The impacts of green spaces in mitigating the urban heat island - The case of Bengaluru, India

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Urban heat island in India

- Increase in city temperatures: Cities are hotter than their surroundings due to high concentrations of heat absorbing material and constructed spaces (Chen et al., 2006)
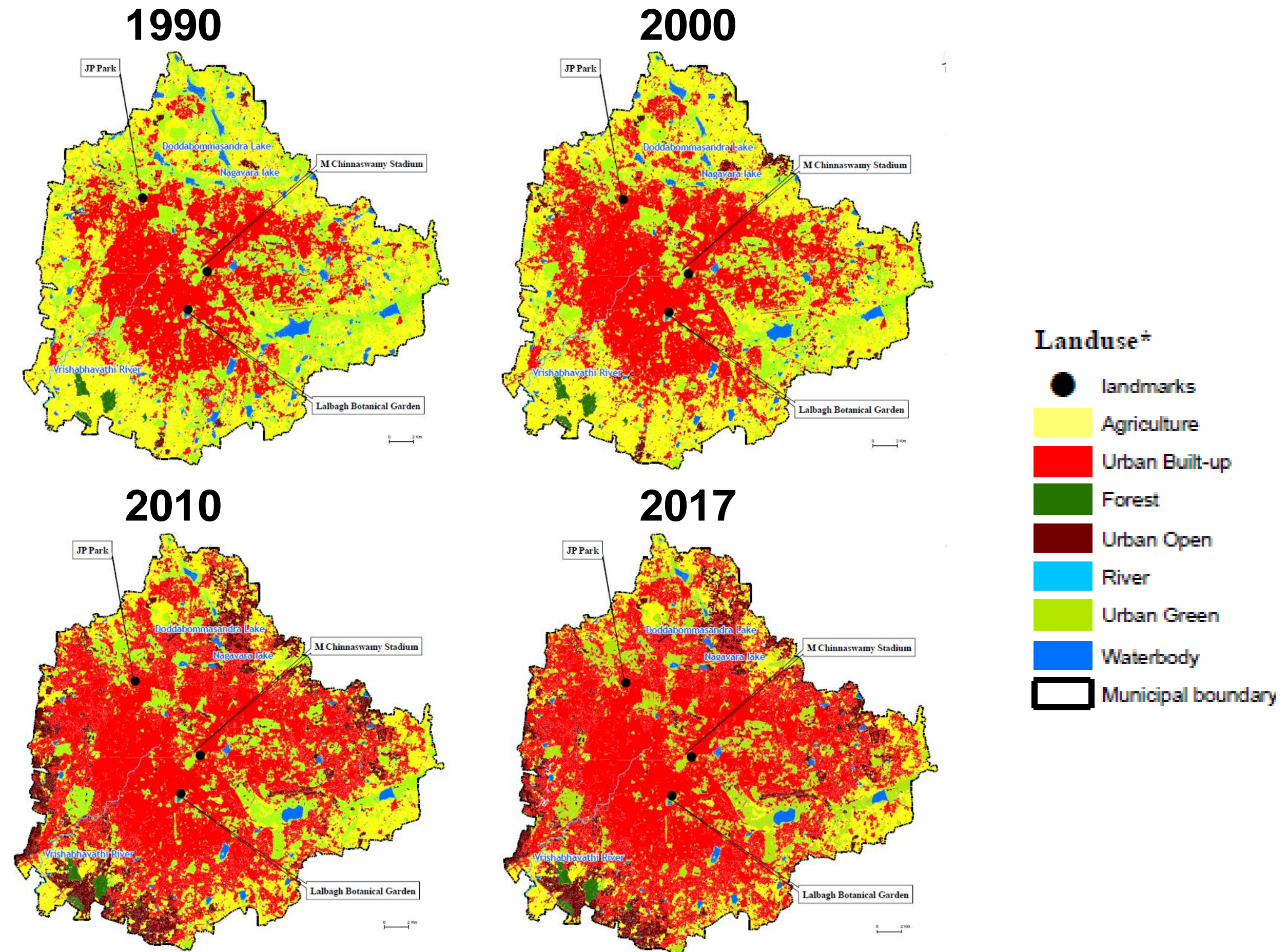
Urban heat island impacts

