



GREEN EQUITY

Designing Heat Resilient Urban Spaces in Delhi

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Designing heat resilient urban spaces in Delhi

by
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ABSTRACT

Delhi, the capital of India, is becoming increasingly hot due to the rising urban temperatures. In recent years, summer temperatures have soared beyond 49°C, with the urban area's average temperatures at least 6°C higher than its rural surroundings. Rapid urbanization, deforestation, the loss of water bodies, and a rapid reduction in green spaces have all contributed to this unbearable heat. But this heat does not affect everyone equally. Low-income communities—often living in the densely packed, poorly ventilated neighborhoods with minimal tree cover—suffer disproportionately from these rising urban temperatures. Their limited access to natural cooling areas further compounds their vulnerability.

This practicum investigates how landscape architecture can serve as a critical tool in mitigating Delhi's rising urban heat. Through spatial analysis, climate data, and design exploration, the practicum addresses the intermingled layers of climate change, social inequity, and environmental degradation.

By analyzing global precedents and conducting a GIS-based heat vulnerability mapping, the practicum identifies neighborhoods most at risk. From this foundation, the practicum develops a multi-scalar urban cooling strategy, deeply rooted in the principles of urban forestry. The design process further concludes in a detailed cooling framework for Bhajanpura, Shahadra, a site characterized by high population density and severe heat stress—where proposed landscape based interventions reintroduce shade, ecological cooling, and communal access these cooling public spaces.

Finally, this practicum offers a scalable framework for designing equitable and heat resilient public spaces, in the face of rising temperatures. It presents a multi-scale approach, incorporating a variety of strategies for urban cooling that can be adapted to different contexts and scales of intervention.

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A. PROBLEM

1 Climate change and rising urban temperatures.



Fig.1. Rising urban temperatures and their effect on the ground level.

"2024 was the hottest year since record-keeping began in 1880,"¹ - NASA Administrator Bill Nelson.

The global climate crisis is accelerating at an unprecedented pace. The world is facing an undeniably urgent reality – global warming and climate change. Since the Industrial Revolution, the Earth's temperature has risen by 1°C. As the planet is warming, so is the urgency to develop climate policies to combat climate change. Approximately 170 countries now have climate policies, yet many nations, including India, have yet to make progress from planning to implementation.²

THE CHALLENGE IN SOUTH ASIAN MEGA CITIES

Temperatures in South Asia are now approximately 2°C higher than preindustrial levels due to climate change, making the region, particularly India, one of the most vulnerable countries globally.³ As temperatures rise, India is facing heat waves that are not only more frequent but also longer and more intense than ever before. For a large proportion of the population, especially those working outdoors, there is no escaping this extreme heat. "Shopkeepers, food vendors, construction workers, drivers, delivery workers and many others have no option but to continue to toil in 50°C temperatures. Hot summers are typical in India, but this year the country saw its longest-ever heatwave, with 24 consecutive days above

40°C in May."⁴ These prolonged heat waves are responsible for over 40,000 suspected cases of heat stroke.⁵

***"The IPCC reports that developing countries (like India) will require \$127 billion annually by 2030 and \$295 billion annually by 2050 to adapt to climate change. Yet the funds allocated are only 4% - 8%."*⁶**

THE CHALLENGE OF RISING URBAN TEMPERATURES AND URBAN HEAT ISLAND EFFECT IN DELHI.

Delhi is one of the fastest-growing megacities in the world, facing the unavoidable challenge of rising urban temperatures and the Urban Heat Island (UHI) effect. With an already high population density of 18,150 people per square kilometer⁷ and a decrease in its green cover from 17.32% to 13.15%,⁸ the city is among one of the most vulnerable cities to the intensifying effects of rising urban temperatures.



Fig.2. A Construction worker working in extreme hot conditions. Photo credit: Sejal Patel



Fig.3. Children seeking relief from Delhi's heat waves. Photo credit: Ana San Juan on Unsplash

WHAT IS THE URBAN HEAT ISLAND EFFECT?

The Urban Heat Island (UHI) effect is the phenomenon where urban areas experience higher and warmer temperatures than their surroundings due to changes in land use changes and anthropogenic activities.⁹ This phenomenon is usually driven by dense built-up areas dominated by impervious surfaces such as concrete, asphalt and glass which absorb and re-radiate heat.¹⁰ The rapid loss of green vegetation, further adds to the problem of rising urban temperatures. These plants provide natural cooling through the process of evapotranspiration.¹¹

DELHI'S VULNERABILITY AND GLOBAL TREND

"By 2050, over two-thirds of the world's population is expected to be urban, many living in unplanned and informal settlements in Africa and Asia." (UNDESA, 2018)

In Delhi's context, by 2050, Delhi's population is expected to reach approximately 36.2 million¹², whereas Delhi's built-up area will expand from 2,210 square km to 5600 square km, projecting a 2.5-fold increase.¹³

PERSONAL EXPERIENCE AND THE NEED FOR EQUITY

Growing up in Delhi, I have witnessed firsthand how the city's climate changed over the years. Unbearable rising urban temperatures, prolonged heat waves and shrinking green spaces have pushed children and adults to stay indoors. Rather than playing outside, children are limited to indoor activities under the cool environment of an air conditioner. But what about children who cannot afford an air conditioner? What about the construction workers who have to work in the extreme heat to earn their livelihood? The marginalized communities, who often lack access to green infrastructure and cooling solutions, bear the brunt of the rising temperatures in the city. We must prioritize equitable green landscapes to combat the heat and create a heat-resilient city. Through a range of nature-based interventions at different scales, I aim to provide cooler urban spaces in a heat-vulnerable neighbourhood of Delhi.

Delhi has started to address rising urban temperatures through measures like the Delhi Heat Wave Action Plan, which focuses on heat-vulnerable areas and implements short-term mitigation strategies. Although these strategies are essential, they are not sustainable and efficient in the long

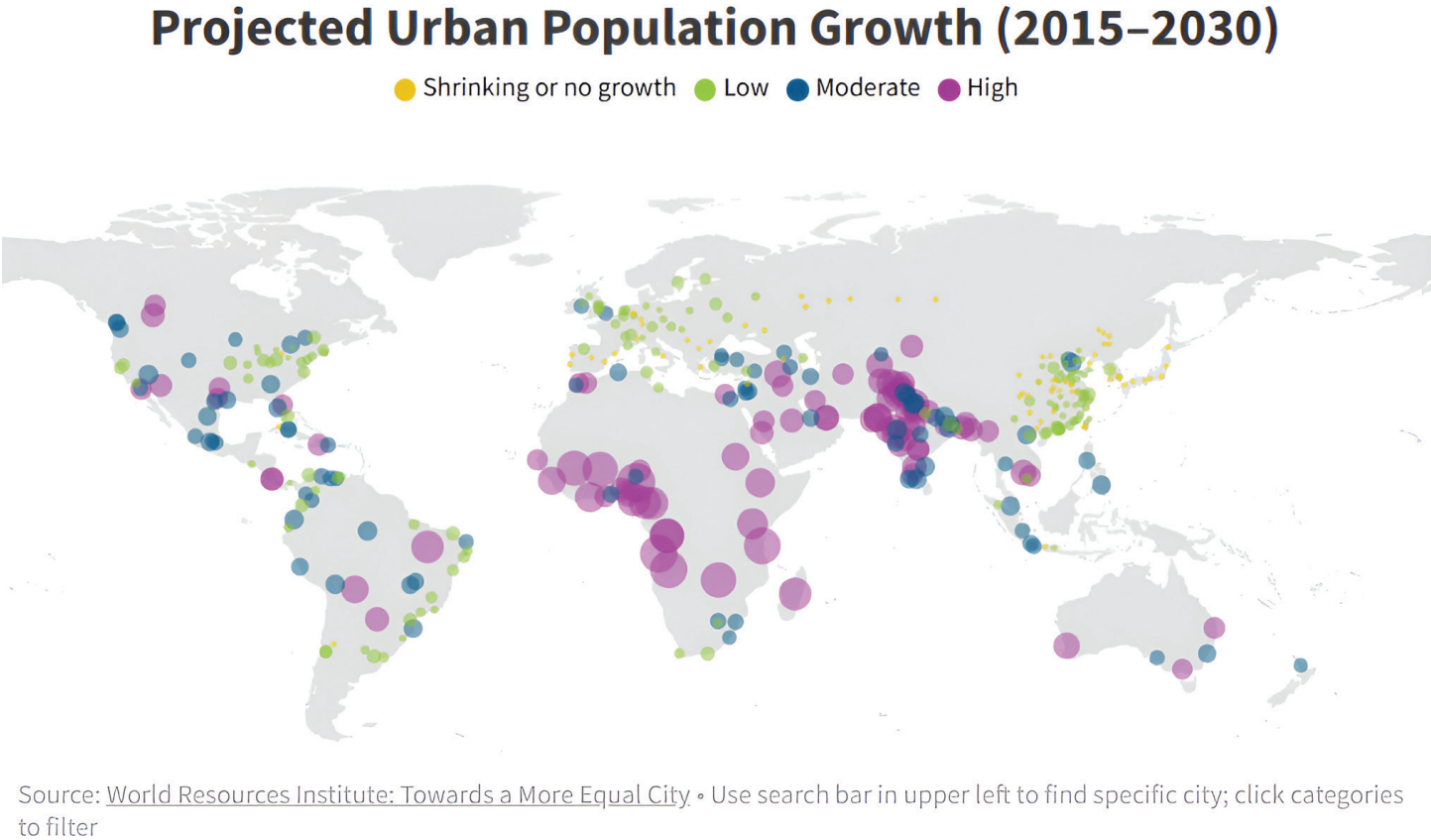


Fig.4. Projected Urban Population Growth (2015 - 2030). Photo credit: World Resource Institute

-term sustainable strategies for urban heat islands and climate change mitigation.

RESEARCH PURPOSE AND SCOPE

This research investigates how landscape-based interventions and equitable green infrastructure can mitigate UHI effects in Delhi. It aims to identify design strategies that enhance ecological resilience while ensuring inclusive access to cooler, healthier, and more liveable urban environments.

RESEARCH QUESTIONS

- 1. How can green and blue infrastructure be integrated into densely built environments to mitigate rising urban temperatures and maximize urban cooling effects?
- 2. What are the most effective plant species and design strategies for creating heat-resilient public spaces in Delhi’s climatic context?
- 3. How can spatial design strategies address these inequities to promote inclusivity and resilience?



Fig.5. Construction workers working under extreme heat conditions. Photo credit: Omer Faruq Khan on Unsplash

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B. CONTEXT

2 CONTEXT

Delhi's warming landscape

Delhi Hits 52.3°C, Highest-Ever Recorded Temperature. - 2024 ¹⁴



Delhi, दिल्ली

Delhi, the capital of India, with a population of over 32 million people, is one of the most populated megacities in the country. The city is bounded by Uttar Pradesh to the East and by Haryana to the North, West and South.¹⁵

Due to its strategic location, Delhi serves as an important hub for governance, commerce and culture. The city is primarily flat with the Delhi Ridge, an extension of the Aravalli Hills, adding an elevation within the urban landscape. The natural landscape of Delhi is broadly divided into four distinct parts based on its geology and geomorphology:

- कोही Kohi (hills),
- बांगर Bangar (mainland),
- खादर Khadar (Sandy alluvium along the Yamuna river),
- डाबर Daabar (low-lying areas/ flood plains)."¹⁶

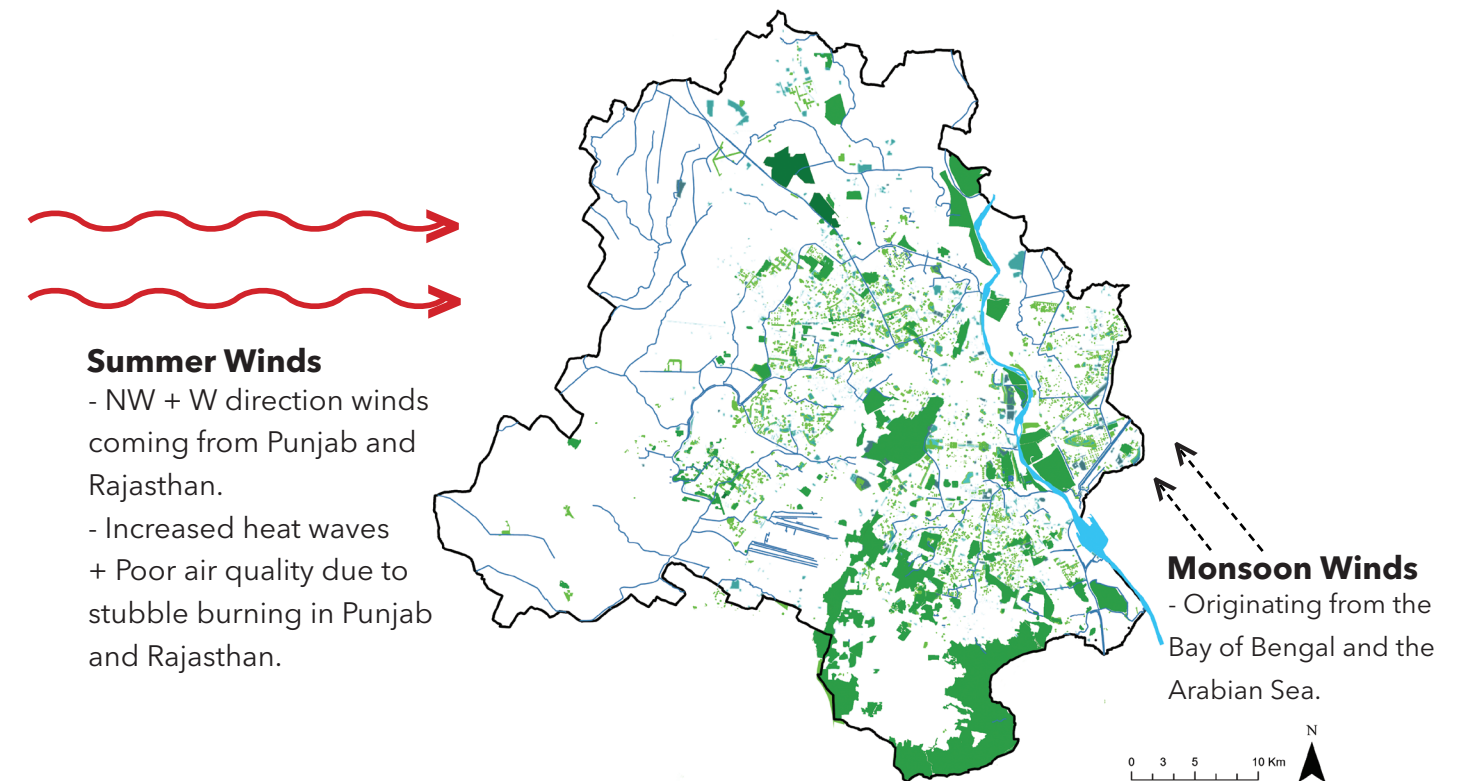
Delhi's climate is also influenced by its strategic location in North Central India. Hot, dry winds from the Thar desert, locally called "loo," travel across Rajasthan and Punjab and sweep across Delhi during the summer months. This "loo" significantly raises Delhi's urban temperature.¹⁷ In addition to these hot wind movements, human-induced factors such as stubble

burning from the neighbouring agricultural states, Punjab and Haryana, add to the problem. The smoke from this stubble burning fills the air with pollutants, worsening Delhi's already poor air quality and making heatwaves even more intense.¹⁸

These factors combine to create a hot, dry, and environmentally strained climate. Rapid urbanization, fragmented green infrastructure, and growing anthropogenic pressure caused by the increasing population further exacerbate this situation—issues that will be explored in depth later in this chapter. Yet Delhi was not always this hot; it was once a city cooled by nature. Delhi's climate is significantly shaped by its natural features such as the Delhi Ridge and the Yamuna River, both of which played crucial roles in regulating the city's temperature. The Delhi Ridge acts as a thermal moderator and traps air pollutants from the urban environment and cooled the city through an increased rate of evapotranspiration. According to the book *Weather in the City*, the land heats up more quickly than the forests, which take longer to warm. This difference in the rate of warming creates an underpressure, thus, the cool air is sucked from the Ridge towards the neighbourhoods, providing a natural cooling mechanism for the city.¹⁹



Fig.6. Delhi location map.



Summer Winds

- NW + W direction winds coming from Punjab and Rajasthan.
- Increased heat waves + Poor air quality due to stubble burning in Punjab and Rajasthan.

Monsoon Winds

- Originating from the Bay of Bengal and the Arabian Sea.

