Urban Forestry & Urban Greening 13 (2014) 253–260

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

Enhancing the thermal comfort on urban level in a desert area: Case study of Dubai, United Arab Emirates

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ARTICLE INFO

Keywords:
ENVI-met software
PMV index
United Arab Emirates
Urban planning

ABSTRACT

The urbanisation of deserts in Dubai is one way in which this city can expand and explore its full potential. In this piece of research, a case study of the Dubai International Academic City was used as a basis from which to study the importance of planning and orientation of projects in open, unpopulated land. It demonstrates the various alternatives for project orientation relative to the sun and wind, its effects on temperature and wind readings and consequently on outdoor thermal comfort levels. ENVI-met was used to simulate various scenarios generated from the existing base case in both summer and winter. The orientation which best promoted and allowed for higher wind flow through the project was found to record the best outdoor predicted mean vote levels, approaching a neutral state. The findings of this research may be used for setting up regulations regarding the planning of desert areas in Dubai on the basis of early assessment of designs.

Introduction

Urban outdoor spaces have implications on the people using them. Architects today strive to design outdoor corridors and urban spaces rather than having them either emerge accidentally or as a by-product of design. Outdoor spaces must be utilised to their full potential, or else the need for such spaces may be completely eliminated and they could become disregarded as a favourable space for people to use. Outdoor spaces, or "urban in-between spaces", need just as much attention and thought in their design as indoor spaces. In urbanising empty deserts and land, planners and designers have the advantage of a clean slate onto which theories of optimum outdoor thermal comfort conditions can be applied. Consideration of the physical characteristics of the site should be done at the onset of such planning. Research which combines thermal comfort studies with urban planning is lacking within the UAE. This work will therefore help to shed light on that aspect of research in the UAE.

This paper presents a case study of the Dubai International Academic City (DIAC) as an example of the urbanisation of a desert area in Dubai. Desert areas here refer to uninhabited land surrounding the edges of the city of Dubai. As the city expands, it ventures into the open desert to utilise the potential of that land for new mega projects. DIAC is a complex of university buildings and educational institutions including facilities to support the student body. The project is surrounded by open land and is about 15 km away from the edge of Dubai. This study intends to test the project from several orientations and consider the impact of such activities on outdoor thermal comfort levels. The results of the research will indicate the impact of planning decisions such as orientation and layout on the comfort of users within a "thought-out" design. Urban design decisions, especially when urbanising deserts, should utilise a more conscious process of design. Even though urbanisation may alter the microclimate, it may be altered in a way in which benefits the users of the outdoor spaces the most. Although a piece of open empty land is a good justification for uninhibited design, it is also a challenge for urban planners and architects to design it as best as possible with the best sustainability practices in mind.

Literature review

Although research on thermal comfort in indoor spaces is abundant, that related to outdoor spaces is much less prevalent due to the complexities it entails. One of the most important factors is that people tend to use indoor spaces 90% of their time as opposed to spending 10% of their time outdoors during the summer and 2–4% during winter. With very minimal time spent outdoors, it is difficult to reach a thermal steady state to get proper thermal comfort results (Hoppe, 2002). Furthermore, outdoor spaces are exposed to uncontrollable climatic variations, which make it increasingly difficult to measure and assess comfort levels. The interaction between the different climatic variables is a complex one and thus has hindered research in the area of outdoor spaces and urban areas, in

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http://dx.doi.org/10.1016/j.ufug.2014.01.003

comparison to indoor studies, where conditions are more controllable.

Thermal comfort, in its basic definition, is the human reaction to the surrounding indoor or outdoor environment. More specific definitions of this term are summarised under three different categories. The psychological definition relates to the mind's expression of satisfaction with the thermal surroundings (ASHRAE). Thermo-physiological definition is related to the biological reaction of the body and nervous system to external influences on thermal receptors on the skin. The third definition, which is more of an "energetic" definition, relates directly to the balance between heat flow to and from the human body (Schellena et al., 2012).

Although outdoor spaces can be modified using smaller design details such as shading devices, a selection of surface materials, vegetation and water bodies on the site, it is of greater importance to start off the design process with the right intentions. Such design details may be used to enhance outdoor environmental quality and therefore individual thermal comfort levels. However, finding the means for predicting the impact of changing a certain climatic parameter and its effect on levels of outdoor thermal comfort is important at the onset of the design process (Givoni et al., 2003). The manner in which the buildings are located in accordance to each other, their solar and wind orientation, configuration and specific parameters are some of the major considerations when it comes to outdoor thermal comfort (Kruger et al., 2011). Furthermore, understanding the psychological adaptation process, how people behave in outdoor areas and their impact on design considerations is yet another concern for planners and architects to take into account (Nikolopoulou et al., 2001).

