Mitigating urban heat island effect through integrated climate-sensitive planning framework: a study based in Singapore

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Background

Urban heat island (UHI) is known as one of the severe environmental problems, and thus, research on UHI mitigation from the perspective of urban morphology is indispensable, especially in tropical regions like Singapore.

Objectives

While studies were carried out to evaluate and relieve UHI effect in urban areas, research that conducted through integrated assessment of urban aerodynamic and long wave radiation is limited. This research aims to provide an integrated climate-sensitive planning framework to UHI mitigation by understanding urban morphology.

Methods

A district-scale case study in Paya Lebar Air Base (PLAB) was conducted to illustrate how the urban morphological study contributes to the initial planning by an integrated analysis of climate information. Two urban morphological indices, frontal area density (FAD) and sky view factor (SVF), were calculated to depict aerodynamic and long wave radiation, i.e., pedestrian-level wind speed and air temperature, respectively.

Results

The SVF modelling results indicate that the UHI intensity at surrounding areas could be 2°C to 3°C. With future development, there is a potential risk to create a spreading and more intensive UHI. Aiming at this problem, the FAD map indicates the importance of linking open spaces to create air paths, while the ΔT map implies the necessity of separating building clusters with intensive UHI. Integrated planning strategies are then developed based on the balance between link and separation, focusing on site layout and building geometry. For site layout, open spaces, e.g., major roads, building setbacks, low-rise built areas, and green corridor, should be linked to form the potential breezeways. At the same time, buffer zones like secondary forest should be arranged between site and surrounding areas to prevent new and existing UHI clusters from merging together. As for the building geometry, as the important design parameters, building height, footprint area, and building height to width ratio (H/W) should be carefully decided. Accordingly, a multi-step workflow is developed as an integrated climate-sensitive planning framework.

Conclusions
Urban morphology makes an important contribution to UHI effect. Integrated UHI mitigations can be developed by balancing the strategies for spatial link and separation in urban planning and design, based on climate information, e.g., aerodynamics and heat. The integrated climate-sensitive planning framework is generally applicable to tropical regions with cooling needs, as the key is to minimize temperature rise due to long wave radiation while introduce cool air to the site.