Generally, the urban forests and water bodies exhibit lower LST (Land Surface Temperatures). These temperature variations are due to various factors, such as the type of vegetation cover, land use, and the thermal conductivity of different building materials which the city is made up of. During the peak hot summer months, Central and Eastern Delhi often experienced temperatures between 34-39°C, while the more vegetated regions, such as Delhi Ridge, were much cooler and experienced temperatures of around 28-30°C. This temperature disparity is a clear example of the Urban Heat Island (UHI) effect, where the urban infrastructure traps heat and makes the areas considerably hotter as compared to the vegetated areas.²⁰

This intra-urban temperature variation significantly highlights not only the rising urban temperatures but also the UHI effect, not just in comparison to the rural areas but also relative to vegetated areas. In Delhi's context, the Ridge functions as a critical thermal moderator, demonstrating the value of restoring green infrastructure and its role in reducing the urban temperatures within the city. In addition to the Delhi Ridge, the Yamuna River also plays an important role in regulating urban temperatures. The river helps cool its surroundings through a process known as the River Cooling Effect (RCE).

When the short-wave radiation from the sun reaches the river, the heat is removed by the process of evaporation, and this flow creates an Urban Cooling Effect (UCI). As noted by Oke (1982), this high rate of evaporation from water bodies leads to an "Oasis effect", where the surrounding air temperature is significantly reduced.²¹ For instance, the mean temperature near the Yamuna River was found to be 33.83°C, which was lower than the city's average temperature of 35.83°C.²² The combined effect from the Delhi Ridge and the Yamuna River, worked together to alleviate the urban heat experienced by the city. However, the efficacy of the Delhi Ridge and Yamuna River in cooling Delhi has now been compromised.

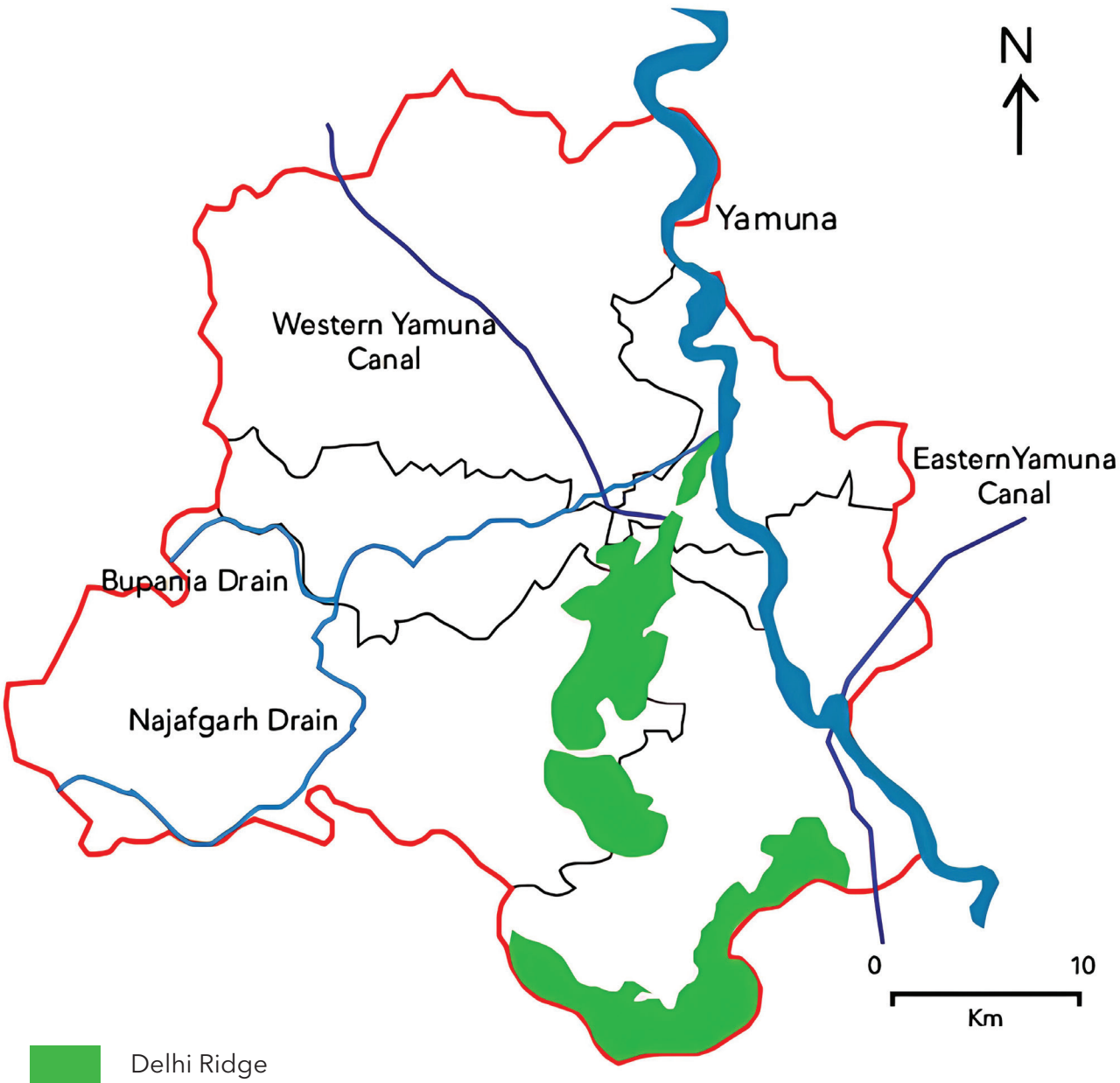


Fig.8. Delhi geomorphological features. Adapted from an original image by Hindi Water, via Flickr

The Yamuna and the Ridge:

Why are Delhi's Natural Cooling Systems Falling Short ?

The Yamuna River is severely polluted as indicated by its high Biochemical Oxygen Demand (BOD) levels in the river. "Biochemical oxygen demand (BOD), is a critical indicator of organic pollution in water bodies, and reflects the amount of dissolved oxygen used by microorganisms as they decompose organic matter." ²³ The BOD levels in the Yamuna River are elevated due to untreated sewage and industrial discharge, leading to increased microbial decomposition. This microbial decomposition consumes oxygen, and generates heat, thereby raising the water temperature and reducing the river's ability to cool the adjacent areas effectively. ²⁴

Research indicates that the Shahadra drain alone contributes about 73% of the total BOD, leading to oxygen depletion in the Yamuna River.²⁵ In response, the government has launched several initiatives such as the Clean Yamuna Mission and setting up decentralized Sewage Treatment Plants (STPs)²⁶ to address pollution at its main source and restore the river's ecological and thermal functions. As a result of these initiatives, the Yamuna's water quality has improved in recent years. For instance, the Delhi Pollution Control Committee reported a 33% reduction in BOD level in the Najafgarh drain, which releases a significant amount

of untreated sewage into the river, from 80 mg/L in January 2022 to 53 mg/L in January 2023.²⁷ This improvement shows a positive trend in enhancing the river's natural cooling capacity. However, this improvement is not enough. To further increase the Yamuna River's role in temperature regulation and promoting ecological health, there is a continued need for cleaning the river.

DELHI RIDGE

The Delhi Ridge, once a vital ecological buffer providing significant cooling to the city, has faced severe degradation due to an increased demand for urban development. Due to the encroachment of urban development, the forested area under Delhi Ridge has been reduced from 15,046 hectares to 7,785 hectares. ²⁸ Additionally, the spread of invasive species like *Prosopis juliflora* and *Lantana camara* have outcompeted native plants, altering the ecosystem and limiting its ability to regulate temperatures.²⁹



Fig.9. Toxic froth in Yamuna, due to high phosphate concentration. Photo credits: Jyotirmoy Gupta on Upsplash



Fig.10. Yamuna water pollution. Photo credits: Enrico Fabian on Unsplash

Factors contributing to rising urban temperatures in Delhi

Climate change and the degradation of natural cooling systems such as forests and rivers are not the only causes of rising urban temperatures in Delhi. Rapid urbanization, the dominant use of heat-retaining materials, increasing population densities, the associated rise in cars and air conditioner usage, and a fractured blue-green infrastructure further exacerbate rising heat levels.

1. RAPID URBANIZATION

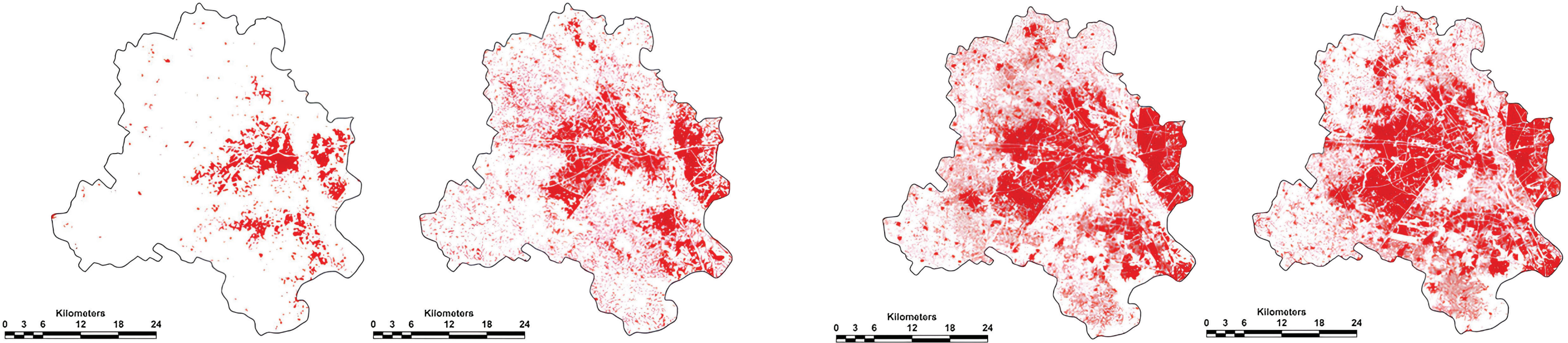
Urbanization is directly related to the increase in built-up areas in the region.³⁰ Delhi has changed dramatically in the last three decades. Built-up areas increased

from 21% in 1991 to 48% in 2018³¹, while the cropland area decreased by half during the same time period.³² This shows the direct relationship between how built areas are being developed at the cost of green infrastructure. Green infrastructure with low albedo surface has been replaced by heat-trapping materials such as concrete, glass, and asphalt across the city's fabric. Unlike open green spaces that don't trap heat, dense urban environments trap heat in the "urban canyons".

These canyons absorb solar radiation during throughout the day and release heat slowly at night, resulting in persistently



Fig.11. Delhi street images showing overdominance of impervious surfaces.



A. Built-up Area of Delhi in 1977

B. Built-up Area of Delhi in 1993

C. Built-up Area of Delhi in 2006

D. Built-up Area of Delhi in 2014

Fig.12. A-D. Rapid Urbanization: Built-up area of Delhi from 1977-2014

high nighttime temperatures and offering little relief to residents. Delhi's cityscape is dominated by asphalt, concrete, glass and other impervious surfaces, which disrupts the natural cooling effect provided by green infrastructure.³³ The surface temperatures of these high heat retaining materials such as concrete and asphalt can reach up to 82°C (180°F) during peak summer months.³⁴

For instance, on May 17, 2010, Delhi recorded a maximum temperature of 45°C, the highest temperature ever recorded for May, according to the Indian Meteorological Department.³⁵ By 2020, these extreme temperatures in Delhi surpassed 46°C repeatedly, highlighting the severity of urban warming.³⁶ Most recently, in 2024, Delhi recorded its highest ever temperature of 52.3°C further highlighting the city's deteriorating thermal comfort.³⁷

URBAN MORPHOLOGY AND HEAT ENTRAPMENT IN DENSE URBAN AREAS

Beyond the heat-trapping materials, urban morphology such as the shape, form and layout of the built environment plays a very important role in urban cooling or in combating the rising temperatures. Delhi's most heat-vulnerable neighbourhoods are often the oldest and most densely built neighbourhoods, which were developed without proper planning and consideration

for climate adaptability and air ventilation.³⁸ These areas often show urban characteristics such as irregular and tight street networks, irregular block patterns, and thus narrow lanes, that restrict the airflow and trap heat. This lack of urban ventilation, use of impervious materials and lack of green spaces, makes it nearly impossible for the hot air to escape.

These unplanned and highly dense urban blocks of the city further exacerbate the Urban Heat Island (UHI) effect, not just through the change in Land use but also through its spatial configuration. According to Balha et al. (2020), Delhi's built-up area expanded fourfold between 1973 and 2016.³⁹ This drastically altered the land surface conditions and led to unplanned urban sprawl. This impact is severely felt in low-income and unplanned built urban areas, where thermal discomfort often overlaps with social vulnerability.

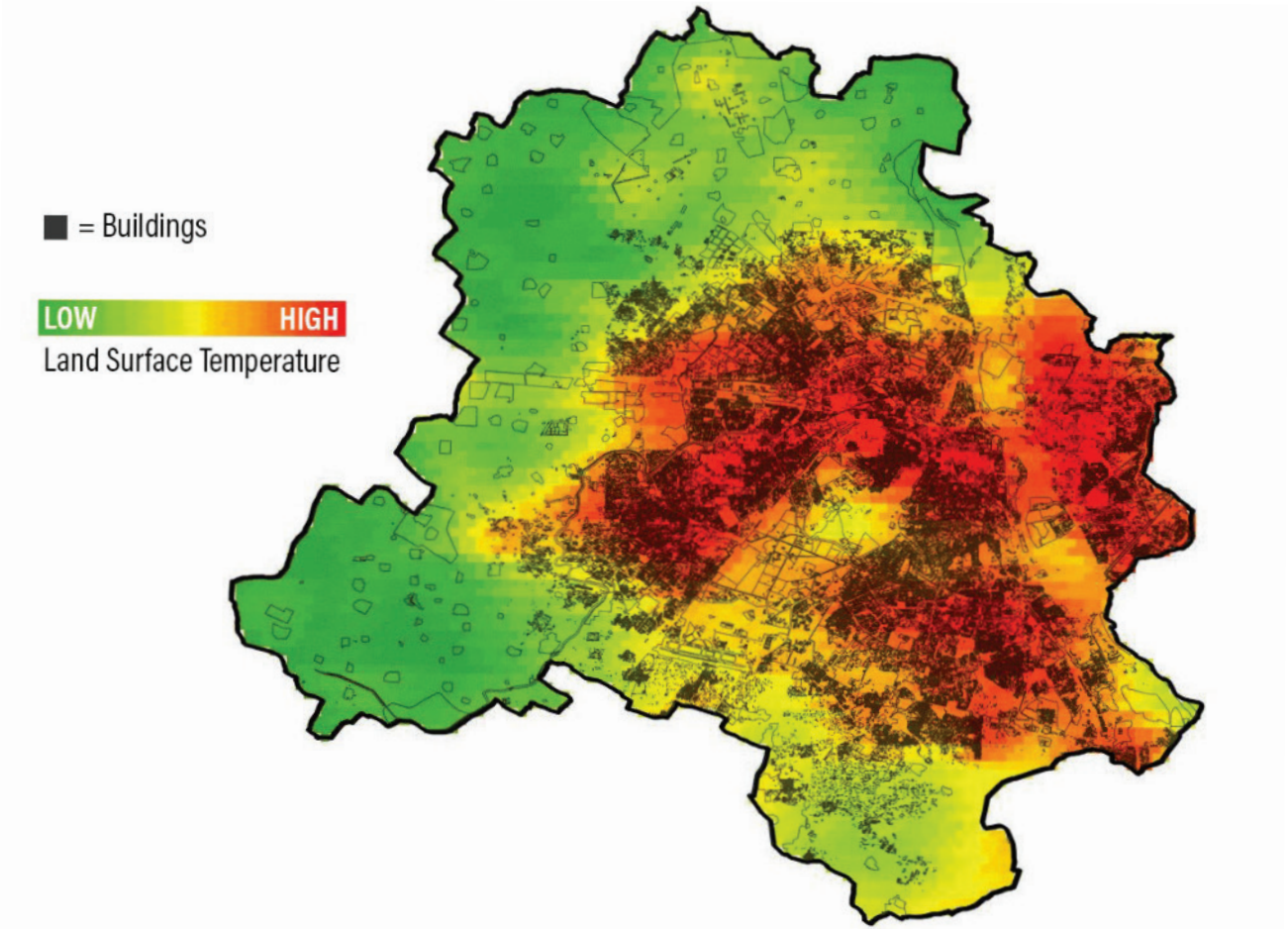


Fig.13. Land Surface Temperature in Delhi. Photo Credit - World Resources Institute.

