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The Influence of Pocket Parks on Microclimate Conditions and Pedestrian Comfort in Urban Neighborhoods

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Abstract: Global warming and the urban heat island (UHI) phenomenon threat to render open urban spaces hostile or even dangerous during summer days. The problem concerns a great part of the world population considering the ongoing assemblage of people in cities. Enriching the urban fabric with natural landscapes qualifies as the best solution. However, the redevelopment of the functional parts of the urban fabric is a particularly difficult task, especially in times of financial crisis, but small, unused pieces of land which are often found in cities, can be more easily converted into green neighborhood parks (pocket parks). To investigate the impact of the dispersion of these spaces on the urban microclimate, the present study analyzes a section of eleven building blocks in the center of the city of Serres, in northern Greece. Concerning the hypothesis of the conversion of ten existing unused small spaces into parks, the result is the improvement of the climatic quantities and thermal comfort during the summer season. In conclusion, the dispersion of small neighborhood parks in the city is a useful tool to mitigate the UHI phenomenon and at the same time a method of upgrading the urban fabric and the quality of life of the residents.

Key words: climate change, pocket parks, thermal comfort, urban green, urban reconstructions

1. Introduction

During the last half century, the urbanization of the planet has been constantly intensifying. According to forecasts [1], in 2050, cities will host 70% of the world's population while the corresponding figure was just 30% in 1950. As a result, maintaining and improving the quality of life of citizens is an intractable issue for the science and practice of urban planning.

Among other things, the enlargement of cities is associated with the intensity of the Urban Heat Island phenomenon [2]. In large urban centres, differences in temperature are recorded compared to the suburban area, reaching 12°C [3]. The synergy of the phenomenon with the rising heat waves due to climate change intensifies the concern of the scientific community [4].

The thermally inhospitable environment of cities, whenever it occurs, traps people indoors with negative effects on their physical and psychological condition, their socialization and in general on their health and quality of life [5]. Along with the review of the role of open urban spaces [6], there is a need for their holistic redesign, including their microclimate redesign.

Greenery qualifies as the best solution to modern urban environmental problems. The enrichment of the urban fabric with elements and spaces of the natural landscape benefits the local climate and restores the attractiveness of open spaces for the citizens [7]. In

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addition, it is proposed by the scientific community as a key measure to mitigate the intensity of UHI [8].

The necessary, for this purpose, regeneration of the densely populated city centres encounters several obstacles, mainly the absence of open areas and the inability of converting built areas due to the great value of the land. Usually, the free public spaces are limited to the sidewalks, often not large enough to be enriched with greenery. The imperative need for cities to become greener leads science and practice to seek other spaces and methods, such as planting roofs and walls of built structures [9].

As an alternative, there is also the proposal of the utilization of smaller spaces, usually of no use, which can be more easily located in city centres [10]. Their transformation into pocket parks benefits the microclimate of their neighbourhood and attracts locals to develop mild activities within them [11].

The present dissertation focuses on the benefits of the above method, after the distribution of pocket parks in the urban fabric in a certain density (one in each building block). It examines the effects on the microclimate of spaces that are converted into parks and their neighbourhoods and on the temperature of the wider area during the summer season.

2. Methodology

This study focuses on the comparative analysis of a densely populated area of eleven building polygons in the centre of the city of Serres (41º05'N, 23º33'E), presented in Fig., and some proposed interventions, evaluated through microclimate simulations using the Envi-met software [12]. The simulations utilized data from the mapping of geometry and plantings, the identification of thermophysical characteristics of structures and the meteorological records of a station operated by the Municipality of Serres in a nearby area with similar characteristics. The analyses target the typically warmest day of the summer season, as the worst-case scenario, July 15th, with daily air temperature range between 24.88°C and 35.78°C, as shown in Fig. and mean wind velocity at 2 m/s.

