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Climate-Conscious Development of an Urban Area in Budapest, Hungary

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1. Introduction

Climate-conscious urban planning, especially that of public spaces, has little history in Hungary. Although Hungary's Environmental Law requires that each settlement prepare a program for the protection of the environment, these documents tend to be either overly theoretical studies or summaries of the initiatives of local non-governmental organizations. In urban planning documents, climate consciousness manifests itself mostly in the parroting of well-known slogans, without any concrete practical suggestions. This situation – found not only in Hungary – is what this study wished to remedy: Relying on several years' worth of research identifying and evaluating factors that influence climate, and inviting the contribution of external partners, we tested the effects that climate-related factors of urban development had on a pilot area.

The Budapest pilot area, where mitigation measures of urban heat island were introduced, lies on the Buda side of the city: an area of approximately 50 ha. Climate-related factors of urban development were tested on this urban region. Background support for the experiment was provided by a computer program called ENVI-met, which is able to use several dozen climatic variables to calculate changes that would occur if the climate-conscious development plans were realised. Before computer simulation a very detailed survey of physical properties of building and pavement materials was carried out on pilot area to fill large input requirements of ENVI-met model. Within the studied area, the planners of the Budapest modelling regions used the following tools provided by the climate specialists of urban heat island phenomenon: single alleys, double alleys, planters, green spaces, permeable pavement, green walls - vertical gardens and green roofs. According to results of ENVI-met simulations it can be stated that within the modelled regions the microclimate and thermal comfort parameters have been improved. Thus climate-conscious replanning of the area will offer, on the one hand, an opportunity for computer modelling that can project climatic conditions for a relatively diverse set of spaces, and, on the other hand, a potential starting point for the examination and analysis of many other modelling regions.

2. Methodology – the tools

The methods applied here are not new to public space planning: it is well known both in and outside professional circles that vegetation, for example, cools the environment through evapotranspiration; and these methods represent the primary tools employed in the redevelopment of outdoor public spaces in general. The novelty of the project – which is hopefully of revolutionary significance – lies in its ability to predict and calculate reliably the climatic effects of the tools employed, as well as the possibility to distribute these tools widely. Unfortunately, in Hungary – as in several other European countries – with the increase of solid paved surfaces, the currently fashionable trends in planning open public spaces often not only fail to improve but actually contribute to the deterioration of climatic conditions in the redeveloped areas, yet this effect is difficult to estimate in practice without reliable quantifiable methods. The methods tested within this study, designed to be made readily available for wide circulation, are expected to help specialists in organisations responsible for the regeneration of public spaces in accepting only commissioned plans that improve, rather than deteriorate, climatic conditions; otherwise visitors using public spaces will have a less comfortable experience in the summer, and even though there might be temporary stop-gap measures taken, such as the installation of mist cooling gates, the new public spaces will be used less often than the old ones were.

3. Description of the pilot area

The Budapest pilot area fits the nature of the experiment rather well, from several points of view, since it is a rather multifaceted area. In terms of neighbourhood character, it is located at the meeting point of traditional high-density urban cores characteristic of the end of the 19th century; rather dense, quasi-urban areas along Margit körút, built in the 1930s and 1940s, with larger, green yards; and a high-prestige green belt with villas. The area is centred around a brownfield regeneration project, which used to be the site of an earlier turbine factory but which in the early 2000s gave way, with a complete change of its functions, to a recreational and cultural centre, retaining and utilising some of the earlier industrial structures and incorporating them into a public park. Another characteristic example of green space in the area is a park called Mechwart liget, which was renewed during the

last few years, keeping intact its proportion of green space. The area also comprises several streets providing typical examples of city canyons, with practically no trees.

Alleys appear only sporadically within the area, and public green spaces or vegetation are present only to a minimal extent. The rows often have trees missing; there are single and double alleys in the area; and there are two areas of significant dimensions which also include water surfaces: Millenáris Park (3.5 ha) and Mechwart liget (1.8 ha). Examples of permeable surfaces in the area are negligible; apart from isolated examples, the dominant surface is asphalt, on both the roads and the sidewalks. The map of public utilities of the area for interventions is shown in Fig. 1.

