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Topic of Research: Assessing the Impact of Urban Street Geometry on Urban Heat Island Intensity and Pedestrian Heat Stress in Composite Climate of India

Keywords: Urban Street Geometry; Urban Heat Island; Surface Thermal Properties; Built Environment; Gurugram City.

Findings

The current research makes an effort to understand the variation of UHI intensity, both spatially and temporally, in a composite climate city. It also tries to describe the contribution of urban street geometry and surface parameters (H/W aspect ratio, orientation, vegetation, and surface materials) on residential street microclimate and if that has an impact on the heat stress conditions in those streets. The focus is on design, and the goal is to deliver quantitative data that urban planners may use with ease of interpretation. Aspect ratios (the ratio of a street's height to its width), axis orientations (the direction in which the street runs), street vegetation, and surface finishes are a few of the street geometry parameters that are studied in the current research. Taking Gurugram, a satellite city of Delhi NCR, as a case study city, a field measurement study (MS) programme was designed to understand the correlation of street geometry parameters, vegetation, and surface finish materials on a residential street's microclimate. This paper uses remote sensing to investigate if Delhi's fastest-growing satellite city, Gurugram, observed any changes in air and surface temperatures over a period of time (2000–2019) when the city was changing rapidly due to urbanization. Remote sensing and ArcGIS examined temperature trends. The analysis indicated that the city's most plentiful agricultural land in 2000 declined by 60% in 2019. The urban built-up also increased by over 62% within the same time period. Gurugram's agricultural regions are rapidly declining, while urban built-up areas have quadrupled in the past two decades. The study helped gain insight into how urbanisation patterns affect the LST of a fastgrowing metropolis. Further, the study did a micro-level analysis of residential streets to ascertain how street geometry parameters, namely H/W ratio, street orientation, vegetation, and surface finishing materials, along with the Local Climate Zone (LCZ) categories, correlate with the microclimatic conditions of the residential streets. This phase of research was carried out in three field measurement programs: post-monsoon (MS I), winter (MS II), and peak summer (MS III). The microclimatic parameters were represented by ambient air temperature and relative humidity. For the study periods, data loggers were installed to xxiv record hourly temperature and relative humidity. According to the study, the UHI intensity ranged from 4.5 C for post-monsoon to 5.3 C for winters and 7.8 C for the hottest month of the year. It was concluded that street orientations and H/W ratios are the most significant parameters that manipulate the microclimate of these residential streets. The study also investigated the role of the surface finish materials of these streets using a thermal imaging camera. The exercise explained that the same material, when exposed to the sun, shows a much higher surface temperature in comparison to shaded surfaces. In some cases, compact planning caused the buildings to shade each other, or the street vegetation was shading the building façade. For open streets, the building facades and roads were exposed to sun irradiance due to limited shading by vegetation since the road width was large. This added to the study's value by demonstrating that, in addition to initial urban design and planning regulations, the choice of surface materials, if included in building codes, can also have a direct impact on surface temperatures. Finally, to understand the pedestrian heat stress conditions on these sample streets, the discomfort index was calculated for each sample site for the post-monsoon and summer seasons. Contrary to general opinion, even the post-monsoon period had a few days of severe heat stress. The study also validated the initial findings that street orientation is a significant factor to correlate with microclimatic conditions since the street with an E-W orientation was the most stressed street for both the summer and post-monsoon seasons. An outdoor thermal comfort survey of the resident and user populations of these streets was done to understand the socio-cultural value of these streets and user perceptions regarding microclimate. Methodologically, the field study proved to be a useful tool to understand the interrelationship of microclimatic parameters and heat stress conditions prevalent yearround in the composite climate city of Gurugram. Urban planners and designers can easily adjust street orientations and H/W ratios in the initial stages of planning residential sectors to create thermally comfortable outdoor spaces and mitigate UHI. Furthermore, vegetation and surface materials can be powerful tools for significantly lowering local temperatures. These can also be easily incorporated in building bylaws and street design planning norms. Thus, through the field study, it could be established that urban planning via urban geometry parameters is an effective mitigation technique to fight heat stress conditions and support heat-appropriate planning.