Assessment of diurnal urban heat island (UHI) intensity in microclimatic urban environment using Local climate zone classification approach -AGU23 Fall Meeting

Ashish Mishra[1] and Dhyan Singh Arya[1]

[1]Affiliation not available

December 27, 2023

Abstract

Urban Heat Island (UHI) effects have significant implications on the microclimatic conditions in urban environments, impacting human health, energy consumption, and overall urban planning. This study aims to assess the diurnal intensity of UHI in a microclimatic urban setting by adopting the Local Climate Zone (LCZ) classification approach. We utilized a combination of remote sensing data, ground-based measurements, and LCZ classification to analyze the temporal and spatial variation of UHI intensity throughout the day and night. The study area, Dehradun city, a densely populated urban area situated in the valley region of Himalayas, exhibited diverse LCZs, including compact low-rise, dense trees, and open spaces. Using satellite-derived land surface temperature (LST) data and hourly in-situ measurements, we quantified the UHI effect during daytime and nighttime hours. The results revealed distinct diurnal patterns of UHI intensity among different LCZs, with peak intensity occurring during late afternoon and early evening hours. Furthermore, we investigated the impact of vegetation and built-up characteristics on UHI variation, highlighting the cooling effect of green spaces and the amplifying effect of impervious surfaces. This research contributes to a better understanding of microclimatic urban environments and their relation to UHI dynamics, providing valuable insights for urban planners, policymakers, and researchers aiming to mitigate heat-related issues and promote sustainable urban development. The findings underscore the importance of considering local land-use patterns and urban morphology when assessing and managing UHI effects.

Assessment of diurnal urban heat island (UHI) intensity in microclimatic urban environment using Local climate zone classification approach

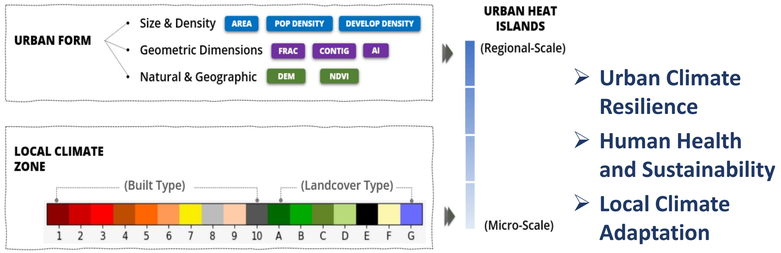
Session Number : GC33G-1225 **Abstract ID:** 1375839

Ashish Mishra*, Dhyan S Arya, Department of Hydrology , Indian Institute of Technology Roorkee, India

ABSTRACT

- Adoption of Local Climate Zone (LCZ) classification to study UHI in a microclimatic urban setting, focusing on Dehradun city's diverse urban landscape.
- Combined use of remote sensing data and ground-based measurements to evaluate the temporal and spatial variations of UHI intensity, both during day and night.
- Discovery of distinct diurnal patterns in UHI intensity, with peak occurrences in the late afternoon and early evening across different LCZs.

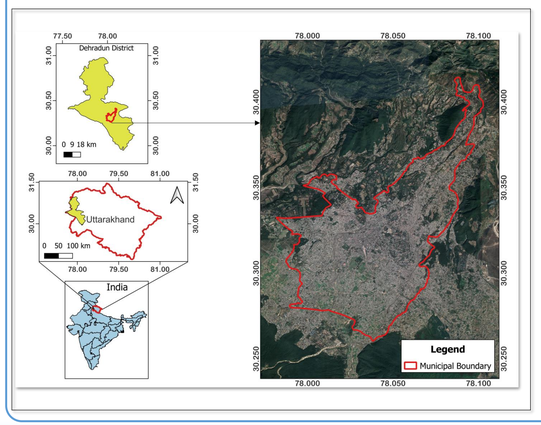
MOTIVATION



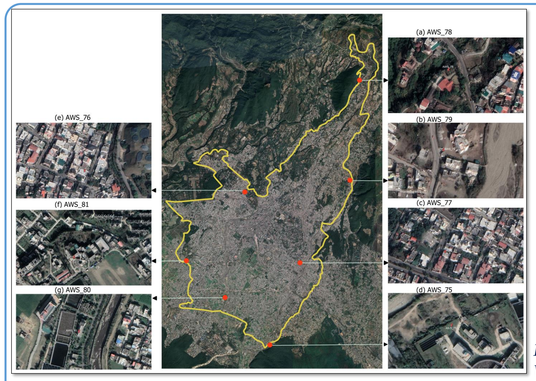
- **Urban Climate Resilience**
- **Human Health and Sustainability**
- **Local Climate Adaptation**

