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MANAGING MICROCLIMATE-SUPPORTING SOLUTIONS IN URBAN SPACES: A CENTRAL EUROPEAN PERSPECTIVE

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Abstract

The escalating impacts of climate change, such as intensified heatwaves, deteriorating air quality, and the pronounced urban heat island effect, pose significant challenges to urban sustainability and livability in Central Europe. This paper explores innovative urban infrastructure designs that enhance microclimates, improving residents' quality of life, reducing energy consumption, and promoting environmental sustainability. The study focuses on densely populated and historically prosperous cities, including the Central Europe region, assessing the efficacy of green infrastructure, water features, and reflective building materials. A comprehensive review of recent studies and real-world applications reveals these interventions' social, economic, and environmental benefits. Additionally, the role of participatory budgeting in facilitating micro-interventions is examined, highlighting its potential to improve urban resilience, foster community engagement, and meet residents' specific needs. The findings indicate that while these strategies effectively enhance urban microclimates, their success depends on precise management and local adaptations. The paper underscores the necessity for ongoing research and investment in microclimate management solutions to prepare urban areas for future climatic uncertainties.

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Keywords: urban microclimate; climate change; green infrastructure; participatory budget; urban management

1. Introduction

The urban landscapes of Central Europe are increasingly under stress due to climate change impacts, such as intensified heat waves, deteriorating air quality, and the pronounced urban heat island effect. These phenomena not only challenge the environmental sustainability of these areas but also pose severe risks to public health and the livability of urban environments. In this context, developing and implementing strategies that support favourable microclimates within urban settings are crucial.

Solutions to support the microclimate in urban spaces are essential to improve residents' quality of life and counteract the negative effects of climate change. With its specific climate, history and urban density, Central Europe faces unique challenges, but it is also introducing innovative solutions. Faced with the global challenges of climate change and the recent COVID-19 pandemic, urban design has taken on a new dimension, combining the need for outdoor activity with the pursuit of sustainability goals. This article focuses on innovative approaches to urban infrastructure design that support the urban microclimate, thereby improving residents' quality of life, minimising energy consumption, cleaning the air and promoting green-blue infrastructure.

Given its varied climate zones and densely built environments, Central Europe offers a distinct backdrop for examining these strategies. Cities like Vienna, Prague, and Warsaw are particularly illustrative, with their historical architectures now facing increased climatic threats. These urban centres are pivotal in studying the integration of adaptive solutions due to their vulnerability and the climatic shifts predicted by current models, which foresee a rise in extreme temperature events.

This paper seeks to assess the impact and efficacy of managing microclimate-supporting interventions such as green infrastructures, water features in urban settings, and using reflective materials in construction. These measures are not merely cooling mechanisms but also vital tools for enhancing urban resilience. They promote biodiversity, reduce energy usage, and ameliorate environmental conditions. Our analysis includes reviewing recent studies and real-world applications within Central European cities to offer a rounded view of these adaptive strategies at work.

This introduction also previews the comprehensive social, economic, and environmental benefits these interventions can provide. Furthermore, it discusses their potential to be modelled and applied in other global regions experiencing similar urban and climatic challenges. By mapping out the terrain of sustainable urban development and climate-responsive strategies, this paper aims to inform and influence policymakers, urban planners, and researchers focused on the future trajectories of urban areas in Central Europe and beyond.

The paper explores innovative urban infrastructure designs that support favourable microclimates in Central European cities. The study focuses on dense urban structures with historical architecture and assesses the impact and efficacy of various microclimate-supporting interventions such as green infrastructures, water features, and graduation towers. The paper also discusses the role of participatory budgeting in facilitating these micro-interventions and their potential to be managed and applied in other global regions experiencing similar urban and climatic challenges.

1.1. Definition and importance of urban microclimate

Urban microclimate, defined as the local climate of small areas or neighbourhoods, can vary in the city spaces distances due to differences in sun exposure, shade, humidity or human activity. The ecological concept of microclimate largely depends on the issue being addressed. For a landscape ecologist, a microclimate may encompass a mountainside or a desert over hundreds of kilometres. For a reproductive ecologist interested in the life history of a mosquito breeding in a pitcher plant, the term microclimate refers to the plant's interior, which has a diameter of only a few centimetres. Thus, from an ecological point of view, the microclimate is primarily defined by the organism or community in question. This complex interaction between each organism and its local environment is one of the foundations of population and community dynamics(Mislan i Helmuth, 2008). A local urban microclimate refers to the specific atmospheric conditions within a small-scale urban area, such as a neighbourhood park, which can vary significantly from the broader urban environment due to localised factors like vegetation, water features, surface materials, and human interactions.

