National Institute of Urban Affairs

8th webinar under the
"SUDSC Webinar Series“
jointly initiated by NIUA and GIZ

“Climate-proofing Urban Infrastructure (focus on Heat Resilience)”

19.04.2024
3.00 – 4.30 pm

german cooperation
DEUTSCHE ZUSAMMENARBEIT

giz

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The IPCC defines HW as *"a continuous period of abnormally and uncomfortably hot weather"* (IPCC, 2007)

(Source: Skymet weather.com)

Moist Heat Waves

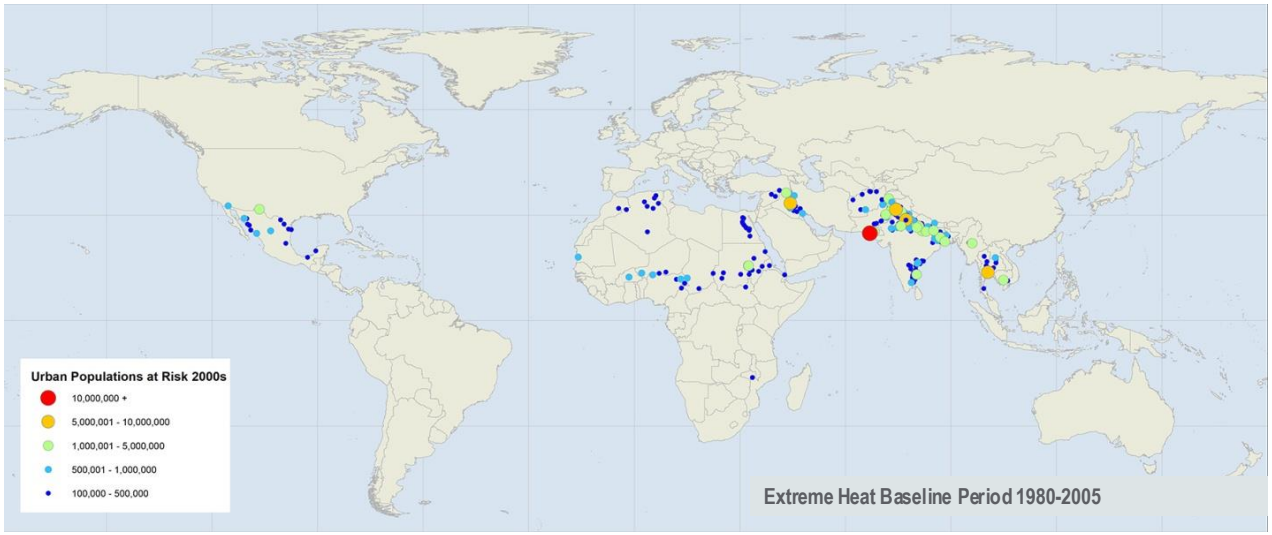
Dry Heat Waves

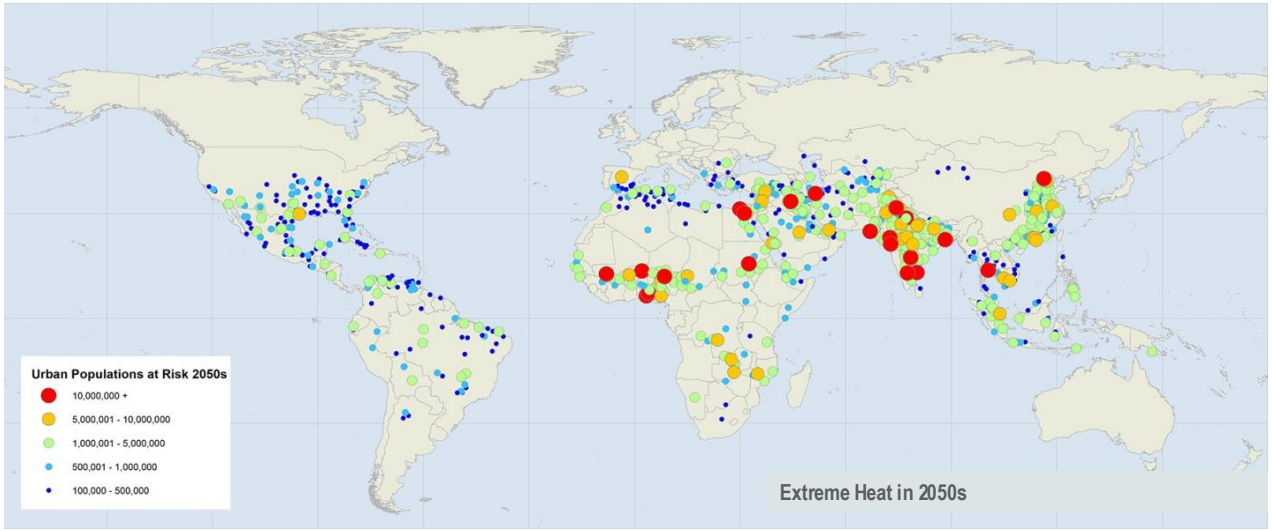
HEAT WAVES (HWs)

The World Meteorological Organization (WMO) defines HW as "***a period during which the daily maximum temperature exceeds for more than five consecutive days the maximum normal temperature by 9°F (5°C), the 'normal' period being defined as 1961–1990***" (WMO, 2013).

(Source: Kunkel et al., 1996; Hunt, 2007; Palecki et al., 2001; Pezza et al., 2012; Huth et al., 2000; Xu et al., 2020)

Urban heat is an increasingly growing issue as urban populations experience higher exposure, greater sensitivity and lower adaptive capacity to extreme heat .



