sándor. Ecological Connectivity Networks for Multi-dispersal Scenarios Using UNICOR Analysis in Luohe Region, China. Journal of Digital Landscape Architecture 1 : 6 pp. 230-244. , 15 p. (2021)

Conference papers

10. **Huawei Li**, Sándor Jombach, Ben Salem Sarah, Guifang wang. A bibliometric review and illustration in urban heat island research from 1975 to 2020. SZIEntific Meeting for Young Researchers. 2020. Dec.07. Szent István University, Buda Campus.
11. Sarah Ben Salem, **Huawei Li**, Mariann Simon, SándorJombach. Urban Green Infrastructure in the historical cores of Budapest and Vienna. **SZIEntific Meeting for Young Researchers.** 2020. Dec. 07. Szent István University, Buda Campus.
12. Sándor JombachIstván,ValánszkiIstván Valánszki, **Huawei Li,** Krisztina Filepné Kovács. *Visualized relations of Land Use, Ecological Network and Heat Island: GIS based Analysis and*

Visualization in Hungarian pilot areas. 4th International Digital Landscape Architecture Conference, **2019**, Southeast University, Nanjing, China. (English)

13. Sallay, Ágnes; Jombach, Sándor; **Huawei Li**. Településszerkezeti változások és a helyi klíma összefüggései Budapesten az Etele út és környékén. In: Fazekas, István; Lázár, István VIII. Magyar Tájökológiai Konferencia: Összefoglalók Kisvárda, Hungary: MTA DTB Földtudományi Szakbizottság (2019) 101 p.
14. Sándor JombachIstván, ValánszkiIstván Valánszki, **Huawei Li**, Krisztina Filepné Kovács. Kinga Szilagyi. Felszínhőmérséklet térképezése Debrecenben. In: Fazekas, István; Kiss, Emőke; Lázár, István (eds.) Földrajzi tanulmányok 2018. Debrecen, Hungary : MTA DAB Földtudományi Szakbizottság, (2018) p. 309

Conference poster

15. **Huawei Li**, Sándor Jombach, Ben Salem Sarah, Guifang wang. A bibliometric review and illustration in urban heat island research from 1975 to 2020. SZIEntific Meeting for Young Researchers. 2020. Dec.07. Szent István University, Buda Campus.
16. Sarah Ben Salem, **Huawei Li**, Mariann Simon, SándorJombach. Urban Green Infrastructure in the historical cores of Budapest and Vienna**.** SZIEntific Meeting for Young Researchers. 2020. Dec.07. Szent István University, Buda Campus.

Abstract:

17. **Li Huawei,** Wang Guifang, Tian Guohang, Jombach Sándor Mapping and Assessment of the Urban Heat Island in Zhengzhou City. Book of Abstracts 6th Fábos Conference on Lanscape and Greenway Planning March 29-30, 2019 Amherst, MA, U.S.A: University of Massachusetts, Amherst Department of Landscape Architecture and Regional Planning, (2019) pp. 92-93. , 2 p. ISBN: 9781945764080
18. Jombach Sándor, **Li Huawei,** Wang Guifang, Valánszki István, Kovács Krisztina F.Greenway Exploration in the Satellite Jungle: Discovery of Urban and Rural Green Network with Satellite Image Analysis in Hungary. Book of Abstracts 6th Fábos Conference on Lanscape and Greenway Planning March 29-30, 2019 Amherst, MA, U.S.A: University of Massachusetts, Amherst Department of Landscape Architecture and Regional Planning, (2019) pp. 93-94. , 2 p. ISBN: 9781945764080
19. Wang Guifang, **Li Huawei,** Yang Yang, Jombach Sándor, Tian Guohang."City in the park," Greenway Network Concept of High-Density Cities: Adaptation of Singapore Park Connector Network in Chinese Cities. Adapting to Expanding and Contracting Cities : Book of Abstracts 6th Fábos Conference on Lanscape and Greenway Planning March 29-30, 2019 .Amherst (MA), U.S.A : University of Massachusetts, Amherst Department of Landscape Architecture and Regional Planning, (2019) pp. 61-63. , 2 p. ISBN: 9781945764080