In urban spaces, the microclimate affects daily life through air quality, temperature, availability of greenery, and the overall enjoyment of using public spaces. Improving the microclimate in temperate continental climates in cities such as Central Europe can bring significant health, economic, and social benefits while mitigating the effects of global climate change. Adapting urban spaces to these changes through microclimate management is essential for creating cities friendly to all residents, regardless of their physical or health condition. Urban spaces with well-managed microclimates can help reduce the number of health problems, such as respiratory diseases, heat strokes, or heat stress. Implementing good quality green areas, such as parks and squares, can improve air quality and lower temperatures, directly impacting residents' health. Thoughtful management of the microclimate-oriented city improves the accessibility of public spaces for those who experience extreme weather conditions that can pose a serious obstacle. Shades, shelters, roofed bus stops, or resting places in natural shade help make urban spaces more accessible and comfortable for everyone. Urban spaces with a pleasant microclimate become places of meetings and social interactions. Parks, squares, and city gardens are not only the "green lungs" of the city but also "community living rooms" where residents can spend time outdoors, strengthening a sense of belonging and improving the community's quality of life.

Managing the microclimate in cities is also a form of adaptation to general climate change. By creating infrastructure capable of dealing with extreme conditions, such as stormwater management systems and greening, cities can better prepare for the future, minimising the adverse effects of climate change. Urban spaces with well-managed microclimates are more attractive to residents and tourists. Improving the aesthetics of the city through greening and creating comfortable public spaces can attract new residents and investors and impact economic and social development.

2. Designing Background

The research methods employed in this study hinge on an in-depth analysis of a case study that scrutinises the existing capabilities for managing urban spaces from a technical perspective. The solutions proposed are viable within the frameworks of participatory budgets, which have garnered significant popularity across Central Europe. Micro-interventions, facilitated by participatory budgeting, enable effective and targeted enhancements to the built environment of cities. Involving local communities in the planning and management processes that aim to improve the microclimate is crucial for the success of these initiatives. Such projects not only bolster community cohesion but also ensure that the implemented actions address the real needs of residents. A substantial number of interventions that beneficially impact the urban microclimate are feasible under the auspices of participatory budgets(Podgórska-Rykała, 2019). Funds in civic budgets are typically allocated across various pools. These allocations are categorised based on territorial criteria (addressing entire municipalities or specific districts), the projected project budget, or the projects' thematic focus. Ecologically oriented projects are the most prevalent and often occur in county towns, which generally receive less funding for renewable energy sources than larger cities. These ecological projects encompass a range of activities, including the installation of green roofs and walls, the creation of pocket parks and community gardens, tree and shrub planting, and the organisation of clean-up drives and environmental education. These projects often include implementing waste segregation systems, further underlining their environmental focus(Martela, Janik i Mróz, 2023).

2.1. Greening cities

One of the key directions in urban development strategies is the greening of urban spaces. Parks, green roofs and walls, and green belts along streets not only enhance the aesthetics of a city but also contribute to lowering temperatures, reducing air pollution, and increasing biodiversity. The specific physical properties of urban building materials (including concrete, asphalt, glass, and brick) absorb more solar radiation than they reflect, and by emitting the stored heat, they increase the air temperature.

Fig. 1. Urban microscale solutions:left- green wall in Radomsko City, right – graduation tower in Wołczyn
(source: Agnieszka Chudzińska – photo and design)

Investments in green roofs and walls are becoming increasingly popular in modern architectural solutions, impacting the improvement of building insulation, noise reduction, and the retention and filtration of rainwater, thereby reducing the amount of sewage discharged into the often overloaded storm sewers of large cities. Additionally, green roofs can provide recreational spaces for residents, contributing to the increase of relaxing green areas in densely built urban environments. Vertical gardens are an innovative solution that transforms urban spaces by introducing elements of nature onto buildings' exterior and interior walls (Fig. 1. Left). The popularity of these technologies stems from their ability to improve air quality, thermal and acoustic insulation, and biodiversity. Different types of green walls are distinguished based on their structure:

- The modular (panel) system consists of prefabricated panels with built-in irrigation and drainage systems, allowing for easy plant installation and maintenance(Plantia, 2024). There are two types of modular systems: those filled with substrate or a unique mineral wool. These solutions are prevalent due to their versatility and quick installation. The panels are most commonly made from HDPE-type synthetic materials. An interesting and cost-effective idea is using gabion baskets for this purpose, which themselves serve as the structural support for the wall. Aluminium or stainless steel modules are also available (*Green Wall Types*, 2024).