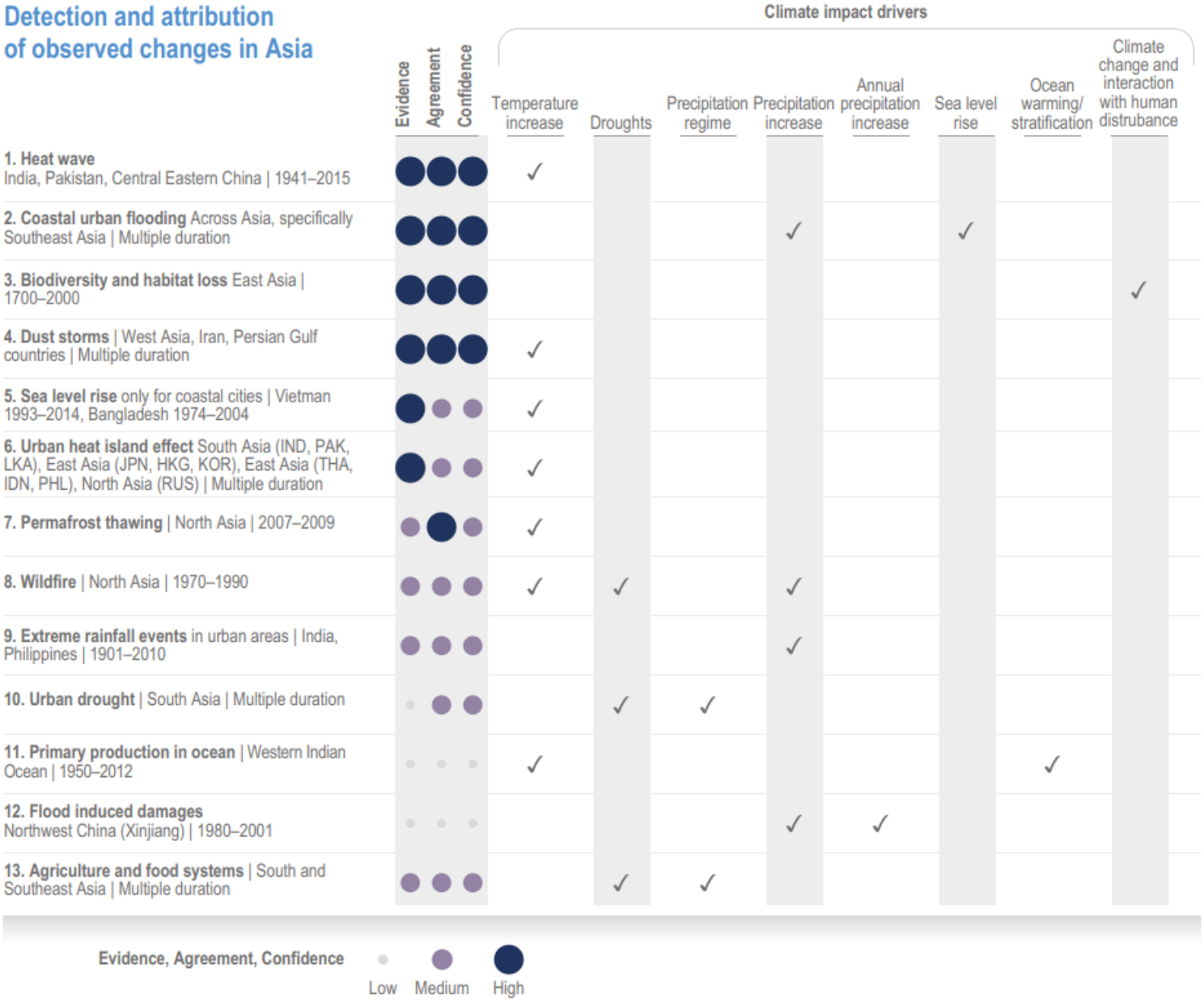


(Source: Kalnay and Cai, 2003; Revi et la., 2014; Moraetal., 2017; Mazdiyasni et al., 2017; Mitchell et al., 2016; Linares et al., 2017; Iñiguez et al., 2016; Wouters et al., 2017; Estrada et al., 2017)

HEAT WAVE & CITIES - Urban populations at risk from heat extremes

- HEAT STRESS
- HIGHER ENERGY USAGE
- EXCESSIVE MORTALITY RATES
- DAMAGE TO INFRASTRUCTURE
- HIGHER HOSPITAL ADMISSIONS
- ECONOMIC AND LABOUR PRODUCTIVITY LOSS

Detection and attribution of observed changes in Asia



By the end of the century, under higher projections (RCP8.5), the daily maximum wet-bulb temperature is expected to exceed the survivability threshold across most of South Asia (Im et al., 2017)

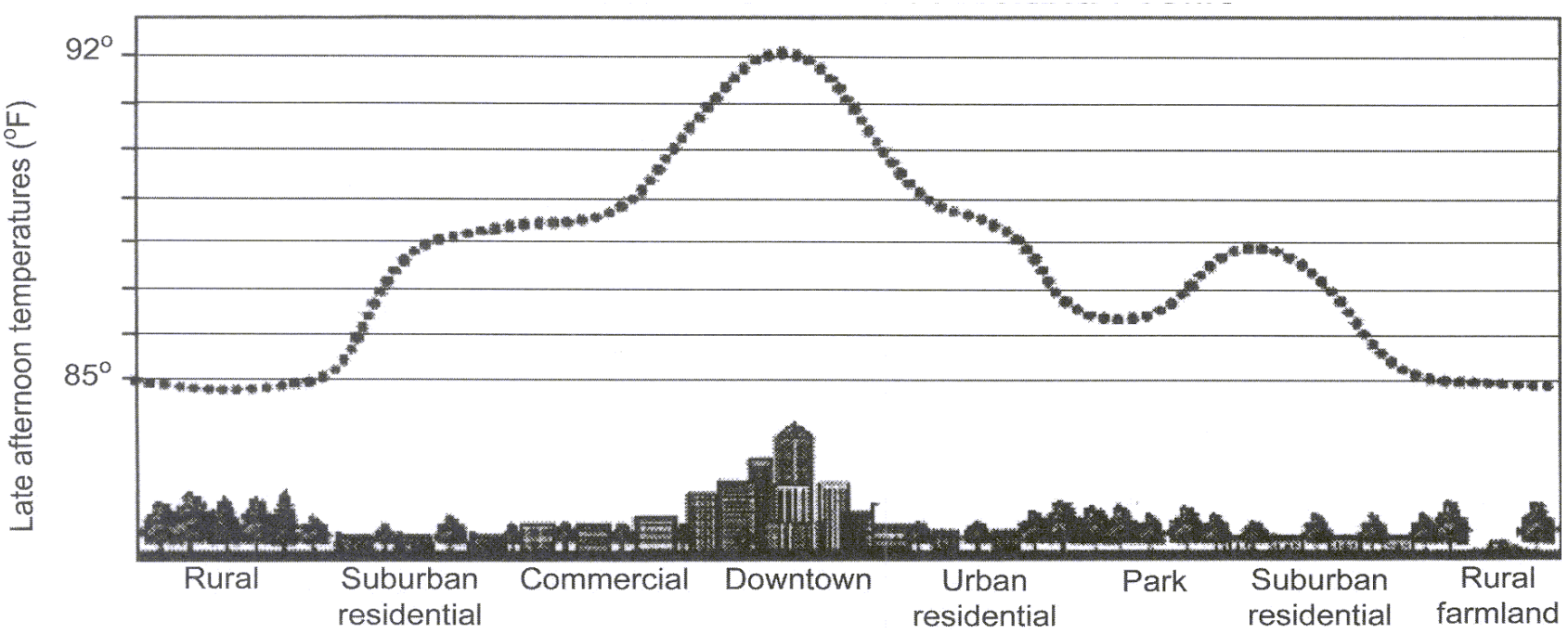
IPCC_AR6_WGII_Chapter10

CLIMATE CHANGE & CITIES

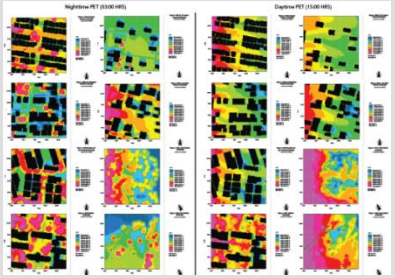
Cities - both as political and material entities - are increasingly playing a critical role in shaping the trajectory and impacts of climate change action.

(Source: Rosenzweig C., W. Solecki, P. Romero-Lankao, S. Mehrotra, S. Dhakal, T. Bowman, and S. Ali Ibrahim. 2015. ARC3.2 Summary for City Leaders. Urban Climate Change Research Network. Columbia University. New York.)