Source: Kang S et.al. (2022)

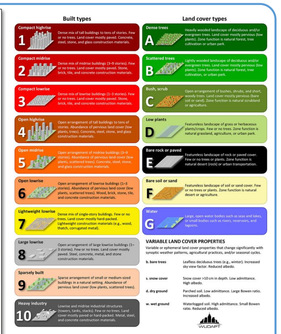
STUDY AREA AND METHODOLOGY



- The municipal region of the city, covering an area of approximately 74 sq. km.
- Average annual temperature of 20.5 °C
- Warm and temperate climate
- Period of Analysis March 2020 to November 2022.



Weather Station information in Dehradun city



LCZ Classification Scheme WUDAPT (Stewart & Oke, 2012)

Height of Instrument: 2 m

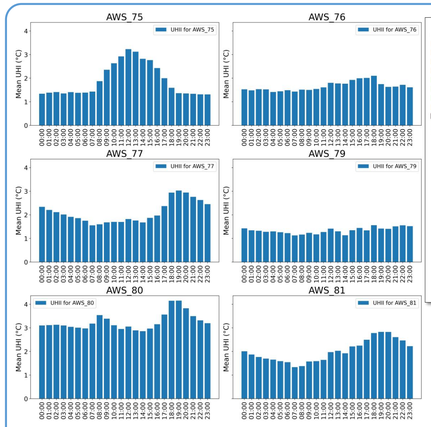
Location : Flat ground (A, D) and Building rooftop (B,C)

Data: Sub-hourly interval (15 min)- **Temperature, Relative Humidity, Wind Speed, Wind Direction, Rainfall, Dew Point, Solar Radiation**

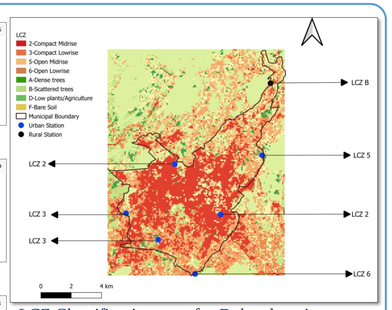
$$UHI\ \text{Intensity}\ (°C) = T_{urban} - T_{rural}$$

KEY FINDINGS

- Identification of diverse LCZs in Dehradun, including compact low-rise, mid-rise areas, dense trees, and open spaces.
- Discovery of distinct diurnal UHI patterns with peak intensities during late afternoon and early evening.
- Notable impact of vegetation and built-up areas on UHI variation – cooling effect of green spaces and amplifying effect of impervious surfaces.
- The rural station AWS_78 was used to compute the UHI intensity for all urban stations. The mean UHI intensity by hour of the day was plotted for all station.
- AWS 75, AWS 77, and AWS 80 exhibit a pronounced diurnal pattern with higher UHI intensity during the late afternoon and early evening hours, typically peaking between 1500 to 2000 hours.



Diurnal variation in UHI across weather stations



LCZ Classification map for Dehradun city

- AWS 76 and AWS 79 show a more uniform distribution of UHI intensity throughout the day, with no significant peaks indicating a less pronounced diurnal UHI effect.

CONCLUSIONS

- Compact urban areas exhibit more stable UHI intensities, while open low-rise zones show greater diurnal variation.
- The intensity of UHI peaks in areas with lower-rise buildings, suggesting a significant impact of urban morphology on UHI.
- The variation of UHI across LCZs highlights the critical role of built form in urban thermal dynamics.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the Indian Institute of Technology Roorkee, India for funding and resources, the AGU for the Student Travel Grant , and the Department of Science and Technology (DST-SERB), Government of India for the International Travel Grant (ITS/2023/005179), enabling attendance at the AGU Fall Meeting 2023.

CONTACT INFORMATION

Ashish Mishra

Dhyan S Arya