National Symposium on

Understanding the science of heat waves under the warming scenario and challenges ahead

Heat Action Plan and related challenges for the Indian cities

organised by
Indian Meteorological Society,
Pune Chapter (IMSP)

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EXTREME HEAT IMPACTS:

AGRICULTURE
HEALTH
ENERGY REQUIREMENTS
ECONOMY
PRODUCTIVITY
FOOD SECURITY
MIGRATION
BIODIVERSITY
WATER ......

RURAL

URBAN

WHAT IS URBAN

CONCENTRATION OF POPULATION

ENGINES OF GROWTH

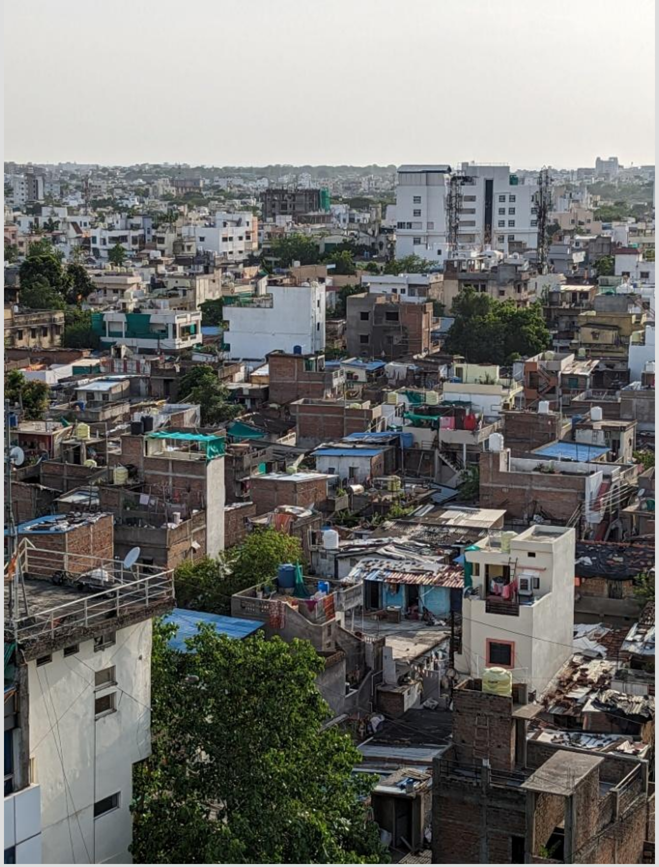
RAPID URBANISATION

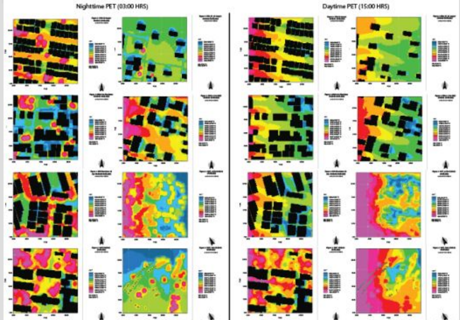
PART OF A PROBLEM AND SOLUTION

DEFICIT IN URBAN SCIENCE READY FOR IMPLEMENTATION

National Symposium on Science of Heat waves by IMS Pune Chapter

Rajashree Kotharkar, Professor, Department of Arch and Plng. VNIT, Nagpur





HEAT ACTION PLAN

NAGPUR: A CASE STUDY

MITIGATION MEASURES

CONCLUDING REMARKS

Heatwaves and Health: Guidance on Warning-System Development

World Health Organization Europe

UNEP DTU PARTNERSHIP

Heat and health in the WHO European Region: updated evidence for effective prevention

Progress in heat management

1995 First HHWS in Philadelphia, USA

1996 Heat watch–warning systems in Washington, USA

2001 WMO chose Rome as a pilot city for HHWS implementation

2002 HHWS in Shanghai, Toronto & 12 cities in USA + HAP in Netherlands

2004 HHWS in Switzerland & HAP in Italy

2006 HHWS operational in 16 European countries

2007 Euro-HEAT project

2008 Guidance on Heat-Health Action Plans (HHAPs) WHO Europe

2009 HHWS operational in 28 European countries

2010 First HW plan in Australia for Victoria

2015 Heat-health Plans in New Zealand + Heatwaves and Health: Guidance on Warning-System Development, WMO & WHO

2016 India-first ever HW national guidelines + Queensland HW response plan

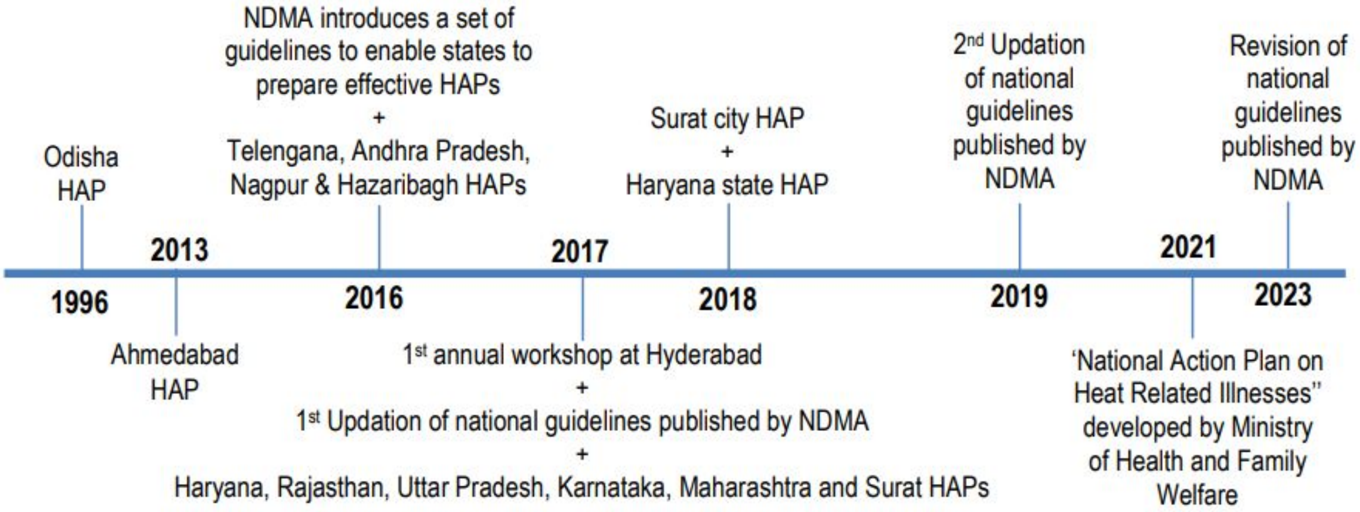
2017 Karachi HW management Plan

2020 HEAT-SHIELD project

2021 Updating the WHO & WMO guidelines on HHAP

Source: R. Kotharkar, A. Ghosh, Progress in extreme heat management and warning systems: A systematic review of heat-health action plans (1995–2020), Sustainable Cities and Society, 76 (2021) 103487, https://doi.org/10.1016/ j.scs.2021.103487.

Progress in heat management: India


1996: Odisha HAP

2013: Ahmedabad HAP

2016: NDMA introduces a set of guidelines to enable states to prepare effective HAPs + Telengana, Andhra Pradesh, Nagpur & Hazaribagh HAPs

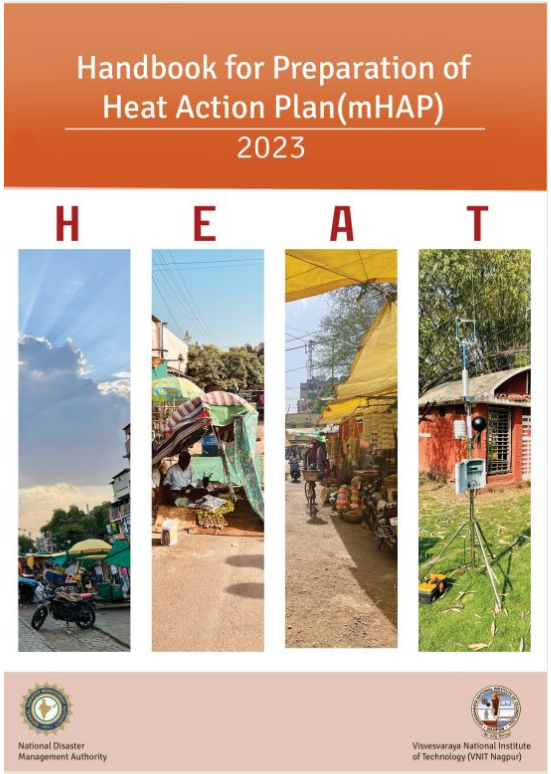
2017: 1st annual workshop at Hyderabad + 1st Updation of national guidelines published by NDMA + Haryana, Rajasthan, Uttar Pradesh, Karnataka, Maharashtra and Surat HAPs

2018: Surat city HAP + Haryana state HAP

2019: 2nd Updation of national guidelines published by NDMA

2021: 'National Action Plan on Heat Related Illnesses" developed by Ministry of Health and Family Welfare

2023: Revision of national guidelines published by NDMA


Handbook for Preparation of Heat Action Plan(mHAP)
2023

H E A T

National Disaster Management Authority

Visvesvaraya National Institute of Technology (VNIT Nagpur)

2019: Chapter on Built Environment was added to the guidelines

Principles for HHAP

Use existing systems and link to general emergency response arrangements: It essentially means that existing infrastructure and policies should be linked with HAP.