2. POPULATION DENSITY

The population density of an area plays a crucial role in the rising urban temperatures. High population density results in greater Anthropogenic heat release with an increase in human activities such as increased transportation, cooking and energy heat release from using air conditioners etc. These anthropogenic activities further warm the immediate surroundings, particularly in densely built environments. Between 2000 and 2020, Delhi witnessed rapid population growth and urbanization leading to a significant increase in anthropogenic activities and land-use changes. These transformations resulted in a noticeable shift in the city's temperature patterns, affecting both minimum and maximum temperatures.⁴⁰

Delhi's Population:
33 million.
Delhi's Population Density:
11,320 people/ km²



Fig. 14. Overcrowded city, with no sight of trees. Photo credit: Meetesh Manjula on Unsplash

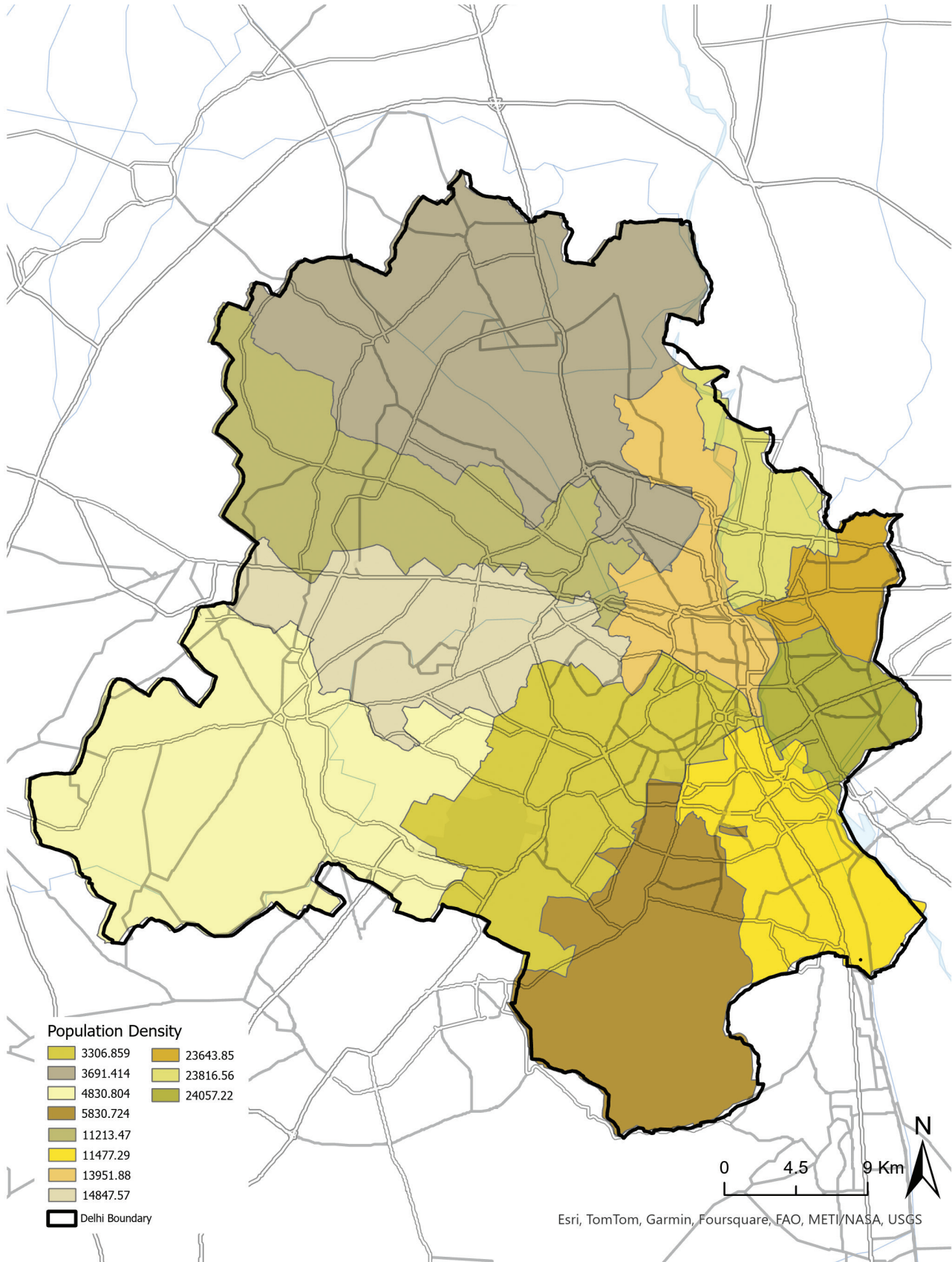


Fig. 15. Delhi Population density

Scale 1: 315,000

3. FRACTURED GREEN INFRASTRUCTURE

As built-up areas rapidly expanded across Delhi, the city’s green and blue infrastructure became increasingly fractured, reducing the impact of evapotranspiration and cooling effects on the surroundings. Over the years, the city’s green cover has experienced noticeable fluctuations, mostly due to rapid urbanization.

According to Naidu, 2022, the city’s green cover declined significantly from 17.32% in 1977 to 10.50% in 2006, reflecting the impact of urbanization and reduced prioritization of green spaces. While the green cover increased to 13.5% by 2022, it still falls short of the ideal green cover of 33% in the city.⁴¹ More critically, this 13.5% green cover is unevenly distributed across districts.⁴²

This disparity in the green cover’s distribution is one of the major contributing factors to higher urban temperatures. This uneven distribution of green spaces highlights the socio-economic disparities, raising concerns about environmental equity in the city.

During this same time period, the Normalized Difference Vegetation Index (NDVI) fell from approximately 82% in 2000 to 62% in 2020, largely due to the rapid urbanization and land-use change. This reduction in vegetative cover has further intensified the impact of the UHI effect, contributing to higher urban temperatures and increased thermal stress.⁴³

Green Cover (in%)

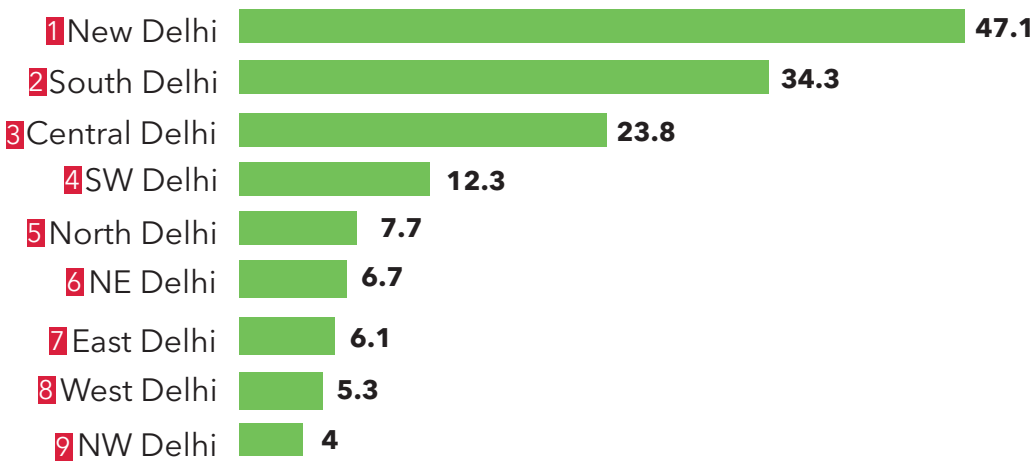


Fig. 16. Delhi Green Cover distribution percentage. Adapted from The Times of India News article.

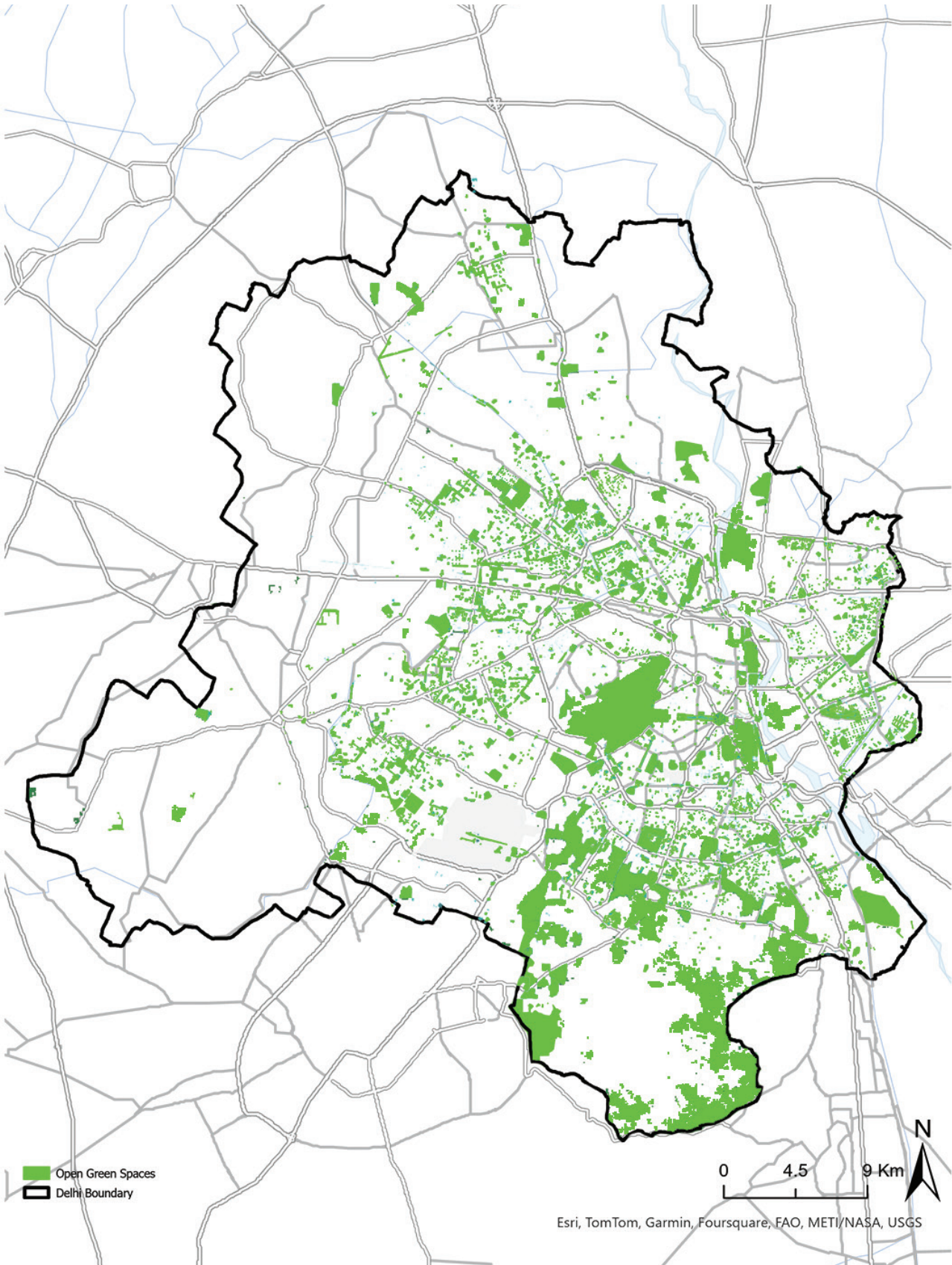


Fig. 17. Delhi Green Infrastructure

Scale 1: 315,000

4. FRACTURED BLUE INFRASTRUCTURE

The city's blue Infrastructure has also followed a similar declining trajectory. Despite historically being a city with more than 900 water bodies, including taalabs, lakes, wetlands, drains and canals⁴⁴, Delhi has lost nearly 49.1% of them due to encroachment and water pollution.⁴⁵ Many of these water bodies such as taalabs, and lakes were particularly important for low-income settlements, serving not just as passive cooling systems but also as important areas for ritual uses as well as for recreational purposes. Their disappearance has left the marginalized areas with no cooling microclimatic buffer to rely on.

Furthermore, many canals especially in East and Northeastern Delhi are highly polluted and choked, further reducing their cooling efficiency. Although Govt. plans such as the Delhi Forest Action Plan and the Yamuna Action Plan recognize the role of green and blue infrastructure in urban cooling, their implementation still remains largely fragmented. The Delhi Forest Plan focuses on increasing forest and tree cover through urban greening efforts such as greening vacant lands, and roadside plantations among many others. For instance, for the year 2024-2025, they are set to plant over 2.4 million trees and more than 3.1 million shrubs through

integrated efforts by agencies such as the Forest Department, DDA, and MCD.⁴⁶ Similarly, the Yamuna Action Plan is mainly focused on pollution control and riverfront rejuvenation via sewage treatment infrastructure.⁴⁷ Even after all these extensive plans, the problem lies in the execution of the Plan to Implementation. Also, the current plans fall short of integrating landscape-based interventions in dense neighbourhoods.



Fig. 18. Delhi Water Infrastructure

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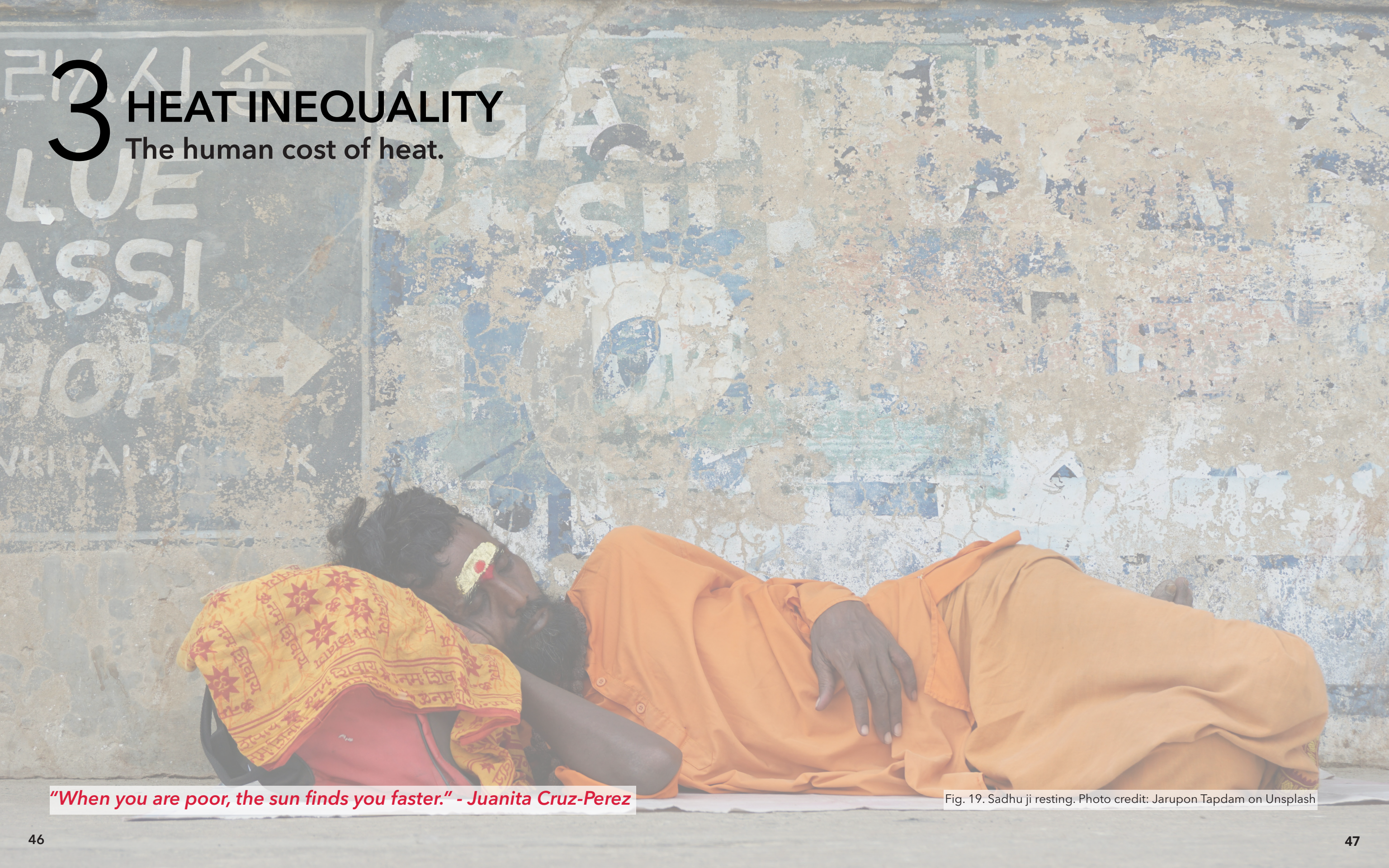
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3 HEAT INEQUALITY

The human cost of heat.