URBAN HEAT ISLAND (UHI) EFFECT



Source: U.S. Environmental protection Agency, 1992.



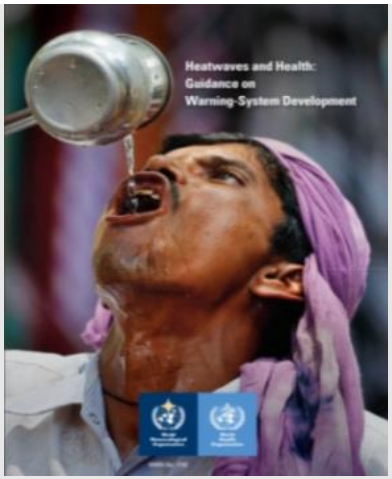
Urban Heat Intensities Mapping
LCZ Classification

Extreme Heat Impact On Energy
Urban Morphology And Extreme Heat

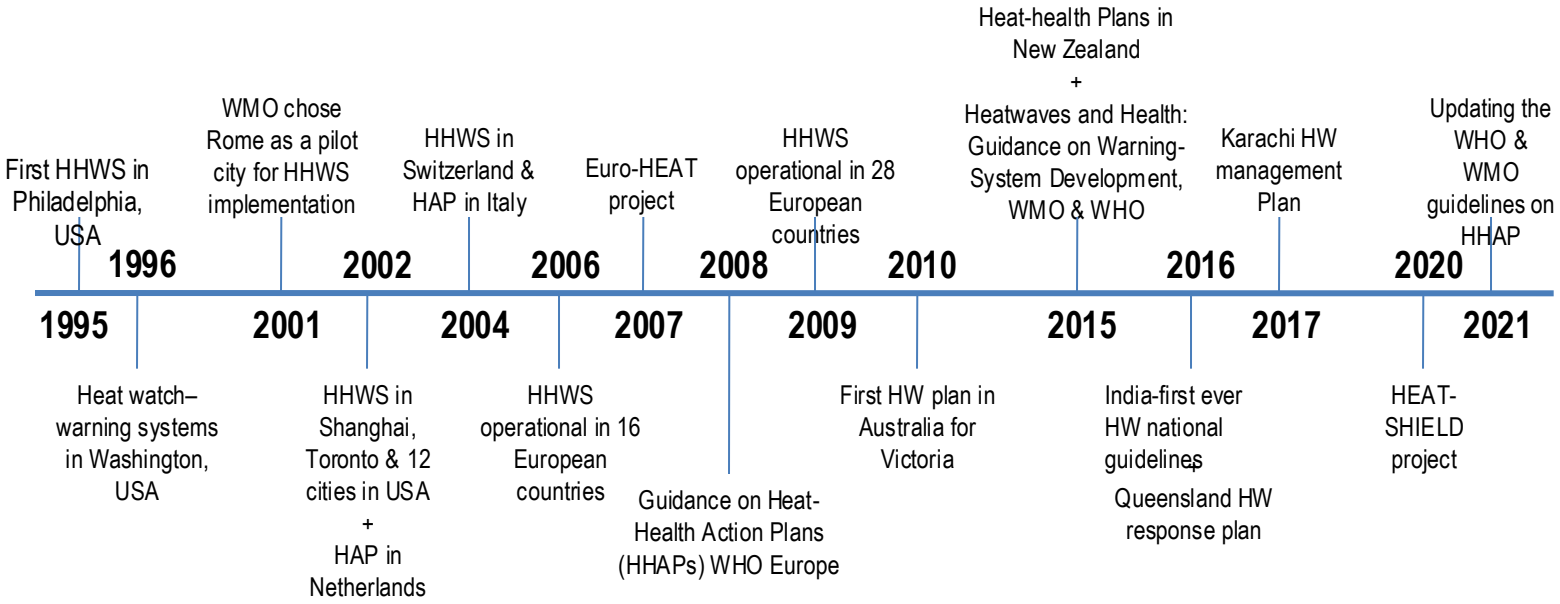
Outdoor Thermal Comfort Studies
Extreme Heat And Mortality

Assessment Of Various Mitigation Measures
Assessment Of Various Housing Typologies

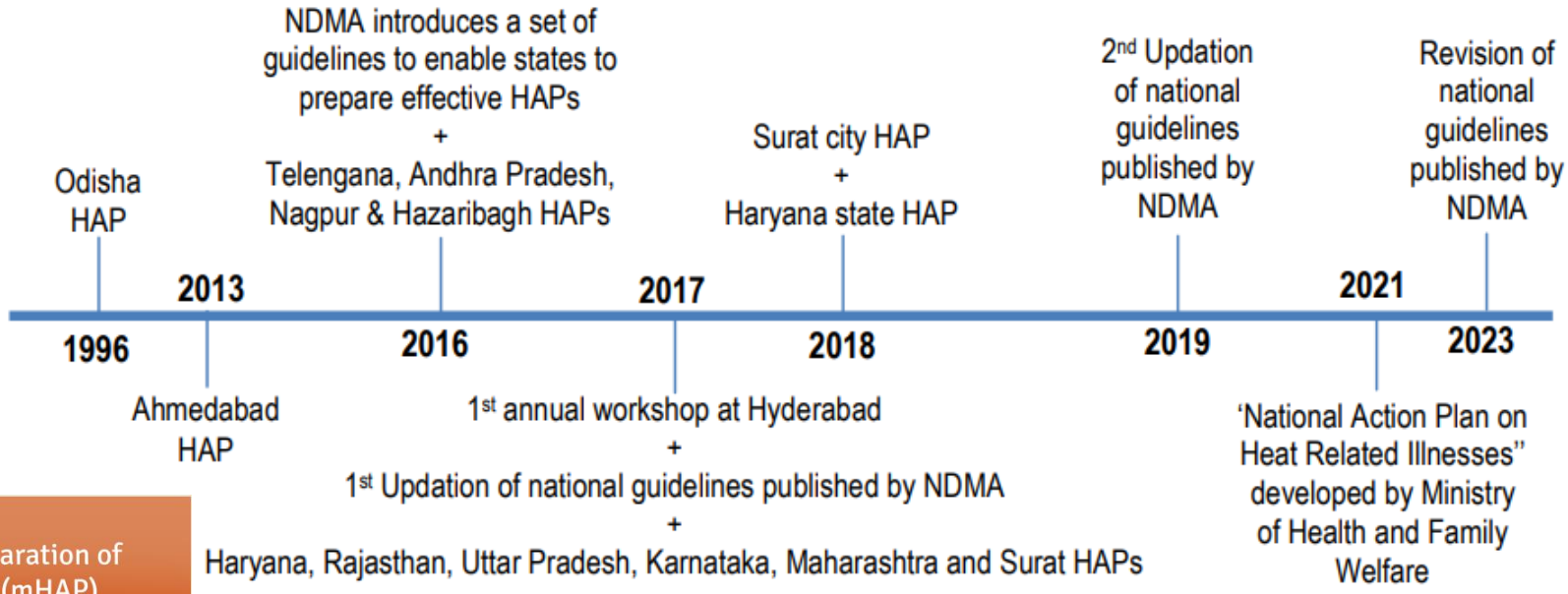
Anthropogenic Heat Assessment In The Cities.
Model Heat Action Plan