Adopt a long-term approach

Be broad: multidisciplinary and shouldn't be peripheral.

Communicate effectively:

Ensure that responses to heat-waves do not exacerbate the problem of climate change:

Evaluate:

Heatwaves and Health: Guidance on Warning-System Development, WMO & WHO, 2015

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04

Heat Action Plans: Concerns

Crisis oriented Public Health Centric approach

Scale and complexity of the city doesn’t get reflected in the HAP design

Lack of proper Heat Wave Definition of Heat Wave: Intensity / Duration / Frequency / Local Threshold

Non-standardised Approach to Heat Vulnerability Mapping

No Periodic Monitoring and Evaluation of HHAPs

Though UHI exacerbates the impact of Heat Waves in cities, there is very little effort to consider UHI while formulating HAPs.

Lack of Integration of HHAPs with National Planning Policies and Development Plans

Neglecting role of Water Resource Management to heat management

Lack of trained / skilled manpower

Lack of forecasting and modelling the impacts

Framework for management and planning of extreme heat.

Guide for the ULB to prepare heat action plan

Holistic

Multi-sectoral and multidisciplinary

Multiple thumb rules and collection of strategies

The various objectives of this mHAP are listed below:

To reduce extreme heat induced human mortality and morbidity

To improve the microclimate of the city without increasing emissions.

To integrate water and heat planning with the city planning for long term measures.

To work towards heat resilient cities.

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- WHAT
- WHERE
- WHEN
- HOW

- SHORT TERM 1-3
- MEDIUM TERM 3-7
- LONG TERM 5-10

- Meteorology
- Epidemiology
- Public Health
- Urban Planning

SHORT TERM MEASURES: PUBLIC HEALTH

To prepare the city to tackle extreme heat during the summer season, reduce death and morbidity due to extreme heat

Effective heat- health warning systems

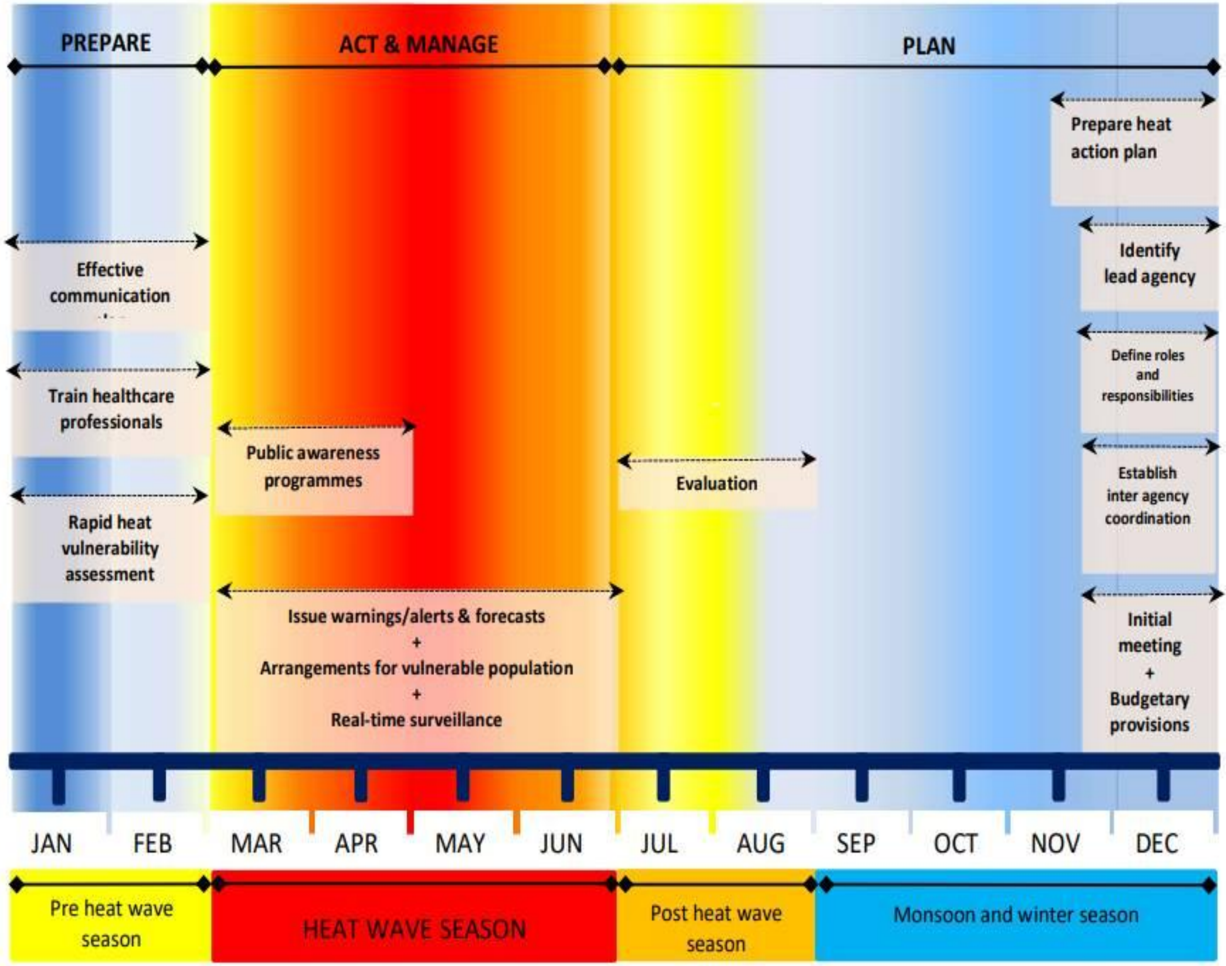
Effective communication plan

Rapid heat vulnerability assessment and identification of vulnerable population

Preparing health infrastructure for possible eventualities.

Quick response to extreme heat crisis.

TIMELINE



MEDIUM TERM MEASURES: Hyper local / Retrofitting / Vegetation

Local threshold based HHWS with **hyper local** implementation **to improve HHWS.**

Improving **heat risk perception** for the success of HAP's.

Providing hyper local information for effective communication plan.

Detailed heat vulnerability and risk assessment to help reduce vulnerability.

To **retrofit the buildings** to reduce indoor overheating.

Integrate the city level plans and policies like **urban greening policy, health plan and mobility plan** with HAPS's.

To map the heat vulnerability, identify factors affecting vulnerability and take measures, i.e. structural and non-structural, accordingly to reduce the heat vulnerability of different administrative areas in the city.

To identify meteorological parameters/indices those affect the mortality / morbidity and develop local thresholds, monitor these thresholds at the hyper-local level and issue warnings at the hyper-local level.

Start mitigation measures at the building and area level; structural as well as non-structural.

To integrate various city level plans and policies for the development cooler cities.
To integrate water and heat initiatives at the city planning level.

To identify possible heat related problems at the city level by monitoring and forecasting (long term forecast) the urban climate of the city.
To predict possible climate change related problems for the cities through climate modelling.

To identify possible future threats to human health due to extreme heat and prepare a plan to negotiate with it.
To build capacity in the governance structure to deal with the complexity of the issue

LONG TERM MEASURES

Public Health and Epidemiology:
To identify possible **future threats to human health due to extreme heat** and prepare a plan to negotiate with it.

Meteorology Department:
To identify heat related problems at the city level by **monitoring and forecasting** (long term forecast) the urban climate (**climate change related problems for the cities through climate modelling).**

Urban Planning:
To **develop cooler cities** by integrating various city level plans and policies.
To **integrate water and heat** initiatives at the city planning level.
To focus on **resilient critical infrastructure**

Heat Health Warning System:

Local Threshold

Heat Vulnerability and Risk Assessment Mapping

Effective Communication Plan

Long Term Measures:

Spatial Framework

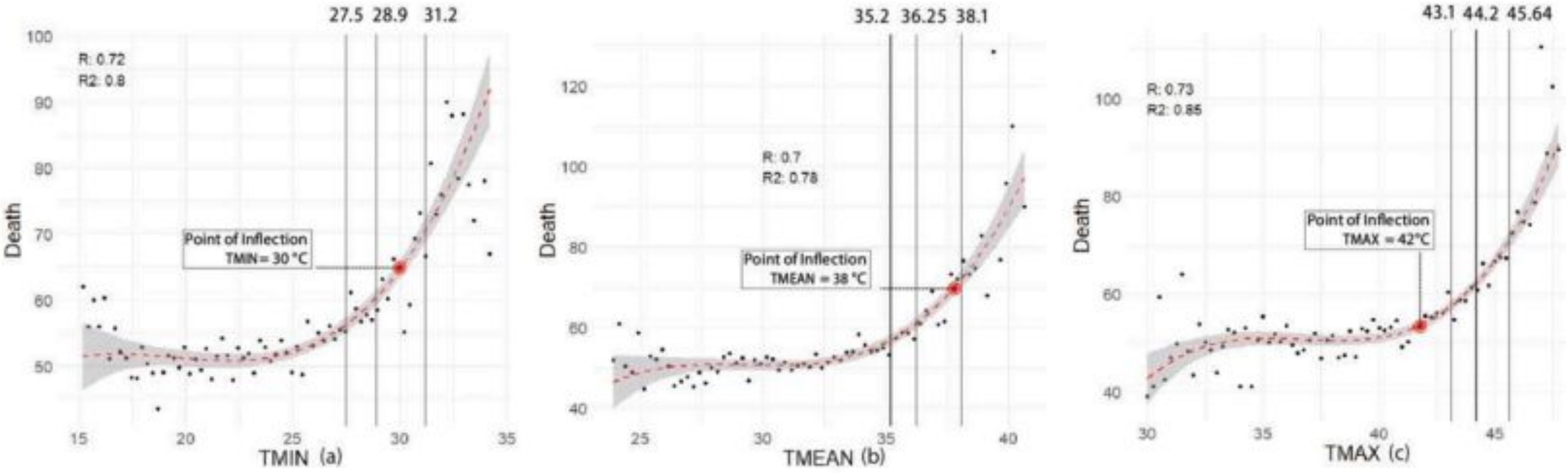
Urban heat Island Studies

Role of Urban Form

Reducing the indoor heat exposure

Heat and Health concerns
Forecasting modelling at the climate urban scale

	Min Temp	Max Temp	Mean Temp
Point of deflection	30 deg cel	42 deg cel	38 deg cel



IMPORTANCE OF LOCAL THRESHOLD

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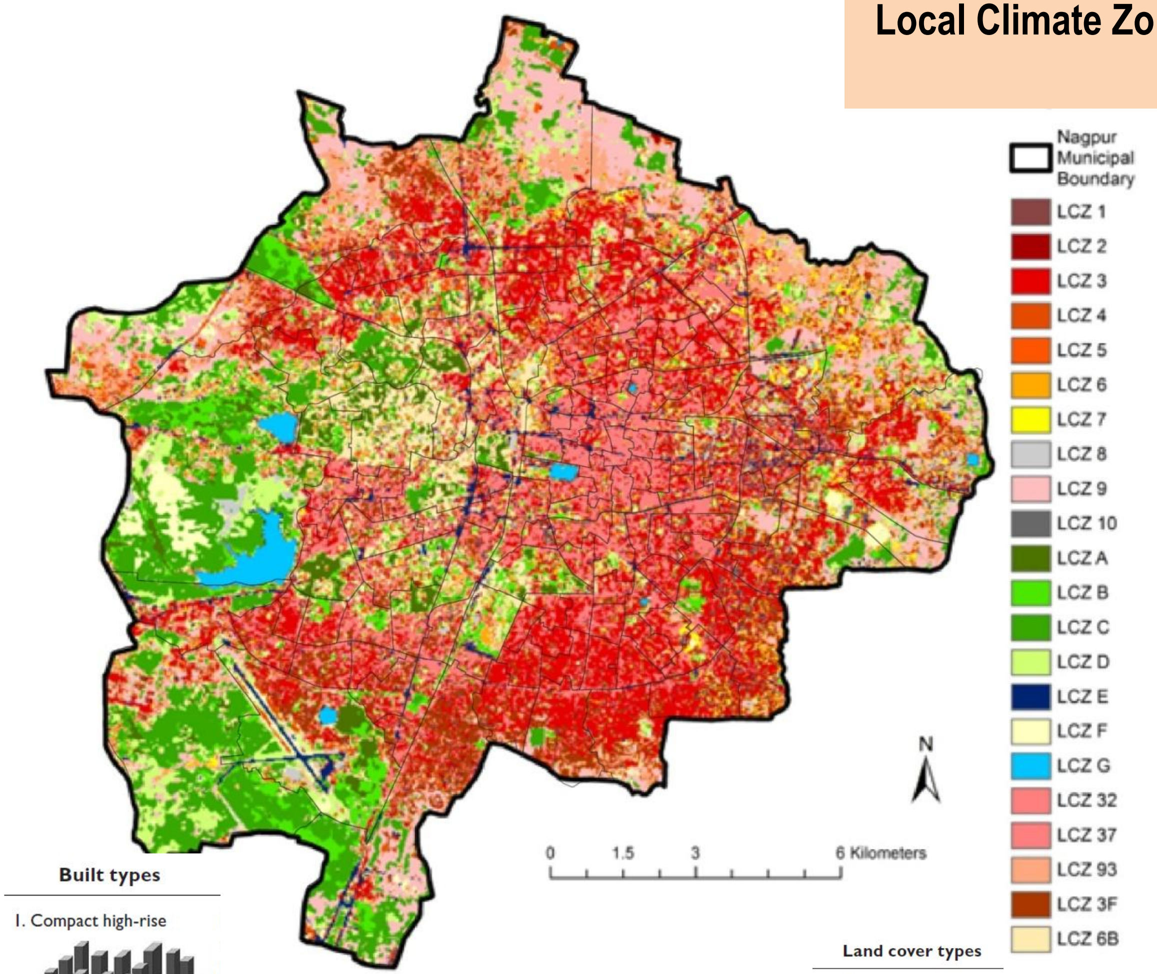
Local Climate Zone Classification of Nagpur City



Sky view Factor

Aspect Ratio

Surface albedo

Building surface fraction

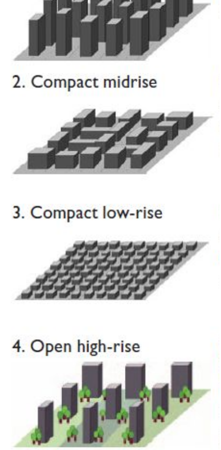
Impervious surface fraction

Pervious surface fraction

Anthropogenic heat output

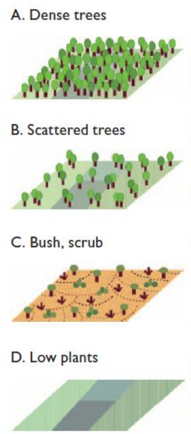
Vegetation Fraction

Roughness



BUILT TYPE

NATURAL TYPE



1 - Compact High-rise
2 - Compact Mid-rise
3 - Compact Low-rise
4 - Open High-rise
5 - Open Mid-rise
6 - Open Low-rise
7 - Lightwieght
8 - Large Low-rise
9 - Sparsely Built

A - Dense Trees
B - Scattered Trees
C - Bush, Scrubs
D - Low Plants
E - Bare Rock or Paved
F - Bare Soil or Sand
G - Water
3_7 - LCZ 7 in 3
7_3 - LCZ 3 in 7

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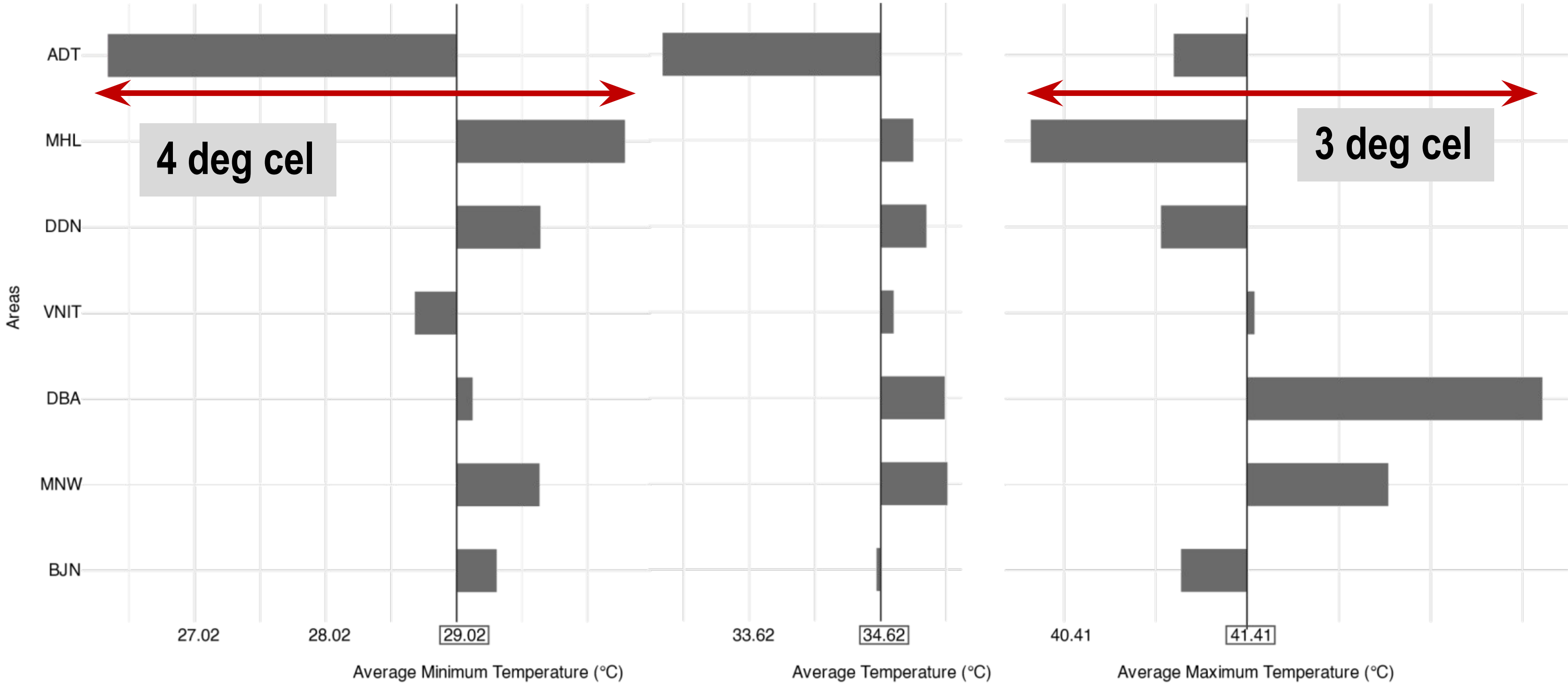
Summer time temperature variation across LCZs 2022