"When you are poor, the sun finds you faster." - Juanita Cruz-Perez

Fig. 19. Sadhu ji resting. Photo credit: Jarupon Tapdam on Unsplash

HEAT’S IMPACT ON THE HUMAN BODY

The rising temperatures in Delhi pose a significant threat, pushing the environment beyond the limits required for normal physiological function. The human body is designed to function within a temperature range of 36-38°C. Maintaining this internal body temperature is critical for enzyme activity and organ performance.⁴⁸

When the environmental temperatures exceed this range, the human body faces significant challenges and activates several cooling mechanisms such as:

A. Excessive Sweating: Sweat glands release excessive moisture onto the skin, leading to evaporative cooling.

B. Vasodilation: Under severe heat waves, 48% of blood flows to the skin, leading to low blood pressure, causing dizziness and fainting.

Under extreme conditions, the body faces several medical symptoms such as:

- 1. Dehydration.
- 2. Heat Strain.
- 3. Cardiovascular Strain.
- 4. Renal Failure.⁴⁹

But this heat doesn’t affect everyone equally. Urban poor communities, Outdoor workers, the elderly, pregnant women, and young children are the most vulnerable.

According to India’s Ministry of Health, over 41,000 cases were reported nationwide.⁵⁰

This group of urban poor communities often live in the hottest part of the city, but not by choice, by design. These areas lack basic cooling amenities such as tree-lined streets, shaded pathways, public parks and ventilated housings.⁵¹ They are also shaped by dense urban fabric, with minimal green coverage, little to no airflow and ventilation, and high surface retention.

Delhi hospitals’ week of horror amid influx of heatwave cases. ‘Saw patients die faster than in Covid’

Before rain brought respite, doctors say surge in number of patients with heatstroke & heat exhaustion put unparalleled pressure on hospitals’ resources, with most needing intensive care.

SUMI SUKANYA DUTTA and MRINALINI DHYANI 22 June, 2024 03:18 pm IST

1.

Delhi govt. directs hospitals to ramp up facilities as heat-related deaths rise

Published - June 20, 2024 12:55 am IST - New Delhi

THE HINDU BUREAU

2.

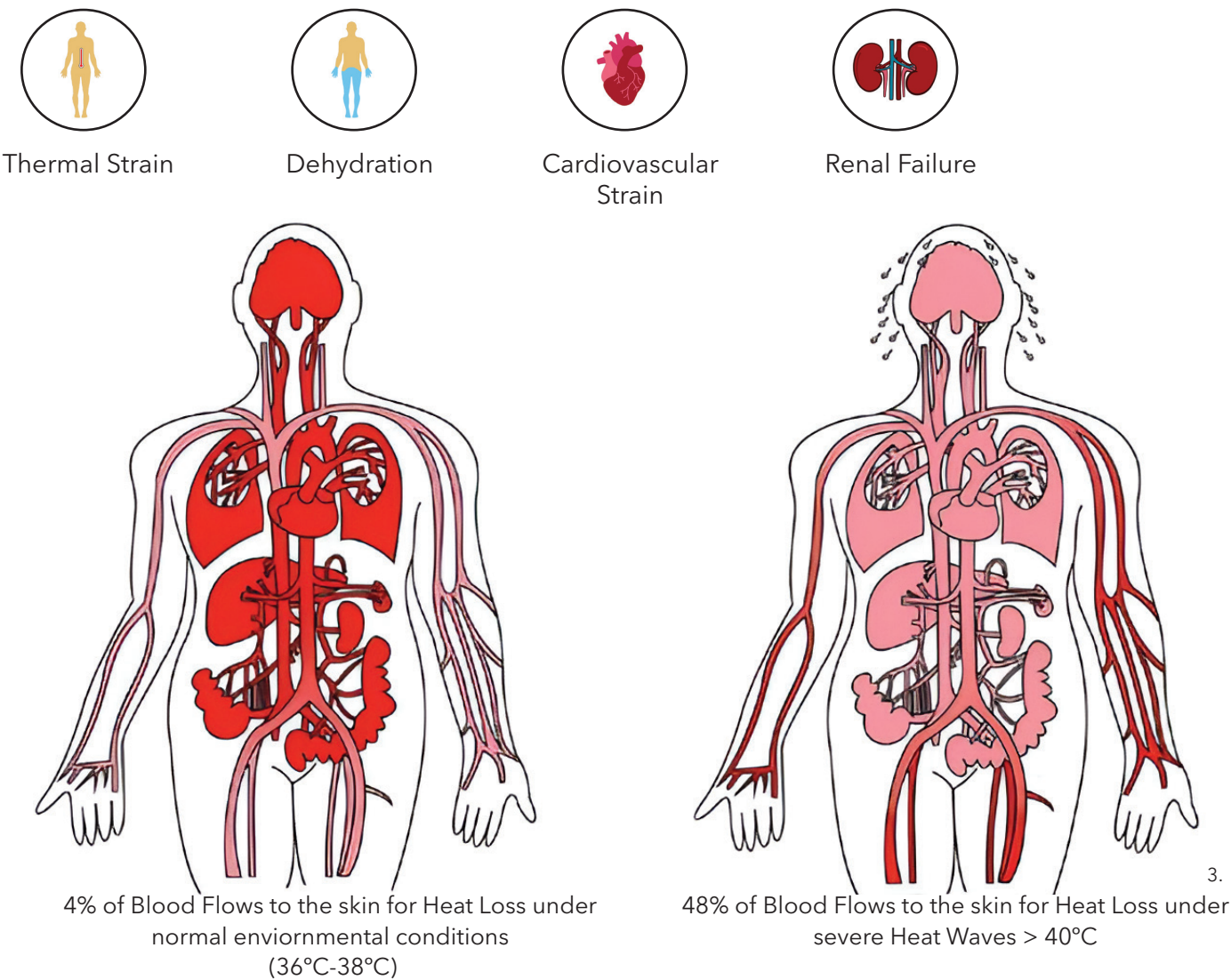
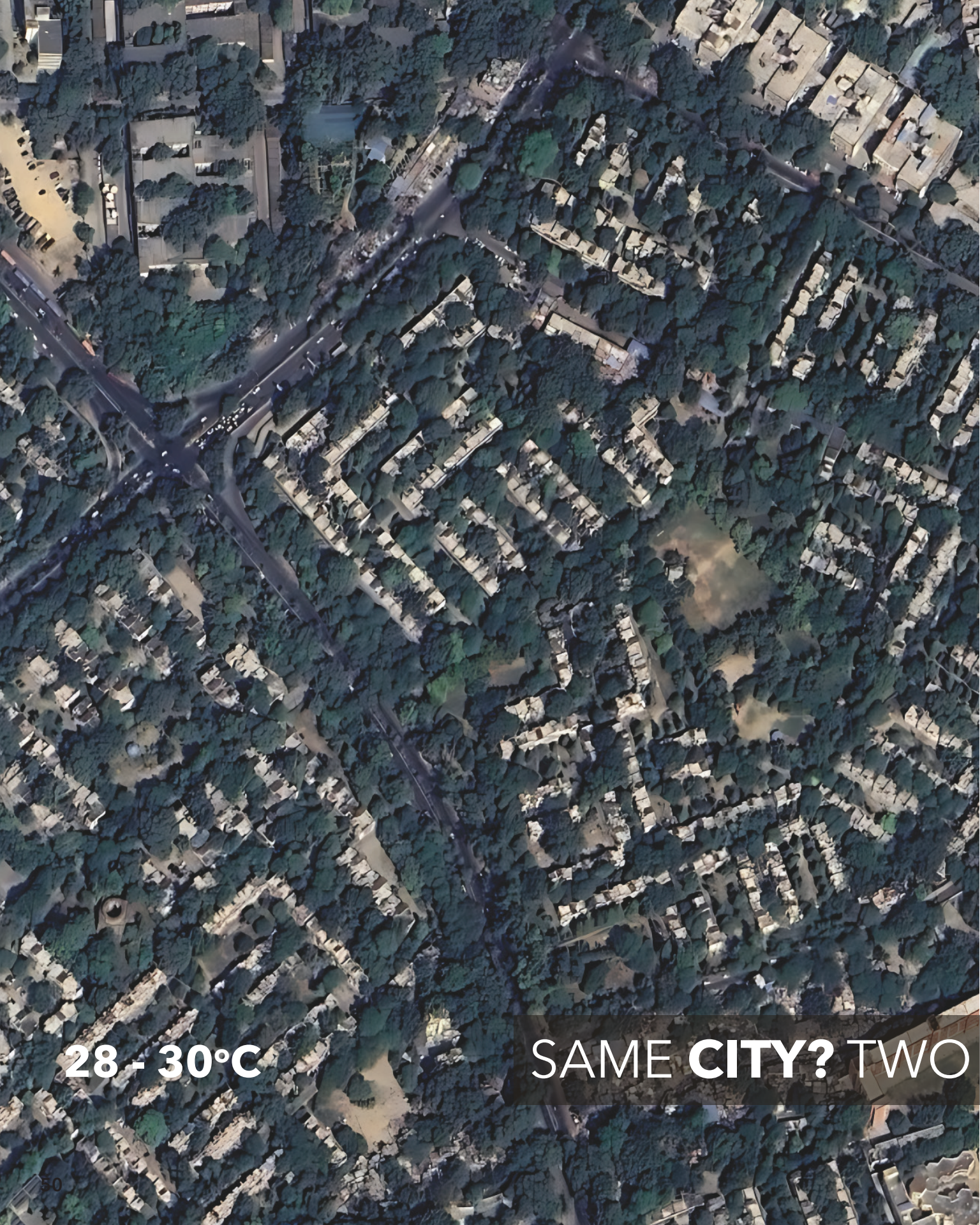


Fig. 20. Heat’s impact on the human body.



28 - 30°C

SAME CITY? TWO



"As Delhi baked under the heatwave, the temperature disparity between rich and poor became painfully clear. In posh neighborhoods with sprawling lawns and air-conditioned homes, the discomfort was manageable. But in Delhi's sprawling slums, a different story unfolded. In urban slums, temperatures can soar up to 6°C higher than other city areas, exacerbating public health and socioeconomic crises." ⁵²

DIFFERENT REALITIES

36°C

Fig. 21. Social disparity within the city.

HEAT VULNERABILITY AND THERMAL COMFORT ANALYSIS - Identifying Heat-Vulnerable Districts.

To actively map and understand the measure of this inequity, a GIS-based heat vulnerability analysis was conducted, based on the research work done by Sonal Gangrade, IIT, India (Gangrade 2023). This heat vulnerability research conducted by Sonal Gangrade identified the zones of high heat vulnerability by taking into consideration factors such as:

- Land Surface Temperature (LST),
- land use/ land cover,
- population density, as well as,
- socio-economic indicators.

The resulting map of this research and the highly heat-vulnerable districts as shown on the map, clearly highlights that the districts most affected by heat as identified in the map are among the poorest, further confirming that Delhi’s marginalized communities are also the most vulnerable to the rising urban temperatures. However, what the study lacked was an extensive examination of the spatial configuration of the urban built form itself - the street patterns, built density and presence of green open spaces affect the local urban temperatures. To fill this gap, and better understand how the spatial configuration of the built form affected the urban temperatures, I conducted an urban fabric analysis using the overlaying method

in ArcGIS. A 10 km x 10km grid was overlaid across the representative districts, capturing the variations in the built form. These selected built areas were then correlated back with the heat vulnerability zones, revealing how the urban design choices add to the social vulnerability. The findings of the research further strengthen our argument. In high vulnerability zones, the urban fabric was characterized by high building density, fractured green spaces, narrow streets and a lack of open areas. The final results were then compiled into a table that highlights and compares the spatial disparity in urban heat exposure across districts. This comparative table further reinforces the need to target and implement heat mitigation interventions (such as adding green infrastructure) starting with the city’s most heat-vulnerable zo

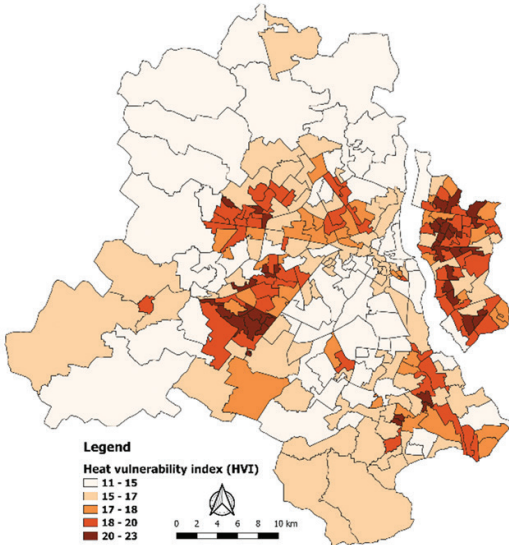


Fig.22. Heat Vulnerability Index.
Credit: Sonal Gangrade, IIT Delhi.

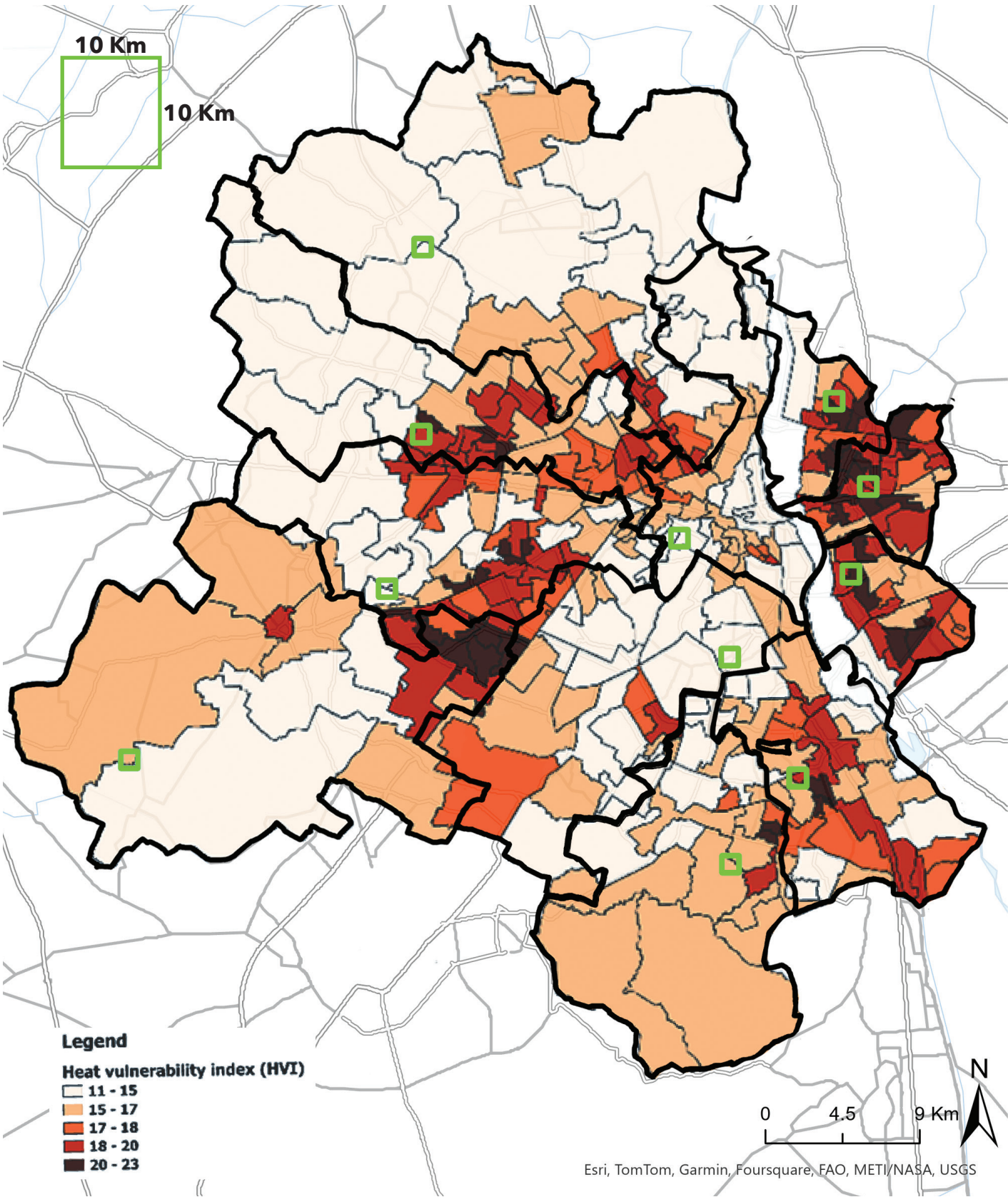
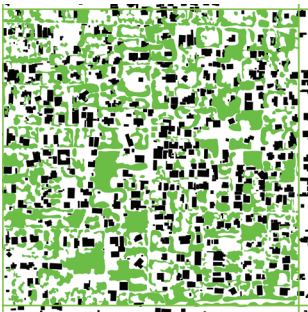
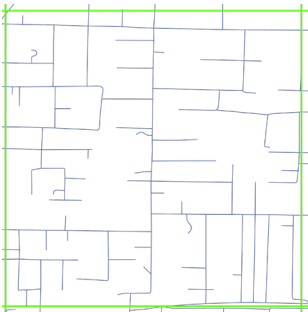
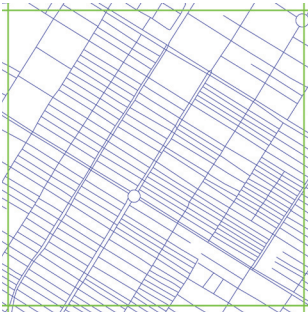
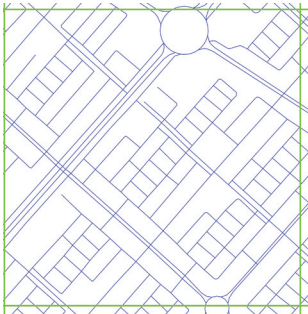
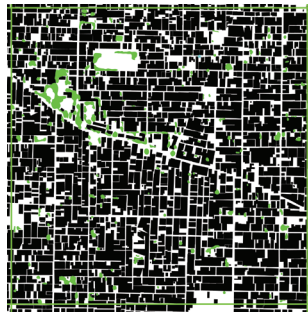
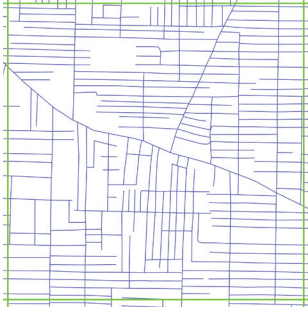
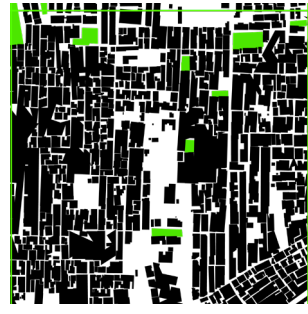
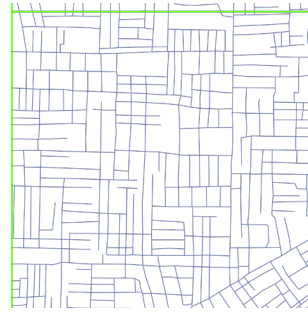
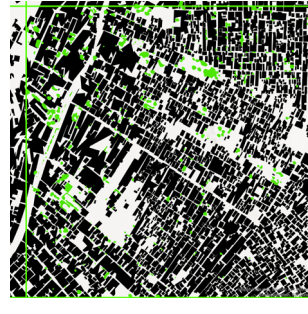


