OPTIMIZATION OF THE ANTHROPOGENIC ENERGY SYSTEM FOR LANDSCAPE PLANNING: CASE STUDIES AT SETTLEMENT AND MICRO-REGIONAL SCALE

DOI: 10.54598/005270

Theses of the Ph.D. dissertation

Zita Szabó

Budapest

2023

Name of the Doctoral School:	**Hungarian University of Agriculture and Life Sciences, Doctoral School of Landscape Architecture and Landscape Ecology**
Research field:	**agricultural engineering**
Head of The Doctoral School:	**Dr. László Bozó,** **University professor, DSc, MHAS** **Hungarian University of Angriculture and Life Sciences** **Institute of Environmental Sciences**
Supervisor:	**Sallay Ágnes, PhD** **University professor** **Hungarian University of Angriculture and Life Sciences** **Department of Landscape Planning and Regional Development**

……………………………………	……………………………………
Approval of the School Leader	Approval of the Supervisor

TABLE OF CONTENT

1. INTRODUCTION

Energy carriers, energy management, renewable energy sources, nuclear energy, coal, and natural gas are concepts frequently used in scientific life and the news daily. In connection with the Russian-Ukrainian war, the issue of energy supply and energy security became a priority. In contrast, nearly 80% of greenhouse gas emissions are related to energy production and consumption, which is closely related to human-caused climate change. The transformation of the energy system can affect not only our present but also our future for centuries.

In connection with landscape architecture planning, be it green area planning, urban planning, or reservoir planning. Two concepts are usually mentioned mainly about climate change: adaptation and mitigation. This narrows the action possibilities of our field of science in the fight against climate change. It is very important to adapt to the changed circumstances, but even more important is to stop the process that caused the change.

In my doctoral dissertation, I am looking for the answer to what role landscape architecture, as an applied discipline, can play in increasing energy management efficiency and reducing greenhouse gas use within the energy system. What new design tools should be incorporated into the different design scales? What new practical solutions should be used?

As landscape architects, we must consider the "well-being" of nature and people; we must ensure a healthy environment for all the plants around us: and the animal world, both for humans. There is no question that energy management plays an essential role in this: we are fighting climate change on a global level, but proper energy management can also contribute to improving the quality of the environment at the local and regional levels. Using a very plastic example, eliminating coal power plants can reduce the amount of greenhouse gases entering the air. No new landscape scars typical of coal mining will appear, and local dust pollution from coal burning will also decrease. Landscape architecture also plays a vital role in creating the aftermath of liquidation.

The example of a single energy source clearly illustrates how much a landscape architect must do in the transformation of the energy system: ensuring a healthy environment and eliminating landscape wounds, but this also includes rural development since energy production typically means prosperity for an area, in the event of its cessation, new functions are needed to give to landscape elements. In my research, I provide a comprehensive answer to these questions.

2. OBJECTIVES

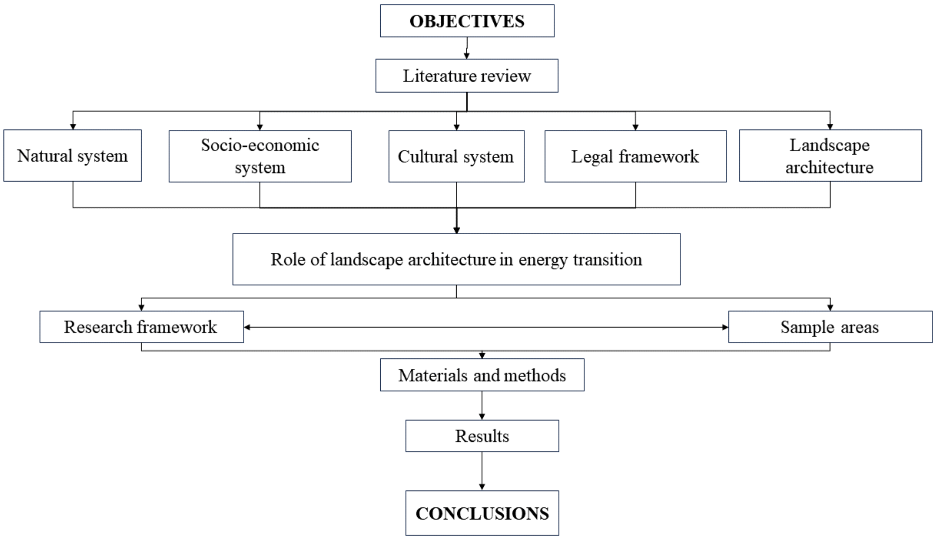
Energy permeates our lives: without electricity, we could not use computers or mobile phones, but we could still work by candlelight in the evenings. A simple example that clearly shows that the energy system is changing. In English, the term 'energy transition' is used for the current change. This is the starting point of my research, with the help of which I unfold the different layers of the concept from the perspective of landscape architecture.