- The felt system is based on hydroponics that uses nutrient solutions instead of traditional soil, which minimises the need for manual intervention and maintenance(*Planta Garden*, 2024). It is among the simplest solutions. This system utilises the properties of mats constructed from intertwined synthetic fibers, which have the ability to accumulate water. These mats are sewn together in such a way that they form individual pockets in which plants are planted. The weave of the mats allows for the roots to grow through the fibers, ensuring constant access to moisture and air.

- The container system, also known as hybrid, is rarely used because it requires a significant amount of space, very sturdy constructions, and considerable time to achieve sufficient effects. This system is cascading and involves placing containers with vegetation on different levels. Implementing such a setup requires the construction of special scaffolding. The container system is exceptionally effective in factories, shipyards, or other locations with old, unused structures (*Green Wall Types*, 2024).

2.2. Stormwater Management

Innovative systems for collecting and utilising rainwater to irrigate urban greenery are another important element in the strategy to improve the microclimate. Such solutions allow for effective water resource management and reduce the risk of flooding and soil erosion in cities. Supporting stormwater management is one of the most emphasised benefits of using blue infrastructure and green areas(Foster, Lowe i Winkelman, 2011). Many types of rainwater tanks differ in location, capacity, construction material, and additional functions. Above-ground tanks, placed above the ground and made mainly of plastic or fibreglass, are easy to install and costly, but they take up much space and are sensitive to frost.

In contrast, underground tanks, hidden under the ground and made of concrete or plastic, are more resistant to weather conditions and less visible. However, their installation is more expensive and requires more labour. Depending on the needs, tanks can be selected according to capacity: small ones with 100 to 500 litres for garden watering, medium ones from 500 to 2000 litres to supply toilets and washing machines, and large ones above 2000 litres for comprehensive home supply. The materials used include lightweight plastic, corrosion-resistant fibreglass, and durable concrete, which withstands low temperatures well. Essential components of the tanks are filters, which ensure water purity, and pumps, which facilitate its transport in the home or garden. The choice of the right tank depends on individual needs, available space, and budget(*Which Rainwater Tank is Right For You?*, 2024)(Cunliffe, 1998).

Another method of altering the urban microclimate involves capturing rainwater for its reintroduction into the soil (Sutkowska *i in.*, 2024). Rain gardens are natural rainwater management systems that utilise plants and soil to purify and infiltrate the water. Several types of rain gardens can be distinguished:

A wet rain garden is designed for areas with low soil permeability. It features a constant water level, which supports the growth of aquatic and marsh plants. A dry rain garden is suited for areas with good soil permeability. The soil absorbs rainwater, and there is no permanent water level. An infiltration rain garden also includes a drainage layer that facilitates water infiltration. A rooftop rain garden is installed on building roofs and retains rainwater. A bioretention rain garden combines the functions of a rain garden with bioretention features, thereby promoting biodiversity(Fundacja Sendzimira, 2021).

The choice of the appropriate type of rain garden depends on several factors, such as soil permeability, available space, rainfall amount, and desired plants. Rain gardens are a way to manage rainwater and are a beautiful and ecological feature of the garden.

2.3. Graduation towers

A graduation tower is a structure that enhances the microclimate of its surrounding area through the natural evaporation of brine, which is water with a high salt concentration ((Fig. 1. right). This process functions like a natural inhalator, dispersing salt micro-particles into the air. These particles can have a beneficial impact on human health, mainly benefiting the respiratory system. Introducing a graduation tower into an urban environment improves air quality and reduces ambient temperatures. During the evaporation process, the water evaporates, leaving salt particles suspended in the air. This results in cleaner air enriched with iodine and other minerals around the tower(Chudzińska i Dybczyńska-Bułyszko, 2019). These salt particles also act as natural filters to reduce airborne microorganisms and pollutants. Additionally, the evaporation process absorbs heat from the surroundings, naturally lowering the temperature around the tower. This cooling effect is particularly valuable during hot days, helping to mitigate the urban heat island effect, a prevalent issue in densely populated urban areas.