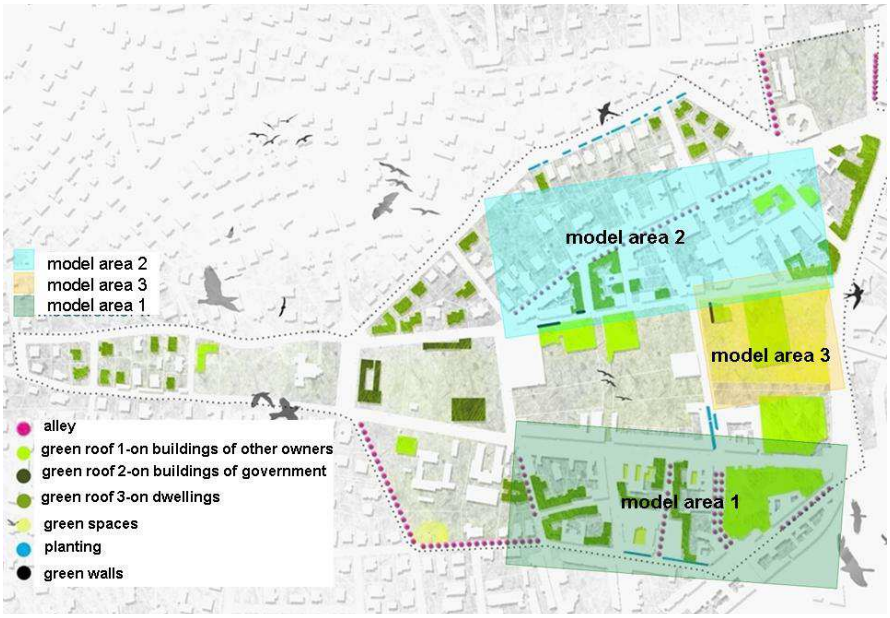

Fig. 1 Pilot area with interventions are used

4. Simulation results

In order to examine the effects on the microclimate created by the most important interventions planned in the area, a microclimate-modelling project was undertaken using ENVI-met modelling software (Bruse and Fleer, 1998). Since the entire area would have been too extensive to model, three representative model areas were selected, as shown by the map in Figure 1.

For modelling microclimates, 4 m x 4 m cells were used throughout. The direction of the wind was defined as north-westerly; wind speed at the elevation of 10 m was defined as 3 m/s. Simulations were started on a typical summer day at 9 p.m.; the period of simulation was 24 hours. Initial air temperature was set to 23°C; relative humidity at the elevation of 2 m was set to 70%. For each selected region the model was projected in two versions: the first one represented the original situation, while the second one represented the planned situation.

Below the effects of the intervention tools will be summarised briefly.

- Alleys: Planting single and double Alleys results in decreases local to each tree, both in terms of mean radiant temperature (MRT) and in terms of predicted mean vote (PMV). With expansion of the canopy of the trees, or by planting trees closer together, the distribution of these decreases tends to become more linear.

As is shown by Figures 2 and 3 (first picture represents actual state, second one shows mitigated state), alleys typically reduce predicted mean vote (PMV) value by 2, occasionally by 3. In our case this means that while in the initial situation 80% of pedestrians on the sidewalk feel uncomfortable, after trees are planted this ratio is reduced to 10-30%.

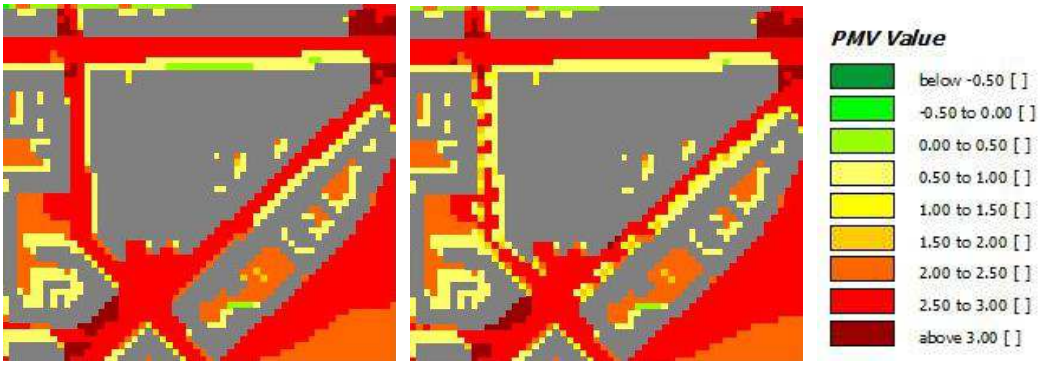

Fig. 2 Effects of single and double rows of street trees on predicted mean vote (PMV) in Fény utca and Retek utca (summer status, 12:00 p.m., 1.6 m)