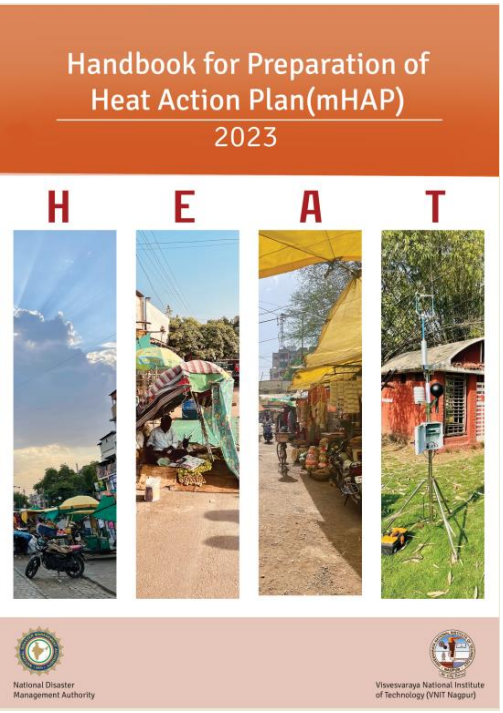


Progress in heat management



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.





2019: Chapter on Built Environment was added to the guidelines

Progress in heat management: India

Meteorology

Epidemiology

Public Health

Built Environment:

Long term urban planning; to address building and city planning design issues that will ultimately reduce the heat exposure

Reduction in indoor heat exposure

Particular care for vulnerable groups

Long-term urban planning

LONG TERM URBAN PLANNING IS THE LEAST ADDRESSED IN THE EXISTING HEAT ACTION PLANS

Heat Vulnerability and Risk Assessment Mapping

Local Threshold

Role of Spatial Framework

Challenges of vulnerability assessment across different groups

Examples of cities

NEED for heat vulnerability and risk assessment

EARLY WARNING SYSTEM

VULNERABILITY

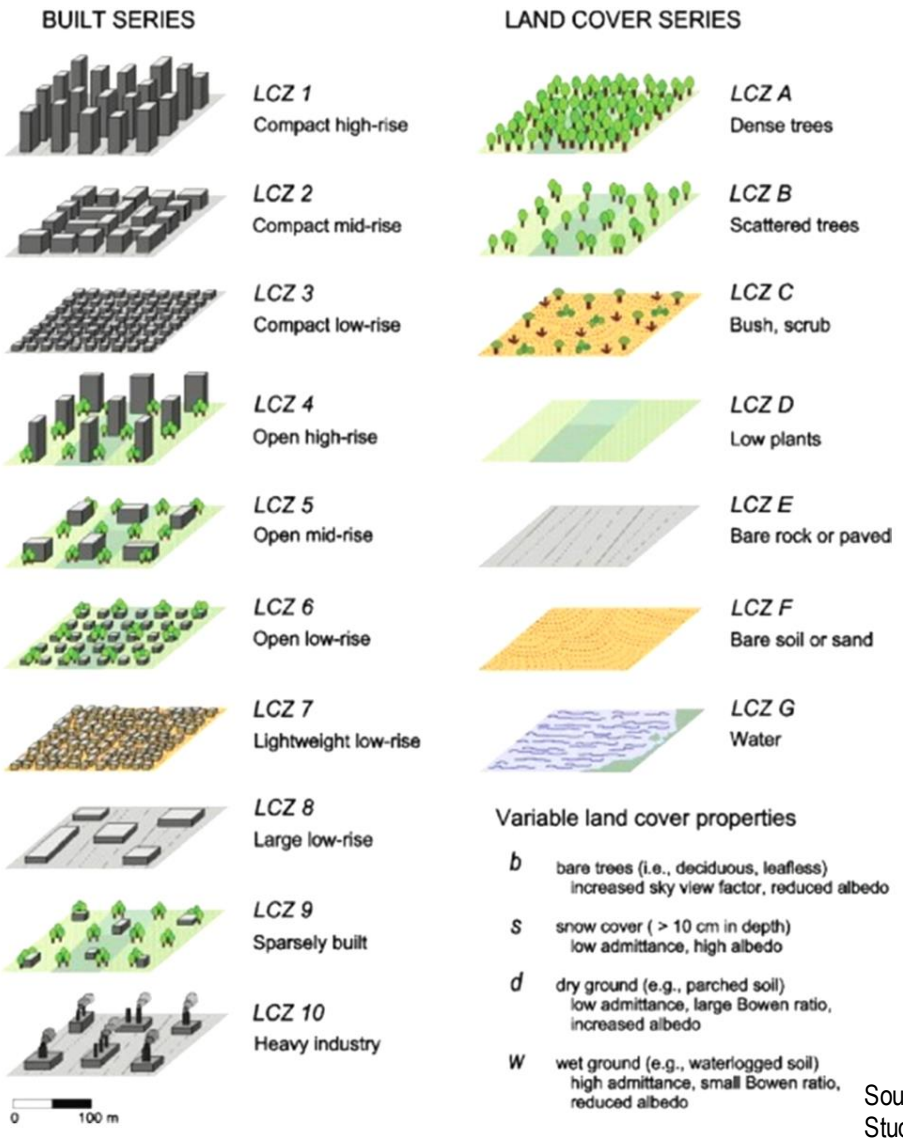
Exposure
Sensitivity
Adaptive Capacity

RISK

Hazard
Vulnerability

A new standard of LULC classification: Local Climate Zones (LCZ)