- Increases severity and duration of heat waves (Azhar et al., 2014; Tan et al., 2010)
    - 2,300+ deaths due to heat stroke in India in 2015 alone
    - 1000+ deaths every year from 2012-18
    - Increase in need for air-conditioning and refrigeration
    - Space cooling needs projected to grow 8X by 2038 (Draft India Cooling Action Plan)

Rapid urbanization in India

- Urban heat island to increase as India urbanizes
  - Urban population to grow from 400 million to 800 million by 2050
  - Large scale construction activities in cities to occur

1990

2000

2010

2017

Landuse*
- landmarks
- Agriculture
- Urban Built-up
- Forest
- Urban Open
- River
- Urban Green
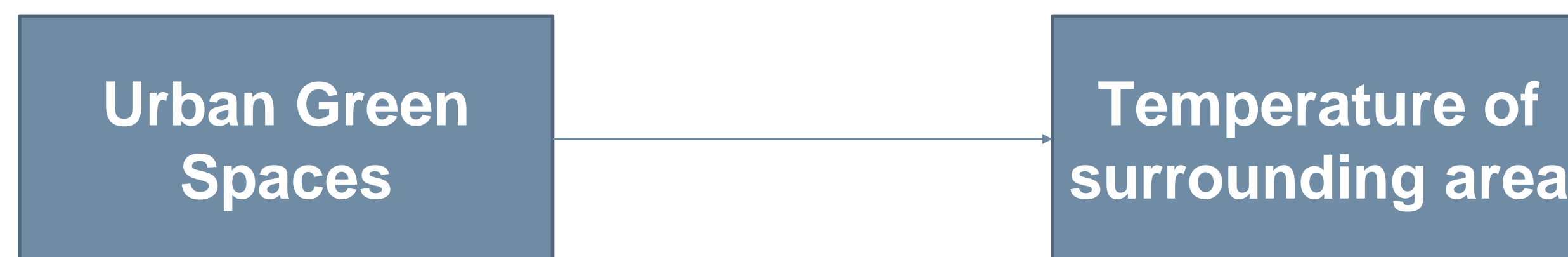- Waterbody
- Municipal boundary

Urban green spaces for cooling

- Small scale studies of a few green spaces in India have shown that urban green spaces are cooler than built-up areas (Mohan et al., 2013; Grover and Singh, 2016)

