Urban Heat Island & Thermal Comfort Research in Chennai, India

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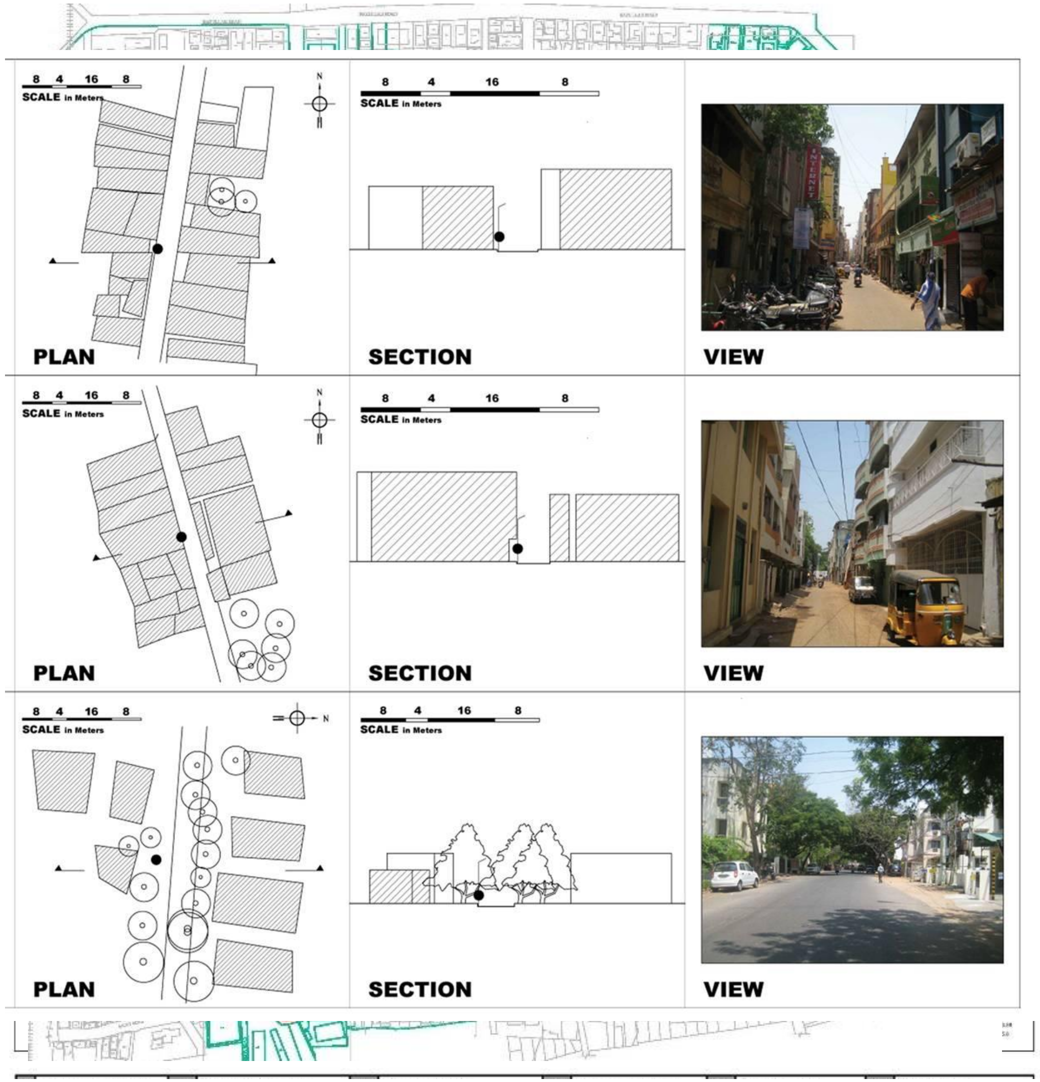


MESO SCALE: Boundary layer – City level :