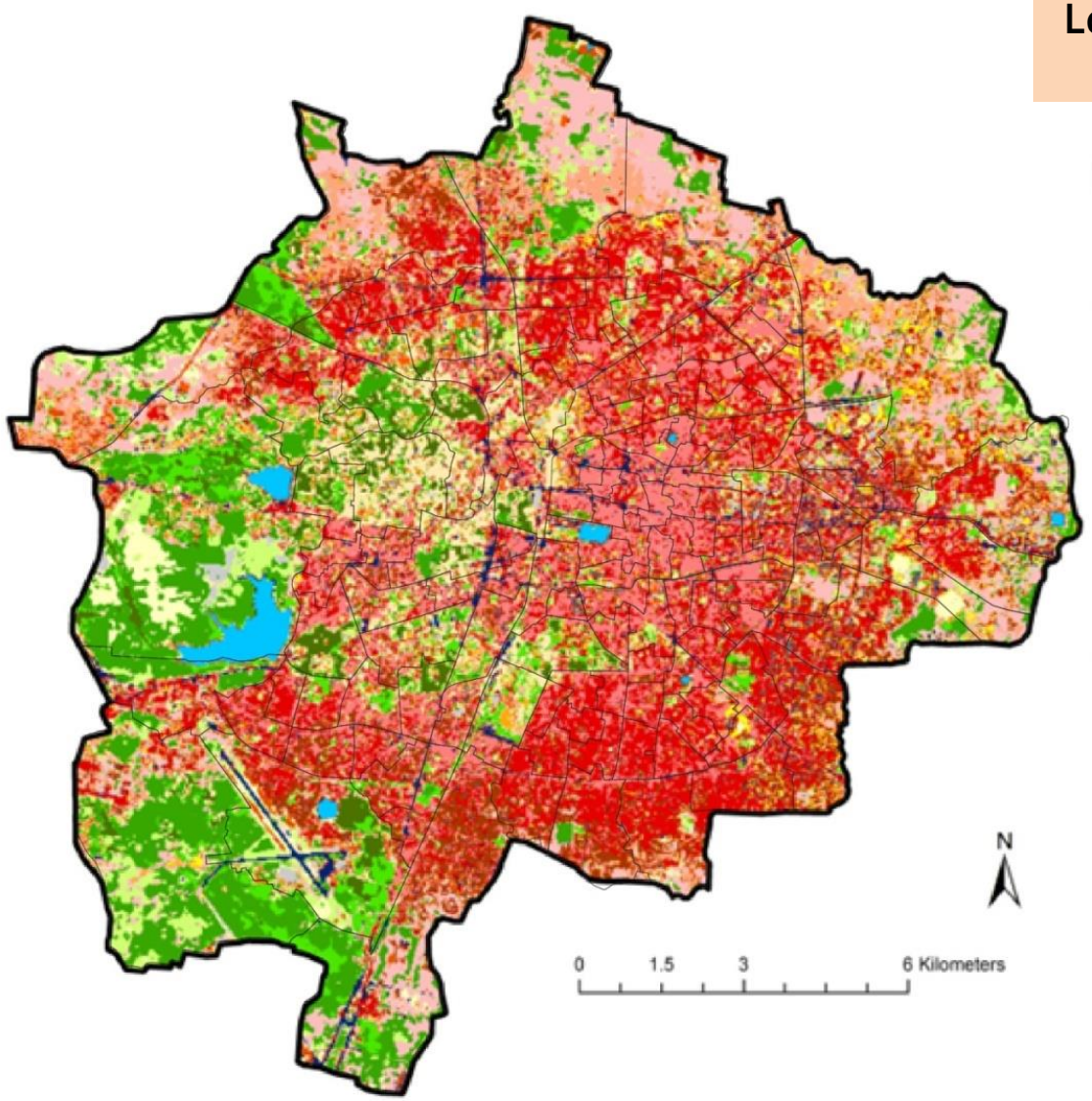
- The landscape universe proposed by Stewart and Oke (2012).
- Defined as "**regions of uniform surface cover, structure, material, and human activity that span hundreds of meters to several kilometres in horizontal scale**".



Local Climate Zones defining properties
Sky view Factor
Aspect ratio
Building surface fraction
Impervious surface fraction
Pervious surface fraction
Height of roughness elements
Terrain roughness class
Surface admittance
Surface albedo
Anthropogenic heat output

Source: Stewart, I. D., & Oke, T. R. (2012). Local Climate Zones for Urban Temperature Studies. *Bulletin of American Meteorological Society* , 1879-1900.

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

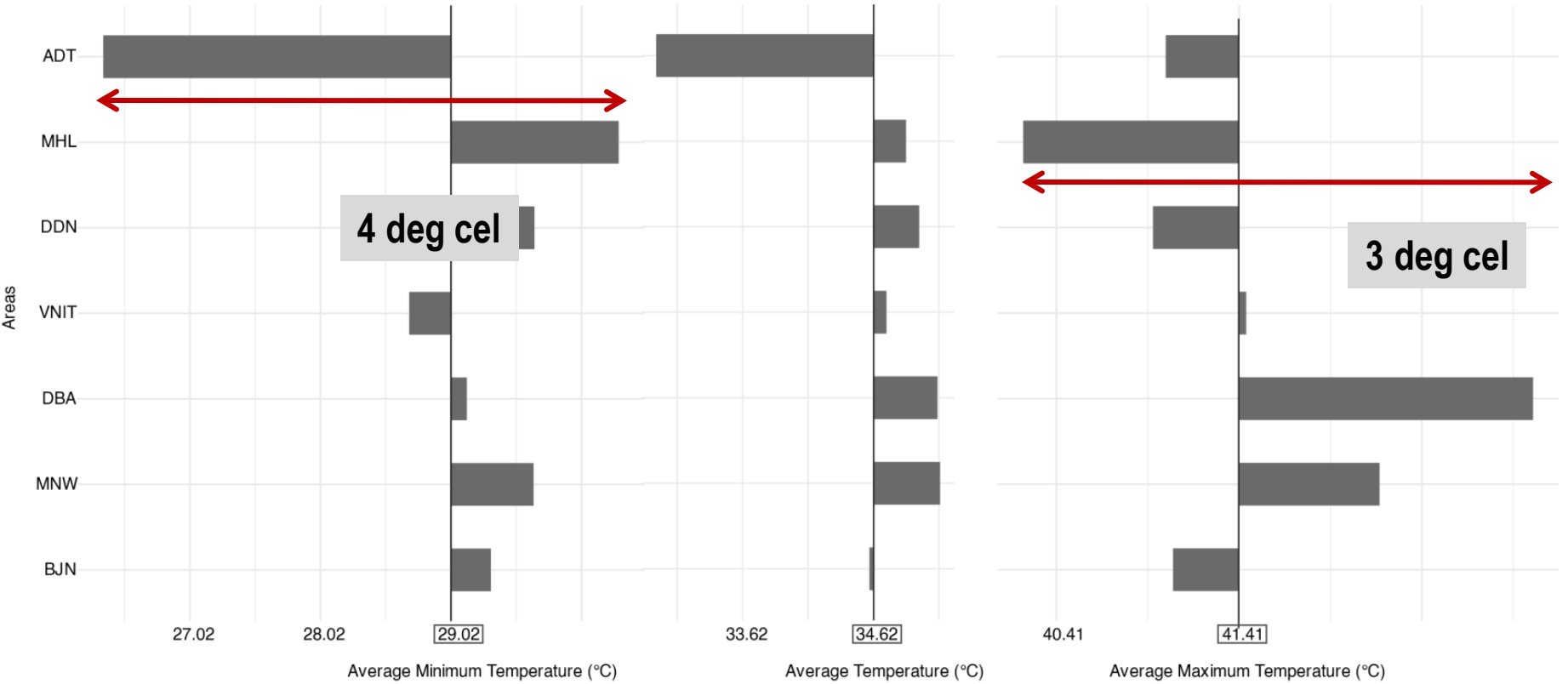
Vegetation Fraction

Roughness

npact High-rise
npact Mid-rise
npact 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

