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FACILITATING CLIMATE ADAPTIVE URBAN DESIGN – DEVELOPING A SYSTEM OF PLANNING CRITERIA IN HUNGARY

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Abstract
Urban microclimate has become a fashionable topic in the last decade to involve quite a few researchers. Numerous researches have proved the effectivity of urban parks, green facades and roofs in providing shade and shelter for the urban dwellers and in also having an important role in creating cool islands inside the urban heat island.
Urban planners do not dispute the mentioned principles, and they seem to have a lively interest towards climate-conscious planning, but they have to face a lack of information regarding the tools of climate adaptive urban design and their microclimatic effect. Even though the importance of climate-consciousness in urban planning has been proved, it hasn't come to the point to develop an articulate, easy-to-use planning system for architects and urban planners
Our aim is to create a system of climate-adaptive planning instruments and their impact on urban microclimate – converting the results of theoretical researches and field measurements – which could help urban planners in their everyday planning routine.
In our work we present a work-in-progress version of a targeted indicator system which can be used in urban renovation projects.

Keywords:
climate-adaptive urban planning; planning guidelines; urban microclimate

1 INTRODUCTION, LITERATURE REVIEW

Considering the dynamic growth of urban population – according to some prognoses [1] in 2050, two-thirds of the whole 10 billion population will be city-dwellers – urban related problems will be and are already the main issues of the 21st century. Besides social and economic issues, the importance of environmental, climate and energy related problems we have to face rises too. To cut down the threatening symptoms into details, the constant rising of air temperatures will have multiple effects. [2] What's more, in urban areas man-made morphology and anthropogenic heat-emission causes a significant rise in temperatures, magnifying the negative effects of climate change. This will have a drastic impact on humans' physiology, affecting not only the ones ill and elderly, but probably everybody [3]. Due to the increase in temperature and disrupted radiation conditions, the city-dwellers' behaviour in urban spaces will change too [4]. These are all problems requiring multi-disciplinary answers, but among other experts urban planners can act in order to mitigate negative effects of climate change and urban heat island.

After delineating the main issues of spatial planning, we have to add that we do have the answers considering knowledge based on multiple research and technology. For instance, the usage of cool materials [5], with ensuring urban cross-ventilation [6] and by creating ponds, fountains, and other water surfaces in urban spaces [7], the human thermal comfort of the passers-by can be improved by a significant extent. In creating good thermal comfort outdoors [8] and indoors too, the role of urban vegetation has to be mentioned.

The mentioned tools' effectivity varies not only depending on the facilities of a public space, but also humans' perceptions differ from one another [9]. Of course the interventions, which are most likely to modify one's thermal comfort in a positive

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way, should be preferred in urban design. Furthermore, planners should also take into consideration the different environmental effectiveness – such as CO2-fixation, air pollution removal [10] – of the mentioned climate-adaptation strategies.

But, what actually hinders turning the results of numerous researches into reality is that there is a lack of one integrated and complex planning system which wouldn't require special and detailed climatologic knowledge from urban planners, but would enable an easy and simple usage in everyday planning routine. Planners of course are not in the position of carrying out dozens of measurements or modelling, they are interested in using the results and data available – and indeed they are interested. In the last years a lively attraction has arisen amongst urban planners for climate-adaptive solutions in spatial planning. There have been courses conducted all over Europe and a unique success has been reported. Seeing the open-minded colleagues, our team decided to set up a system of climate-adaptive planning criteria which gives a guideline not only for planners, but for stakeholders, investors, municipalities and project-managers being involved in spatial planning too. For the current work some previous and similar guidebooks and strategies have been used. [11]

2 METHODOLOGY

2.1 Measurements

In the frame of a long-term human-bioclimatologic project initiated by the urban climate workgroup of the Department of Climatology and Landscape Ecology (University of Szeged), six local public areas with different surface morphology and function were investigated. The on-site data collection was carried out in 5 to 7 week long phases in the spring, summer and autumn of the project years 2011 and 2012.