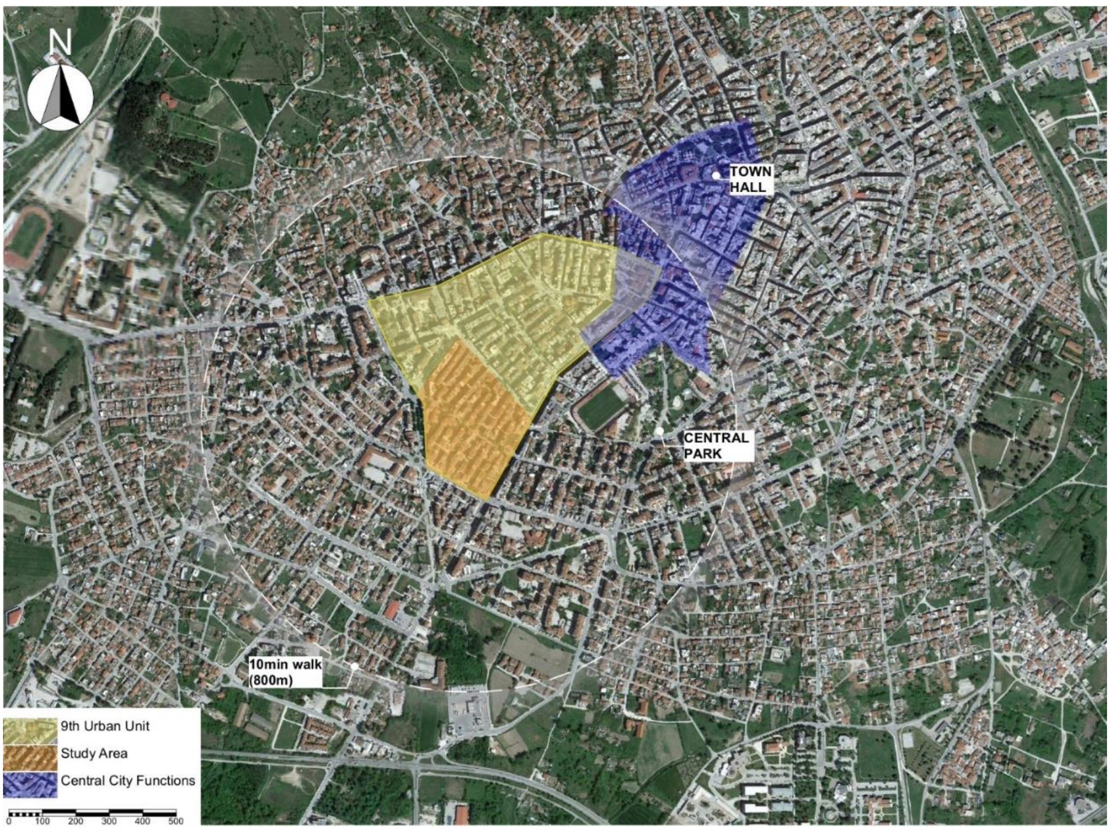

Fig. 1 The location of the study area in the city.