Nocturnal UHI

VEG ++

BUILT UP +++

Daytime UHI

BUILT UP ++

Sparse BUILT UP

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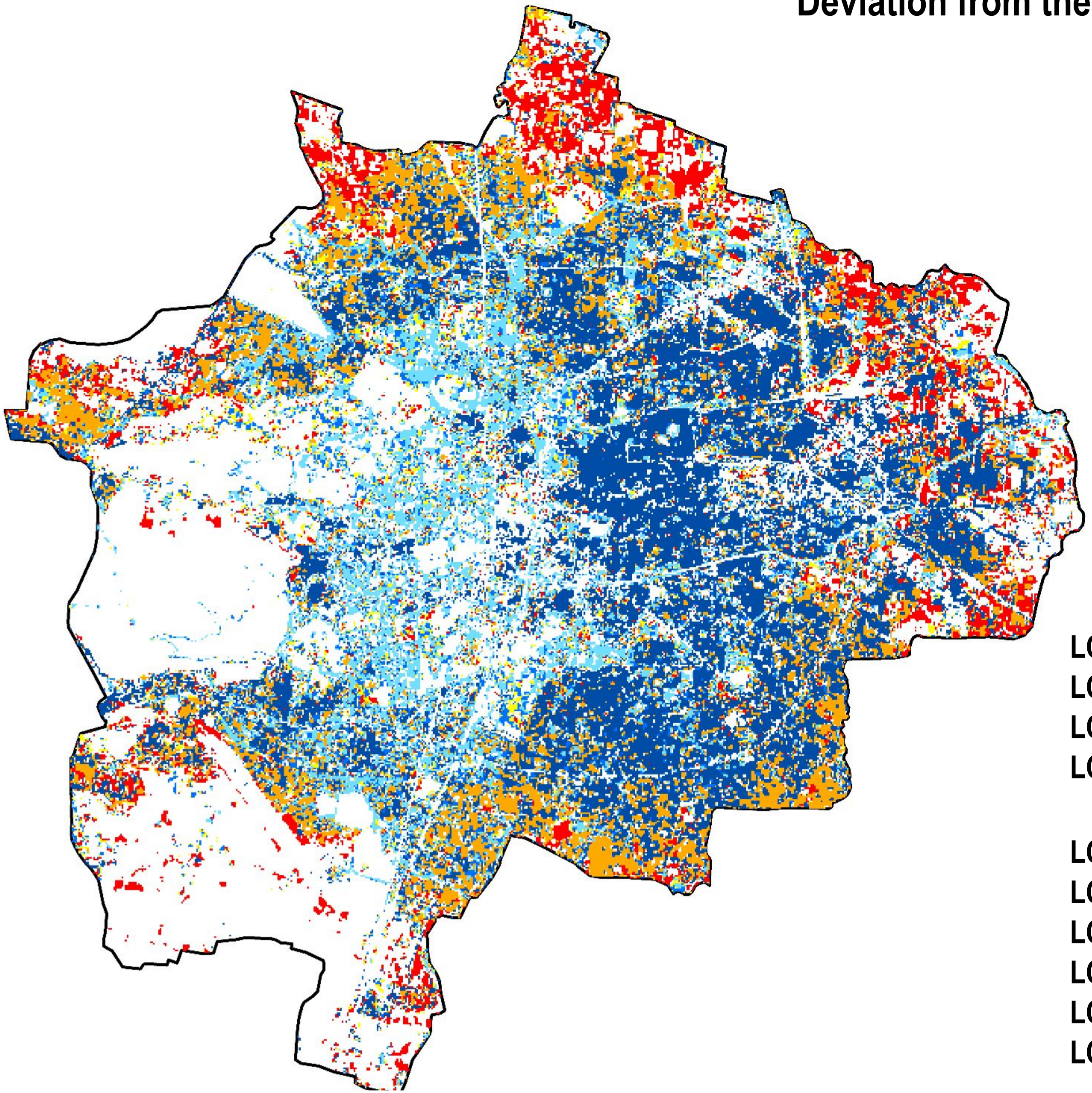
Deviation from the Group Mean



LCZ	Daytime
LCZ 6	+0.1
LCZ 9	+1.9
LCZ 93	+1.6

LCZ	Daytime
LCZ 3 +37	-1.2
LCZ 3F	-0.4
LCZ 5	-0.3
LCZ 65	-0.3
LCZ 6B	-0.4

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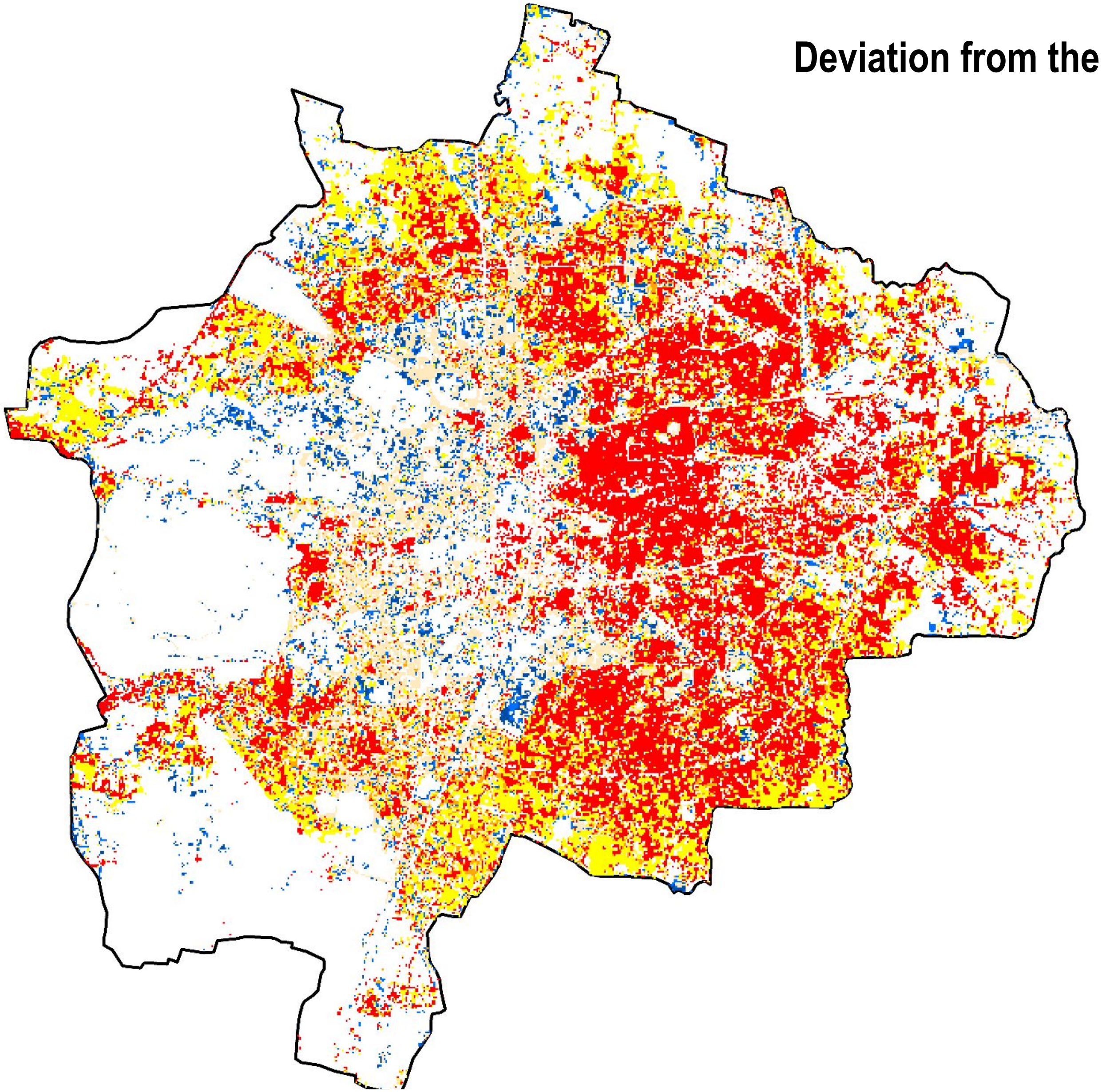
Deviation from the Group Mean