Fig.23. Thermal Comfort Analysis - Overlaying Method GIS

Urban Form and Heat Vulnerability: Key Findings

Districts	Building Footprint and Green Cover	Street Pattern	Urban Heat Island (UHI) Effect	Key Observations	HVI
New Delhi			Least Susceptibility	- High Green cover (Lutyen’s Delhi, and Central parks like Lodhi gardens). - Low population density. - Land use: Mostly administrative government infrastructure with large green spaces in the vicinity. - Planned urban landscape.	
South Delhi			Low Susceptibility	- Green areas such as Asola wildlife sactuary and Nehru park present in the vicinity). - Lower building density and wider street network in many parts of the district.	
Central Delhi			Low - moderate Susceptibility	- Dense urban core with intense commercial activity. - Lack of open spaces in many areas. - Densely populated space	
South West Delhi			Low - moderate Susceptibility	- The South West district contains Delhi’s airport and some urban-ized area at the core. - Comparatively low density zone with agricultural fields on the out-skirts or on the periphery.	

North Delhi			Moderate Susceptibility	- Dense population in urban cores. - Moderate green cover. - Grid style street pattern.		
North West Delhi			Moderate Susceptibility	- Mix of semi rural and urbanized areas. - Rising commercial and residential developments. - Increasing UHI susceptibility due to expanding urban footprint. - Irregular street pattern.		
West Delhi			High Susceptibility	- Highlyh dense residential areas. - Limiting green zones with increasing impermeable surfaces. - Irregular street pattern.		
North East Delhi			High Susceptibility	- Dense population and high commercial activities seen in the district. - Marginal green zones. - One of the most crowded and overpopulated districts. - Irregular street pattern.		
Shahadra			High Susceptibility	- Urban Sprawl with very limited green cover. - Poor ventilation in the urban blocks due to dense residential and commercial zones. - Irregular street pattern.		

CONCLUSION

West, North East, and Shahdara emerge as Delhi’s most heat-vulnerable districts, primarily due to their dense built fabric, scarce green infrastructure, and irregular urban built form. In these areas, compact development restricts airflow and open space, trapping heat throughout the day and intensifying thermal discomfort during the night. The lack of vegetative cover further limits the natural cooling processes of shade and evapotranspiration, while narrow, winding streets prevent the introduction of tree-lined corridors or cooling breezes.

Among them, Shahadara was found to be particularly heat-vulnerable. Shahdara is also one of the city’s oldest (See fig 24) and most unplanned districts—characterized by informal settlements, deteriorating infrastructure, and a chronic lack of spatial equity. This packed informal built district leaves little room for conventional urban interventions and thus increases the exposure to heat stress. Adding to this internal pressure is Shahdara’s location along Delhi’s eastern edge. Just beyond Delhi’s administrative boundary is a rapidly urbanizing peri-urban fringe that is now almost entirely built up. Rather than acting as a green buffer, this fringe contributes additional heat and pollution, compounding the district’s exposure

to rising urban temperatures. Together, all these conditions make Shahdara a uniquely vulnerable district to heat. All these unique challenges require a bold, multi-scalar design response—one that not only mitigates heat but reimagines the role of landscape in addressing environmental injustice and urban cooling.

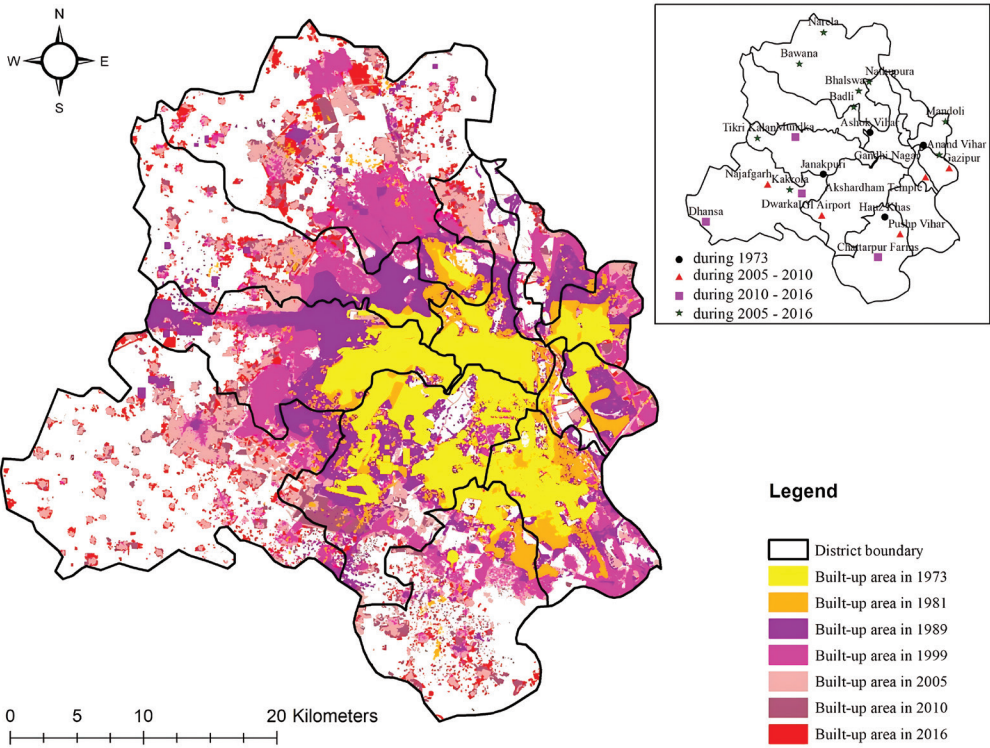


Fig.24. Urban Expansion in Delhi from 1973 to 2016. Indicating Shahadara as one of the oldest parts of Delhi.

ENDNOTES

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4 DELHI'S RESPONSE:

Policy Analysis

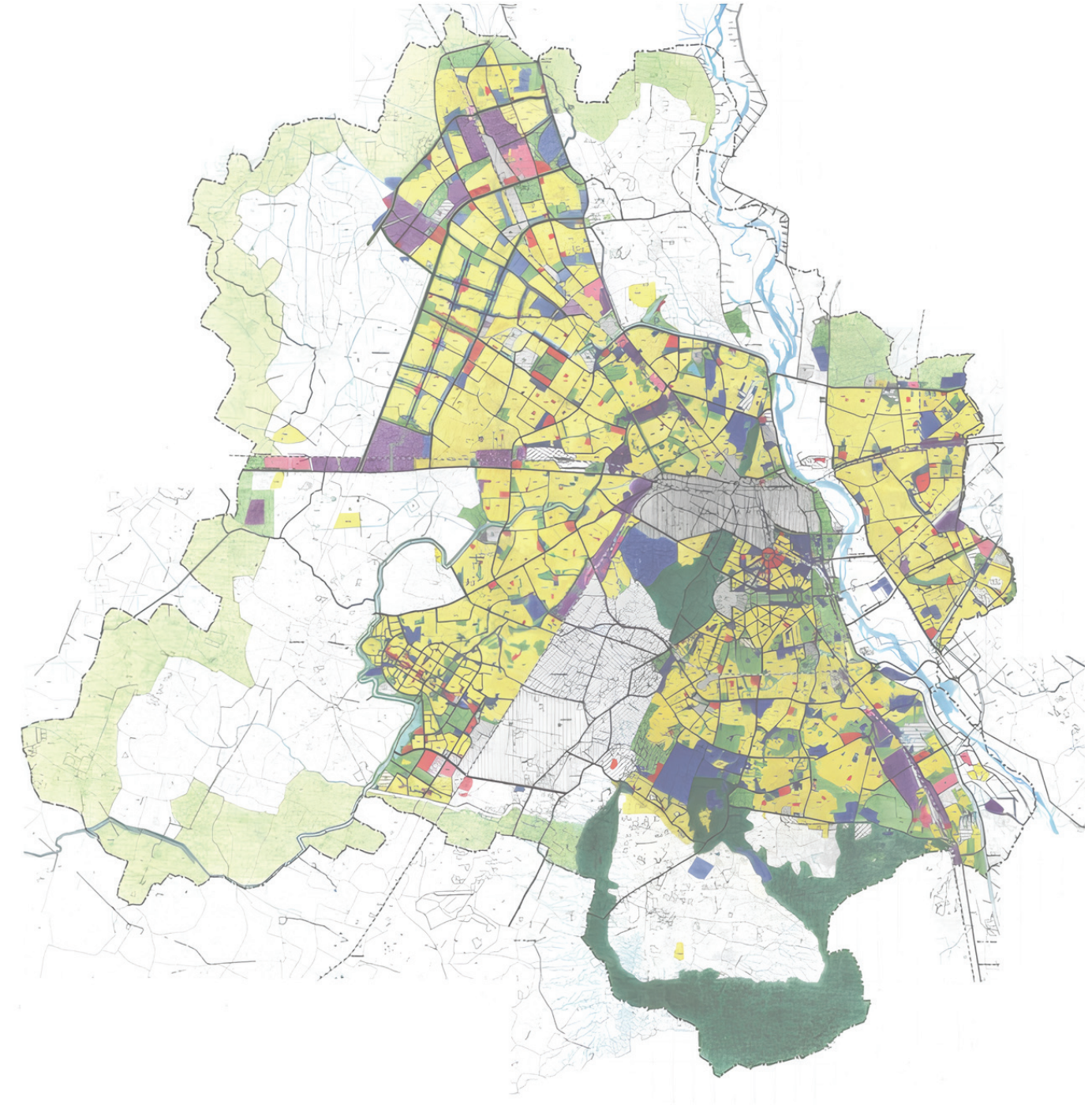


Fig.25. Delhi's Master Plan 2021

In response to Delhi's increasing heat crisis, marked by last year's urban temperatures exceeding 52°C and intensifying Urban Heat Island (UHI) effect, the govt. of Delhi has developed several frameworks such as the **Master Plan for Delhi 2041**, the **Delhi Climate Action Plan (DCAP)** and the **State Action Plan on Climate Change and Human Health (SAPCCHH)**, all aiming at climate adaptation, green-blue infrastructure and sustainable urban design. The following section provides a critical overview of the key objectives and interventions proposed under each of these frameworks.

1. Delhi Climate Action Plan (DCAP)

This plan is the city's formal initiative for tackling climate change through mitigation and adaptation strategies. The plan emphasizes the following:

- Expansion of Urban green cover, with a focus on heat-prone areas.
- Using passive cooling initiatives such as cool roofs, reflective surfaces and shaded public infrastructure.
- Integration of climate resilience adaptation strategies into development control regulations.⁵⁴

2. State Action Plan on Climate Change and Human Health (SAPCCHH): Linking Heat to Health.

The SAPCCHH, developed by the National Centre for Disease Control (NCDC), is the first plan developed by the Government

of Delhi which highlights the rising urban heat as a public health emergency. It directly connects the effects of the rising urban temperatures with increases in heatstroke, dehydration and cardiovascular strain, especially in low-income communities and outdoor workers class. Key points in this plan include:

- Establishing early warning systems for heatwaves.
- Developing urban heat action plans at various scales.
- Creating cooling shelters, and shaded zones in vulnerable zones.⁵⁵

3. Delhi Master Plan 2021 & 2041: Green - Blue Infrastructure and Urban Regeneration

The draft Master Plan for Delhi 2041 has a vision for "Sustainable, Liveable and Vibrant Delhi"⁵⁶ While the plan does not include explicitly framed policies for urban cooling, It includes several policies that have direct relevance to heat mitigation. Some of those key mitigation policies are:

- Protection and enhancement of natural assets: The plan proposes policies for maintaining a comprehensive green-blue infrastructure plan, restricting development in Yamuna floodplains and establishing healthy 300 m riparian buffer zones along the Yamuna river, drains and water bodies.⁵⁷

- Creation of new green-blue assets: two proposed policies that stand out for urban cooling and heat mitigation are:

a. Green Development Area (GDA) Policy:

this policy proposes a peripheral green belt by allowing restricted development while mandating that a significant portion of the land remain as forested and peri-agricultural spaces. This measure is very critical for preserving ecological continuity and also enhancing the regional cooling effects.⁵⁸

b. Green Buffers and Green Mobility Corridors along drains and canals:

This policy proposes a city-wide ecological cooling and mobility network along Delhi's existing Drain and Canal system. Key features include:

- Mandatory integration of green buffers in all new developments.
- Integrating at least 10 meters of green buffers along the drains and canals into multi-use public spaces.
- Integration of green corridors along the water infrastructure, enhancing both cooling and cultural connectivity.⁵⁹

Conclusion:

While Delhi has taken important steps to address the effects of climate change through initiatives such as Delhi's Master Plan, Delhi Climate Action Plan (DCAP), and State Action Plan on Climate Change and Human Health (SAPCCHH), these efforts remain uncoordinated and overly generalized lacking targeted impact on the neighbourhoods most vulnerable to extreme heat. This practicum actively responds to this policy gap and bridges the gap between "planning and implementation" by offering a landscape design-based approach towards heat mitigation and urban cooling.

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C. DESIGN

5 GLOBAL APPROACHES: Precedent and Research Insights

Many cities across the globe have been struggling with the impact of rising urban temperatures. This section will review a range of precedents and research papers to study how these cities mitigate rising urban temperatures and have significantly reduced temperatures through several urban cooling strategies. These cases will demonstrate how cities with similar socio-environmental challenges have successfully implemented landscape-based solutions to mitigate the urban heat island (UHI) effect.

PRECEDENTS:

1. Green Corridors Initiative - Medellin, Colombia.

Medellin, similar to Delhi, has been struggling with rapid urbanization, ecological fragmentation, High urban temperatures and the effects of the Urban Heat Island (UHI) effect. In response to the rising urban temperatures, Medellin launched the Green Corridors initiative in 2016, converting over 30 transportation and river corridors into cooling corridors. These corridors significantly cooled the city by reducing the urban temperatures. This initiative recorded notable results in urban cooling, such as:

- A reduction in surface temperatures by up to 10.3°C, and in ambient temperatures by 2-3°C, significantly alleviating the effects of the Urban Heat Island (UHI) phenomenon.

