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Evidence-based neighborhood greening and concomitant improvement of urban heat environment in the context of a world heritage site - Malacca, Malaysia

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ABSTRACT

Malacca, located on the west coast of the central part of the Malaysian Peninsula, has been designated as a UNESCO World Heritage Site. At present, the urban heat environmental condition is feared to gradually worsen in the future. By applying a new design that modifies the heat environment by creating organically linked neighborhood green spaces, which encourage pedestrian use, will assist in efforts to conserve and improve the town as a sustainable heritage site. In this research, areas with future greening potential are first extracted based on field surveys and the results of overlaid site appraisals that, by using computer simulations, account for pedestrian thermal comfort, visibility of the historical landscape, and movement. Based on the identified and extracted areas with greening potential, three neighborhood greening scenarios are established: case 1 is based on the existing conditions, case 2 is based on following existing conservation plans, and case 3 is based on maximizing green areas by implementing the proposed pedestrian walkway. A microclimate simulation was done for each scenario and the results are compared specifically from the viewpoint of where and how much each scenario contributes to mitigating the urban heat environment, focusing on changes in physiologically equivalent temperature distribution and numerical changes. From the results, we conclude that the streetscape conservation-oriented neighborhood greening approaches proposed herein should improve the urban heat environment in such historical towns in tropical regions.

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1. Introduction

Malacca city, located on the west coast of the central part of the Malaysian peninsula, is a historical town that, after a period of colonial occupation by several countries, contains many historical buildings with multicultural influence in the inner-city townscape. The town was designated as a UNESCO World Heritage Site in 2008 and has since become one of Malaysia's most popular tourist destinations, attracting more than 12 million visitors annually from both inside and outside Malaysia in recent years (The Star online, 2016). With a mean monthly maximum temperature exceeding 32 °C, Malacca city is one of the hottest towns in the country. The district designated as historical heritage site is next to the central business district in downtown Malacca and, because of chronic traffic congestion and big commercial facilities nearby, is increasingly affected by exhaust heat from passing vehicles. Consequently, the urban heat environmental conditions are feared to gradually worsen over time (Asian Development Bank, 2014). As a result, the walking environment for pedestrians strolling around the historical area is rather unpleasant. In general, in a historical district where the townscape should be preserved, changing and improving building form or volume or street width or placement is a very difficult task. However, in the context of historical districts, the surrounding heat environment may be reasonably and effectively ameliorated by installing green spaces, which includes planting trees (Givoni, 1991; Jim, 2012; Bajsanski, Stojakovic, & Jovanovic, 2016). In its current condition, the historical area in Malacca contains few green spaces or open spaces, and those that do exist are small and widely dispersed.

Previous studies have examined the Southeast Asian region to look at how effective urban greening is to improve the heat environment, and some of these studies have focused on Malaysia and Singapore (Wong et al., 2007; Wong & Jusuf, 2008; Shahidan, Jones, Gwilliam, & Salleh, 2012; Yang, Wong, & Jusuf, 2013). However, to few fundamental findings are available and, in particular, insufficient reliable research and evidence are relevant to historical towns. In addition, the urban design studies of Malacca done to date (Amran & Rosli, 2006, Lee, Lim, & Nor'Aini, 2008) focus mainly on methods to conserve the entire

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historical district and on the value of the intangible historical and cultural aspects as one of preparatory activities for future UNESCO bids. To date, very little quantitative research has been done focusing on tangible or physical aspects such as street patterns or historical buildings as components of the heritage landscape. The overarching goal of this research project is to create a virtuous cycle in the future whereby improving the heat environment by neighborhood greening would promote pedestrian activity by local residents and tourists, thereby reducing the through traffic within and into the area, which would lead to further improvement in the heat environment and pedestrian activities, and so forth. Looking toward the future, such a virtuous cycle could contribute significantly to upgrading the town's value as a World Heritage Site.

Given this current condition, the primary aim of the present study is to develop methods for neighborhood greening, which facilitates pedestrian activity by improving both the landscape and the urban heat environment in the historical town in the hot and humid climate of Southeast Asia. Specifically, the first step of the study consists of a quantitative analysis and evaluation of the existing characteristics of the outdoor heat environment and landscape components in historical Malacca. Second, we examine the technical procedure to identify areas with future greening potential by combining the results of a multi-aspect analysis with the requirement of consistency with the existing urban conservation plans for Malacca. Finally, neighborhood greening scenarios are proposed based on the extracted areas with greening potential, and the contribution of such greening to urban cooling is objectively examined through a comparative study.