- Globally, researchers are starting to study the relationship between green spaces and the temperatures of the area surrounding the green spaces (Feyisa et al., 2014; Lin et al., 2015)
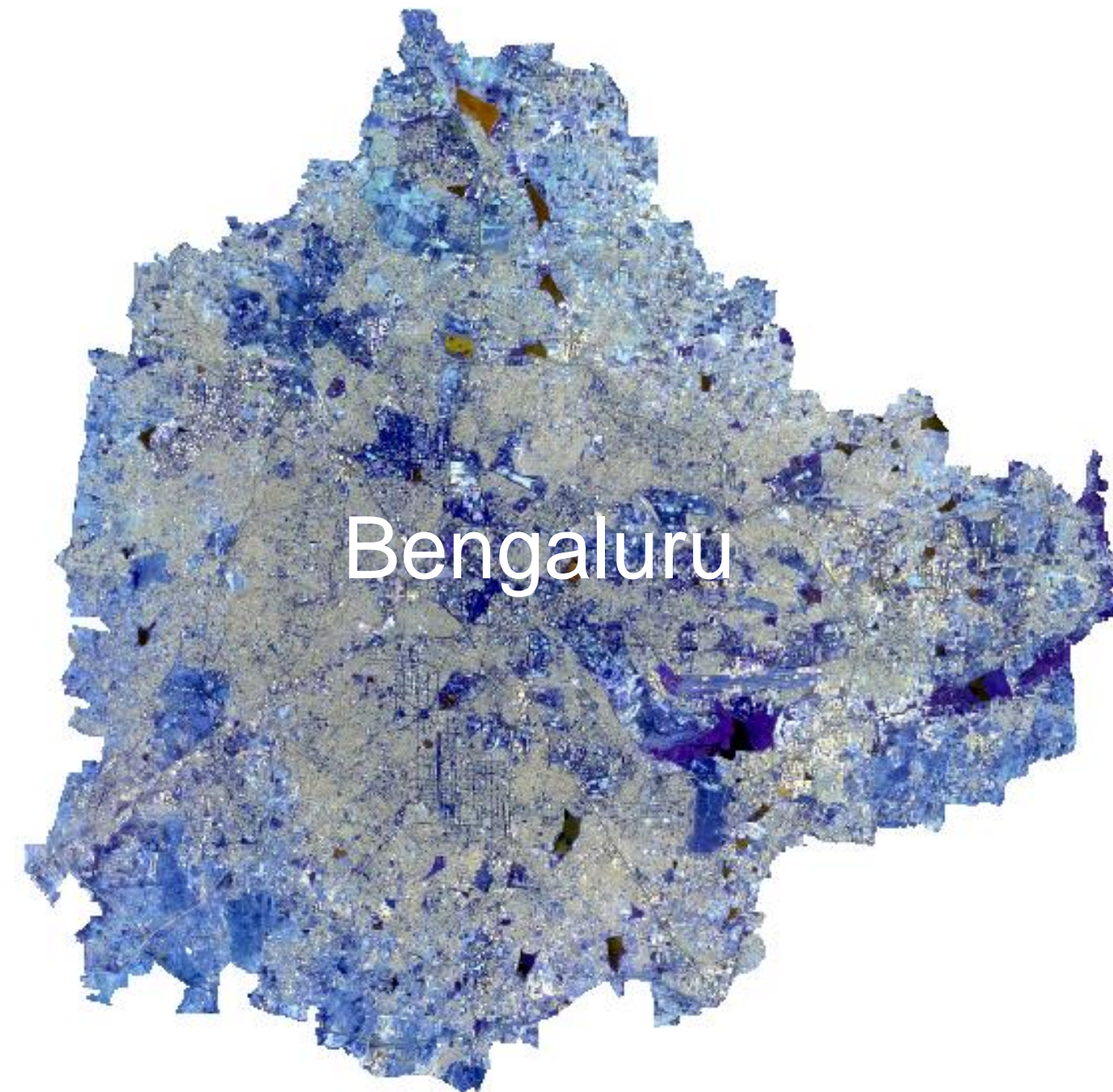
Objective of study

- What is the impact of urban green spaces on local temperature in the area surrounding the green space?

- What characteristics of green spaces impact this relationship?

| Urban Green Spaces | → | Temperature of surrounding area |

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Data sources

- Satellite data

- Google Earth

- Local knowledge

NASA Landsat 7 data

Area of Bengaluru: 708 sq.km
Area of each pixel: 30m by 30m (900 sq.m)