- The planting of over 880,000 trees and 2.5 million plants along the corridors, enhanced biodiversity and established a continuous habitat and cooling network throughout the city.
- The integration of 20 km of new cycle lanes, which led to a 34.6% increase in cycling activity, thereby contributing to lower carbon emissions by reducing car dependency.⁶⁰

2. Chandigarh, India - Green mobility and sector-based planning.

Much closer to Delhi, the city of Chandigarh city showcases a multi-scalar approach to urban cooling through the integration of green and blue infrastructure, designed in a way to passively regulate the city's microclimate. Some of the key landscape elements of the planning are as follows:
Sukhna Lake as a cooling engine:

- Strategically located in the northeastern part of the city, Sukhna Lake plays a critical role in the city's thermal regulation.
- The lake's large surface area enhances evaporative cooling, which significantly lowers the ambient temperature in its immediate surroundings.
- The lake is strategically placed in alignment with prevailing wind patterns coming from the Himalayas due to which the lake channels cooler air into the urban areas via adjacent open green spaces and road corridors.

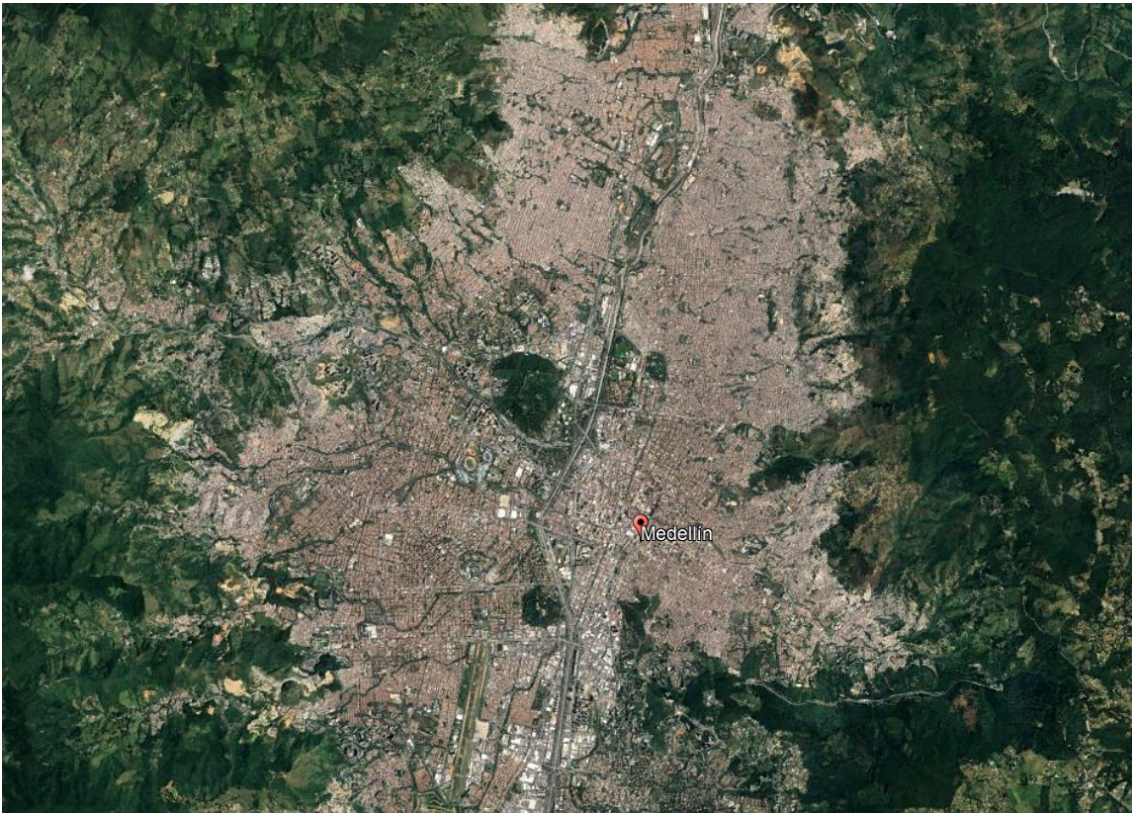


Fig.26. Medellin's Green Corridors initiative

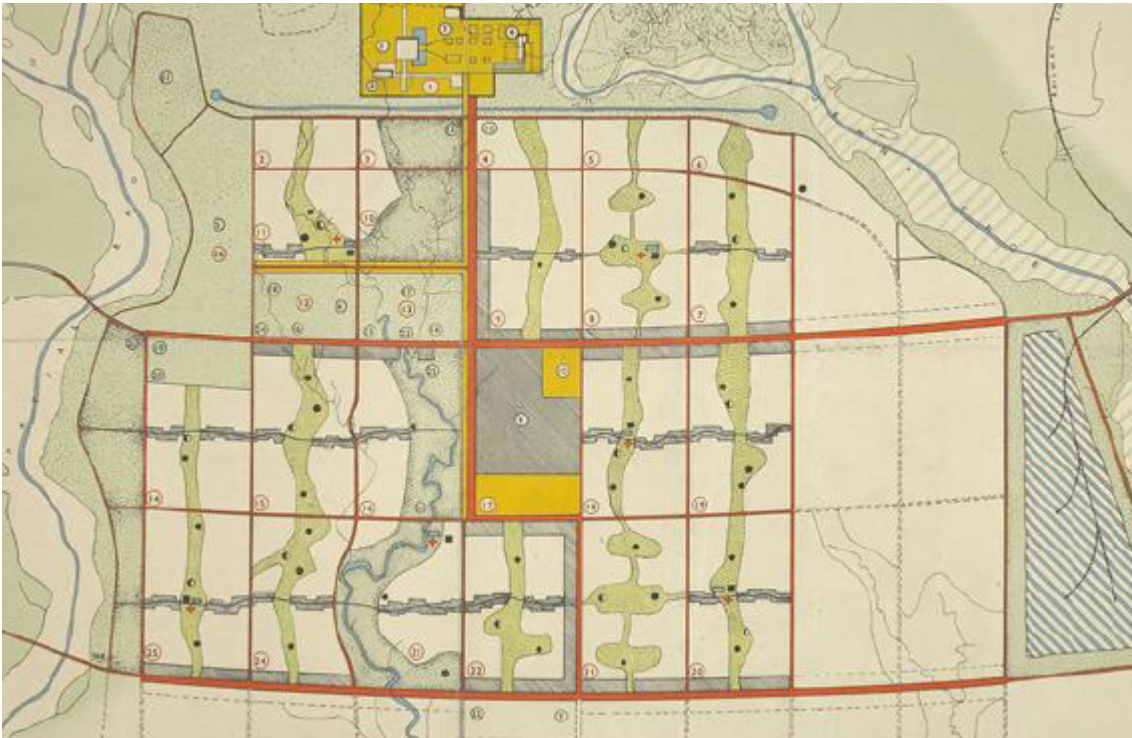


Fig.27. Chandigarh Masterplan

Green Buffers as Ventilation Corridors

- Chandigarh’s planning includes continuous green belts between built zones that act as urban cooling corridors.
- These green belts allow the flow of cooler air from the lake and peripheral forest areas to penetrate deeper into the city.
- Combined with tree-lined avenues, they contribute to reduced surface and ambient temperatures, particularly during peak summer months.⁶¹

3. Ahmedabad, India.

In response to the rising urban temperatures and prolonged heat waves faced by India, Ahmedabad was the first South Asian city to implement a formal Heat Action Plan (HAP).

- Cool roof programs reduced the indoor temperatures by 2-5°C in low-income housings.
- Early warning systems reduced or minimized heatstroke cases.⁶²

EVIDENCE-BASED DESIGN AND RESEARCH STRATEGIES

1. Role of Urban Forestry in Urban cooling and heat mitigation.

Urban forestry is one of the most effective cooling tools in mitigating heat stress in cities. They cool the city through the combined effects of shading, evapotranspiration and low albedo regulation.

- The tree canopies deflect the UV solar radiation from the sun and thus reduce the amount of UV radiation directly reaching the streets, pavements and building walls. Acc. to Berry et al. (2013), building walls shaded by trees received 50% less solar radiation and reduced the wall surface temperatures by 9°C. ⁶³
- Acc. to Livesley et al. (2012), evapotranspiration from trees alone can reduce air temperatures by 1-5°C, especially when the tree canopies are dense and are spatially distributed across neighbourhoods. ⁶⁴

2. Depaving and Surface Albedo enhancement

Depaving refers to the strategic removal of impervious surfaces like concrete and asphalt, by replacing them with more permeable and reflective materials with lower albedo so that it reduces surface heat retention and improves water infiltration.

- Temperature reduction and Urban cooling: A study by Peluso, Persichetti, and Moretti (2022) shows that replacing asphalt with high albedo and permeable pavements can reduce surface temperatures by 1.5-2.5°C. However, when this is combined with the cooling effects of vegetation, the overall cooling effects can be even greater. ⁶⁵

URBAN COOLING IMPACT SUMMARY TABLE

Strategy/ Precedent	Cooling mechanism	Temperature reduction	Additional benefits
Land based strategies			
Green Corridors initiative	Tree-lined corridors, urban forestry and green mobility car lanes.	Surface temperature reduced by upto 10.3°C Ambient temperatures reduced upto 2-3°C	Improved air quality, increased biodiversity and increased active mobility.
Sector based planning and green mobility	Green belts, integrated green blue infrastructure	Localized microclimate cooling	Increased walkability and ecological continuity
Tree Canopy shading	Urban forestry + Solar radiation deflection	Wall temperatures reduced upto 9°C	50% reduction in solar irradiance on shaded surfaces.
Evapotranspiration via trees	Evaporative cooling through tree cover	Ambient temperatures reduced by 1-5°C	Carbon sequestration, air quality improvement.
Passive Cooling Strategies			
Cool Roof Program	Reflective roof coatings	Indoor temperatures reduced by 2-5°C	Reduced heatstroke risks by temperature reductions
Depaving + Albedo enhancement	Reflective, permeable pavements replacing the impervious ones.	Surface temperatures reduced by 1.5-2.5°C	Increased water infiltration

ENDNOTES

⁶⁰ Sustainable Energy for All. 2022. "Creating a Greener, Cooler, and Healthier Medellín." Last modified July 2022. <https://www.seforall.org/stories-of-success/creating-a-greener-cooler-and-healthier-medellin>.

⁶¹ Chandigarh Administration. "Chandigarh Master Plan 2031." Accessed April 18, 2025. <https://chandigarh.gov.in/chandigarh-master-plan-2031>.

⁶² GHHIN (Global Heat Health Information Network). "Ahmedabad Heat Action Plan 2019." Accessed March 12, 2025. <https://ghhin.org/resources/ahmedabad-heat-action-plan-2019/>.

⁶³ Tree canopy shade impacts on solar irradiance received by building walls and their surface temperature - Rowan Berry a, Stephen J. Livesley a, Lu Aye b <https://doi.org/10.1016/j.buildenv.2013.07.009>

⁶⁴ The Urban Forest and Ecosystem Services: Impacts on Urban Water, Heat, and Pollution Cycles at the Tree, Street, and City Scale S. J. Livesley, E. G. McPherson, C. Calfapietra First published: 01 January 2016 <https://doi.org/10.2134/jeq2015.11.0567>

⁶⁵ Peluso, Pierpaolo, Giulia Persichetti, and Luca Moretti. "Effectiveness of Road Cool Pavements, Greenery, and Canopies to Reduce the Urban Heat Island Effects." Sustainability 14, no. 23 (2022): 16027. <https://doi.org/10.3390/su142316027>

6 DESIGN FRAMEWORK



DESIGN FRAMEWORK

The design framework for this practicum proposes a multi-scalar, landscape-based cooling strategy employed at various scales, including the city, district, and neighbourhood scales. The framework is informed by various precedent studies, such as Medellín’s green corridors and Ahmedabad’s heat action plan, as explored in depth in Chapter 5. These strategies, adapted from various global precedents, are tailored to the specific spatial and climatic conditions of Delhi. The following sections outline how this framework will unfold across three scales:

City-scale interventions:

At the city scale, the design will focus on establishing a large-scale cooling buffer. The primary interventions at this scale will include the establishment of the Green Forest Belt along the city’s periphery, per-urban agroforestry systems, and the restoration of critical Water Infrastructure, such as the Yamuna River, main drains, and city canals.

District-scale interventions:

At the district scale, the design will focus on establishing a more decentralized ecological cooling network within the district. The primary interventions at this scale will include the establishment of an integrated green network of green spaces, each spaced 500 meters apart,

and the establishment of main green and wind corridors across the area, utilizing the existing road and rail infrastructure.

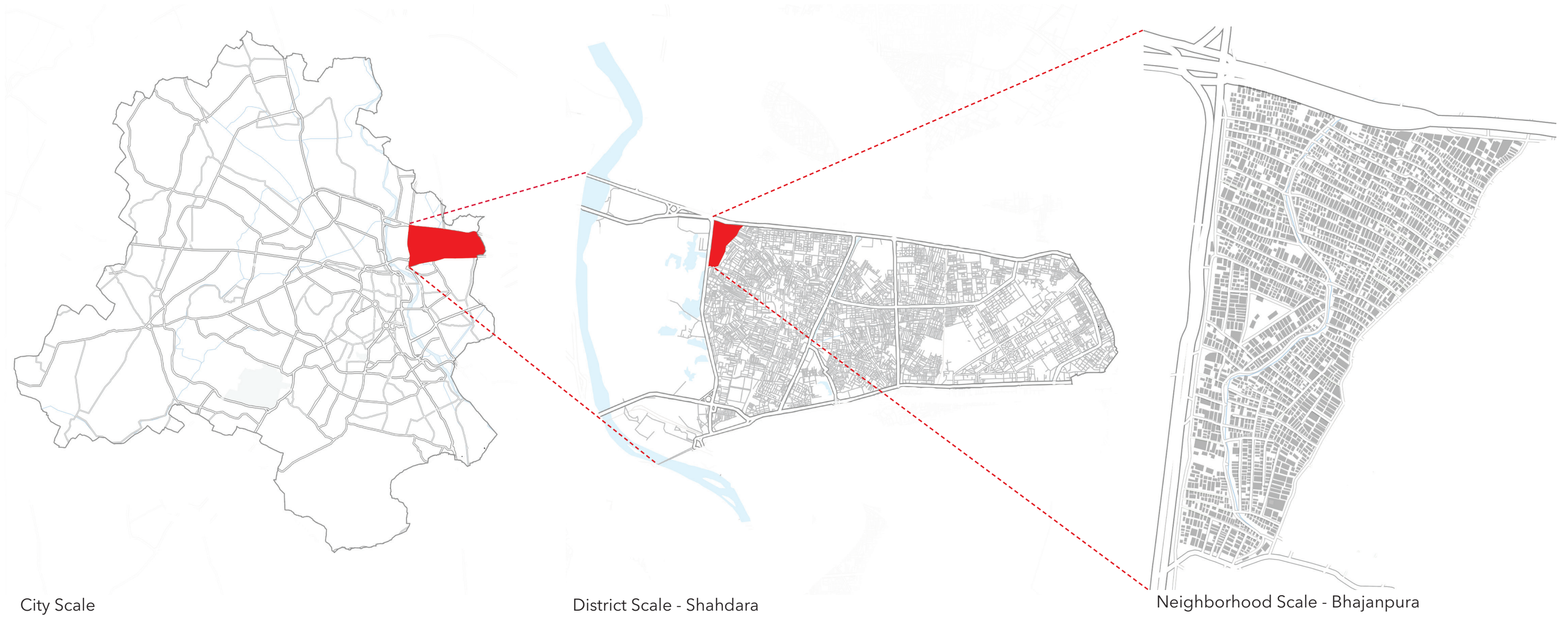
Neighbourhood-scale interventions:

At the neighbourhood scale, the design will focus on establishing cooling interventions which are adapted to the specific urban street typologies and local microclimate. The aim here is to develop interventions and assess how these interventions adjust to the local urban conditions of one particular neighborhood - Bhajanpura. The main interventions at this scale will include the establishment of a fine-grained cooling matrix of patches and corridors.

These strategies and interventions will form the backbone of a neighborhood cooling network and will be explored through detailed design, and site specific spatial configurations.

