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An investigation into minimizing urban heat island (UHI) effects: A UK perspective

Christopher O'Malley[a], Poorang A. E. Piroozfarb[b,*], Eric R. P. Farr[c], Jonathan Gates[b]

[a]*Ground Construction Ltd. One Oaks Court, Warwick Road, Borehamwood, Herts, WD6 1GS, UK*
[b]*School of Environment and Technology, University of Brighton, Cockcroft Building, Brighton, East Sussex, BN2 4GJ,UK*
[c]*NewSchool of Architecture and Design, 1249 F Street, San Diego, CA 92101, USA*

Abstract

Cities are major sources of Green House Gas (GHG) emissions and the effects of mass urbanization upon the environment have now become clear. Great opportunities exist within cities for tackling climate change. Urban Heat Island (UHI) effect is a phenomenon where significant temperature difference between inner micro-climates of a city and their neighboring micro-climates can be perceived. Mitigation of UHI effects can positively contribute to alleviate detriments of climate change. This research project aims to investigate effective and resilient UHI mitigation strategies and to provide guidance for their application in future. A review of literature indicates that UHI is a growing problem in the UK and that mitigation of such effects would enhance sustainable development at urban scale. The lack of guidance for designers and planners looking into mitigating the UHI effect is also identified. Utilizing ENVI-met simulations and through Urban Futures Assessment Method (UFAM), this research identifies and tests resilient and effective UHI mitigation strategies. Results show that building form, orientation and layout are among the most effective UHI mitigation strategies. Trees, shrubs and grass (TSG), and use of high albedo materials (HAM) in external building surfaces are also indicated as effective measures whose success is dependent on building form. All assessed mitigation strategies (TSG, HAM, UIWB) are shown to have a similar level of resilience which could be improved if properly future-proofed against subsequent changes. Accordingly some practical suggestions are provided to help improve the resilience of tested UHI mitigation strategies.

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Keywords: Mitigating Strategies; Sustainable Cities; Urban Heat Island Effect; Urban Resilience; Urban Sustainability

* *Corresponding author, Tel: +44(0)1273 642421; fax: +44(0)01273 642285*
E-mail address:a.e.piroozfar@brighton.ac.uk

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1. Introduction

The demographics of human habitat are changing towards urbanisation. Over 50% of the planet's population currently live in cities [1, 2]. The current release of Green House Gas (GHG) emissions (predominantly from cities) and increasing risks of climate change as a result of human action will decapacitate cities to respond to future generations' needs due to their deteriorating conditions. Therefore ideas about how to effectively combine urbanization and sustainability are of critical and immediate importance [3]. Concurrently the effects of mass urbanisation upon the environment have also become clear with cities contributing to 60% – 85% of the world's energy consumption [3, 4]. This is not only due to the need for heating/cooling the spaces in which we live or the need for hot water but also because the cities are the main centres of fuel intensive industries while also being the social, political and economic centres of the world [2]. Furthermore research has stated that the cities have the ability to effectively respond to issues such as climate change at a local level because the co-benefits of climate change mitigation and adaption are largest in cities [5, 6, 7].

This study aims to investigate strategies for mitigation and reduction of an Urban Heat Island (UHI) – a microclimate effect which indicates significant differences in temperature between urban adjacent areas, or between a city and its suburban areas. UHI is used as a quantitative measure to gauge and promote urban sustainability. To do so, Urban Futures Assessment Method (UFAM) will be employed to assess the resilience of UHI mitigation strategies. Resilience in this paper refers to the extent to which these UHI mitigation strategies will be able to achieve their design purpose and sustain in the face of a changing future. ENVI-met – a prognostic three-dimensional microclimate model, designed to simulate the surface-plant-air interactions in urban environment based on the fundamental laws of fluid dynamics and thermodynamics – will be deployed as tool to simulate UHI effects in the selected case for this study, a planned development in borough of west Kensington in city of London. The research is expected to be used first and foremost as a methodology and subsequently as an exemplar frame of reference for planning and design interventions for architects, urban designers, urban planners and city authorities to help them make more sustainability-aware decisions.

2. Literature review

2.1. Sustainable city

It is within the cities that lay a great opportunity for combating the climate change. Cities have an indisputable role to play in driving to, and securing of a sustainable future for humankind [8, 9, 1, 10, 6, 11]. Described a response to environmental disturbance, how habitats and ecosystems can re-organise spontaneously after a disturbance, or as vulnerability of a system to irreversible change resilience of cities and the need for cities of the future to be resilient has also been identified [12, 13, 14, 1, 15, 16] with today's sustainable strategies requiring the capability to deliver their intended benefits whatever the future may hold [17]. A sustainable city can be defined as a multifaceted complex entity with numerous interconnected networks and cycles [10].

2.2. The urban heat island (UHI) effect

The UHI effect is a phenomenon in which a significant difference in temperature can be observed between a city and its surrounding rural areas, or between different parts of a city [18, 19, 20, 21]. The areas of maximum temperature can be found within the densest part of the urban area [19]. This is commonly illustrated in Fig 1.