In the chapter, I formulate my objectives, which can be divided into two parts: in the research, I examine the theoretical background of the topic, and I formulate research questions related to the expression of the energy transition and, based on these hypotheses; on the other hand, I formulate the other group of hypotheses with the help of questions that analyse the relationship between planning practice and energy transition. These other problems also raise issues of applicability in practice.

1) Research questions related to the concept of 'energy transition'.
    a) Research question:
        i) How can we define the concept in landscape architecture?
        ii) Can the concept be fully identified with decarbonisation?
        iii) Is the definition suitable for use in landscape architecture?
    b) Today, the term 'energy transition' refers to decarbonisation. The term 'transition' includes change. With a historical study and, on the other, an examination of 'energy' as a phenomenon, it can be revealed whether the concept can be narrowly identified with decarbonisation.
2) Research questions related to practical application:
    a) Research questions:
        i) Can the design of the energy system be integrated into the practice of landscape architecture?
        ii) Can energy planning be integrated into all scales?
        iii) If it can be incorporated, what similarities and differences do the different planning levels show?
    b) The issue can be examined through case studies: it is possible to demonstrate how energy management and landscape planning can be integrated through different scales.

3. STRUCTURE OF THE DISSERTATION

In my doctoral dissertation, I formulated the objectives for the first time; based on this, I interpreted the literature related to the topic in the natural sciences, economics, and social sciences within the framework of landscape architecture; the research and tools related to the energy system of landscape architecture; the legal framework. Based on this, I define the tasks related to the energy transition of landscape architecture. After that, I defined the doctoral research framework and the sample areas. I developed the research methodology and determined the research material. After presenting the results, I concluded them.



4. METHODOLOGY

Based on the literature, I determined the role of landscape architecture in the energy transition. On the one hand, this represents the existing toolbox in current planning practice, which contributes to increasing energy efficiency, tasks related to environmental education, and environmental impact studies related to the objects of the energy system. Determining the renewable energy potential of the landscape, considering the landscape and environmental effects, appears as a new task. I narrowed down the framework of the research to the latter. When choosing the sample areas, I considered that the data underlying the calculation of the estimation of renewable energy sources is the most reliable at the settlement level. As a sample area, I chose the city of Kecskemét and a microregion of Bükk, where I also examined the data by settlement. In the research, I first present the sample areas with the help of literature, statistics, and maps, whose analysis focuses on the factors influencing the energy system of the areas. The visual analysis of the historical maps is also part of the presentation, as the changes in the energy system over time can be identified. I looked for the elements on the maps that indicate that the energy production system has changed. After that, I performed calculations to determine the potential of renewable energy production on a regional scale, for which I used several data sources. I determined the potential of the sun, wind, biomass, waste, and biogas among the renewable energy sources and derived the geothermal heat. In addition, I designated the possible sites for the utilization of hydropower, excluding the area under ecological protection. After that, I estimated the consumption side and summarized the data source in Table 1. I estimated the consumption side based on the data of the Central Statistical Office, the International Energy Agency and the MVM to compare them with the energy potential data at the local level. Finally, with a visual analysis of the existing energy network of the sample areas, I explored the possibilities of incorporating renewable energy sources into the current infrastructure from a landscape architecture point of view.

5. RESULTS OUTLINING NEW SCIENTIFIC ACHIEVEMENTS

In this chapter, I presented the results of my research, which I carried out by examining the questions and hypotheses formulated in the objectives. Based on this, I formulate the new scientific results in theses.