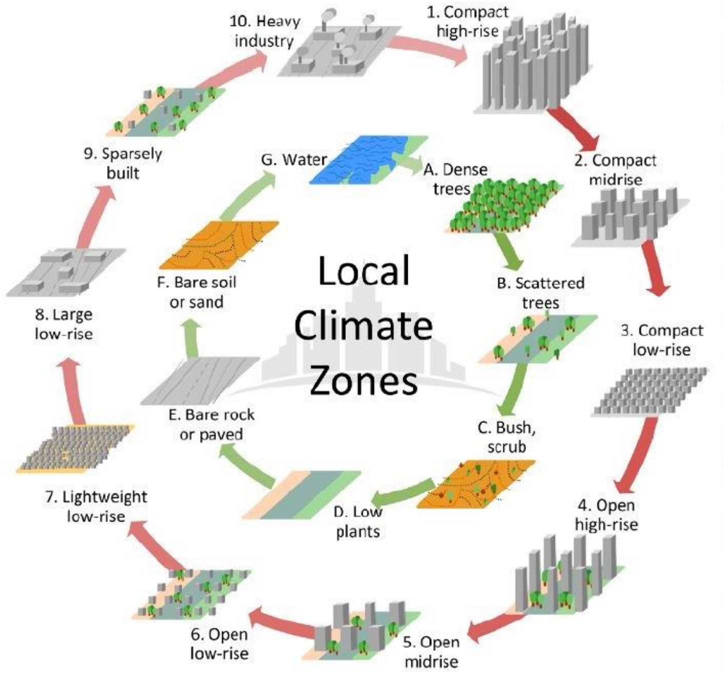
- Climate and comfort trends using **historical data from meteorological stations (City & Rural)** in CMA.
- Urbanization and thermal comfort trends in CMA by **comparing typical climate (before urbanization) and recent climate (during rapid urbanization)**
- Assessment of **SUHI** in Chennai through **remote satellite imagery** (1991, 2000, 2006) and **CLUHI** through **fixed and traverse measurements** (2008, 2017) and their correlation with land use and land cover pattern.

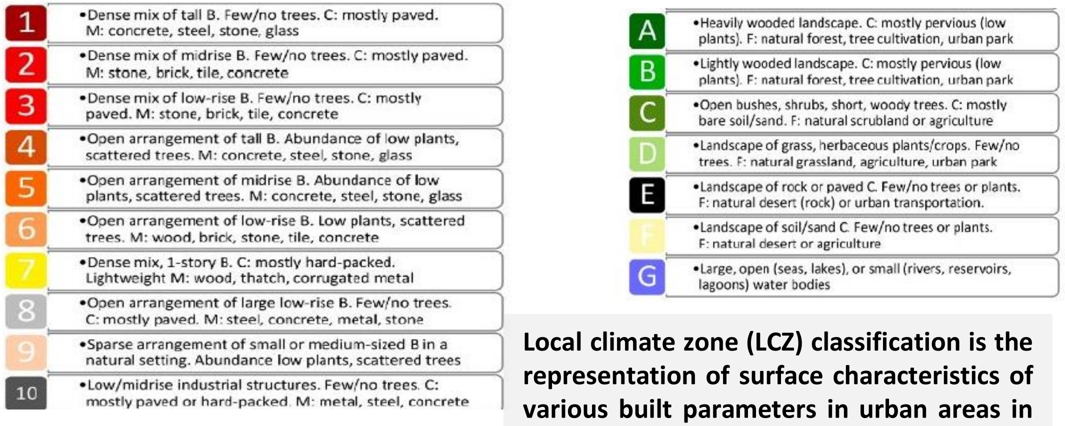
LOCAL SCALE: Roughness layer – Neighbourhood level :

- **Impact of building regulations on outdoor comfort conditions** at neighbourhood level using **local climate zone (LCZ) based approach** (fixed measurements (2018) and Envi-Met Simulations)
- **Open Spaces and Built Form Metrics**: Identification and Implementation of Strategies **to Mitigate UHI** in Tropical Climates

MICRO SCALE: Canopy layer – Street level :

- Analysis of the **impact of urban built form on air temperatures** and outdoor comfort conditions at street level through fixed measurements (2008, 2018) and Envi-Met Simulations





Local climate zone (LCZ) classification is the representation of surface characteristics of various built parameters in urban areas in the UHI study, classified by Stewart and Oke (2012)

Impact of building regulations on outdoor comfort conditions using local climate zone (LCZ) based approach