During the environmental monitoring in local areas micro-meteorological parameters determining the thermal comfort (such as air temperature, T_a, relative humidity, *RH*, wind speed, *v*, and short- and long-wave radiation fluxes from the 3D environment) were measured on-site. Micro-meteorological data was registered by two mobile urban micrometeorological stations at a height of 1.1 m, as set by human-bioclimatologic guidelines. The stations were placed in different shading situations and on different land cover surfaces in local public areas in order to investigate the climatic effect of the urban vegetation and surface morphology. Based on on-site measured meteorological data, the mean radiation temperature, *MRT*, characterising the complex thermal effects of radiation conditions, and the physiologically equivalent temperature, PET, describing the thermal load on the human body were calculated.

Since data collection was carried out not at the same moment on different land covers (namely, we have only two mobile meteorological stations, however at least 4-5 different urban conditions) the simultaneous examination of the different land cover types was not possible. Therefore, the meteorological background parameters during the on-site measurements (such as air temperature, relative humidity, wind speed, and global radiation) were also used as obtained from the database of the meteorological station of the Hungarian Meteorological Service, Szeged. This meteorological station is located at a distance of about 6 km from the public spaces, in a typical suburb open grassy environment, without buildings and trees. During the data processing *MRT* and *PET* values in this latter case were also calculated from these background data.

2.2 Modelling

For modelling purposes the ENVI-met software was used. ENVI-met is a three-dimensional microscale climate model, which is capable of simulating the interactions of the physical environment and the microclimate with relatively high temporal (10 min) and spatial (0.5-10 m) resolution [12]. The simulation requires two groups of model input data. The 'Area input file' includes the morphological elements (buildings, plants, land covers etc.) and the 'Configuration file' contains the basic settings (such as the durations of the simulated time period and the time steps) as well as the necessary initial meteorological parameters related to the simulation.

2.3 The concept of the guide

After carrying out the described measurements and model simulations, the results are usually not appropriate for urban planners to understand and use in their planning routine. Typically, the results derived from the above described measurements and simulations are not easy to understand and use by practicing urban planners. Results of modelling might have complex messages, and it is also a long process to evaluate the findings. The results of simulations are often presented in a graphic display, but this can easily mislead to wrong or not precise conclusions. On the other hand, statistical evaluation that carries punctual data of several cases and measures, in order to prognosticate correctly the effects of a climate-adaptive intervention in urban environment, not only takes too long, but it is also a work which urban planners an landscape architects are usually not obliged to do. Therefore, what could help planners greatly in taking into consideration the effects of climate-adaptive tools, is to represent the different possible effects in a simple way. Thus, we have chosen to use the results of numerous measurements and modelling carried out during the last few years by the co-authors and sum up the mentioned results in a table. The table, which focuses mainly on summer outdoor thermal

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comfort, must function as a part of a guide for designers in order to support and improve the effectiveness of climate-conscious urban planning. The guide should also be coherent with the Hungarian Building Code, and correspond to the requirements of typical municipality plans.

For giving a more detailed overview, the contents of the named tables are described in the following.

3 RESULTS

The mentioned tables sum up the changes occurring in the most important microclimatic characteristics due to the usage of some green-infrastructure elements. The investigated elements are the following: alleys, green spaces and paving materials. An alley is defined as a line of trees planted on one or both sides of the road between the pedestrian way and the carriageway, depending on the width of the street. Trees can be planted in different distances from each other. These features, of course, determine the amplitude of the microclimatic effects. Green space is an open space covered with dense vegetation (grass, shrubs, and trees) mainly meant for common use. Both tables summarise the most important characteristics of human thermal comfort. These are the following: air temperature (ΔT_a), mean radiant temperature (*ΔMRT*[1]), wind velocity (*Δv*) and human comfort (*ΔPET*[2] *or ΔPMV*[3]). The first table *(Table 1.)* shows the minimising and maximising values of the possible changes occurring due to the usage of alleys, medium scale green spaces and different paving materials. Data on green spaces and paving materials are gained from on-site measurements, the effect of a simple alley is based on modelling results. The table helps designers to judge the possible “negative” and “positive” effects of the used green infrastructure element.

According to *Table 1.* the most effective way of minimising mean radiant temperature, and so improving thermal comfort, is the planting of an alley, as it can minimise the values of MRT by 34°C. On the other hand, the importance of using appropriate paving materials becomes also clear as medium dark stones increase air temperature by 3.7°C and mean radiant temperature by 24.6°C.