2. Methodology

As shown by the conceptual framework in Fig. 1, the analysis of the study area contains three major components that encompass (1) the outdoor microclimate from the viewpoint of pedestrian thermal comfort; (2) the urban design elements from the viewpoint of degree of linkage between each space over street network as an urban structure (connectivity), securing the pedestrian line-of-sight to historical buildings within the study area (visibility), and pedestrian movement patterns (human behavior); and (3) consistency with existing urban conservation plans. Second, the results of these analyses are integrated to semi-automatically identify areas with greening potential. By combining the extracted areas with greening potential and the existing urban conservation plans developed by local authorities, multiple neighborhood greening scenarios are proposed and implemented in the study area. Next, the cooling effects of each greening scenario are quantitatively verified. Finally, we discuss the effectiveness of the technical process for extracting areas with greening potential and the possibility of applying this proposal in similar conditions. To date, although several studies have objectively evaluated the impact of regional weather conditions or microclimate on tourism or recreation (Scott & McBoyle, 2001; Freitas, 2003), only a few have applied urban design methods and neighborhood greening by integrating an analysis of two major aspects such as microclimate and urban landscape components.

2.1. Study area

The study covered the central area of Malacca, Malaysia. The town of Malacca is located on the west coast of the Malaysian Peninsula and faces the Strait of Malacca. The town is rich in tangible and intangible remnants of diverse cultures from ancient times through the present day as a result of its long history as a colonial city occupied by different western countries (Portugal, the Netherlands, and Britain). Inherited historical buildings and streetscapes that reflect diverse cultures occupy the central area of the town, which was registered as a UNESCO World Heritage Site in 2008 (Fig. 2(a)). The designated heritage site contains two zones: the core zone (0.37 km^2) and a buffer zone (1.69 km^2) surrounding the core zone. This study narrows the study area to an area measuring 480 m × 320 m, including the Malacca River that flows through the town center for further micro-scale consideration (Fig. 2(b)). The core zone encompasses mostly so-called shophouses, which are two-to-three story structures and six-to-nine meters high, as shown in Fig. 2(c).

2.2. Analysis of neighborhood outdoor heat environment

To assess the outdoor heat environment in a three-dimensional space, we use the microclimate model ENVI-met (Bruse & Fleer, 1998; Bruse, 2016.) as a main tool in this study. The ENVI-met software is widely used to simulate microclimate environments, particularly on

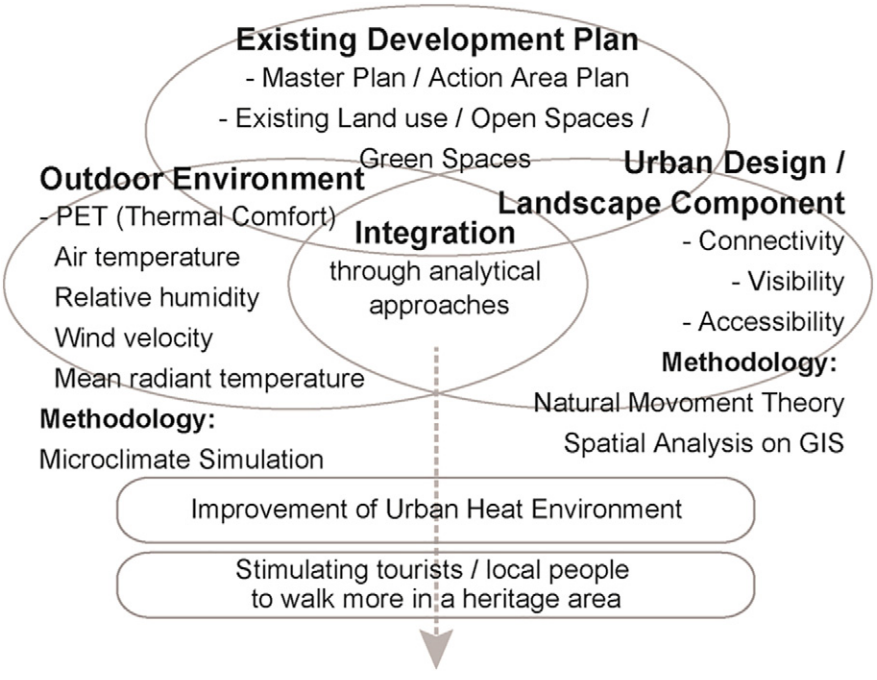

Fig. 1. Conceptual framework for evidence-based neighborhood greening.

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