Number of pixels in image: ~780,000

Bengaluru

Selected image for 10.40 AM, April 24, 2017

Method

- From satellite data, we derive the following at 30m resolution
  - Land use pattern for Bengaluru (using hybrid classification techniques)
  - Normalized difference vegetation index for Bengaluru (using procedure prescribed by NASA)
  - Temperature pattern for Bengaluru (using procedure prescribed by NASA)
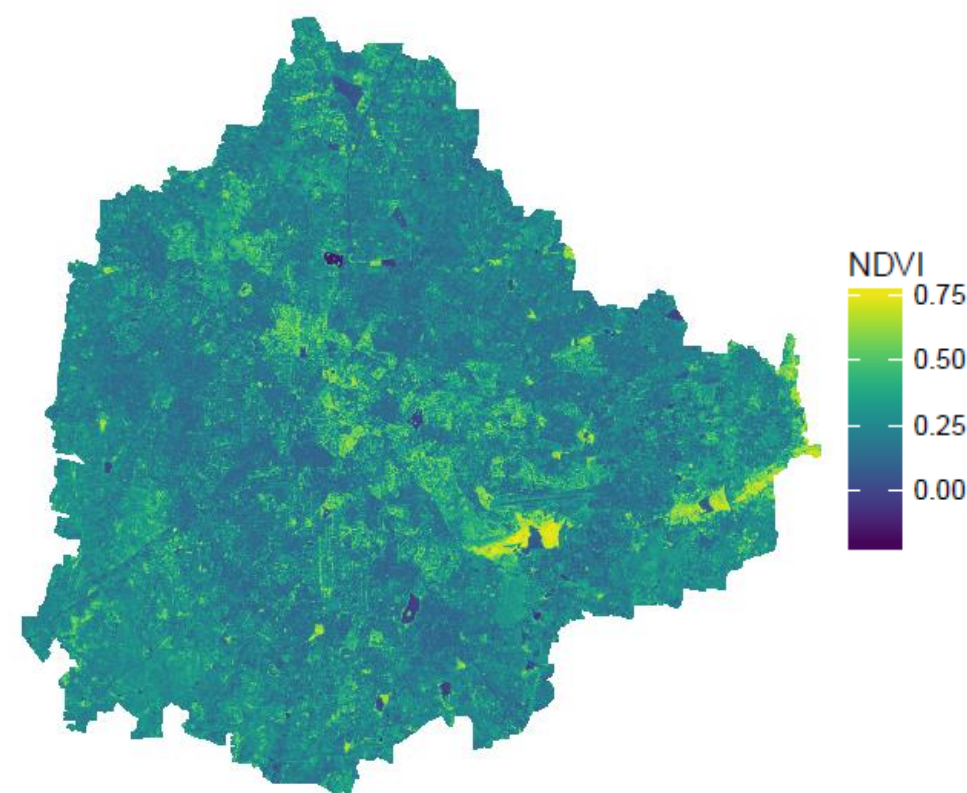
- Softwares used: ArcGIS 10, RStudio 3.4