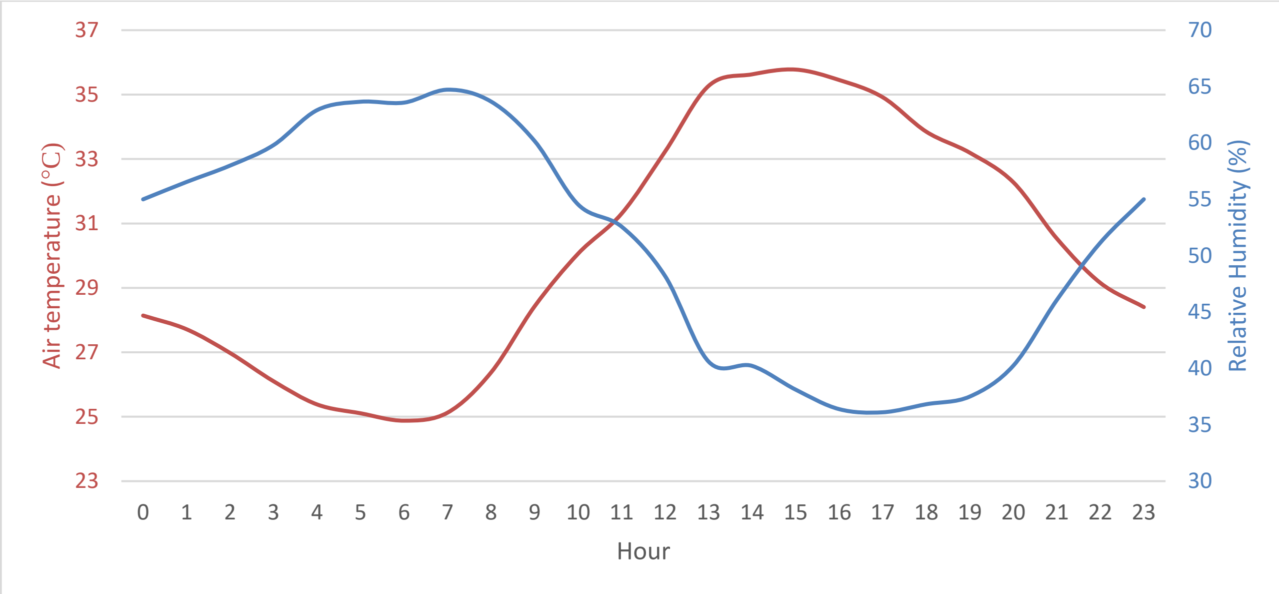

Fig. 2 The hourly evolution of the air temperature and the relative humidity of the atmosphere on July 15.

As a working hypothesis, ten spaces were located, one in each building polygon in the selected urban area, which offer the potential to be redeveloped into parks. Three of the above spaces were designed in a greater level of detail to extend the assessment of the effect the parks have on the microclimate of their neighbourhood and the thermal comfort of the locals.

3. Study Area and Upgrade Suggestions

3.1 Study Area Analysis

The urban area selected for assessment is located in the central part of the city, enclosed by Kilkis St, Paleologou St, Kioutacheas St, 8th May 1821 St and Merarcheas St. and presented in Fig.. It is part of the most densely populated urban neighbourhood with 221 inhabitants/ha. It covers an area of 9.2 ha, with the 69% being urban blocks which have an elongated shape in a north-south direction.

The buildings contain residences and a small number of shops. Their height ranges from 4 to 27 m. The area is divided into two urban sectors with different building conditions. Thus, its northern part is more densely built up with taller buildings. Detailed geometric features of the blocks and the open spaces distribution is presented in Table 1.

About 55% of building polygons remain unstructured but only 3% remain without concrete pavement or other waterproof material. The streets of the area have a similar width and the ratio is H/W = 1 in most cases. Planting is limited to sidewalks, where occasionally there are rows of deciduous trees, 10m high.

Public free spaces are absent from the specific study area. The spaces that are converted into parks, as a working hypothesis of the study, belong mainly to the courtyards of the building blocks. Overall, the 3.4% of building blocks were recorded as potential pocket parks, but it was considered preferable to limit the green area to 2.7% in order to maintain the character of a small park and to extract results that would be applicable to those areas of cities where it is more difficult to find similar spaces.

3.2 Upgrade Proposal

The development of pocket parks initially attracts residents of the wider neighbourhood [11]. Thus, they are designed to offer new opportunities for recreation, socializing and mild activities while improving the microclimate. The transformation of the selected areas into parks follows the following basic characteristics:

Fig. 3 Plan of the study area which includes the eleven urban blocks and the existing vegetation. Orange blocks indicate the locations of the proposed pocket parks.

Table 1 Analysis of building blocks.

Building block		1	2	3	4	5	6	7	8	9	10	11
Area	m^2	5477	4542	5743	5058	6231	5719	6038	6157	8104	7144	3746
Uncovered	%	59.3	60.5	53.8	51.4	60.6	53.1	55.2	55.9	50.7	49.7	57.0
Uncoated ground	%	22.5	18.4	6.0	0.4	0.3	0.3	0.3	7.0	3.3	0.6	0.9
Max height	m	20.0	24.0	18.0	27.0	19.0	24.0	18.0	27.0	24.0	24.0	18.0
Mean height	m	11.8	17.2	12.8	17.4	12.7	19.6	15.0	17.9	18.9	18.6	11.5
Allowed plot ratio		1.40	2.40	1.40	2.40	1.40	2.40	1.40	2.40	2.40	2.40	1.40
Realized plot ratio		1.28	1.94	1.79	2.36	1.36	2.63	1.86	2.2	2.63	2.53	1.34

• The replacement of the pavements and their underlying layers: the new pavements are made of water-permeable natural materials on a suitable substrate to achieve the enrichment of the subsoil and the retention of moisture. The floors that are proposed to be of such kind are the stabilized soil, the vegetated soil and the natural rocks placed on the ground.