7 COOLING DELHI

A multi-scale approach to urban heat resilience



7.1. CITY - WIDE SCALE

"A significant portion of air pollution and hot winds, particularly from stubble burning, originates beyond Delhi's geographic boundaries. This highlights the need for coordinated regional action to effectively address these challenges."
- Delhi Master Plan 2021



City Scale



District Scale - Shahdara

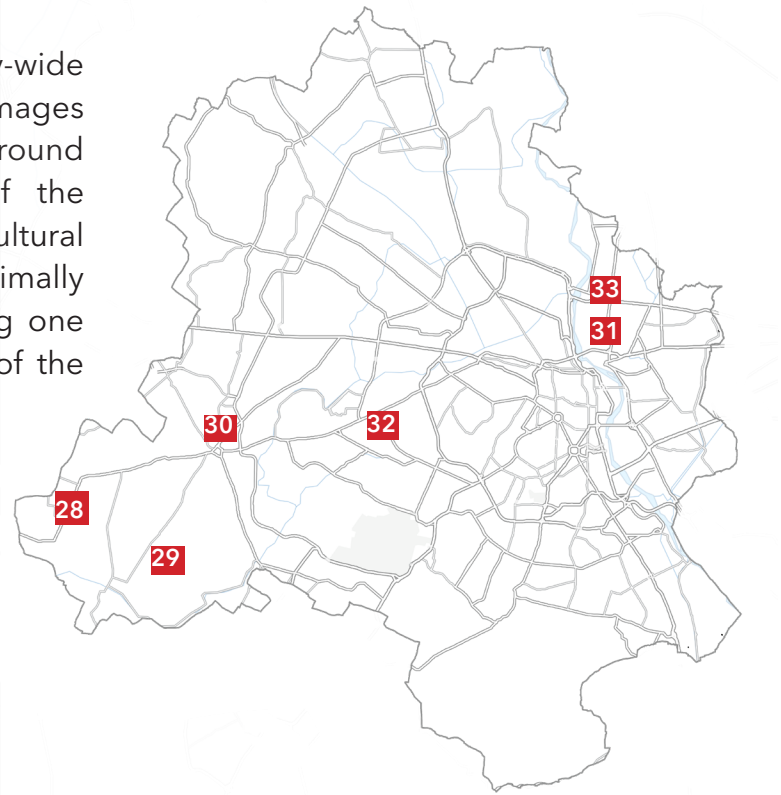


Neighborhood Scale - Bhajanpura

EXISTING CONDITIONS

As outlined in Chapter 2, Delhi experiences a dry humid climate due to a combination of regional and local environmental conditions. On a regional level, Hot, dry winds, also known as “loo”, sweep across the city coming from the northwest and west directions, carrying not only the heat but also the pollutants from the stubble burning in the neighbouring states like Punjab and Haryana. To exacerbate the rise in urban temperatures, the city has experienced severe environmental degradation, such as deforestation, and a shrinking peri-urban green buffer, as well as the deterioration of its water infrastructure (Drains, Canals and Rivers).

To highlight the need for the city-wide scale interventions, the illustrated images (on the right hand side) provide a ground reality of the visual snapshot of the current state of the peri-urban agricultural spaces (which are often fallow, minimally vegetated or vegetated only during one season and then left bare for rest of the year).



Peri-Urban dynamics at the city Periphery



Fig.28. View of fallow land near Bakkargarh village, Delhi.



Fig.29. Post-harvest agricultural field near Khera Dabar village, showing minimal tree cover and limited vegetative buffering.

Degraded state of Drains and Canals of Delhi.



Fig.30. View of degraded Mungashpur Drain, Delhi.



Fig.31. View of the degraded Eastern Yamuna Canal, Delhi.



Fig.32. View of degraded Drain near the Nala Rd, Delhi.



Fig.33. View of degraded Drain near the Bhagat Singh Rd, Delhi.



Fig.34. View of fallow land near Bakkargarh village, Delhi.

PROPOSED STRATEGIES

1. FOREST GREEN BELT + AGROFORESTRY PRACTICES

To address the rising urban temperatures, a strategically designed green belt is proposed around the city’s periphery. This green belt will act as a vegetated cooling buffer, and will help to reduce the impact of the hot summer winds coming from the Thar desert and thus will help in the thermoregulation of the urban temperatures. The width of this green belt will vary across the city. Due to wider land availability on the west, the green belt would be wider and densely vegetated, whereas, due to lesser land availability on the east, this green belt would be much thinner. This forest green belt will provide ecological as well as sustainable values. This belt will also help in limiting the urban sprawl, and provide a pathway for a sustainable, greener and cooler city.

Beyond this green belt, peri-urban agricultural fields and fallow lands will adopt agroforestry practices. Agroforestry practices such as incorporating windbreaks and mixed alley cropping will help in reducing wind velocity, trap air pollutants, provide shade to the field and thus will help to reduce the heat stress on the crops. With the incorporation of various crops, the soil’s health and diversity will be improved as well. Overall, these agroforestry practices will provide heat

mitigation along with productive land use.

Policy Alignment: Green Development Area (GDA), MPD 2041:

As discussed in Chapter 4, the proposed strategies align with the Green Development Area policy outlined in the Master Plan for Delhi 2041. This policy designates the city’s periphery for restricted development and reclaiming the land for green belt development. By leveraging this framework, the above-outlined strategies become spatially feasible and policy-compliant.

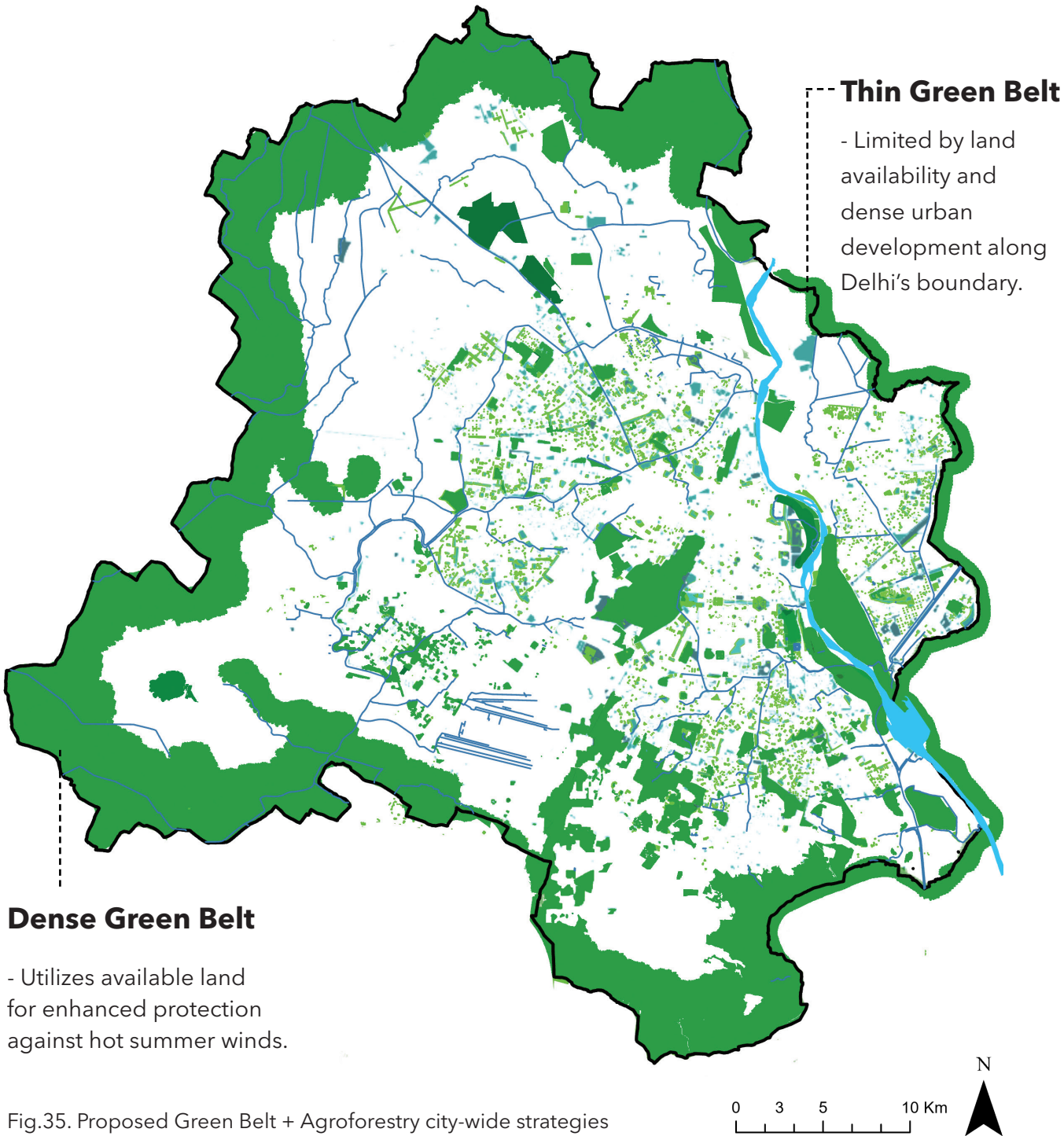
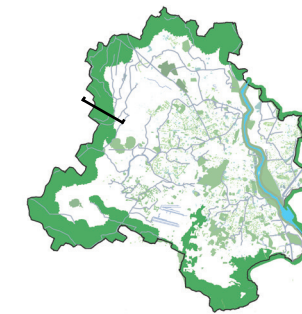
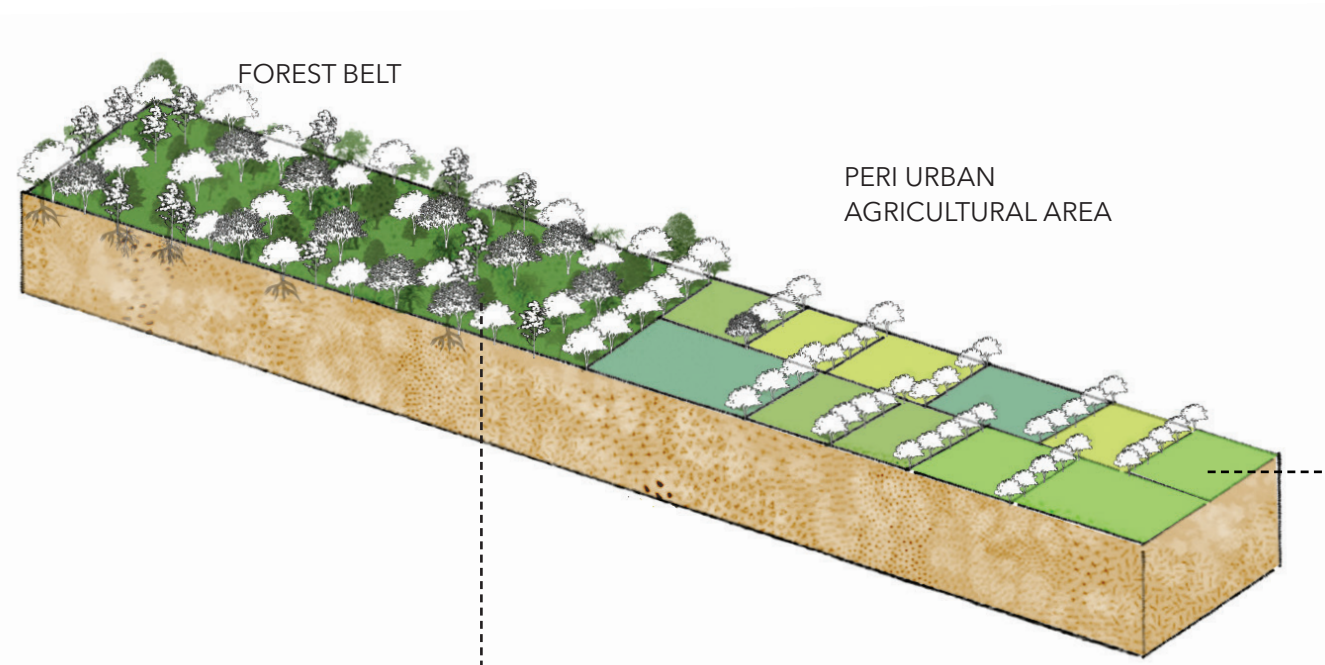


Fig.35. Proposed Green Belt + Agroforestry city-wide strategies



1. FOREST GREEN BELT + AGROFORESTRY PRACTICES

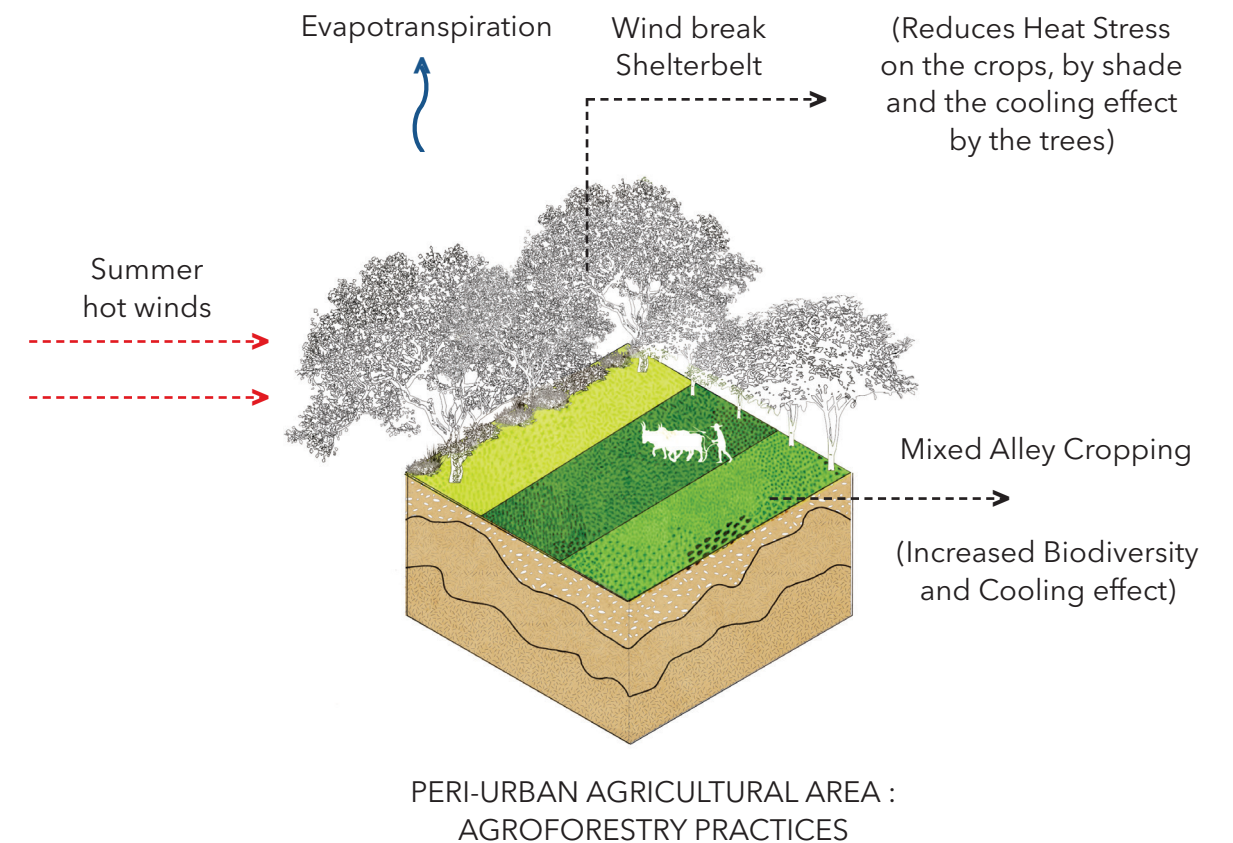
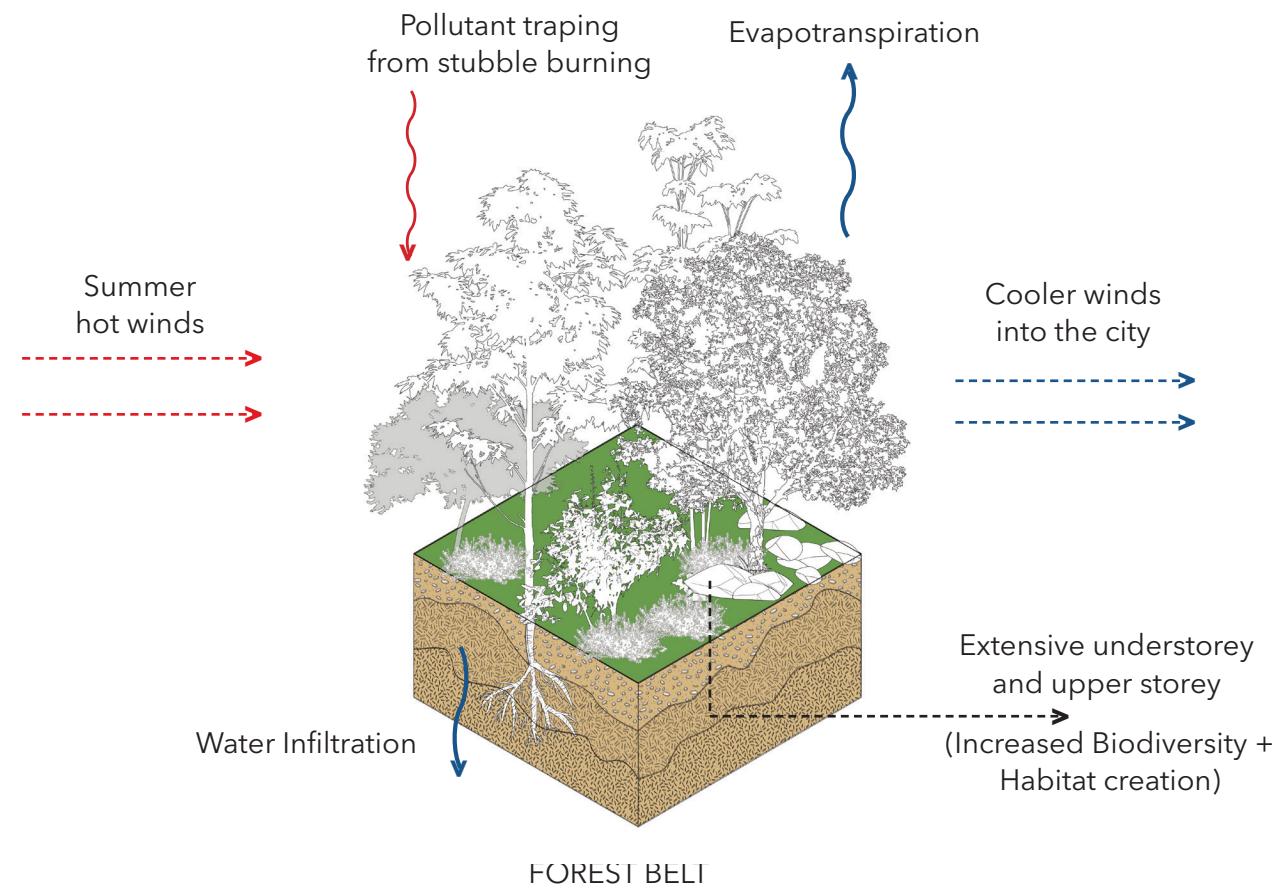




Fig.36. View of degraded Mungashpur Drain, Delhi.