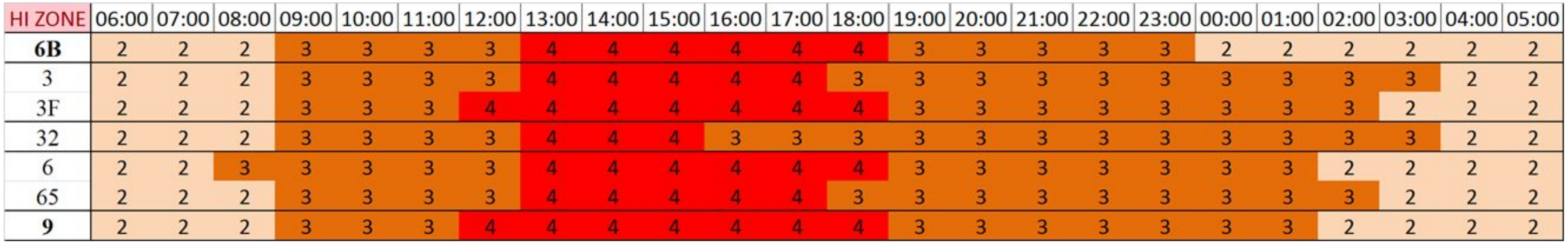
LCZ	Nighttime
LCZ 6	-0.3
LCZ 6B	-2.75

LCZ	Nighttime
LCZ 3 +37	+1.25
LCZ 3F	+0.75
LCZ 5	+0.3
LCZ 65	+0.3
LCZ 9	+0.5
LCZ 93	+0.6

Summer time heat stress variation across LCZs

TYPICAL HEAT-WAVE EXPOSURE PERIOD IN A DAY

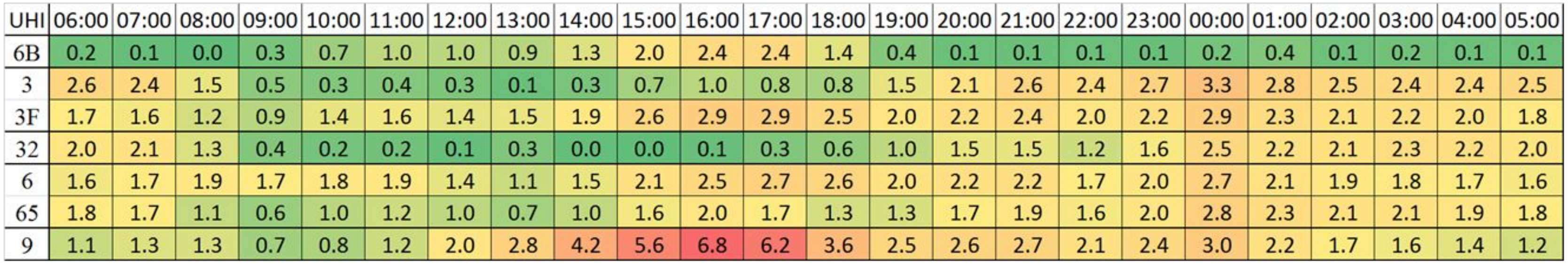
Heat Index Zones for LCZs



HI ZONE	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	00:00	01:00	02:00	03:00	04:00	05:00
6B	2	2	2	3	3	3	3	4	4	4	4	4	4	3	3	3	3	3	2	2	2	2	2	2
3	2	2	2	3	3	3	3	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3	2	2
3F	2	2	2	3	3	3	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	2	2
32	2	2	2	3	3	3	3	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	2	2
6	2	2	3	3	3	3	3	4	4	4	4	4	4	3	3	3	3	3	3	3	2	2	2	2
65	2	2	2	3	3	3	3	4	4	4	4	4	3	3	3	3	3	3	3	3	3	2	2	2
9	2	2	2	3	3	3	4	4	4	4	4	4	4	3	3	3	3	3	3	3	2	2	2	2

During Heat waves, City spends,
22.14% of time in Zone IV (Danger),
53.91% of time in Zone III (Extreme Caution)
23.94 % of time in Zone II of HI (Caution).

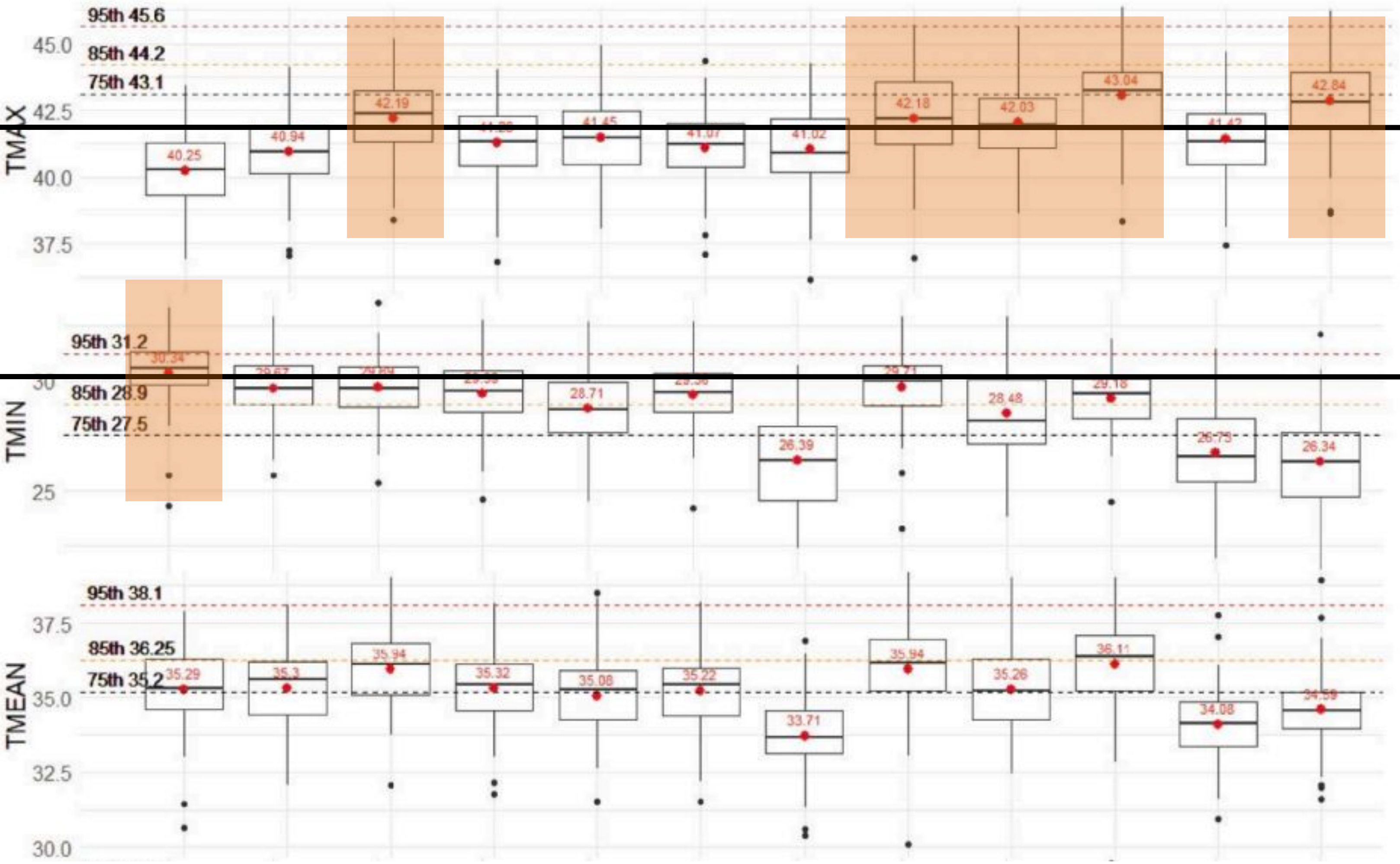
LCZ 9 covers 36.3 % of the exposure in caution zone.
More than a quarter of period is spent within the zone of danger (26.79%).
During this time, UHI reaches average maximum to 6.8 ºC.
More than 60% of the danger zone period covers the UHI range from 4-10.33 ºC in LCZ 9.
Therefore, LCZ 9 may be termed as the most critical LCZ amongst all.