Summer time temperature variation across LCZs 2022



Nocturnal UHI

VEG ++

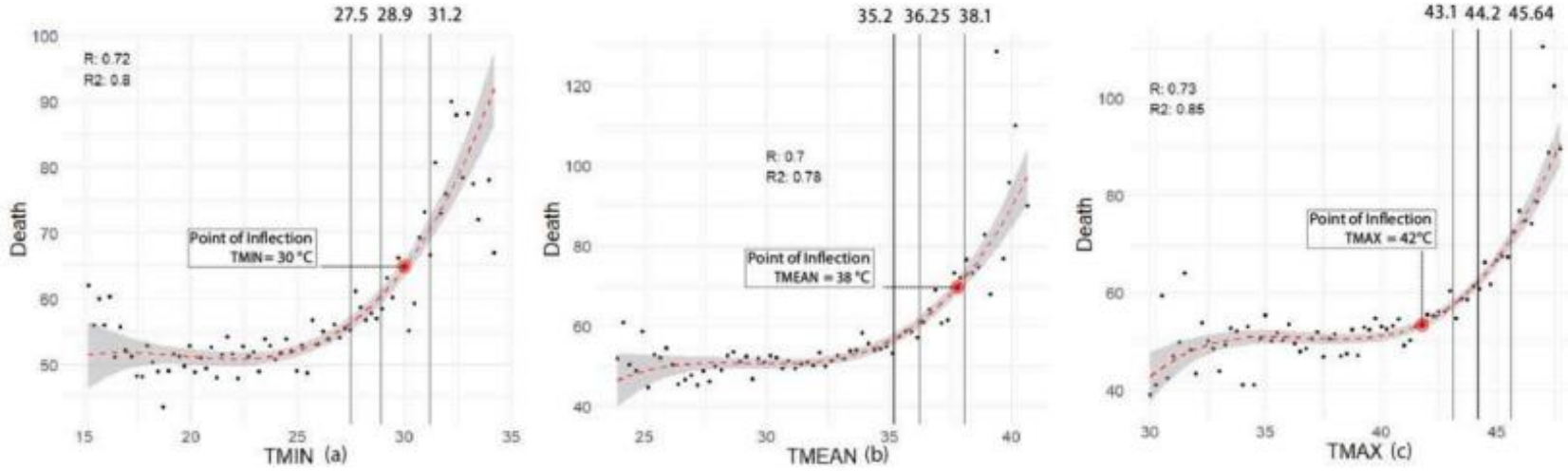
BUILT UP +++

Daytime UHI

BUILT UP ++

Sparse BUILT UP

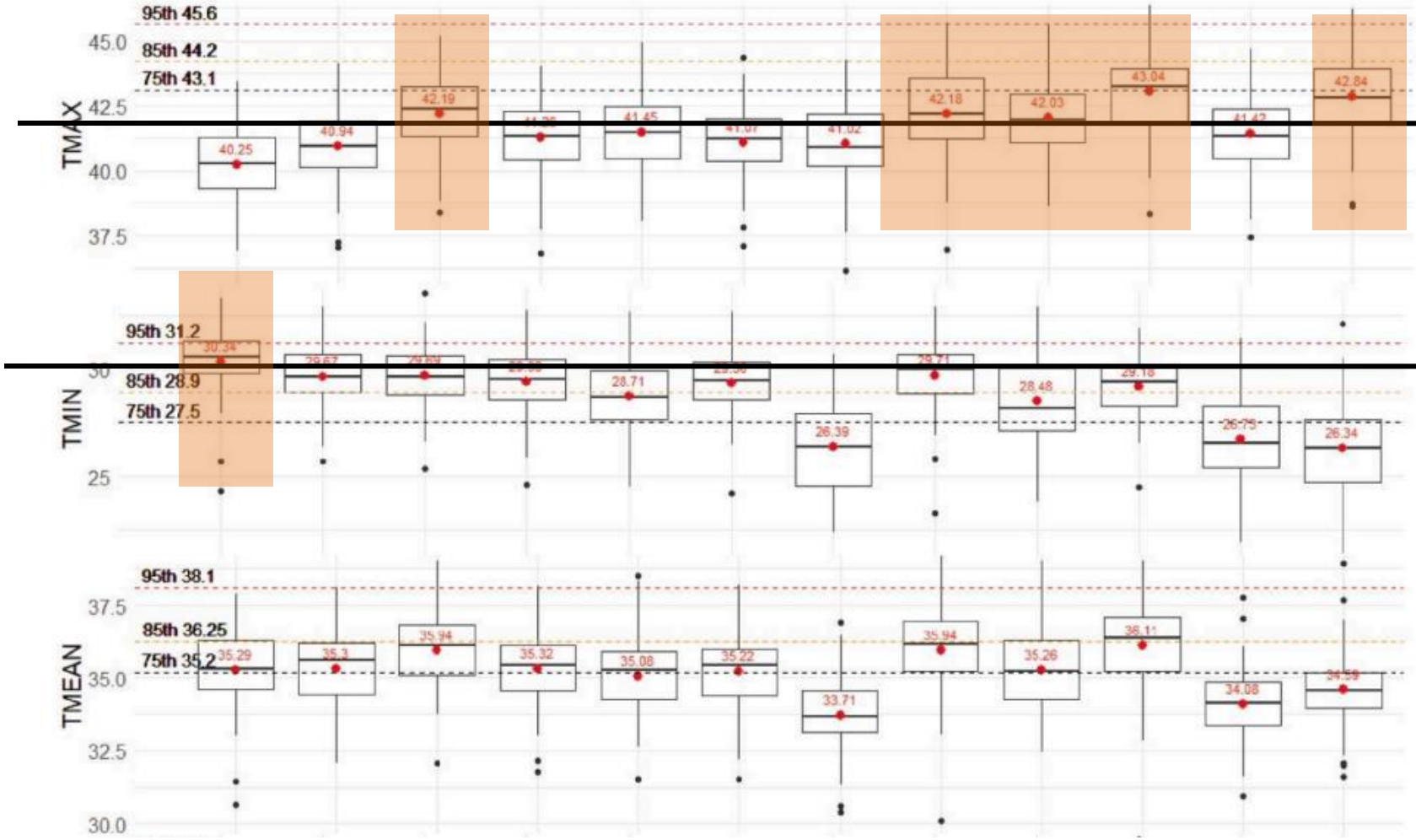
	Min Temp	Max Temp	Mean Temp
Point of deflection	30 deg cel	42 deg cel	38 deg cel



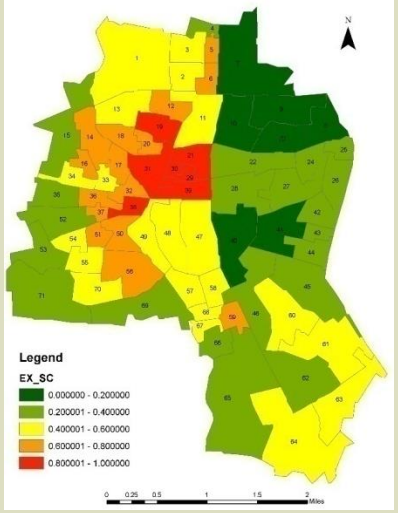
IMPORTANCE OF LOCAL THRESHOLD

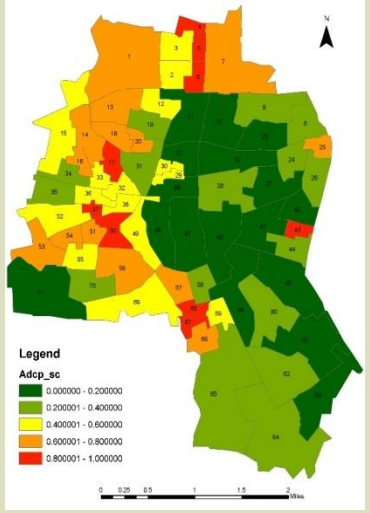
	Min Temp	Max Temp	Mean Temp
Point of deflection	30 deg cel	42 deg cel	38 deg cel

