Urban Climate xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Urban Climate

journal homepage: http://www.elsevier.com/locate/uclim

Green roofs: Experimental and analytical study of its potential for urban microclimate regulation in Mediterranean–continental climates

Susana Saiz Alcazar *, Francesca Olivieri, Javier Neila

Universidad Politécnica de Madrid, Spain
Escuela Tecnica Superior de Arquitectura, Departamento de Construcción, Spain

ARTICLE INFO

Article history:
Received 1 June 2015
Received in revised form 7 December 2015
Accepted 22 February 2016
Available online xxxx

Keywords:
Ecosystem services
Climate change
Green roofs
Microclimate
Computer Fluid Dynamics (CFD)

ABSTRACT

Green infrastructure elements such as green roofs, walls and urban forests provide multiple regulating ecosystem services to the urban environment, including storm water management, heat island effect control, esthetic values and improvement of air and water quality. However, specific regulating services on urban microclimate at street level have not been widely quantified. This article analyzes the effects of green roofs and urban forests on urban microclimate, quantifying its potential for regulating ambient temperature in hot season in Mediterranean–continental climates. The results show a moderate effect of green roofs on the surrounding microclimate, but a larger contribution when combining it with vegetation at pedestrian level. This experimental study has identified the potential of the ground moisture content for microclimate regulation leading to alternative solutions for microclimate regulation based on permeable materials used for ground coverage in urban cores in combination with shading elements. The conclusion shows the potential of the green roofs, urban forests and porous-moist materials as a strategy for adapting urban ecosystems to the effects of climate change.

1. Introduction

Climate change has moved to the header in the list of global problems in recent years. Many times refuted, the effects of climate change have already become an undeniable reality and its effects are increasing worldwide. In recent years, many organizations have arisen whose goal is to develop strategies and mechanisms to

* Corresponding author at: Paseo de Rinconete y Cortadillo 17, Portal 14, 3-A, 28906 Getafe, Madrid, Spain.
E-mail address: susana.saiz.alcazar@alumnos.upm.es (S.S. Alcazar)

http://dx.doi.org/10.1016/j.uclim.2016.02.004
2212-0955 © 2016 Published by Elsevier Inc.

control and curb the emissions that cause climate change and assess its consequences. One of them, the Intergovernmental Panel on Climate Change (IPCC), has set on place mechanisms designed to control emissions and deforestation. The IPCC calls for two types of strategies considering that the effects of climate change are non-stoppable and are already beginning to manifest globally; adaptation strategies and mitigation strategies (Halsnæs, 2007).

Within the agents involved in urban development, there is a growing interest in understanding the consequences of climate change on urban areas and the required design changes to mitigate their effects and enhance the resiliency of the cities. With forecasts showing an increase of around 1.5 million square kilometers of new urban land area by 2030 which triples the global urban land area accounted in 2000 (Seto et al., 2012). There is an urgency for a change in the design and shape of new urban developments, and call for new mechanism able to regulate these new ecosystems and keep the balance with the natural surrounding environment.

Climate change effects are even more relevant in urban cores by the effect of heat island effect, a phenomena which occurs as a result of increased sensible heat flux from the land surface to the atmosphere near cities, it is referred to city overheat that is enhanced by the massive substitution of vegetated and impermeable areas by hard surfaces and buildings (Kato, 2007). Higher urban temperatures, have a very important impact not only on human comfort, but also on electricity demand for air conditioning (Santamouris, 2001). The heat island effect reduces dramatically the microclimate regulating capacity of the urban hard surfaces that absorb heat during the day and radiate the heat overnight as infrared radiation.

Within this context, strategies based in the inclusion of vegetated elements in urban spaces have become a trend and raised huge interest at academic and urban policy level. This is majorly because of their potential not only to mitigate heat island effect, but also due to their restoration capacity and the way they enhance esthetics of urban areas (Oberndorfer et al., 2007). One of the areas with higher potential for improvement is the building roofs (Frazer, 2005) which play an important role in regulating the heat flux through buildings. The addition of vegetation and permeable soil in urban areas would be a way to reduce the detrimental effects of urbanization on local ecosystems and show how even “nonfunctioning” space can be made functional (Davis, 2005). Green roof systems are very diverse, depending on the soil media and depth. The type of green roof and the soil depth will influence deeply on the benefits provided by this nature solution, being the deeper and denser foliage solutions those with larger reported benefits. These benefits though shall be balanced with the structural requirements and cost imposed by the extra load added to the roof. Given this, the most common green roofs are “extensive roofs”, that are those systems with soil media between 5 and 20 cm soil depth, which adds between 80 to 225 kg/m^2 to the roof (saturated), allow for a wide range of shrubs and grass vegetation types and have little or no maintenance requirements.

Green roofs reduce the proportion of infrared radiation returned to the air, so that the air temperature does not overheat and help to create an adapted microclimate able to provide comfort conditions to humans. Studies, have reported that reductions in median air temperature was up to 1.06 °C lower at 300 mm over a green roof with relation to a concrete roof peaking at with 1.58 °C reductions, when Urban Heat Islands are most common (Speak et al., 2013).

They can also reduce the energy required for the maintenance of interior climates (Del Barrio, 1998; Saiz and Kennedy, 2006) because vegetation and growing plant media intercept and dissipate solar radiation. Beyond microclimate regulation and energy consumption reduction, green roofs can also regulate stormwater flows during storm events given the retention capacity of the growing media helping to regulate peak flows during storm events. Additionally vegetated roofs have proven to improve ambient noise attenuation (Dunnett and Kingsbury, 2004), fire resistance (Köhler, 2003), and increase waterproof membrane over the roof life cycle (Porsche and Köhler, 2003).

Much generic research has been conducted on green roofs and walls to evaluate the specific benefits of installing them at a building level. Specially their capacity for improving building energy efficiency (Saiz and Kennedy, 2006), stormwater management (Mentens, 2006; VanWoert, 2005) and potential for heat island effect reduction (Susca, 2011; Santamouris, 2014). These benefits have been widely investigated and reported over the last decade. However, there are few analyses dealing with the microclimate regulating capacity of green roofs and their effect at pedestrian level.

This article describes and quantifies the microclimate regulating effect provided by green roofs by modeling their surrounding microclimate. For this analysis, computational dynamic predictive simulations have been compared with monitored data to evaluate the impact of greenery on urban microclimate.

Please cite this article as: Alcazar, S.S., et al., Green roofs: Experimental and analytical study of its potential for urban microc..., Urban Climate (2016), http://dx.doi.org/10.1016/j.uclim.2016.02.004