UHI	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	00:00	01:00	02:00	03:00	04:00	05:00
6B	0.2	0.1	0.0	0.3	0.7	1.0	1.0	0.9	1.3	2.0	2.4	2.4	1.4	0.4	0.1	0.1	0.1	0.1	0.2	0.4	0.1	0.2	0.1	0.1
3	2.6	2.4	1.5	0.5	0.3	0.4	0.3	0.1	0.3	0.7	1.0	0.8	0.8	1.5	2.1	2.6	2.4	2.7	3.3	2.8	2.5	2.4	2.4	2.5
3F	1.7	1.6	1.2	0.9	1.4	1.6	1.4	1.5	1.9	2.6	2.9	2.9	2.5	2.0	2.2	2.4	2.0	2.2	2.9	2.3	2.1	2.2	2.0	1.8
32	2.0	2.1	1.3	0.4	0.2	0.2	0.1	0.3	0.0	0.0	0.1	0.3	0.6	1.0	1.5	1.5	1.2	1.6	2.5	2.2	2.1	2.3	2.2	2.0
6	1.6	1.7	1.9	1.7	1.8	1.9	1.4	1.1	1.5	2.1	2.5	2.7	2.6	2.0	2.2	2.2	1.7	2.0	2.7	2.1	1.9	1.8	1.7	1.6
65	1.8	1.7	1.1	0.6	1.0	1.2	1.0	0.7	1.0	1.6	2.0	1.7	1.3	1.3	1.7	1.9	1.6	2.0	2.8	2.3	2.1	2.1	1.9	1.8
9	1.1	1.3	1.3	0.7	0.8	1.2	2.0	2.8	4.2	5.6	6.8	6.2	3.6	2.5	2.6	2.7	2.1	2.4	3.0	2.2	1.7	1.6	1.4	1.2

UHI exposure over LCZs

	Min Temp	Max Temp	Mean Temp
Point of deflection	30 deg cel	42 deg cel	38 deg cel



LCZs - 9, 9(3), 3F, 8 (during day); 3 (during night)

RELEVANCE OF HYPER-LOCAL

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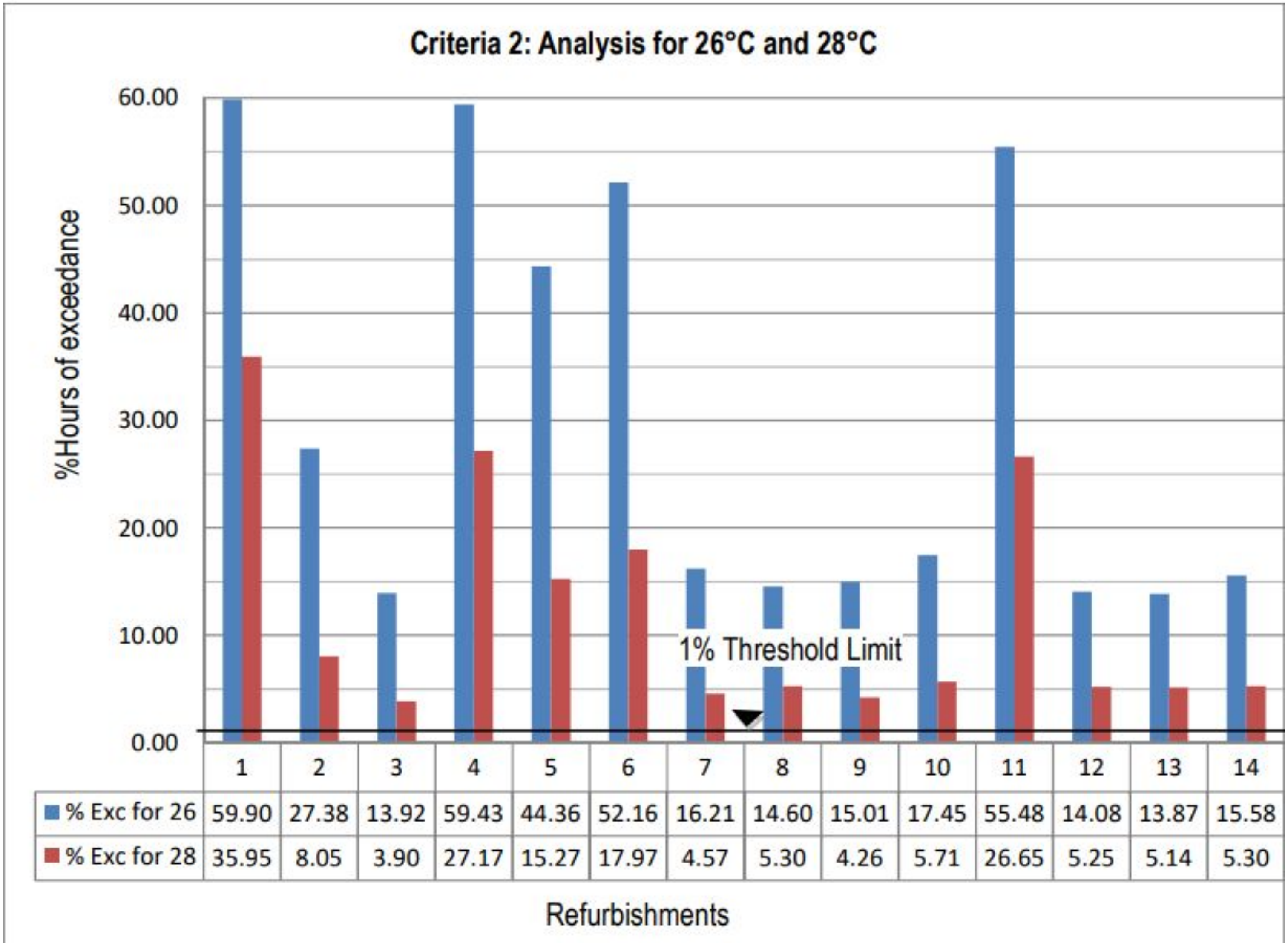
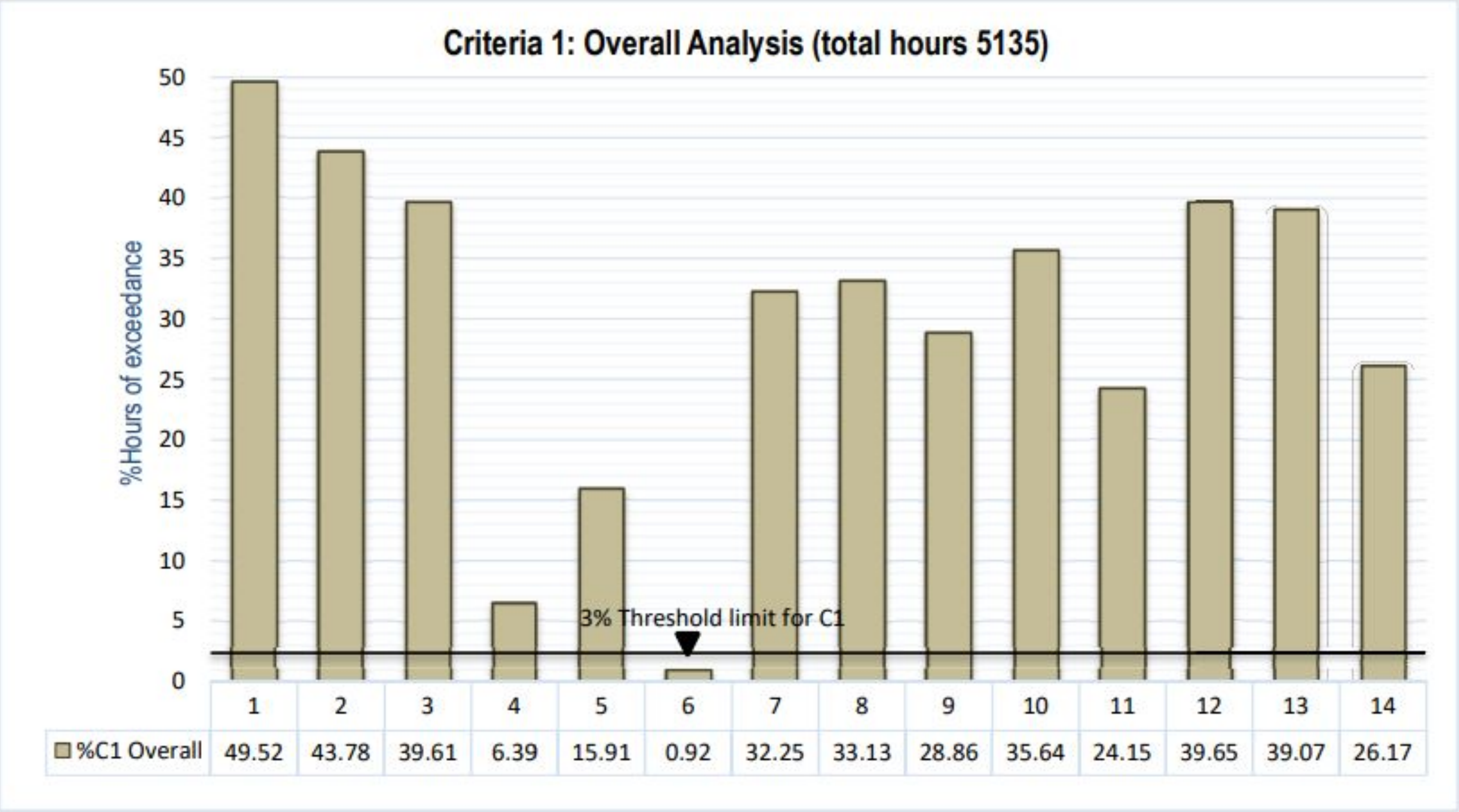
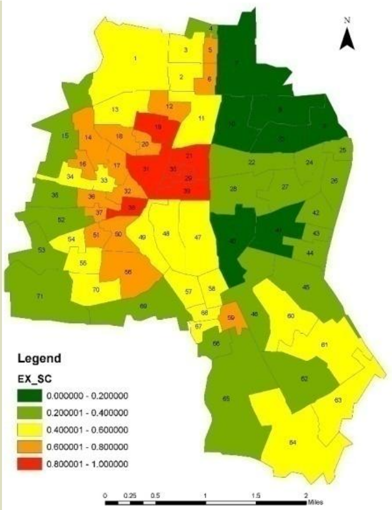