• Planting areas with tall deciduous trees in appropriate locations and densities to achieve shading of most floors

• Planting with low shrubs and perennials to aesthetically improve the area and enhance cooling through evapotranspiration.

• The utilization of the water elements for the improvement of the microclimate with the construction of fountains mainly in sunny parts of the area.

• The combination of fixed and mobile urban equipment (tables, seats, toys) to make each park attractive to locals and to be able to use it differently during all seasons and hours of the day.

To indicate ways of combining the above basic principles for the production of an architectural proposal for the new parks, a draft study was prepared for three of them (Fig.). The trees and pergolas were

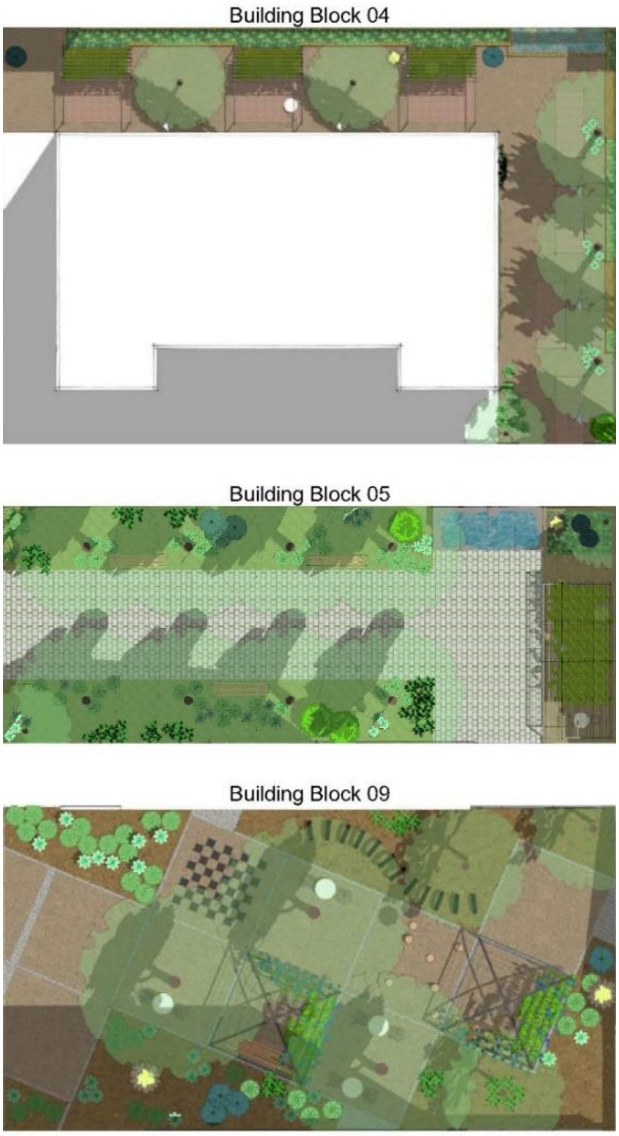

Fig. 4 Park design proposals, for three urban blocks.

combined in a variety of heights, proportions, and relations among each other to draw conclusions about their effect on the microclimate of the park.

4. Results and Discussion

As mentioned, the simulations of the climatic factors in the study area targeted the hottest summer day. From the results of a 24-hour cycle, 15:00 in the afternoon was the warmest time of the day. The observations and diagrams focused on the height of +1.40 m from the ground level, to cover the influence of microclimate conditions both the pedestrians and the seated users of the space.

The analysis of the existing conditions of study area, revealed air temperatures between 33.67°C and 35.50°C. The highest temperatures are observed on the widest roads around the area and at the roundabouts, where asphalt paving and the absence of shading predominate. It is distinctive that the same areas show the highest average radiant temperatures reaching 78°C. As expected, the thermal discomfort is reflected in the PMV indices with values above 3 (very hot) and up to 7.

