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The Impact of Vegetation Arrangement on Outdoor Thermal Comfort: A Simulation Study in a Tropical Urban Public Square

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Abstract

Thermally comfortable urban squares attract people and provide various social benefits to the urbanites. Compared to urban parks, squares are more vulnerable to thermal discomfort due to surrounding buildings and the high percentage of hard surface coverage, especially in tropical climates. The spatial arrangement of green infrastructures can improve Outdoor Thermal Comfort (OTC) by reducing hot air flows, evapotranspiration, and shading to reduce the negative effect of warming urban environments. However, it is not yet adequately discovered the specific correlation of different vegetation arrangements on OTC. Still, urban policymakers are looking for new, quantitative methods to assess the performance of their designs in terms of the cooling effects provided by vegetation. Therefore, the current study investigates the effect of different vegetation arrangements on OTC in a tropical urban public square (Independence Arcade in Colombo) using micrometeorological fluid dynamics (CFD) modeling validated by field measurements. Air temperature (Ta), relative humidity (RH), wind speed (WS), and wind direction (WD) were measured at 1.5 m above ground level as the inputs for the ENVI-met simulation model to assess the cooling performance of proposed scenarios employing Physiological equivalent temperature (PET). Nine scenarios were developed using trees with high leaf area density (LAD) and spherical canopy form to compare OTC improvements of cluster, random and individual planting patterns, and the size of trees (large, medium, small). The results showed that vegetation improves the OTC levels irrespective of the planting pattern. However, linear individual planting pattern with large trees performed the best cooling performance, and scenarios were ranked according to improved PET values. Vegetation parameters are recommended to arrange in different ways to achieve OTC and aesthetics. The study was limited to the existing vegetation database of the ENVI-met software package, but further research could consider the context-specific tree species and the impact of combined landscape scenarios using grass, shrub coverage, and water bodies to find proper arrangements to improve the microclimate and OTC. This study guides urban planners and landscape architects to assess the cooling performance of the proposed designs and arrange urban vegetation to create thermally comfortable urban outdoors in the tropics.

Keywords: Vegetation arrangement, Urban square, Outdoor thermal comfort, ENVI-met, PET

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