My hypotheses can be classified into two groups: on the one hand, to interpret the concept of energy transition in landscape architecture, which examines the theoretical background of the research area; on the other hand, the implementation of the related landscape architecture tasks of the energy system into practice. The structure of the dissertation also maps these two extremes: on the one hand, the literature research examines the theoretical background of the topic, and on the other hand, I present the practical application through case studies in the results. The link between the two is represented by the material and the method, which partially integrates the knowledge of literature research into practical application. According to my research results, the chapters Anag and Method and the Results reflect on each other, while I concluded the literature review, which appeared during the methodological investigation. I illustrate the structure of the dissertation and the relationship of the hypotheses and theses to the thesis in Figure 113. In the following, I present the results of the hypotheses based on my research, with the theses formulated because of the conclusions drawn from it.

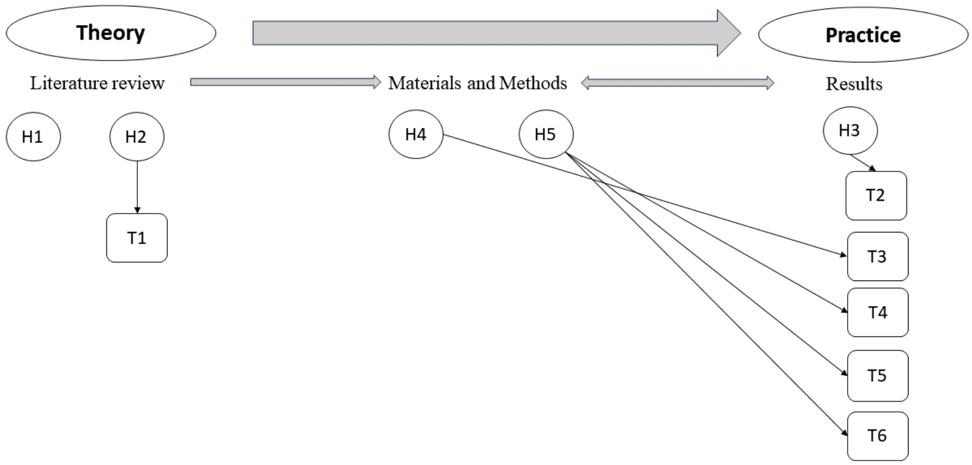


Figure 2. Relation between the hypotheses, theses and parts of the dissertation.

H1: The definition defining the spatial and temporal changes of the energy system includes changes in energy production and consumption in an environmental, economic, social, and cultural sense; this can be interpreted in the context of landscape architecture.

I examined the hypothesis from several angles since physics, environmental science, and the economic-social system can describe the energy change. In the physical sense, energy means some change, which presumably has the dimensions of time and space. I also analysed the environmental science background of the hypothesis: environmental systems can always be characterized from the point of view of matter and energy. Landscape architecture deals with closed and open systems, where, in each case, there is a process of energy change with elements outside the system. As in physics, energy describes a process, so it has the dimensions of space and time. In addition, I presented the theoretical models of the economy in the literature research; the current goal is the circular economic model, the foundations laid by industrial ecology. In this model, too, energy can be linked to the change in pressure. From the literature research, I concluded that the energy system changes in space and time; physics describes it as a fundamental science and other disciplines adopt this interpretation. I analysed the changes in the energy system of the landscape by analysing historical maps in the results section, where I identified the objects on the historical maps that are evidence of changes in the energy system.

The hypothesis is true, and previous landscape architecture research has already been confirmed; it is not possible to formulate a new scientific result.

H2: The energy transition reinterprets some tools and frameworks of landscape architecture, and new tasks and tools are integrated into the planning processes.

To verify the hypothesis, I reviewed the previous research related to the energy system of landscape architecture. Both international and Hungarian books on the practical application of landscape architecture, published in the 1980s, deal with the energy system of nature and the built environment. In most disciplines, due to the oil crisis of the 1970s, science also drew attention to the fact that planning the energy system requires thorough research. Based on the international literature, I found that landscape architecture design impacts the energy management of environmental elements and systems; this can be landscaping, material use, and orientation. These tools should be considered both as an object and on a larger scale. Based on the Hungarian literature, I found a connection between the energy system and the landscape structure. Reviewing the cultural system, he concluded that environmental education affects energy use. By examining the legislative background and environmental science foundations and reviewing recent landscape architecture research, I found that landscape architecture deals with the landscape and environmental effects of energy system facilities. From the past decade and a half, I highlighted two doctoral research, based on which I determined that the new challenges of landscape architecture are the examination of the landscape and its energy potential, and the examination of the landscape and environmental effects is directly related to it.