Aim: To assess the **severity of the heat island** at neighbourhood level in Chennai, and its **relationship with the changing urban built form and outdoor thermal comfort.**

Objectives:

- To **identify the parameters of urban built form** and understand their **impacts on local climate zone and heat island intensity**.
- To **analyze the impact of existing urban form,** (consequence of development control regulations with amendments up to 2013) and their contribution towards formation of heat pockets
- To **evaluate the impact of resultant-built form** of Tamil Nadu Combined Development and Building Rules 2019 and alternate scenarios on local climate and outdoor thermal comfort indices
- To **develop urban planning guidelines at city level and optimized built form recommendations at neighbourhood level** that can improve thermal performance of outdoor spaces specific to the context.

Developing a Standard Urban Heat Island Effect Mapping Methodology

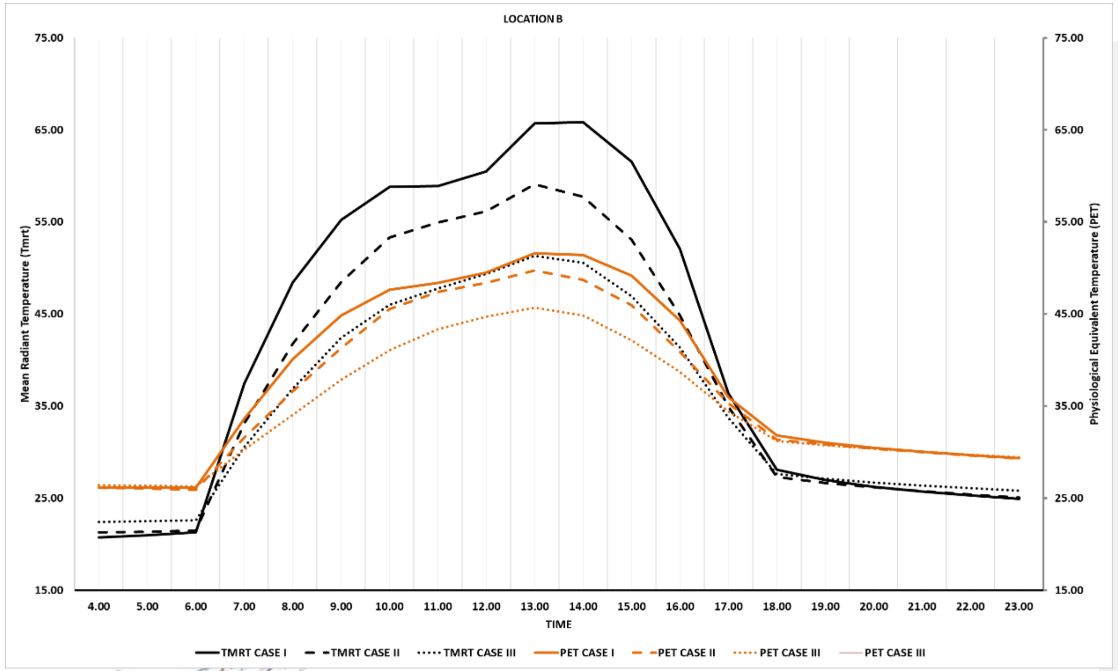
STEP	DISCRIPTION	DATA COLLECTION	TOOLS
1	Physical Survey of the three identified locations and modified as per 2019 building rules.	Plot by plot survey was done and the detailed development plan (DDP) published by Chennai Metropolitan Development Authority (CMDA) was used as reference map to record building height and plot coverage	**Physical Survey and preparation of scaled drawings using AutoCAD software**
2	Onsite survey and Field Measurements	Air Temperature and Relative Humidity	**HOBO data loggers (HOBO U23 Temp/RH)**
3	Estimation of thermal comfort indices using Simulation for locations.	Computation of mean radiant temperature (Tmrt) and Physiological equivalent temperature (PET)	**operating range of -40° to 70°C and accuracy of ±0.21°C**
4	Study on the influence of urban built form on air temperature and outdoor thermal comfort conditions at the micro scale level to establish the impact of the proposed Tamil Nadu Combined Development and Building Rules, 2019 on outdoor comfort	Analysis of the spatial distribution of Mean radiant temperature (Tmrt) and Physiological equivalent temperature (PET).	**ENVI-met (version v.4.4.4)**