- Planters: In isolation, planters have little effect on the microclimate; however, they exercise an undeniably positive effect on the streetscape and on the psychological well-being of the population. In Bimbó út, planters appear in combination with Alleys; here their effects cannot be clearly distinguished from the microclimatic effects of the trees, and, therefore, far-reaching conclusions cannot be drawn concerning their effectiveness.

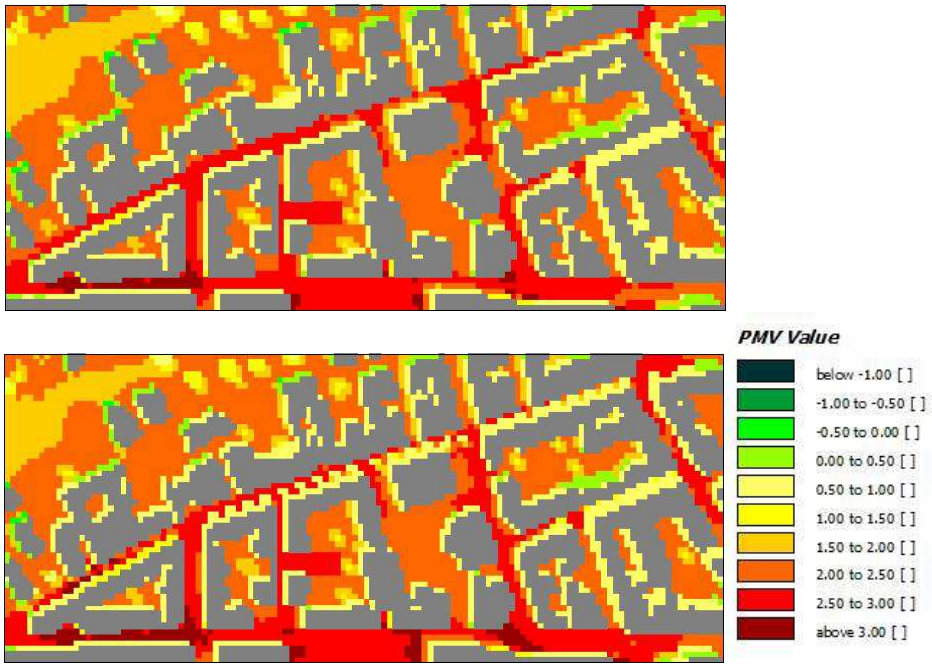

Fig. 3 Effects of rows of street trees on predicted mean vote (PMV) in Keleti Károly utca (summer status, 12:00 p.m., 1.6 m)

- Permeable Pavement: Permeable pavement cannot be modelled using the ENVI-met program, thus its effects can only be estimated based on descriptive studies. It is well known, however, that, depending on the base layer, permeable pavement is typically able to retain 35-60% of the water. This has several advantages. Due to its porosity and absorbance, it warms more slowly and cools more quickly than traditional pavement surfaces and, therefore, has a positive effect on the microclimate. It decreases storm water runoff, thus allowing water to reach the trees along the street, and helps replenish the water table. Using permeable pavement therefore addresses two important problems of urban heat islands: it improves the radiation and water balances.

- Green Walls – Vertical Gardens: For the scale of the modelling regions, the planned green walls and vertical gardens could not be modelled; earlier research shows, however, that green walls – vertical gardens that are nearly parallel to the direction of the prevailing winds significantly decrease mean radiant temperature (MRT) and predicted mean vote (PMV) values in their immediate surroundings (Szkordilisz, 2014).

- Green Roofs: The effects of the planned green roofs are rather complex, and, therefore, difficult to model. Green roofs not only decrease the intensity of urban heat islands but also decrease storm water runoff, thus also reducing the amount of greywater to be treated. They also play a significant role in improving the quality of life for people working or living in the buildings by offering a natural area for relaxation and recreation.