Method
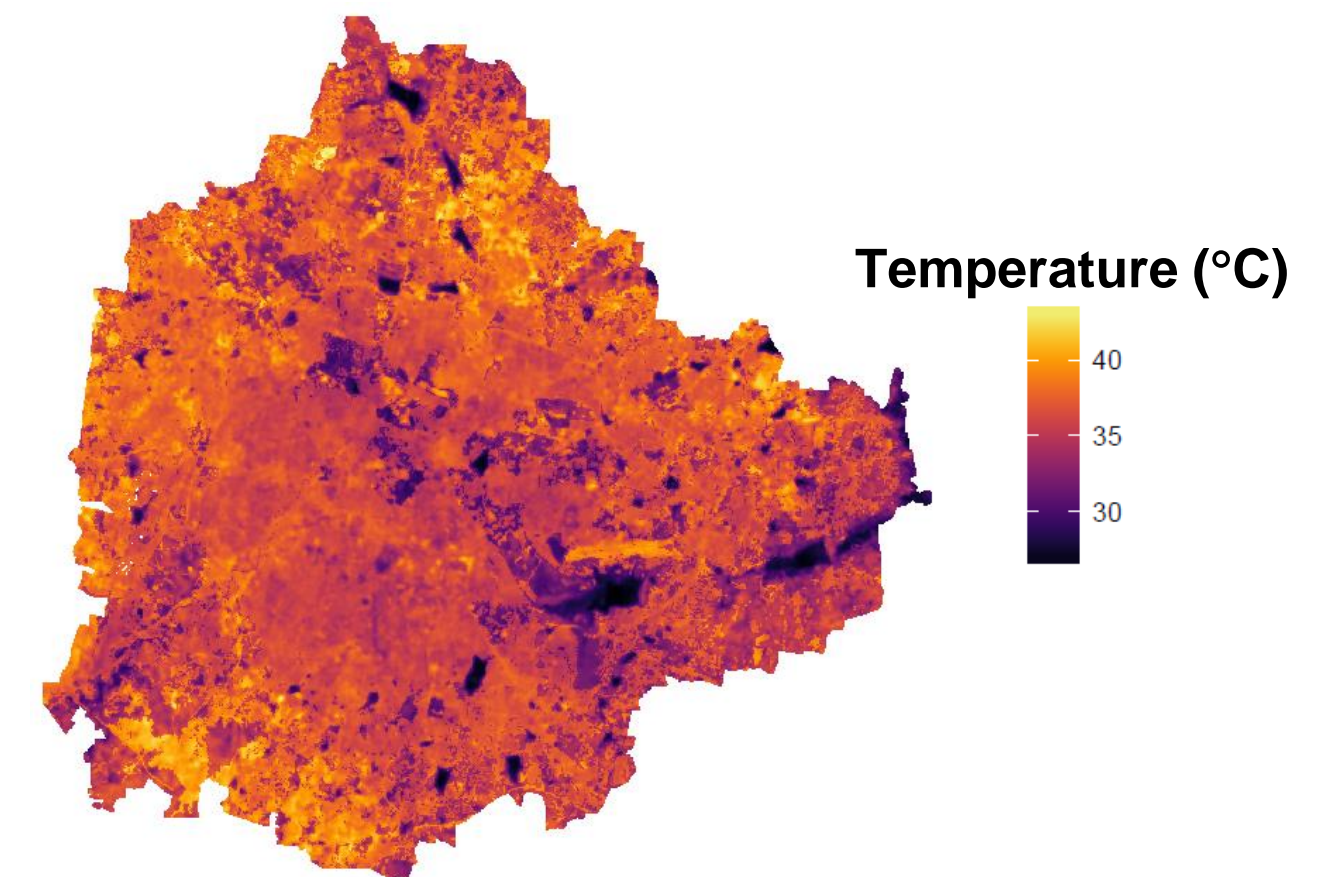

Landuse