The simulation results of the area with the proposed pocket parks show that air temperature decreases to 0.5°C (Fig. 3). This reduction is concentrated in the new parks and spreads through the neighborhood decreasing according to the distance from them. The decrease in air temperature seems to have a spatial effect on a larger scale in the northern part of the area which was already more shaded. Also, we can observe that the wind direction influences the distribution of air temperature.

In several parts of the area, that were selected based on geometric characteristics such as street orientation and distance from the proposed pocket parks (indicated as spots in Fig.), the simulation results of climatic factors were recorded in an hourly pace. At all those parts the proposed interventions cause a drop in air temperature throughout the day, with the highest reductions observed in the areas near the parks (Fig. 1).

Trees, in combination with pavement materials replacement, seem to significantly reduce the average radiant temperature in the parks, in agreement with results by previous studies [13]. In the case of the area studied, this reduction is at least 7-10°C in all parks while it can reach up to 30°C at places where the radiant temperature initially had remarkably high values. According to the more detailed simulations of the three selected parks we observe that the use of tall trees for this purpose is preferable to the use of pergolas.

Fig. 5 Comparative analysis of the simulation results between the existing conditions of the site and the conditions after implementation of proposed interventions at the pocket parks locations, indicating air temperature differences at 1.4 m height above ground level.

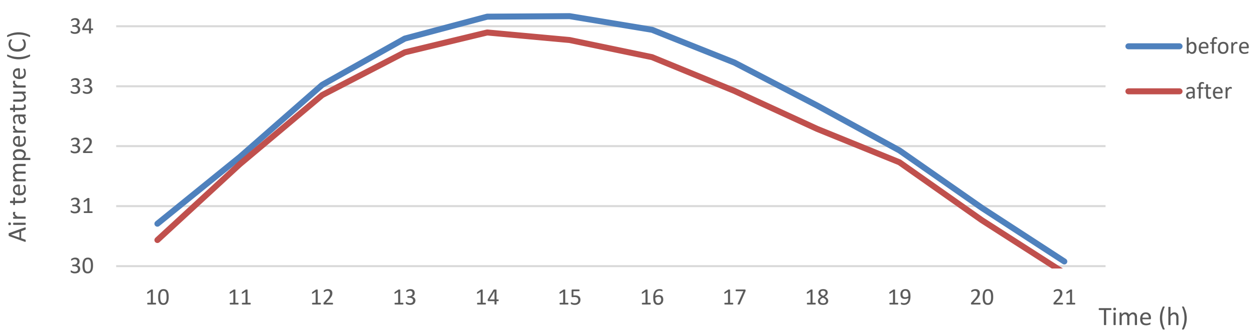

Fig. 1 Comparison of air temperatures during the day near a park before and after the implementation of proposed interventions.

The improvement of the microclimate is also reflected in the thermal comfort index PMV. PMV values were reduced up to 4 units in all parks. The PMV value, in the proposed case, is close to 3, and considered as a significant improvement for the given time of year and day, compared to the initial extreme conditions. The more detailed analysis of the three selected parks shows the influence of shading types (trees, pergolas) on the PMV index as well as the concentration of this reduction at a short distance from the parks (Fig.).