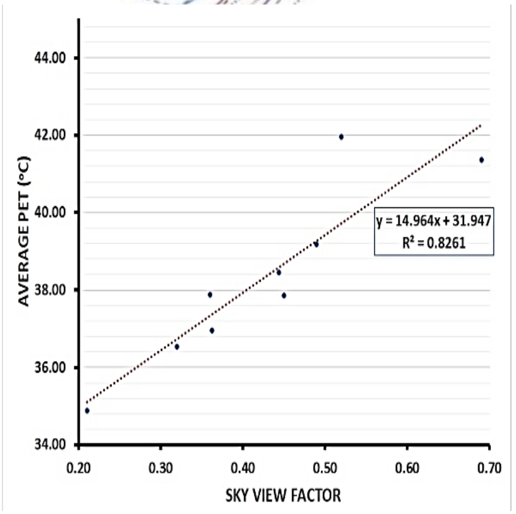
Assessing the impact of development regulations using Local climate zone (LCZ) approach that enables to evaluate he contribution of various combinations of built parameters in mitigating the UHI.

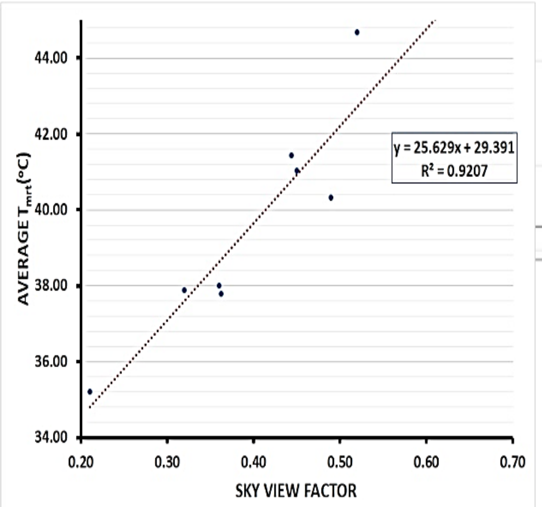
Methodology

- Thyagaraya Nagar - **a mixed residential neighbourhood of 3 km², ** in Chennai was selected for the analysis of DR variations and its impact on UHI.
- **Three locations A B and C** in the neighbourhood with Local Climate Zone (LCZ) classifications (Stewart and Oke, 2012) as **LCZ5 (open mid rise), LCZ3 (compact low rise) and LCZ6 (open low rise) respectively were analysed**.
- The urban built form of the three locations A B and C were analysed for three different variations (Case-I to Case-III)
  - i. **Case-I,** the existing built form which is the resultant of the **Development regulations with amendments incorporated up to 2013** were analysed
  - ii. **Case-II**, the proposed built form as per the TNCDBR 2019 were analysed, in which the plot coverage was arrived by utilizing **the maximum permissible height and FSI,** while considering the existing amount of on-site vegetation cover.
  - iii. **Case-III** is a slight modification of Case-II, in which **50 percent of the building setbacks were considered as vegetation with trees** planted at 6m to 9m intervals.
- Tmrt & PET were computed for 30th May 2018 through Envi-met simulations using using the Nungambakkam meteorological data and the **simulated data were validated with the measured data** in in Case-I.
- Further, the thermal comfort indices were simulated for case-II and case-III to analyse the **impact of varying development regulations on the outdoor thermal comfort conditions** to arrive at appropriate built geometry that **mitigates UHI.**