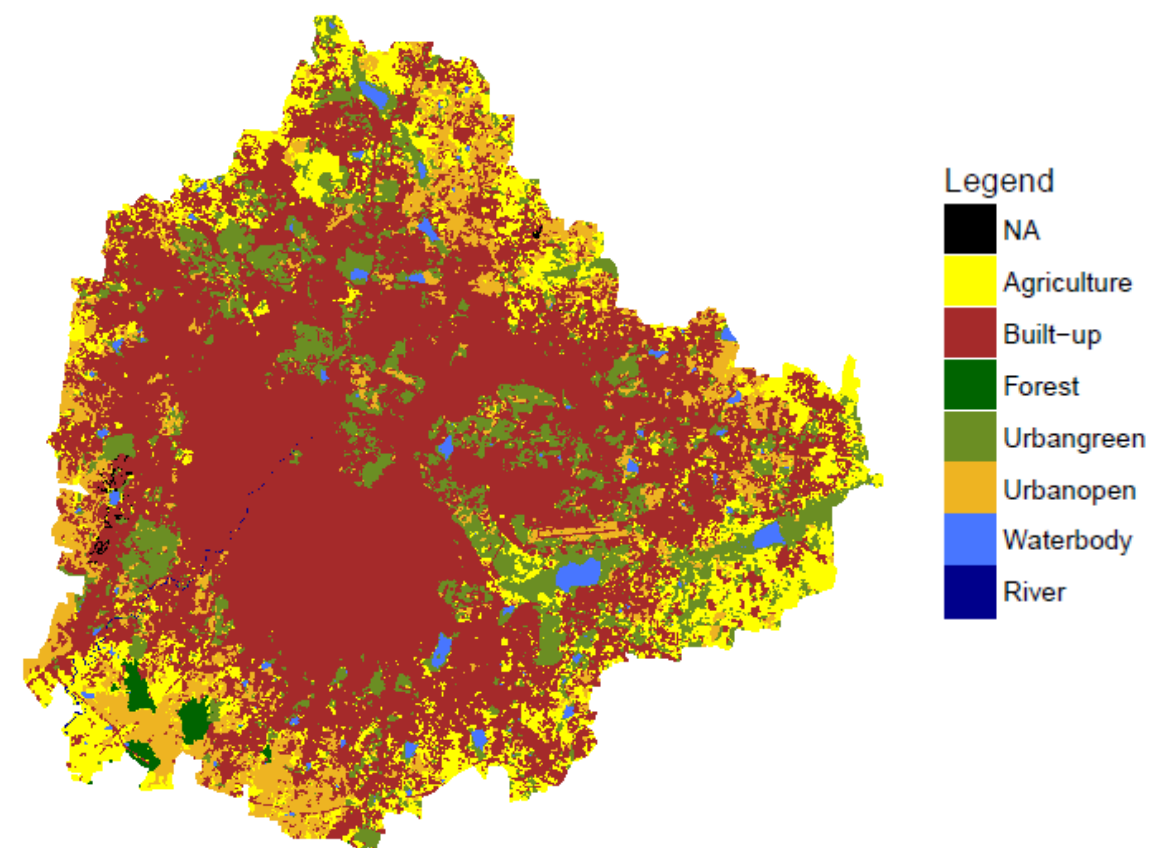
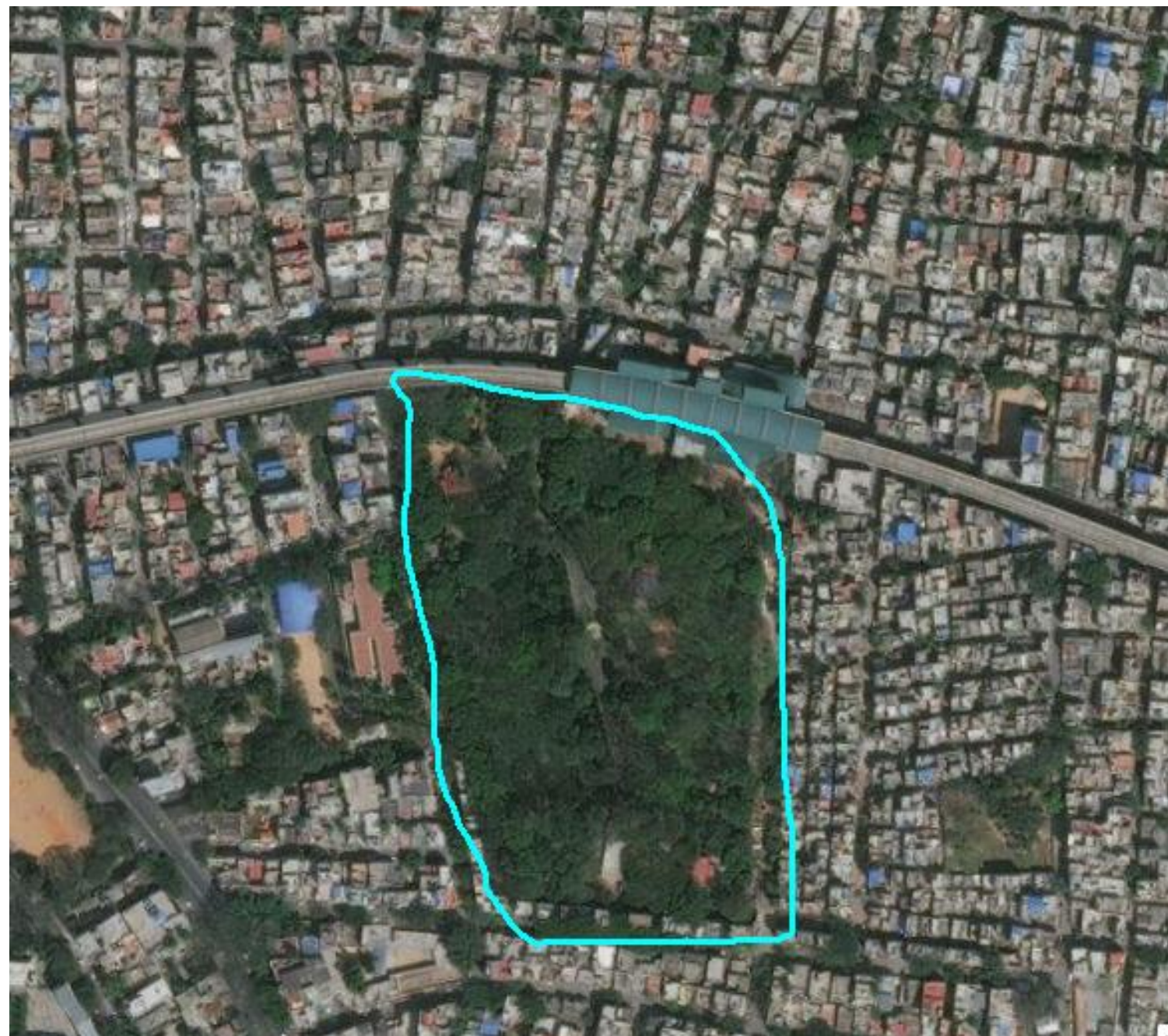NDVI