• Green Spaces: Within the pilot area, there are two significant public green spaces, Millenáris Park and Mechwart liget, where no changes were recommended. The model did, however, examine the effect of a new green space: the new park, to be created at the site of a soon-to-be-demolished ministry building, which will significantly increase the green spaces of Millenáris Park. The disappearance of the ministry block and the creation of the new green space will decrease air temperatures by 1.5-2.5°C, according to the microclimate modelling results (see Fig. 4).

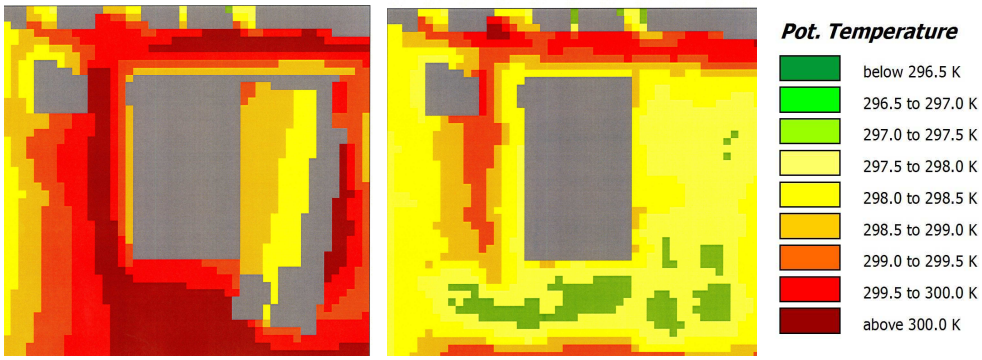

Fig. 4 Area of Széllkapu Park: status before (left) and after (right) the demolition of the ministry building and the installation of the planned park (air temperature, summer status, 12:00 p.m., 1.6 m

In summary, it can be stated that within the modelled regions the microclimate – following the localised nature of the intervention – improves in discrete areas due to the proportionate increase of green spaces: cross-ventilation improves, relative humidity increases, mean radiant temperature (MRT) significantly decreases and, in cases of drastic intervention, air temperatures also show significant decreases.

4. Suggestions concerning organisation and logistics

For the realisation of climate-conscious development of the area, the suggested solutions are similar to traditional solutions, undertaken in such a way that the role of the local government is in harmony with existing tools on the one hand and with the ownership relations of the properties to be developed or regenerated on the other, with special attention to properties owned by the local government.

Due to the diversity in ownership, interests and abilities, it cannot be hoped that the suggested plans could be realised in their entirety in one, well organised initiative, in a short period of time - yet most elements of the plan could indeed be carried out in such fashion, while a smaller proportion of the plans could be realised as – preferably coordinated – individual actions carried out by the other parties but initiated, and on occasion supported, by the local authorities.

For the preparation and organisation of tasks, especially those to be carried out by the local authorities, the relevant local government body responsible for urban development and planning should be appointed as coordinator – who will, then, invite the contributions of other parties, such as planners and constructors, as necessary.

As for the timing of individual tasks, priority should be given to properties owned by the local authorities, to tasks that can be carried out within the jurisdiction of the local authorities, primarily to public spaces that could serve as direct examples, such as green roofs on buildings of institutions controlled by the local authorities. An equally important recommendation is the simultaneous commencement of negotiations with the property managers of national institutions, to invite them to participate in the program and to help realise climate-conscious redevelopment for elements of their buildings. The installation of a green wall or vertical garden on the Kis Rókus utca facade of the buildings in Millenáris Park may have a special position in this respect, as the soil in which the vegetation is planted is in a public space owned by the local authorities, while the vegetation climbs on the walls of a building under national ownership. Here a special agreement will be necessary between parties concerning to maintenance, the recommended solution being that the local government takes responsibility for planting and watering the plants.

The inclusion of local businesses and condominiums in the program requires yet another set of solutions. In both cases the recommended procedure would be for the local government to invite owners to participate in the program, and to explain in the course of preparatory negotiations how advantages and savings will accrue as a result. In addition, for businesses, PR-based incentives might be introduced (such as the establishment of the title 'Climate-Conscious Business of the Year'), while for condominiums a system of financial support might be successful.

Acknowledgment

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