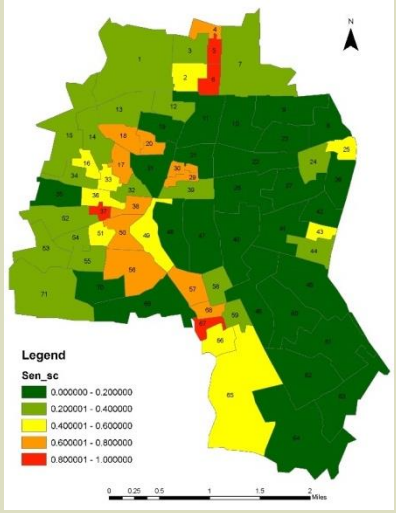
LCZs - 9, 9(3), 3F, 8 (during day); 3 (during night)



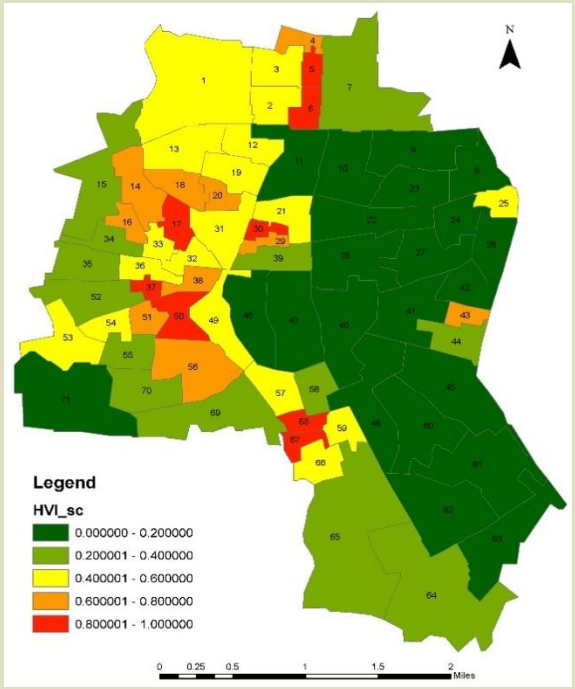
Indicators	Data Source
1. Electricity supply	Census of India-2011
2. Water supply	
3. Communication facilities	
4. Personal vehicle	
5. Bank account	
6. Health facilities	Remote Sensing & Municipal Corporation
7. Social facilities: religious facilities & schools	
8. Normalized Difference Vegetation Index (NDVI)	LANDSAT-8 imagery
9. Illiterate Population	Census of India-2011
10. Female population	
11. Population aged under 6 years	
12. Population aged under 18 years	
13. Population aged over 60 years	
14. Population of Socially vulnerable	
15. Population density	
19. Average number of people per household	
20. Rented housing	
21. Temporary structure	
22. Roof material	
23. Population that has disability 18-64 years	
24. Land Surface Temperature (LST)	LANDSAT-8 imagery







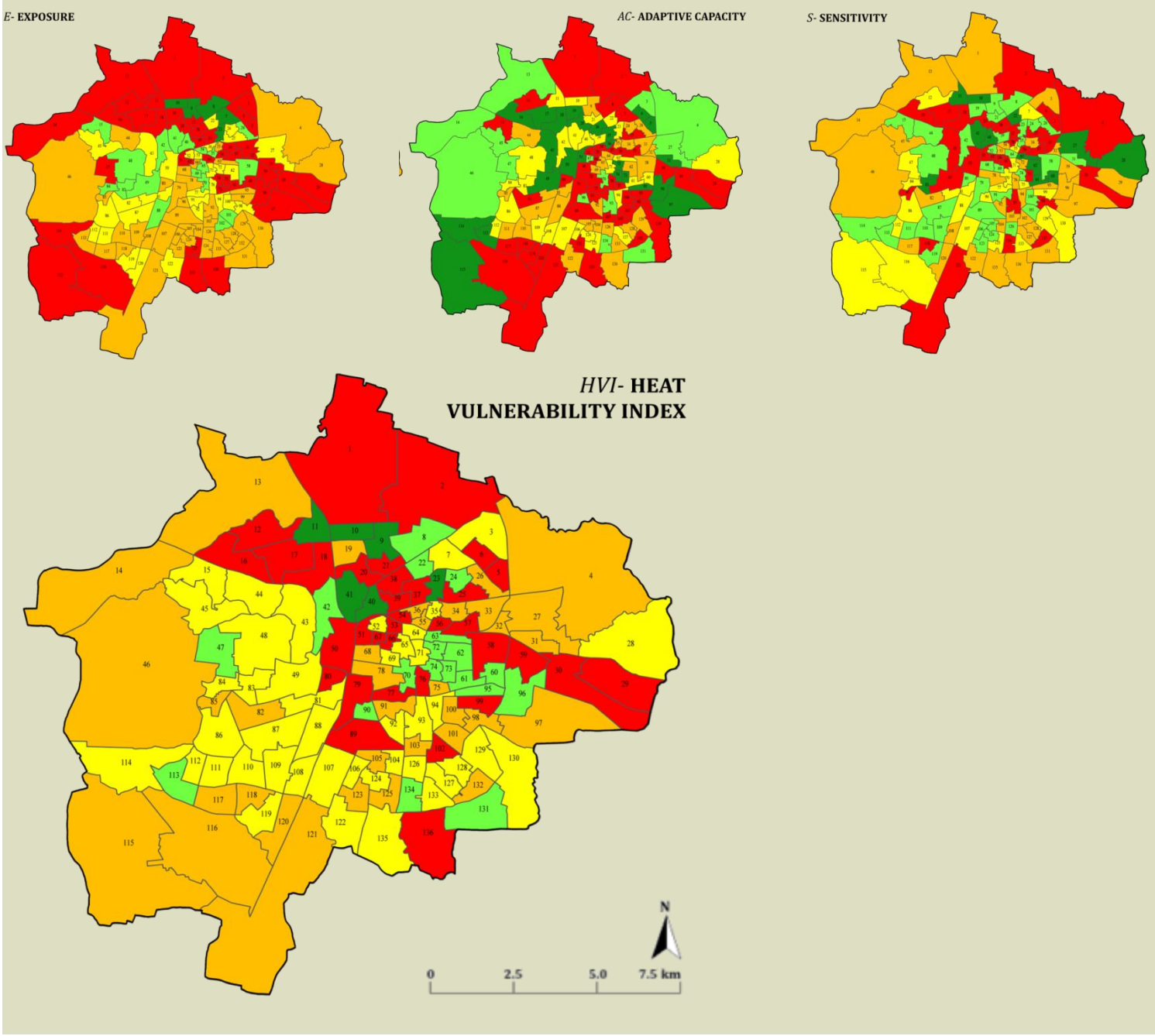
Exposure Index Sensitivity Index Adaptive Capacity Index