Installing graduation towers in urban spaces can be an effective strategy for enhancing public health and well-being and cooling urban environments. However, their effectiveness is contingent upon proper design and operation. Despite their simplicity as a form of urban architecture, improper use of materials, brine quality, construction details, and operational management can lead to adverse effects, such as disseminating harmful microorganisms in the air(Burkowska-But, 2016).

3. Conclusion and future implications

The article highlights the importance of innovative approaches to urban infrastructure design aimed at improving the microclimate and quality of life for residents. Particularly in moderate climates, urban challenges are especially complex; these solutions respond to communities' ecological, social, and economic needs.

Participatory budgets prove to be a key tool in modernising urban spaces in Central Europe, enabling the funding of ecological projects that are tailored to local needs. Such micro-interventions, like greening cities, installing small infrastructure elements, or managing stormwater, can significantly improve cities' microclimate and quality of life. However, although these solutions may seem simple to design, each requires specialised knowledge and precise management to be effective.

Although technologically advanced, these actions must be designed with local specifics in mind to lower temperatures effectively, absorb pollutants, and enhance urban biodiversity. For example, seemingly simple graduation towers require proper construction and good management to prevent them from becoming sources of biological contamination instead of improving air quality.

For this reason, proper design and implementation of each project within the scope of participatory budgets are crucial to bringing the expected benefits to local communities. This is a clear signal that further investments in solutions supporting the microclimate must go hand in hand with intensified research and skill development in green infrastructure. Only then will these projects be able to meet the challenges associated with adapting to climate change and contribute to a lasting improvement in the quality of life for residents of urban agglomerations?

References

Burkowska-But, A. (2016) *Tężnie jako czynnik kształtujący mikrobiologiczną jakość powietrza w uzdrowisku(eng: Graduation towers as a factor shaping microbiological air quality in the spa)*. Toruń: Wydawnictwo Naukowe Uniwersytetu Mikołaja Kopernika.

Chudzińska, A. i Dybczyńska-Bułyszko, A. (2019) „Brine Graduation Towers – a Modern Take on Tradition", w *Defining The Architectural Space – Tradition and Modernity in Architecture. vol. 2*. Wrocław: Wrocławskie Wydawnictwo Oświatowe, ss. 19–31.

Cunliffe, D. a. (1998) *Guidance on the use of rainwater tanks*, *National Environmental Health Forum Monographs Water Series No 3*.

Foster, J., Lowe, A. i Winkelman, S. (2011) *The Value of Green Infrastructure for Urban Adaptation*. The Center for Clean Air Policy.

Fundacja Sendzimira (2021) *Fundacja Sędzimira*. Dostępne na: https://sendzimir.org.pl [access: date: 25.02.2024].

Green Wall Types (2024) *Green Roof Technology*. Dostępne na: https://greenrooftechnology.com/living-architecture/green-walls/.

Martela, B., Janik, L. i Mróz, K. (2023) *Barometr budżetu obywatelskiego (eng:Citizens' budget barometer). Edycja 2022*, *Barometr budżetu obywatelskiego. Edycja 2022*. Warszawa - Kraków: Obserwatorium Polityki Miejskiej IRMiR. doi: 10.51733/opm.2023.16.

Mislan, K. A. S. i Helmuth, B. (2008) „Microclimate", *Encyclopedia of Ecology: Volume 1-4, Second Edition*. Elsevier, 3, ss. 472–475. doi: 10.1016/B978-0-444-63768-0.00520-5.

Planta Garden (2024).[access: https://www.plantagarden.pl, date: 25.02.2024].

Plantia (2024) *Plantia*. [access: https://www.plantia.pl, date: 25.02.2024].

Podgórska-Rykała, J. (2019) „Citizens' budget and participatory budget. Two solutions for one city as a consequence of the amendment of the local government law of 2018", *Roczniki Administracji i Prawa*, specjalny(XIX), ss. 221–236. doi: 10.5604/01.3001.0014.1029.

Sutkowska, M. *et al.* (2024) „Fostering sustainable urban development: integrating school areas to support the city's green-blue infrastructure.pdf". Warsaw: Acta Scientiarum Polonorum. Architectura, 23, ss. 12–31. doi: 10.22630/ASPA.2024.23.2.

Which Rainwater Tank is Right For You? (2024) *Expert Plumbing & Gas Services*. [access: https://expertplumbing.com.au/blog/rainwater-tanks/, date: 25.02.2024]