I verified the hypothesis; I summarized this in the following thesis:

T1: Based on the literature research, I divided the tasks of landscape architecture related to the energy transition into two parts: on the one hand, the tools used in current design practice (these influence the energy balance of environmental elements and systems), which can help with energy efficiency, environmental education and the preparation of environmental impact studies; on the other hand, it can be interpreted as a new task to determine the energy potential of a given area, taking into account the landscape and environmental effects.

H3. The planning of the energy system can be incorporated into the practice of landscape planning and territorial planning.

I verified the hypothesis; I summarized this in the following thesis:

In the material and method chapter, I connected the definition of renewable energy potential and the landscape and environmental effects. I determined the renewable energy sources according to end use and the energy potential I could determine with the available statistical data and technological descriptions. In some cases, I could not determine the energy potential, on the one hand, due to the complexity of energy production beyond landscape architecture (use of solar energy for heating, use of waste for district heating, hydropower, geothermal energy, electricity, and district heat). I also examined the energy mix of the energy potentials that can be determined with landscape architecture tools in several scenarios. I compared them with the estimated energy consumption of the study area. From the point of view of the reliability of the currently available data, I designated the settlement scale as the smallest unit of planning, and from the point of view of the data, the unit that gives the most relevant results from the point of view of landscape architecture planning.

T2: Using landscape architecture tools, I determined the solar energy, biomass, wind energy, biogas, and energy potential of an area produced from waste. In addition, I can designate places that are suitable for the use of hydropower. I also determined the geothermal potential depending on the electricity produced from them, so I determined different energy mixes with the examined energy sources depending on the end use.

H4: Renewable energy sources and their landscape and environmental effects are directly related, thus influencing the energy potential.

In the material and methodology chapter, I examined the possibilities of determining the energy potential of each renewable energy source separately, and I summarized their landscape and environmental effects with a life cycle approach. Based on this, I was able to directly connect the potential of wind and solar energy and limit the production at the settlement level from a landscape architecture point of view. In both cases, energy production objects appear as secondary land use on the one hand in built-up areas and on the other hand in agricultural areas. In other cases, energy production is tied to objects, and at the settlement level, the effects cannot be directly linked to the potential.

I partially verified the hypothesis and formulated it in the following thesis:

T3: In the material and method chapter, based on the examination of the potential and environmental effects of each renewable energy source, I formulated the correlations of solar and wind energy in a generally applicable thesis: During landscape planning, the amount of energy potential of the sun and wind can be directly linked to the landscape and environmental effects, from the nature of the production therefore, they can be directly linked to land use and to limit the potential by taking landscape and environmental effects into account. In the case of biomass, biogas, waste and geothermal energy, the environmental effects can be formulated generally at the settlement and micro-regional level, depending on the end use. However, the production must also be examined at the object scale for decision-making.

H5: The physical characteristics of renewable energy sources can be interpreted on a landscape scale; they must be considered when planning the energy system.

I examined the hypothesis through the case studies, on the one hand, by comparing the energy mix of each sample area and, on the other hand, the results of the two sample areas. The theses belonging to the hypothesis are labelled T4, T5, and T6; I formulated the justification separately. All statements made in the thesis can be linked to weather-dependent, uncontrollable energy sources,

therefore, I verified the hypothesis partially.

In the case of both sample areas, I summarized the potential of the energy sources that can be determined in landscape planning in an energy mix, based on which I formulated the relevant thesis. Since the solar energy potential dominates the energy mix, and the energy source cannot be controlled, production from the network's point of view is technologically limited in producing electricity.

T4: Based on the energy mix of the examined sample areas, I found that even with the area restriction, the solar energy potential dominated the energy mix in all cases, so the area use restriction can be justified from technological and economic aspects.