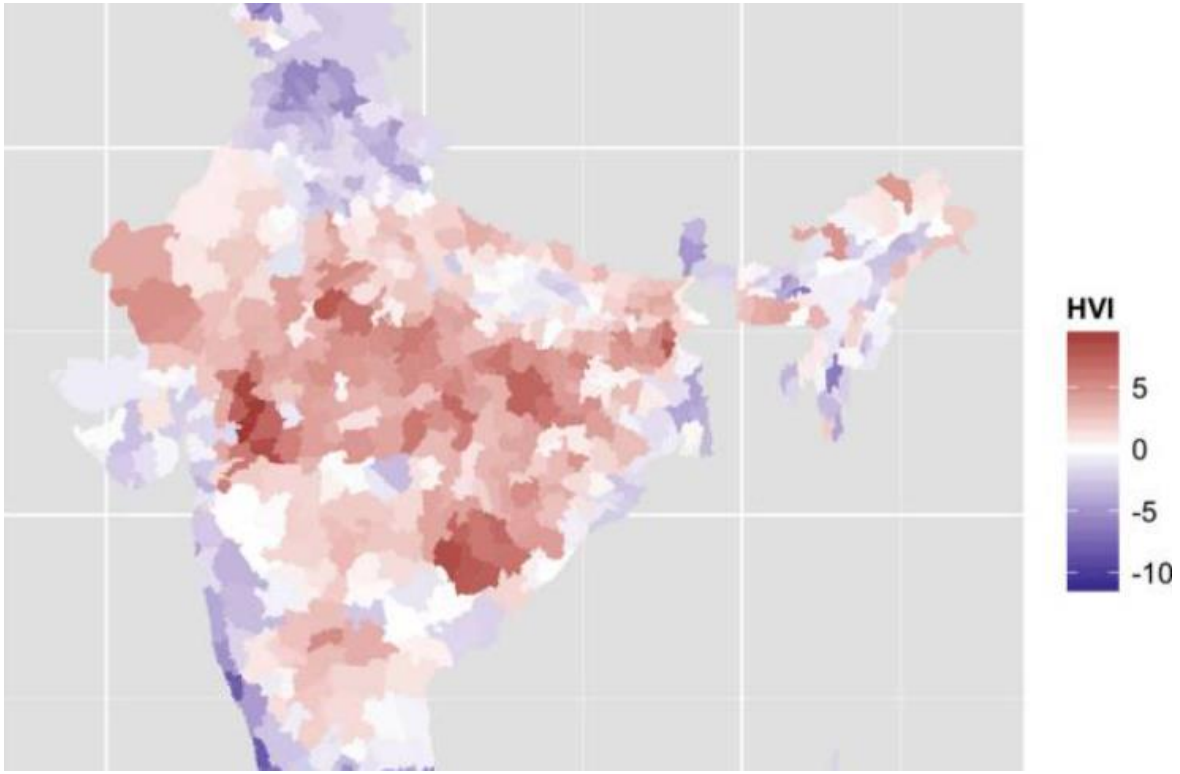


HEAT VULNERABILITY INDEX

HEAT HAZARD CAN BE ADDED TO MAP RISK.

AKOLA


E- EXPOSURE
AC- ADAPTIVE CAPACITY
S- SENSITIVITY
HVI- HEAT VULNERABILITY INDEX
N
0
2.5
5.0
7.5 km



Int J Environ Res Public Health. 2017 Apr; 14(4): 357.
Published online 2017 Mar 30. doi: 10.3390/ijerph14040357
Heat Wave Vulnerability Mapping for India
Gulrez Azhar,[1,2,*] Shubhayu Saha,[3] Partha Ganguly,[4,5] Dileep Mavalankar,[4,5] and Jaime Madrigano[1]

Indicators affecting the heat vulnerability
Population density
Population aged under 6 years
Population aged over 60 years
Average household size
Literacy
Roof material
Housing typology
Health facilities
Water supply
Communication facilities
NDVI

RISK

Vulnerability
(Infrastructure)
+
Hazard level
(Urban Form)

HEAT HAZARD in cities are strongly influenced by CITY PLANNING Measures

CHALLENGES OF HEAT RISK ASSESSMENT:

Definition Of Hazard And Data for Hazard
Local Threshold

Spatial Framework – Ward(?)

Dynamic Data for Adaptive Capacity and Sensitivity
Static Nature of the Assessment

Purpose of the Assessment
Adaption and Mitigation Measures Based on the HRA

IMPROVING THE HEAT RESILIENCE:

PHYSICAL :

CITY PLANNING
INFRASTRUCTURE
BLUE GREEN
BUILDINGS

NON-PHYSICAL

Climate resilient approach to city planning is the key...

Referred Publications:

Kotharkar, Rajashree et. al**, "Approach to local climate zone based energy consumption assessment in an Indian city",** Energy and Building, 259 (2022) 111835, https://doi.org/10.1016/j.enbuild.2022.111835, 2022

Kotharkar, Rajashree and Ghosh. Aveek, **"Progress in extreme heat management and warning systems: A systematic review of heat-health action plans (1995-2020)"**, Sustainable Cities and Society, 76 (2022) 103487

Kotharkar, Rajashree and Ghosh. Aveek, "**Review of heat wave studies and related urban policies in South Asia"**, Urban Climate, Volume 36, March 2021, 100777, https://doi.org/10.1016/j.uclim.2021.100777

Kotharkar Rajashree , Ghosh Aveek and Kotharkar, Varun, "**Estimating summertime heat stress in a tropical Indian city using Local Climate Zone (LCZ) framework**", Urban Climate Volume 36, March 2021, 100784, https://doi.org/10.1016/j.uclim.2021.100784

Kotharkar Rajashree and Bagade Anurag and Singh, P R, **"A systematic approach for urban heat island mitigation strategies in critical local climate zones of an Indian city.",** Urban Climate 34, 100701, 2020

Kotharkar Rajashree, P Bahadure, **" Achieving Compact City Form through Density Distribution: Case of Indian Cities"**, Journal of Urban Planning and Development 146 (1), 04019022, 2020

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Kotharkar, Rajashree; Pallapu A. and Bahadure, Pankaj. **" Urban Cluster–Based Sustainability Assessment of an Indian City: Case of Nagpur"** J. Urban Plann. Dev., 2019, 145(4): 04019018 ; DOI: 10.1061/(ASCE)UP.1943-5444.0000527

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Kotharkar Rajashree, Bagade Anurag and Ramesh, Aparna,**" Assessing urban drivers of canopy layer urban heat island: A numerical modeling approach**" Landscape and Urban Planning 190, 103586

Kotharkar Rajashree, Ramesh, Aparna and Bagade Anurag,**"Urban Heat Island Studies in South Asia: A Critical Review"**, Urban climate 24, 1011-1026, 2018.

Kotharkar Rajashree and Bagade Anurag, **"Evaluating urban heat island in the critical local climate zones of an Indian city**", Landscape and Urban Planning, ISSN,01692046 169 (2018) page no 92-104; https://doi.org/10.1016/j.landurbplan.2017.08.009

Kotharkar Rajashree and Bagade Anurag, **"Local Climate Zone classification for Indian cities: A case study of Nagpur",** Urban climate 24, 369-392, 2018

Kotharkar Rajashree and Surawar Meenal, **"Land use, land cover, and population density impact on the formation of canopy urban heat islands through traverse survey in the Nagpur urban area, India",** Journal of Urban Planning and Development , ISSN 07339488142 (1): 04015003-1-13, 2016;DOI:10.1061/(ASCE)UP.1943-5444. 0000277.

Thank You....

ANY QUESTIONS.....

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