There are physical characteristics of a site that contribute to thermal comfort: air temperature (Ta), mean radiant temperature (MRT), wind speed (Wv) and direction and relative humidity (RH). Additionally, other external factors contributing to thermal comfort include: clothing (insulation) and activity level (metabolism) (Gaitani et al., 2007). To calculate thermal comfort using the predicted mean vote (PMV) index, at least three out of the six criteria are those that can be used to orient and plan project during the design process. Considering solar orientation, wind direction, wind speed, and surface material selection are a means of predicting thermal comfort levels before even implementing the design.

Universal Thermal Climate Index (UTCI) was recently developed based on the most advanced multi-node model of thermoregulation (Jendritzky et al., 2012). A combination of air temperature, wind, radiation, and humidity, UTCI is defined as the isothermal air temperature of the reference condition that would elicit the same dynamic response of the physiological model is appropriate

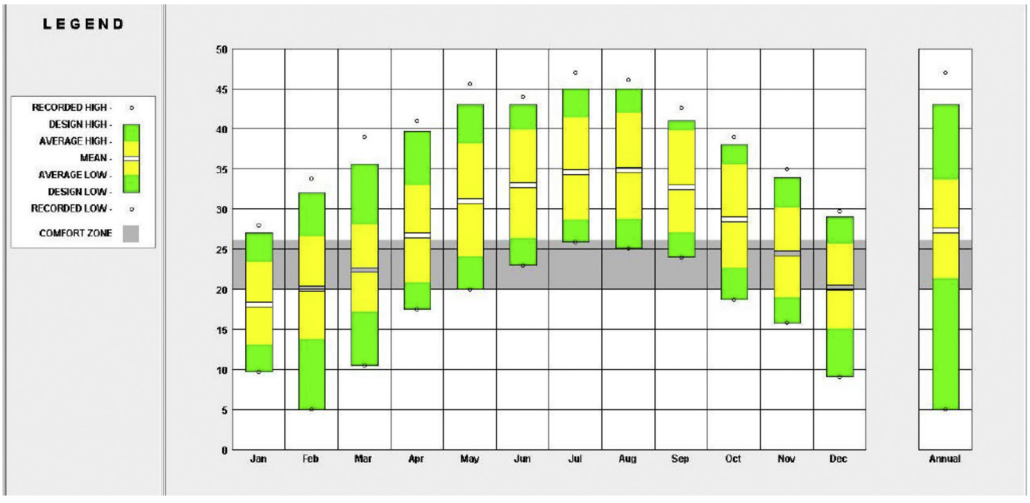

Fig. 1. Temperature ranges in Dubai.

Source: Climate Consultant Software 2012

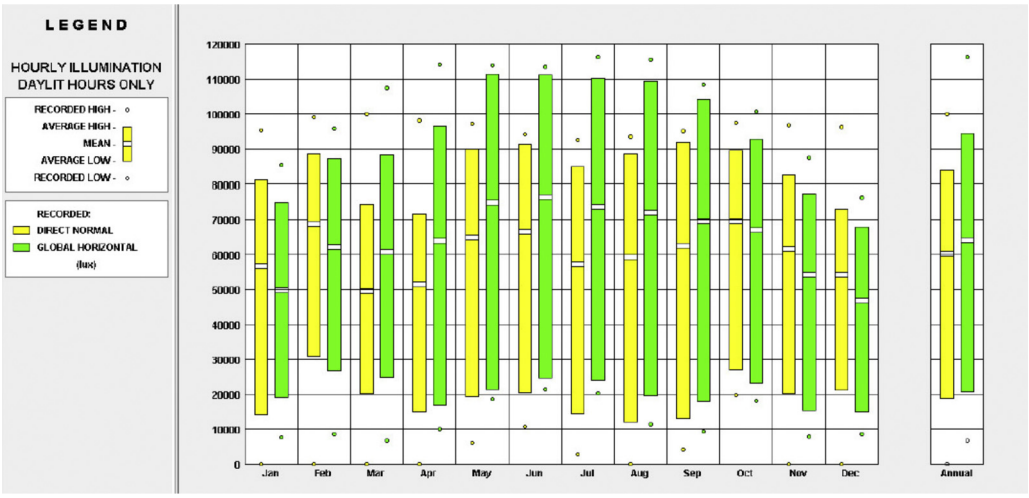

Fig. 2. Illumination ranges in Dubai.

Source: Climate Consultant Software 2012