When using wind for energy, I examined the two scales regarding landscape and environmental effects. On the one hand, turbines can be used in households based on slow wind movement, suitable for large-scale, significant electricity production. I limited the latter's production, considering the landscape and environmental effects. However, this is a significant potential for energy system planning. The distribution of the annual production potential of solar and wind shows that wind can partially supplement production at the system level. The systemic examination goes beyond the framework of landscape architecture.

T5: I limited the wind energy production to built-up areas considering landscape effects. This energy potential is insignificant in the energy mix, and this ratio can be increased by including large-scale turbines and other land uses.

During the case studies, I examined the energy sources' potential separately and compared the settlements at the micro-regional level. Based on this, I determined that the geographical features, even at the settlement level, influence the production of energy sources linked to weather phenomena.

T6: When determining the energy potential, I observed that in the case of the sun and wind, even on a small scale, the geographical features influence the potential, so the settlement level is the most miniature scale for determining the energy potential.

6. CONCLUSION AND RECOMMENDATION

Doctoral research raises at least as many new questions as it closes. In the chapter, I draw the general conclusions of the research, based on which they can be transferred into planning practice. In addition, I formulate the questions that can lead to new research for more efficient energy system operation.

Based on the literature research, it can be established that landscape planning has taken the energy system into account in various planning tools for a long time. External factors (climate change, Russian-Ukrainian war) give these tools a new focus. On the other hand, new tasks must be integrated into the planning practice, as the energy system is highly complicated today, and we have such new knowledge. In my research, this theoretical foundation marked the path by which I was able to develop methods that could be incorporated into design practice, and I was able to analyse the relationship between the energy system and landscape planning.

Based on the currently available statistical data, these renewable energy sources, which may represent the energy potential of the given area in the future, can not only be designated in a general way for the development of settlements and areas but based on my research, some data can be used to quantify these energy sources. The area's potential can be assessed through the sun, wind, biomass, waste and biogas, and geothermal heat. This knowledge can contribute to increasing the efficiency of regional development.

From the point of view of planning, the current legal framework is twofold: the vision of the future was defined in decentralization; on the other hand, decision-making is centralized. Part of the reason for this is that there are only a few projects on a scale smaller than the national scale which would examine the issues of the energy system numerically by examining several energy sources. Using the methodology that I know, data on the numerical potential of specific renewable energy sources can already be partially included in regional development documents starting at the settlement level.

Based on the research, I recommend creating a legal cross-system of spatial planning to calculate the energy potential. Based on the material and method and the results chapter, I showed that the energy potential of the sun, wind, biomass, biogas, and indirectly of geothermal energy can be quantified in whole or in part at the settlement and regional level. Based on this, I recommend that the renewable energy potential of the given area and its environmental effects be quantitatively assessed in the settlement and territorial plans. In addition to these, it is essential not only to analyse the energy potential but also the energy network. This way, the energy system becomes more plannable and can be assigned to economic developments. The transfer can also help implement the circular economic system into the legal framework since, in this way, the energy surplus and energy deficit can be assessed in smaller regional systems.

Through the Bükk microregion, I presented a breakaway region. In these cases, preparing energy plans at the settlement level can contribute to rural development and reduce energy poverty, to which they are particularly exposed. Since I analysed the landscape and environmental effects as well, the overall environmental condition of the settlement can also improve. This can contribute to a more efficient use of EU cohesion funds.

It is also characteristic of energy system planning that the environmental effects are almost the last to be considered, whether we are talking about global climate change or the environmental condition of a settlement. The ideal would be first to assess the environmental effects of energy sources, the principles of life cycle analysis should apply, and in addition to the energy sources, the characteristics of the network; this is followed by a technological assessment, then economic planning, the different areas reflect on each other. The examination of the energy potential of the sun clearly showed that there are energy sources whose potential can be unlimited from a technological or economic point of view, so the principles of landscape and environmental effects could be applied as a first step.