Developing a Standard Urban Heat Island Effect Mapping Methodology

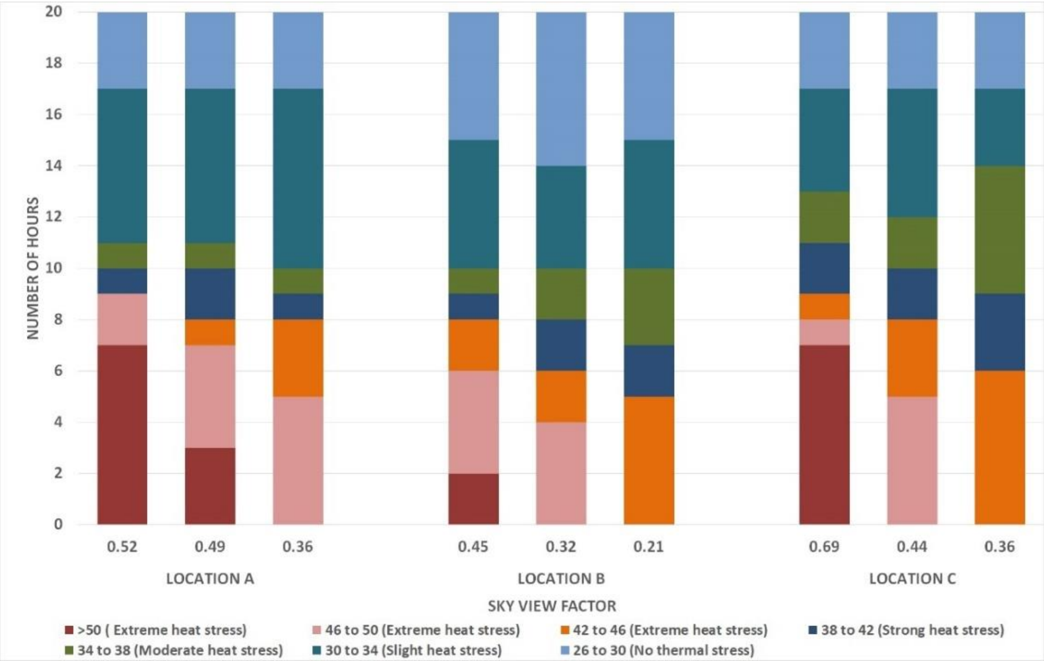






Scientific Outcomes

- Built form parameters such as **density, orientation, building heights, aspect ratio (street geometry), vegetation, percentage of green cover, sky view factor, floor space index, plot coverage** etc., at neighbourhood level have been identified to impact the Canyon Layer UHI.
- The **built characteristics** in Case-II & III have **changed the LCZ classifications** of location B & C to LCZ2 (compact mid rise) and LCZ5(open mid rise) respectively..
  i. Case II **reduced the plot coverage with increased building heioght and open space** within each plot.
  ii. Case III **increased permeable surface fraction and green cover** to enhance outdoor thermal comfort.
- The difference in air temperatures between the three cases is significant during the daytime (in the presence of solar radiation) when compared to night., indicating that **the impact of built form variations on air temperatures are minimum in the night but are significant during day influencing the outdoor thermal comfort at the canyon level.**
- The addition in building height created **deeper asymmetrical canyons with higher accessibility to direct sunlight** and resulted **in high Tmrt in case II.**
- **Increase in pervious ground cover and tree canopy** in case III, **reduced the PET significantly,** which in turn improved the comfort conditions outdoors by considerably reducing the **duration of high thermal stress during the day**.



The **duration of Extreme heat stress** (>50°C) has been **reduced** in all locations and a minimum of two to three hours has been added to the **moderate** to **no thermal stress** sensation from the strong and extreme heat stress

Challenges to be addressed:

- Context specific **LCZ sub classification** of cities
- Assessment **of inter LCZ temperature variations** for identification of critical LCZs
- deployment of instruments for **in situ measurements**
- **Simultaneous measurements** to enable comparison for longer durations
- Location of **reference meteorological stations** in the study area
- **Software constraint** in simulating larger neighbourhoods.
- Accuracy of assessments of **future scenarios in regulations** as the plot coverage, building height and FSI varies based on provision of premium FSI with payment of additional fees.
- **Conversion of Setbacks** with pervious fraction depends on the individuals decision.
- **Air pollution & anthropogenic heat**

Recommendations for improving outdoor thermal comfort at the neighbourhood level:

... of direct radiation into the street canyons.

... on of individual plot by mandatory conversion of **50 percent of the setbacks with landscape areas and canopy trees.**

Thus, **LCZ based approach can be effective in formulating urban design guideline that would reduce UHI and increase outdoor thermal comfort.**

Thank You

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