Land Surface Temperature

Method

- From Google earth, we identify 249 green spaces in Bengaluru

Example of green space
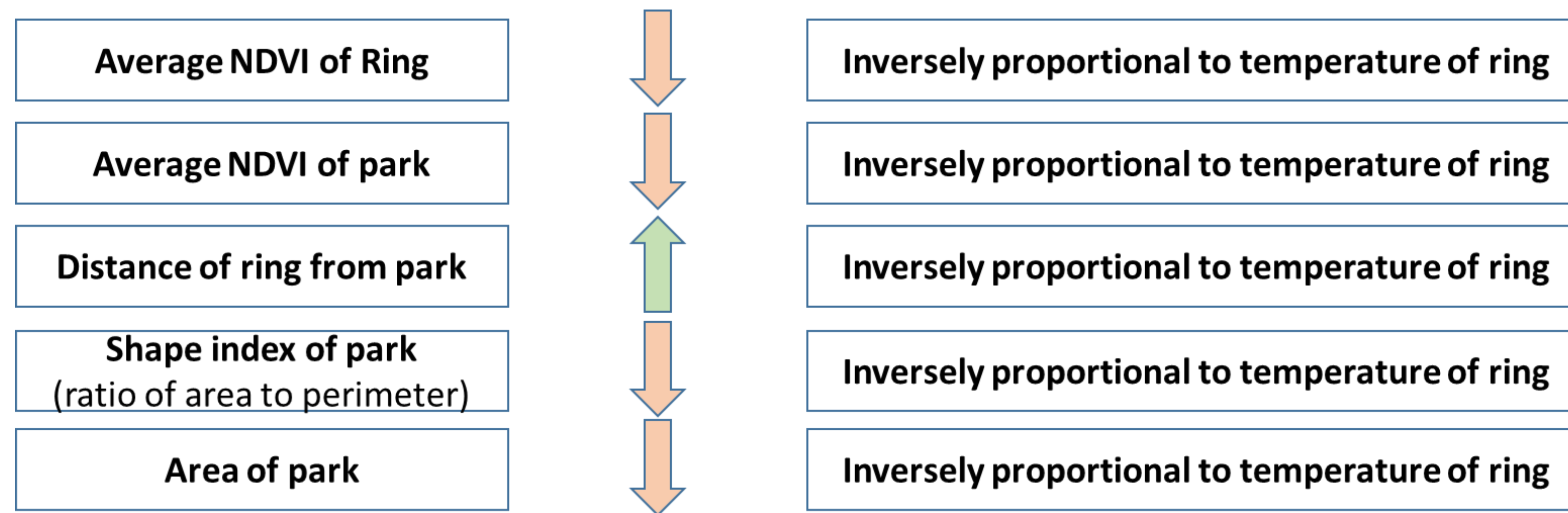
Green space with rings around it

Ring width 30m

25 such rings up to a distance of 750m from the green space

Regression model

- *Average temperature of ring = f (Average NDVI of ring, Average NDVI of park, Distance of Ring from Park, Shape Index of Park, Area of Park)*

Average NDVI of Ring	⬇	**Inversely proportional to temperature of ring**
Average NDVI of park	⬇	**Inversely proportional to temperature of ring**
Distance of ring from park	⬆	**Inversely proportional to temperature of ring**
Shape index of park (ratio of area to perimeter)	⬇	**Inversely proportional to temperature of ring**
Area of park	⬇	**Inversely proportional to temperature of ring**