My second proposal, which concerns a legal framework, concerns solar energy. Based on the results, the solar energy potential dominates the energy potential even if I limit it to the roof structure of the buildings. This is how I recommend limiting solar energy investments to urban areas. At the settlement level, the built environment's protection must be considered. In the case of potentially protected buildings, the possibility of installing solar panels must be investigated separately. When estimating the energy potential of biogas and biomass, I examined the efficiency of end-use. Further complex research is required for those energy sources where multi-purpose energy use is possible. On the one hand, the environmental effects are different in the case of use. However, it is also essential to consider that the amount of useful energy decreases during energy conversion. From an ecological point of view, the most essential issue beyond my doctoral research is the role of water. Through the case studies, I showed that there may be potential places where even a small-scale hydropower plant can be investigated. First, I examined the topography and excluded the areas under ecological protection. Aquatic and water-related ecosystems are incredibly fragile, so that any change can cause severe environmental damage. Climate change causes significant changes in the water cycle, so it is not easy to detect how this affects the production of hydropower plants. Why bother with this? From the point of view of the energy mix, an element whose production can be controlled can be included in the energy mix, and according to our current knowledge, the most efficient way to store electricity is the pumped hydropower plant. In the latter case, it is also essential to plan on a small scale, with which the adverse environmental effects can be reduced. Another critical issue is that water is not only involved in production but is a cooling medium in thermal power plants and is necessary for energy production.

In conclusion, I return to the classic landscape engineering toolbox. Although I examined the new tasks thoroughly in my research, in the literature review, there were many examples of how landscape planning can be made more efficient by influencing environmental elements and systems. This toolbox must be consciously integrated into practice, using it appropriately when it is necessary to "heat" and when it is necessary to "cool".

7. PUBLICATIONS

Journal articles connected to the research topics:

Szabó, Z., Guifang, W., Sallay, Á. (2023). Estimating Solar Energy Potential of Hungary Based on Raster Maps. *JOURNAL OF DIGITAL LANDSCAPE ARCHITECTURE,* 8, 112–123.

Szabó, Z. ; Prohászka, V. ; Sallay, Á. (2021) The Energy System of an Ecovillage: Barriers and Enablers *LAND (BASEL)* 10 : 7 p. 682 Paper: 682, 20 p.

Szabó, Z. ; Sallay, Á. (2020) Az energiatermelés tájtörténeti szempontú áttekintése. *TÁJÖKOLÓGIAI LAPOK / JOURNAL OF LANDSCAPE ECOLOGY* 18 : 1 pp. 45-64. , 21 p.

Conference full papers connected to the research topic

Szabó, Z.; Sallay, Á. (2022) Energy Transition of an industrial settlement through the example of Kecskemét. *Proceedings of the Fábos Conference on Landscape and Greenway Planning* 7: 1 Paper: 52

Szabó, Z.; Sallay, Á. (2019) Assets of Water Mills in Hungary. *Proceedings of the Fábos Conference on Landscape and Greenway Planning* 6 p. 18

Szabó, Z.; Sallay, Á. (2019) Historical research of electrical transmission lines from landscape planning point. *In: Fodor, Marietta; Bodor, Péter (ed.) SZIENtific meeting for young researchers - Ifjú Tehetségek Találkozója (ITT) Gödöllő, Magyarország : Szent István University* 353 p. p. 256

Szabó, Z.; Szabó, I., Sallay, Á. (2019) Erőművek teljesítménye és táji hatásuk összefüggései. *In: Fazekas, István; Lázár, István (ed.) . Debrecen, Magyarország : MTA DTB Földtudományi Szakbizottság* 452 p. pp. 259-263. , 5 p.

Sallay, Á. ; Szabó, Z. (2018) Tájtipizálás az energia szempontjából. *In: Lázár, István (ed.) Környezet és energia: Hatékony termelés, tudatos felhasználás Debrecen, Magyarország : MTA DAB Földtudományi Szakbizottság* 281 p. pp. 271-274. Paper: 3372007 , 4 p.

Conference abstracts connected to the research topic:

Szabó, Z.; Sallay, Á. (2022) Defining energy transition in landscape architecture. *In: Bevk, Tadej; Krošelj, Manca (ed.), Ljubljana, Szlovénia: University of Ljubljana, Biotechnical faculty, Department of Landscape Architecture* 145 p. p. 127 Paper: 157, 1 p.

Szabó, Z.; Sallay, Á. Toorn, van den M. (2021) Energy Transition and Hungarian Landscape Architecture. *In: Burcu, Yigit Turan; Sara, Westerdahl (ed.) Stop and Think : Book of Abstracts Uppsala, Svédország : Swedish University of Agricultural Sciences (SLU)pp.* 18-18. Paper: 273, 1 p.