	1	2	3	4	5	6	7	8	9	10	11	12	13	14
🟦 % Exc for 26	59.90	27.38	13.92	59.43	44.36	52.16	16.21	14.60	15.01	17.45	55.48	14.08	13.87	15.58
🟥 % Exc for 28	35.95	8.05	3.90	27.17	15.27	17.97	4.57	5.30	4.26	5.71	26.65	5.25	5.14	5.30

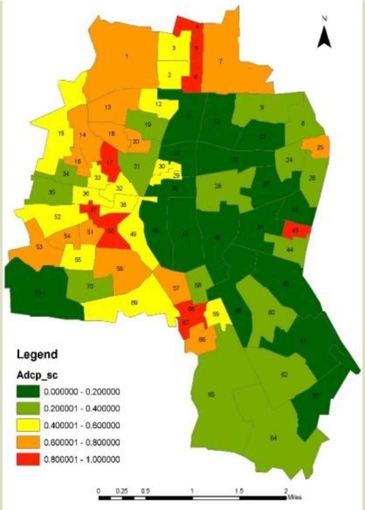
Percentage of occupied hours during which ∆T = Top – Tmax greater than or equal to 1 °C, Tmax is maximum acceptable temperature (threshold)
Acceptable percentage is 3%.



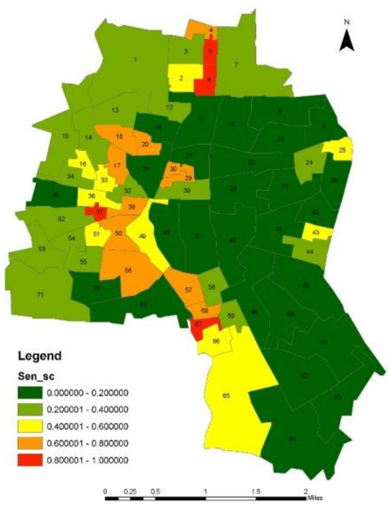
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
▨ %C1 Overall	49.52	43.78	39.61	6.39	15.91	0.92	32.25	33.13	28.86	35.64	24.15	39.65	39.07	26.17



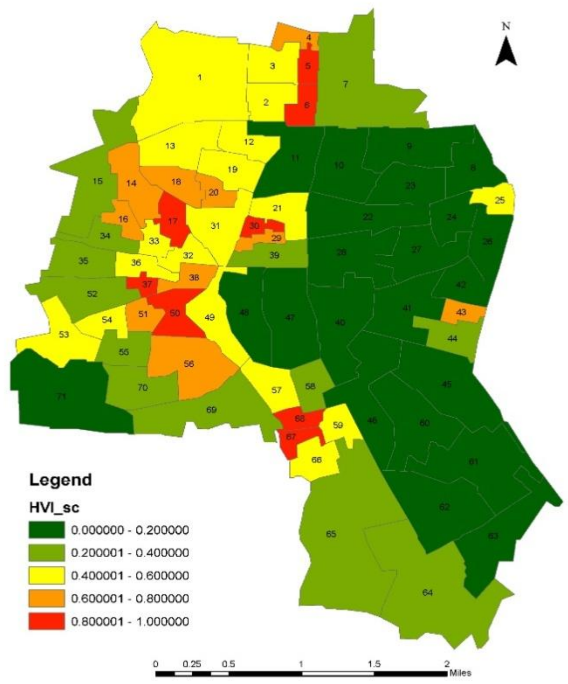
Exposure Index



Sensitivity Index



Adaptive Capacity Index



HEAT VULNERABILITY INDEX

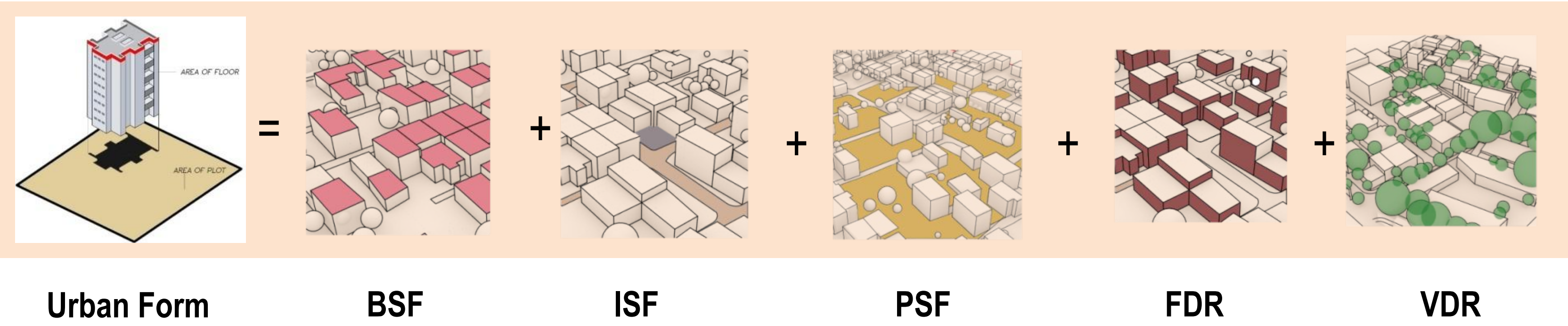
HEAT HAZARD CAN BE ADDED TO MAP RISK.

URBAN FORM & URBAN HEAT

This study concluded that morphological parameters like BSF, PSF, VDR. FDR, AR and SVF are the dominant parameters affecting night-time air temperature and HI.

	0h	1h	2h	3h	4h	5h	6h	7h	19h	20h	21h	22h	23h
BSF	0.49	0.56	0.62	0.66	0.67	0.69	0.62	0.26	0.09	0.21	0.31	0.37	0.44
ISF	0.1	0.12	0.12	0.1	0.1	0.08	0.05	0	0.08	0.09	0.08	0.08	0.1
PSF	0.44	0.49	0.53	0.53	0.56	0.55	0.49	0.17	0.11	0.21	0.28	0.34	0.38
VDR	0.85	0.83	0.79	0.79	0.77	0.76	0.79	0.74	0.56	0.74	0.83	0.85	0.86
FDR	0.56	0.62	0.67	0.71	0.74	0.72	0.67	0.26	0.11	0.26	0.37	0.45	0.5
AR	0.51	0.59	0.64	0.68	0.72	0.72	0.68	0.3	0.06	0.19	0.31	0.39	0.45
SVF	0.76	0.85	0.9	0.9	0.92	0.92	0.88	0.24	0.04	0.01	0.2	0.45	0.61
PD	0.34	0.36	0.4	0.42	0.44	0.48	0.49	0.42	0.14	0.22	0.28	0.3	0.3
DI	0.03	0.05	0.08	0.1	0.13	0.14	0.12	0.01	0.14	0.04	0	0	0.01
AL	0.49	0.55	0.61	0.61	0.62	0.62	0.53	0.18	0.17	0.29	0.36	0.4	0.44

Air temperature (Coefficient of determination -hourly analysis)



