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Evaluation of comfort conditions in urban open spaces. Application in the island of Crete

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ABSTRACT

The thermal environment in outdoor public spaces and their level of use are strongly connected. The design of outdoor spaces, especially in urban areas, is very critical in Southern Europe due to their extended use during summertime where the urban heat island phenomenon deteriorates the microclimatic conditions.

In this paper the main outcomes of outdoor spaces field surveys are presented, which were carried out in four different urban open spaces in Crete. On site measurements were implemented and a questionnaire was used in order to estimate the thermal comfort of visitors. Thermal indices like Predicted Mean Vote, Physiologically Equivalent Temperature, Standard Effective Temperature, Wet Bulb Globe Temperature are used to evaluate the features of urban microclimate and then are being compared in order to find the most suitable for the Mediterranean microclimate. This suggests another way of approach to the researcher and provides essential tools to the designer.

1. Introduction

It is well known that the urban open space is directly affected by the habitants and vice versa the habitants' quality of life and social status is related with the open urban space design [1].

The major determinants of the use and viability of an open place that are analysed in the survey are: (1) the climate conditions in the micro-scale environment [2,3]. Humidity levels, especially in hot climates and coastal regions [4,5]; (2) the mean radiant temperature, as well as (3) the cold air supply within the urban space [6]. All these features have multiple effects not only in health and well-being of the citizens, tourism and local market but also to the residences and the energy consumption of the surrounding buildings [7–10]. This relationship is more evident, especially in islands, because the majority of the open spaces is in the form of a large central square in the city centre; in this way every intervention to the open space may have beneficial results in the sustainability of the whole urban system; obviously a large scale integration of solar applications in urban areas could improve this sustainability and self-efficiency dramatically [11].

Studying the microclimatic factors in relation with the comfort factors of people using them, the basic parameters of sustainable design could be determined [12–14]. The initial findings of this study aim to implement additional information about the correlation between the microclimatic characteristics of open urban spaces and the comfort votes of people using them.

After the calculation and comparison of a variety of indices and climatic parameters, the most crucial for the sense of comfort in the outdoor environment are being determined [15–17]. Similar studies that either include interviews or only simulation scenarios use other indices that are not taken into account in this study like COMFA method, Thermal sensation (TS), mean radiant temperature, Temperature Equivalent Perception (TEP), MENEX model and Potential Storage Index [18,19].

This paper focuses on the way microclimatic conditions, such as air temperature, solar radiation, relative humidity and wind speed and direction affect the use of urban open spaces in a Mediterranean island climate, with the use of field surveys conducted in four different cities in Crete, Greece [20]. The influence of these factors can be measured and quantitatively evaluated. In the final results, psychological factors and non measurable parameters like aesthetic and personal preferences are not included.

The aim of the paper is to provide basic rules critical for a sustainable design of open urban spaces in every type of Mediterranean island, such as:

- Classification based on the hierarchy of the climate parameters, to calculate their contribution to the overall comfort levels;

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- Determination of the comfort levels of every microclimate parameter according to the answers given, both in winter and in summer time;
- Determination of the basic human parameters that affect the comfort levels;
- Valuation of these parameters depending on the different uses of the four squares.

Given the prior experience, this research implements the findings into a particular type of climate, the Mediterranean climate [21]. This way the basic indices can be validated and if possible recalculated in a different scale that is constructed by real votes and real data. No model can be properly implemented to a specific situation unless it has been properly adjusted first to the specifics of the given situation.

2. Methodology

In order to examine the variety of the several urban climates and design parameters within Crete, all selected sites have different characteristics considering their vegetation, their location and their use. The first one is on the coastal zone within the historical center of Chania, the second one is between the shopping center and the port in Rethymnon the third one is a nearly reconstructed square within the shopping center area of Iraklion and the fourth is located on a mountainous village near Iraklion called Archanes.