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Results

Temp vs. distance from greenspace
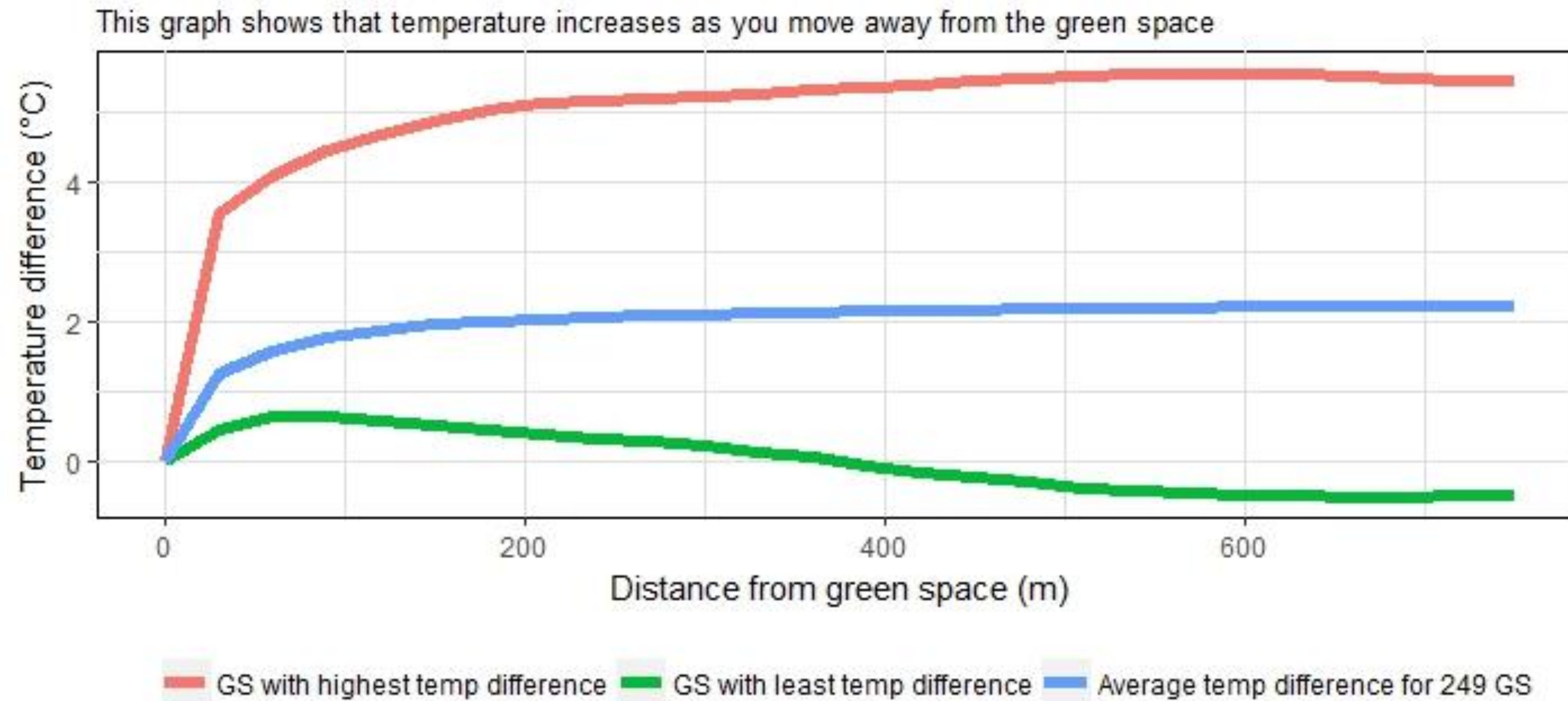
This graph shows that temperature increases as you move away from the green space

Legend: GS with highest temp difference · GS with least temp difference · Average temp difference for 249 GS

X-axis: Distance from green space (m)

Y-axis: Temperature difference (°C)

Thermal impacts of green spaces on their surroundings

	AVG_TEMP
Average NDVI of ring	-13.79***
	(.41)
Average NDVI of green space	-6.58***
	(.36)
Distance of ring from green space (m)	.0008***
	(.0002)
Shape index	-.19***
	(.04)
Area of green space (sq. m)	-.0000008***
	(.0000001)
Constant	42.52***
	(.13)
Observations	2,988
R^2	.61
Adjusted R^2	.61
Residual Std. Error	.92 (df = 2982)
F Statistic	929.2965000*** (df = 5; 2982)

Notes: *P < .05
**P < .01
***P < .001

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Urban policy implications

- Findings provide evidence for the need for safeguarding green spaces in cities - Important in the context of India's Smart Cities Mission

- Nature-based solutions to temperature increase need to be local in nature

- Urban local bodies can use vacant public spaces (vacant lots, roadsides, etc.) for tree plantations

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