Szabó, Z. ; Prohászka, V. J.; Sallay, Á. (2021) Analysis of energy management and possibilities for its development in ecovillages with tools of landscape architecture through the example of Visnyeszéplak *ACTA BIOLOGICA MARISIENSIS* 4 : Supplement 1 p. 13

Z., Szabó ; Á., Sallay (2021) Energy transition in mountainous areas through the example of micro-region in Borsod county in Hungary. *In: CASEE CONFERENCE 2021 Book of Abstracts: "CASEE universities as laboratories for new paradigms in life sciences and related disciplines" June 7th – 8th, 2021 (online event)* 59 p. pp. 21-22. , 2 p.

Other journal articles:

Bérczi, S., Szabó, Z., Sallay, Á. (2022). Strategic Directions: Evaluation of Village Development Strategies in the Case of Applicants for the Hungarian Village Renewal Award. *LAND (BASEL)*, *11*(5), 681. http://doi.org/10.3390/land11050681

Erdélyi, R.; Szabó, Z. ; Sallay, Á. (2021) 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. *4D TÁJÉPÍTÉSZETI ÉS KERTMŰVÉSZETI FOLYÓIRAT / JOURNAL OF LANDSCAPE ARCHITECTURE AND GARDEN ART:* 59 pp. 72-83. , 12 p.

Wang, G., Cushman, S. A., Wan, H. Y., Li, H., Szabó, Z., Ning, D. G., & Jombach, S. (2021). Ecological Connectivity Networks for Multi-dispersal Scenarios Using UNICOR Analysis in Luohe Region, China. JOURNAL OF DIGITAL LANDSCAPE ARCHITECTURE, 1(6), 230–244. http://doi.org/10.14627/537705020

Bérczi, S., Szabó, Z., Nagy, B., Sallay, Á. (2020). How can the sustainable development goals, specifically a correct energy policy, help the succes of a small region? *4D TÁJÉPÍTÉSZETI ÉS KERTMŰVÉSZETI FOLYÓIRAT / JOURNAL OF LANDSCAPE ARCHITECTURE AND GARDEN ART*, (57), 44–57. http://doi.org/10.36249/57.4

Other conference full papers:

Nagy, B., Szabó, Z. (2019). Introduction to the Green Belt of Auroville: A Detailed Description on How its Actual Practices Contribute to the UN SDGs. *Proceedings of the Fábos Conference on Landscape and Greenway Planning, 6,* 27. http://doi.org/10.7275/kjbe-yz91

Sallay, Á., Szabó, Z., Kollányi, L. (2019). Greenway Planning in the 11th District ofBudapest. *Proceedings of the Fábos Conference on Landscape and Greenway Planning*, *6*, 24. http://doi.org/10.7275/59y2-0486

Sallay, Á., Mikházi, Z., Máté, K., Szabó, Z. (2018). Hidak az Ipoly mentén. In *Földrajzi tanulmányok 2018* (pp. 341–344

Szabó, Z., Prohászka, V., & Sallay, Á. (2018). Tanya mint az ökológiai gazdálkodás potenciálja. In *Őshonos- és Tájfajták - Ökotermékek - Egészséges táplálkozás - Vidékfejlesztés* (pp. 517–524).

Other conference abstracts:

Szabó, Z., Sallay, Á.. (2022). Uncertainty of scales. The scale of uncertainty. In a trace of the flow. In *Scales of change* (p. 86).

Szabó, Z., Sallay, Á., Martin, van den T. (2021b). Setting up an Introductory Seminar in the Context of Climate Change as Part of PhD Research. In *Stop and Think* (pp. 19–19).

Szabó, Z. (2019). The Concept of Landscape in Secondary Education in Hungary. In *Lessons from the past, visions for the future* (p. 278).

Szabó, Z., Sallay, Á., & Máté, K. (2018). Separate or Connect? In *Spaces Crossing Borders* (pp. 69–69).

Szabó, Z. (2010). Assessment of Streams as Ecologocal Corridors and as Part of Greenway Planning. In *Fábos Conference on Landscape and Greenway Planning 2010* (pp. 62–62).