Table 2. describes even more simply the effects of some green infrastructure elements. This table is needed to give direct instructions: different urban environments might need changes in different ways, which can be solved with the usage of different elements of climate-adaptive planning. Facing the complex problematics of urban comfort one must take into consideration the possible changes affecting air temperature, surface temperatures and wind-environment at the same time. Bad thermal comfort needs complex answers using severe elements simultaneously. In order to get more detailed images of the planned site, microclimatological modelling might be still needed during the planning period with the parallel use of the guide, but it can greatly help designers to foresee the effects of their plans in terms of human thermal comfort.

Both tables show both “negative” and “positive” effects of green infrastructure elements. This does not mean that green infrastructure would have negative effects on long term in the classical meaning, but shows, that for achieving different aims one must use different tools. The negative values show the decrease, positive values show the increase in physical parameters. Thus, negative values, in most cases, represent a positive change from a thermal comfort point of view.

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[1] MRT (Mean Radiant Temperature is the uniform temperature of an imaginary enclose where the radiant heat fluxes equal to the actual, non-uniform environment [13]

[2] PET (Physiologically Equivalent Temperature) is a widely used human bioclimatology index. PET is defined as the air temperature at which, in a typical indoor setting, the heat budget of the body is balanced with the same core and skin temperature as those under the prevailing complex outdoor conditions [14]

[3] PMV (Predicted Mean Vote) is a model taking into consideration heat balance equations developed by P.O. Fanger. The scale for outdoor environment is -4<PMV<+4

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BENEFITS / ELEMENT OF GREEN INFRASTRUCTURE		mitigation of air temperature	mitigation of mean radiant temperature	change of wind speed	Human comfort
		ΔT_a [°C]	ΔMRT [°C]	Δv [m/s]	ΔPET [°C]
1	alley	min: -1 max: +0.1	min: -34 max: +2	min: 2-2,5 max: -0,25-1	min: -2,5 max: 0,5 [PMV]
2	green space	min: -1.8 max: 1.5	min: -32.6 max: 0.5	min: -9.2 max: 0.2	min: - 16.1 max: 3.1
3	covering / paving medium dark pave stone	min: -1.6 max: 3.7	min: -17.3 max: 24.6	min: -5.0 max: 1.7	min: -9.8 max: 13.5
	light-coloured gravel	min: -0.7 max: 3.2	min: -13.1 max: 19.5	min: -9.1 max: -0.7	min: -3.3 max: 14.6

Table 1: Minimum and maximum values of differences caused by the most important climate-adaptive tools.

BENEFITS / ELEMENT OF GREEN INFRASTRUCTURE		change of air temperature	change of mean radiant temperature	change of wind speed	Human comfort?
		ΔT_a [°C]	ΔMRT [°C]	Δv [m/s]	ΔPET [°C]
1	alley	-1	-34	-65% - +10%	-2.5 - +0.5 PMV
2	green space	-2.4	-36.3	-10.8	-16.1
3	covering / paving	+3.7	+31.3	-	+20.1
4	water surface	-0.006	No precise data available		
5	green façade	-0.3			
6	green roof	0			

Table 2: Characteristic values of changes in thermal environment occurred through the usage of different green infrastructure elements.

4 DISCUSSION AND FURTHER PLANS

As introduced, this work is still an ongoing project and there are further plans to improve and extend the guide. The importance of involving urban planners in climate adaption is undeniable. The most important aim of the guide is to show the many possibilities, and both the responsibilities designers hold in creating a better urban environment.

For ensuring the coherence with the Hungarian planning system the guide must be cut down to different scales of urban planning, however the guide mainly concentrates on short-term and medium scale action plans. Moreover, during the further development of the guide, more elements of green infrastructure must be taken into consideration; the guide should give more precise data on different urban situations (e.g. orientation of roads, open spaces, etc.), and some more benefits too: such as energy use, storm water

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runoff regulation, air quality and carbon sequestration.

There are also plans for testing the helpfulness and usefulness of the guide among practitioners, and enhance the quality and possibilities of usage based upon feedback.

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