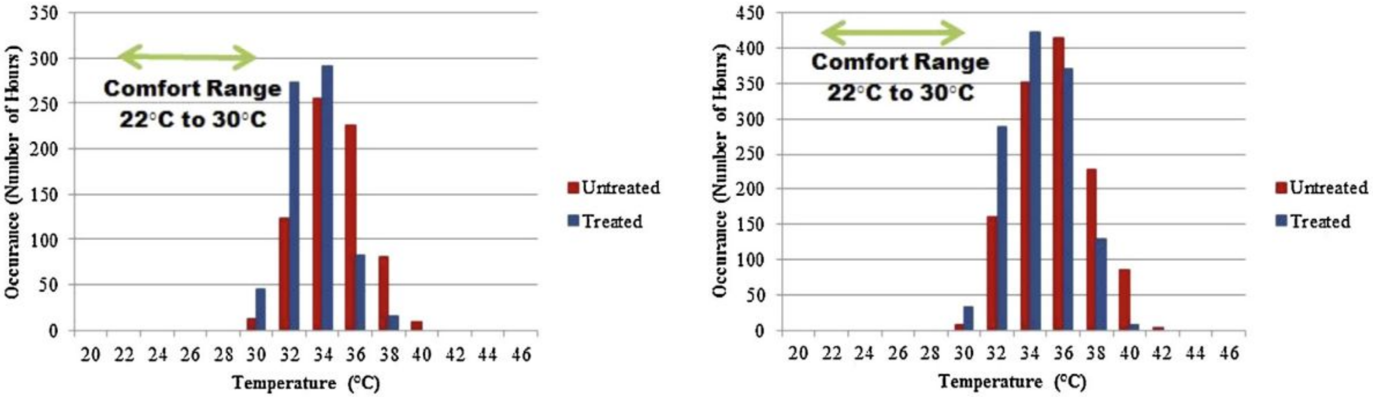
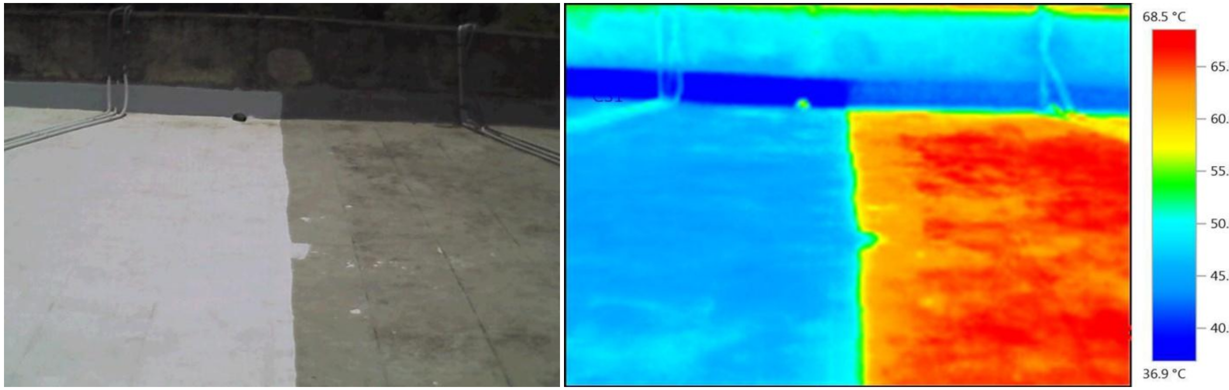


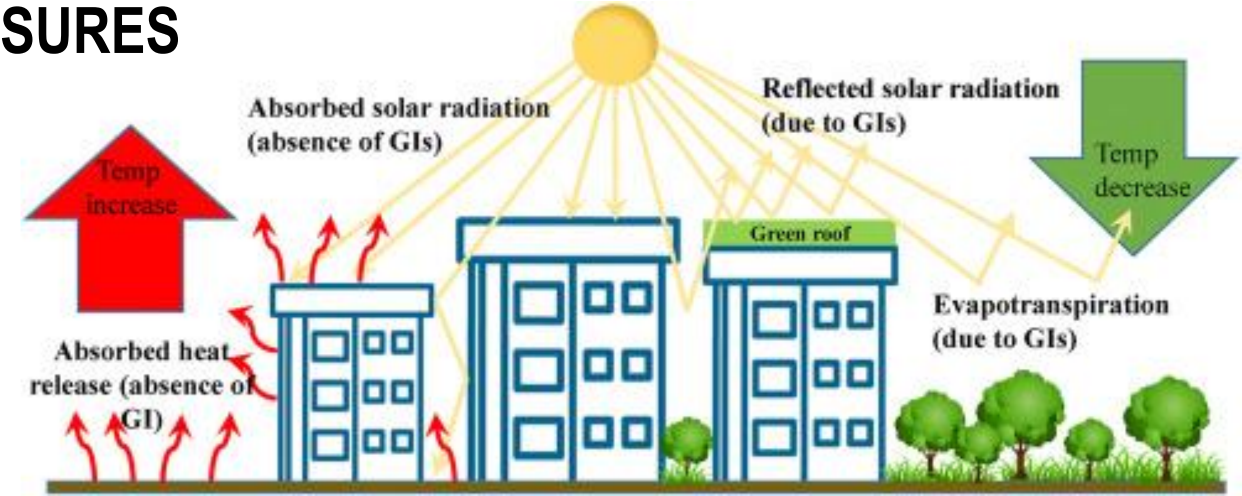
Fig. 10. Histogram of indoor air temperatures for treated and untreated rooms in VNHM School for the month of April (left) and May (right).

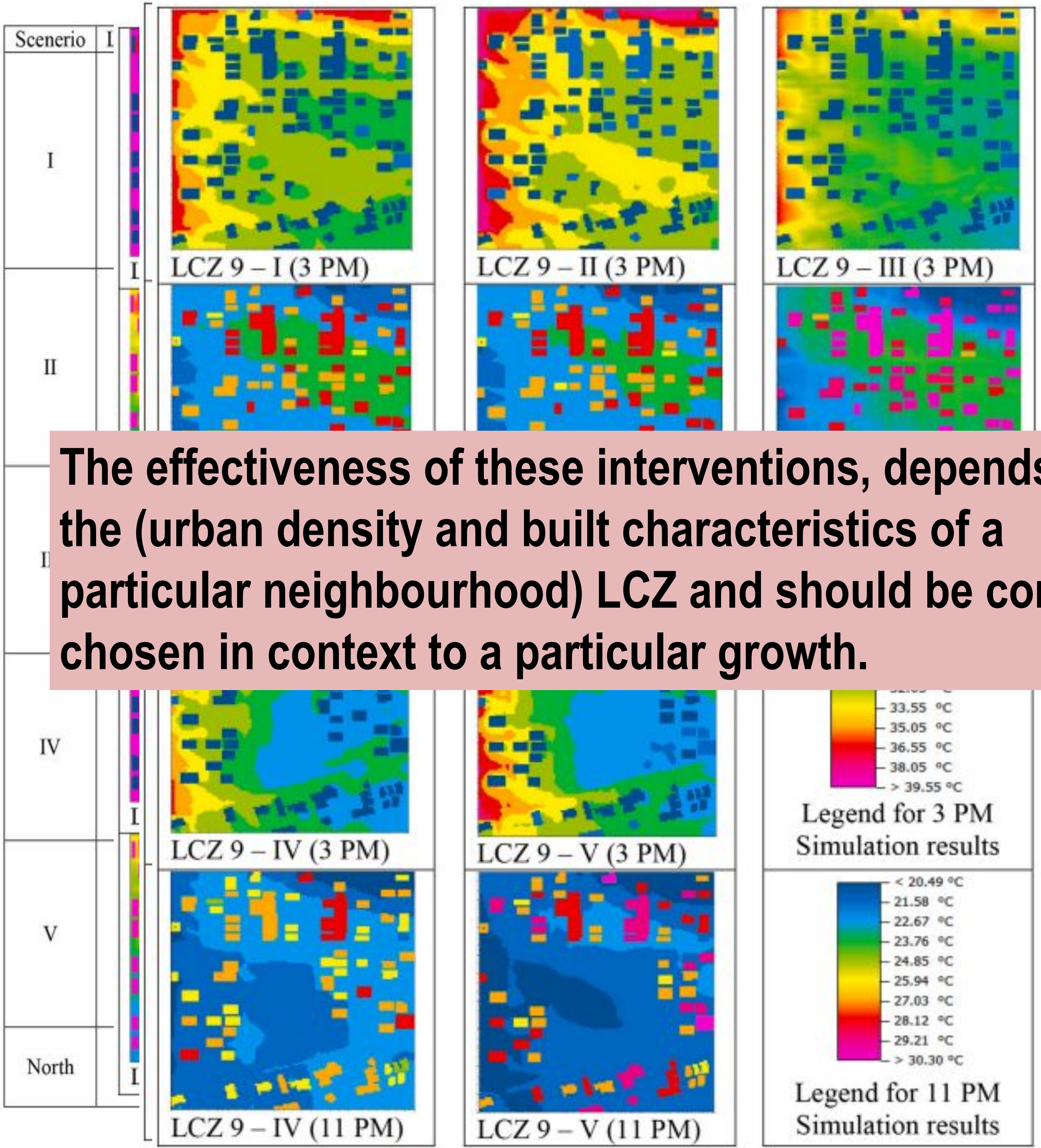
Cool Roof



Measurement Objects	
Cold spot 1	41.7
Hot spot 1	69.8

MITIGATION MEASURES





The effectiveness of these interventions, depends upon the (urban density and built characteristics of a particular neighbourhood) LCZ and should be correctly chosen in context to a particular growth.

CRITICAL INFRASTRUCTURE:

BUILT ENVIRONMENT

ELECTRICITY

WATER

HEALTH

TRANSPORTATION

CONTRIBUTION OF THIS FRAMEWORK

Importance of local threshold
Heat Vulnerability Assessment in cities
Heat Risk Perception among the people

Role of climate type in extreme heat management
Impact of urban morphological parameters on heat stress
Potential of vegetation to mitigate heat stress in urban areas

Spatial framework for the assessment of heat stress in urban areas
Hyper local approach in managing and planning for extreme heat

Significance of integrating heat and water into urban planning

Traditional Knowledge in the given region

Monitoring, Evaluation and Review

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Thank You....

ANY QUESTIONS.......

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