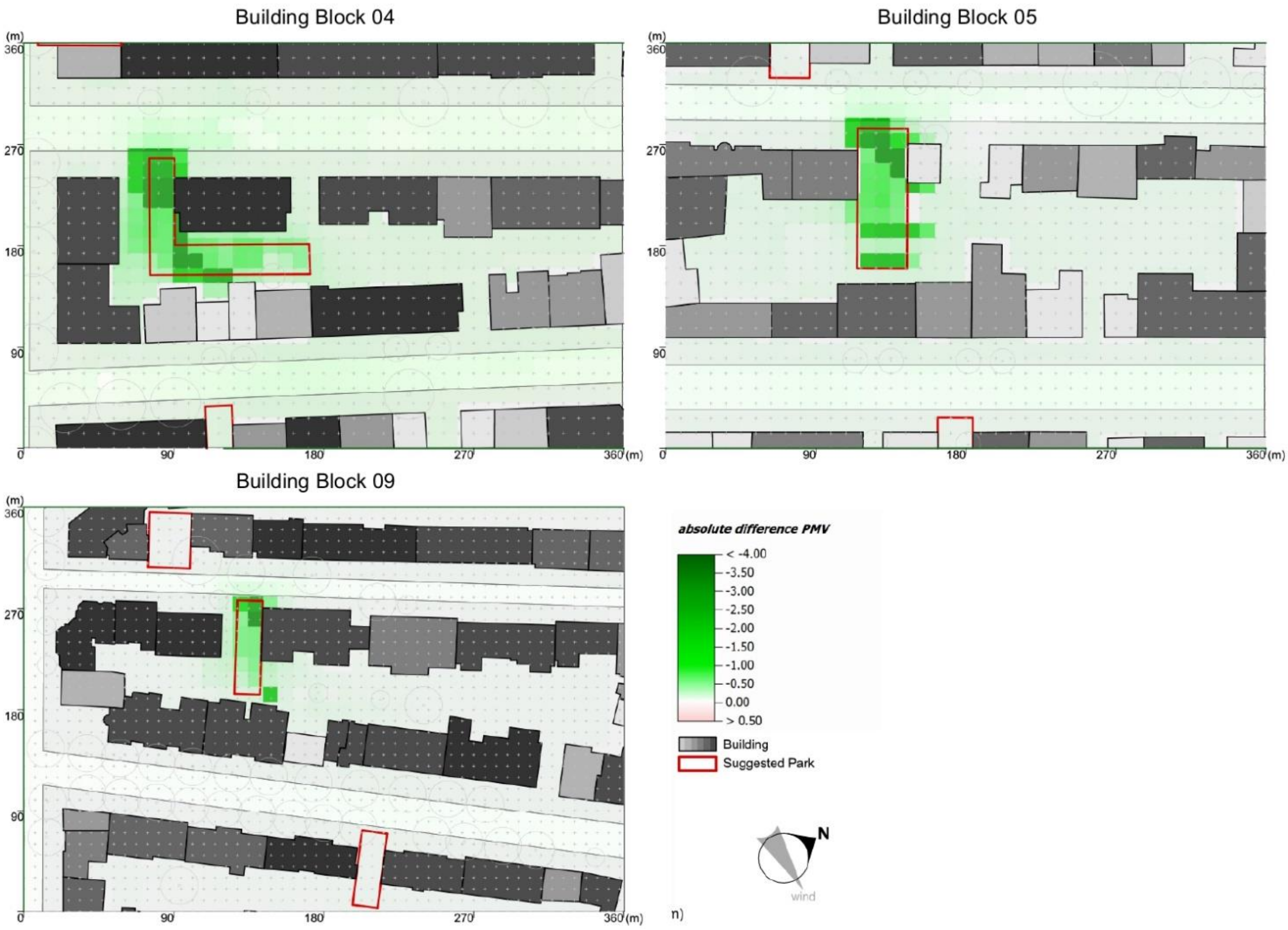

Fig. 7 Comparison of PMV values reduction, after the implementation of proposed interventions at the three selected parks, based on the simulation results of the existing cases and the proposed scenarios, in summer afternoon at 1.40 m above ground.

5. Conclusions

To regenerate the densely populated urban centres, while enriching them with elements of the natural landscape, the transformation of small spaces of no use into neighborhood parks can compensate for the lack of free space.

Comparative analysis in the study area showed that despite their small size the interventions reduced the average air temperature of the total area. As expected, the areas inside and near the new parks showed the largest decrease (0.5°C). This effect on temperature spreads spatially in the entire neighborhood and to a greater extent in the part of the area which already has more shading because of the taller buildings and trees.

In addition, the improved microclimate of the parks, compared to their neighborhood, can attract the locals. This strengthens their social interactions, level of activity and health.

In conclusion, the distribution of small pocket parks in the city is a useful tool to mitigate the UHI phenomenon and at the same time a method of upgrading the urban fabric and the quality of life of the residents.

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