In every square studied two surveys were conducted, one in the winter (February 2009) and one in the summer (July 2009). They were conducted from 10 a.m. to 4 p.m, and 200 questionnaires were carried out, 100 each time. This number of responses is minimally sufficient to conduct valid and reliable conclusions and it was pre-calculated by tests in significance level 0.05 [22]. All the statistical tests run for the need of the survey (e.g. linear regression, significance of coefficients, etc.) were statistically significant in 0.05 significance level. It was used simple random sampling as the method of collecting the data (there was no need for stratified sampling, since the groups of interest were residents and visitors to the squares, and not the age or sex groups). The selection of the specific dates of the measurements was done by following observations of the general climate, in every city during the whole month so as the climatic data collected would be realistic replica of the microclimatic environment of the square the day of the measurement (Fig. 1). The comfort votes for the evaluation of all the microclimatic parameters and also for the total state of comfort obtained through questions in a 5 or 3 point scale. The 5 or 3 point scale included the comfort votes in the middle (0), and two levels of discomfort, tolerable discomfort (±1) and intolerable discomfort (±2). The parameters thermal comfort and wind tolerance were studied in a 5 point scale while the parameters of sun tolerance, humidity tolerance and traffic sound annoyance were studied in a 3 point scale. The questionnaire also included questions about the user's preferences in general and his/hers additional opinion about the meaning and type of the ideal open urban space. All the answers were afterwards linked with the microclimatic data measured at the time of the interview.

The questionnaire included information about (Fig. 2):

(A) Observations (apparel; consumption of cold drinks; kinetic status -at rest or in motion; residence time in the square).
(B) Questions (criteria for comfort in the heat, wind, sun, moisture, acoustic environment).
(C) Other criteria (naturalness of the area; expectations based on proposed changes pictured; experience – impressions from their stay in the square; reasons of visiting and using; aesthetics of the area).

The survey tried to take into consideration the majority of the factors that affect comfort, which include microclimate factors, physical and psychological parameters. This paper focuses more on the microclimate factors like air temperature, solar radiation, relative humidity and wind speed. Other parameters that may affect thermal sensation like health issues, alcohol consumption, consumption of food or cold drinks before the interview, etc. are also being included.

The data measured were afterwards compared to the mean climatic conditions of the relative city in order to confirm their quality (Fig. 1). The site monitoring included the use of a portable weather station (HOBO weather station) and all the sensors were calibrated in order to conform to ISO 7726 [23]. The portable weather station, which was put in the middle of every square, saved values of air temperature (°C), air velocity (m/s), relative humidity (%) and sun radiation (W/m^2) whereas the additional equipment that could easily be transported around in the exact

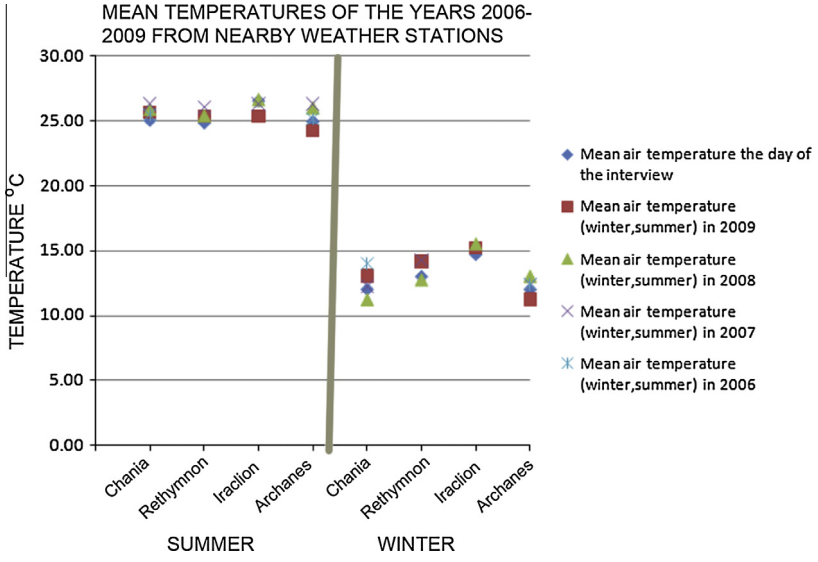

Fig. 1. Mean temperatures in the survey cities for the years 2006–2009 in relation with the temperature in the days of the survey.