PROPOSED STRATEGIES

2. WATER INFRASTRUCTURE REVITALIZATION

To address the deteriorating health of the Yamuna River and improve its ecological health as well as its cooling capacity, a 300-meter riparian zone is proposed along its whole length within Delhi. This riparian zone will act as an ecological cooling spine of the city, serving various functions such as:

- Improving water quality by stopping the direct sewage discharge into the river,
- Biofiltration by rewilding the riverbanks and increasing biodiversity, and,
- Cooling the urban microclimate through the combined effects of evapotranspiration from the vegetation and the river.

Similar to the Yamuna River, Delhi's fragmented, deteriorating & underutilized water network of drains and canals will be naturalized and transformed into a blue-green cooling corridor system. This strategy will include cleaning and desilting the drains and canals and naturalizing their embankments with native vegetation. These naturalized and vegetated banks will help cool the surrounding urban areas, reduce surface temperatures and improve the resident's thermal comfort by regulating cool air movement into the various neighbourhoods across the city.

Furthermore, these blue-green corridors will also be converted into green mobility corridors by integrating pedestrian and cycling paths along their waterways. This connection will also improve the city's social structure by connecting people back to its rivers and waterways while providing ecological heat mitigation.

Policy Alignment: Green Mobility Corridors

The proposed interventions directly align with the Green Mobility Corridors policy as mentioned in Chapter 12: Environment and Sustainability in the Master Plan for Delhi 2041. By leveraging this framework, the above-outlined strategies become spatially feasible and policy-compliant.

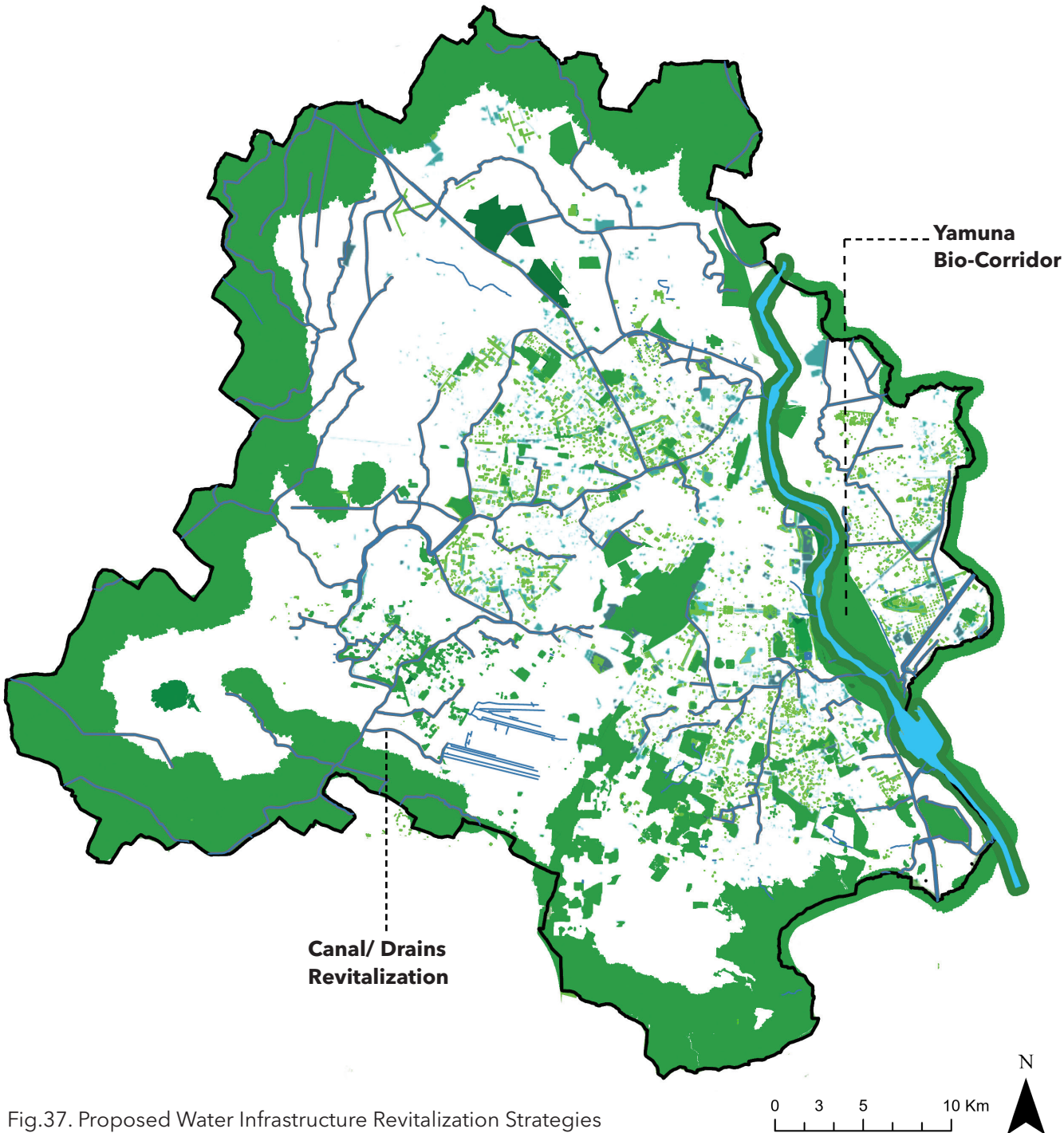


Fig.37. Proposed Water Infrastructure Revitalization Strategies

2.1. YAMUNA BIOCORRIDOR RESTORATION

The first 30 meters of the Yamuna corridor is categorized as a grass buffer and will be responsible for bank stabilization, sedimentation trapping and filtration of the surface runoff. Beyond this 30 m grass zone, a densely forested riparian zone with drought-resistant tree species is established, creating a multilayered canopy.

This zone will serve several functions such as evapotranspiration cooling, air pollution control and habitat continuity. It will also act as a thermal buffer, regulating urban temperatures by absorbing heat and reconnecting the fragmented habitats.

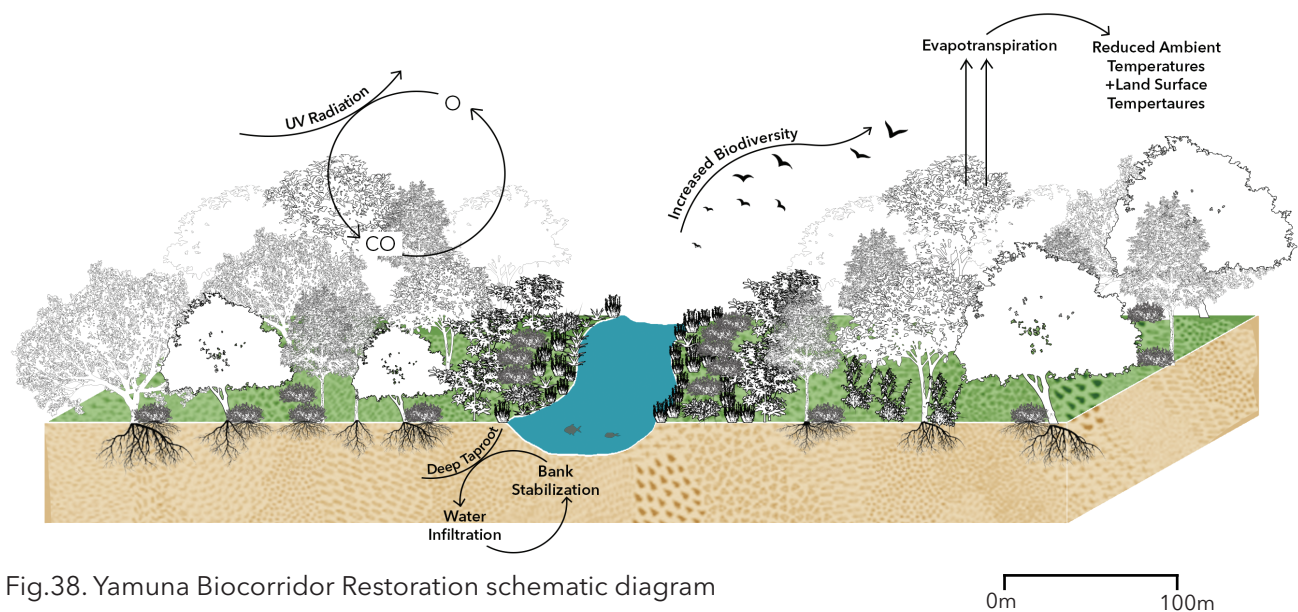


Fig.38. Yamuna Biocorridor Restoration schematic diagram

2.2. NATURALIZATION OF CITY'S CANALS + DRAINS

The city's interconnected network of canals and drains is reimagined as cooling green mobility corridors. These drains and canals will be a network of continuous vegetated buffer (around 10 m wide) densely planted with native grasses and trees. This vegetated buffer will help slow down the stormwater, filter pollutants and help cool down both surface and air temperatures through natural cooling processes like evapotranspiration. These 10-15m vegetated buffers will support shaded walkways and cycling green mobility corridors connecting various parts of the city.



While this proposed 10 - 15 m wide is ideal for significant urban cooling and ecological benefits, its width may vary across the city due to certain limitations like land availability and local conditions.

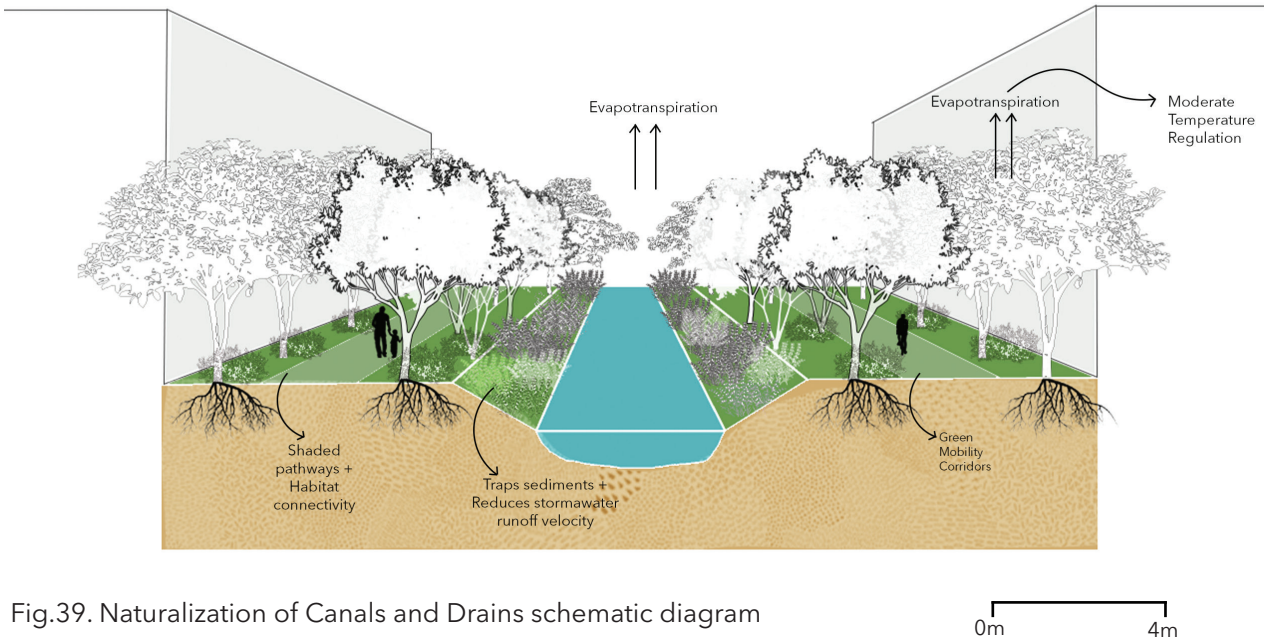
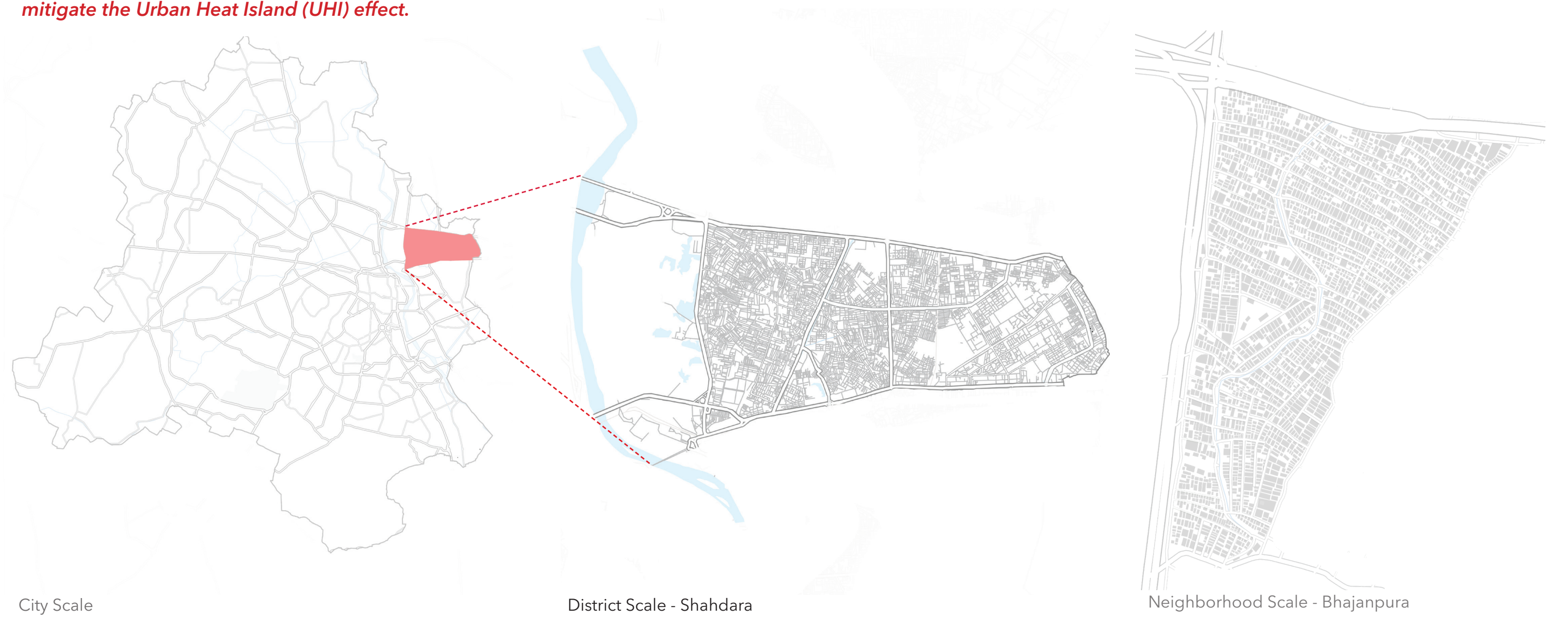


Fig.39. Naturalization of Canals and Drains schematic diagram

7.2. DISTRICT - WIDE SCALE

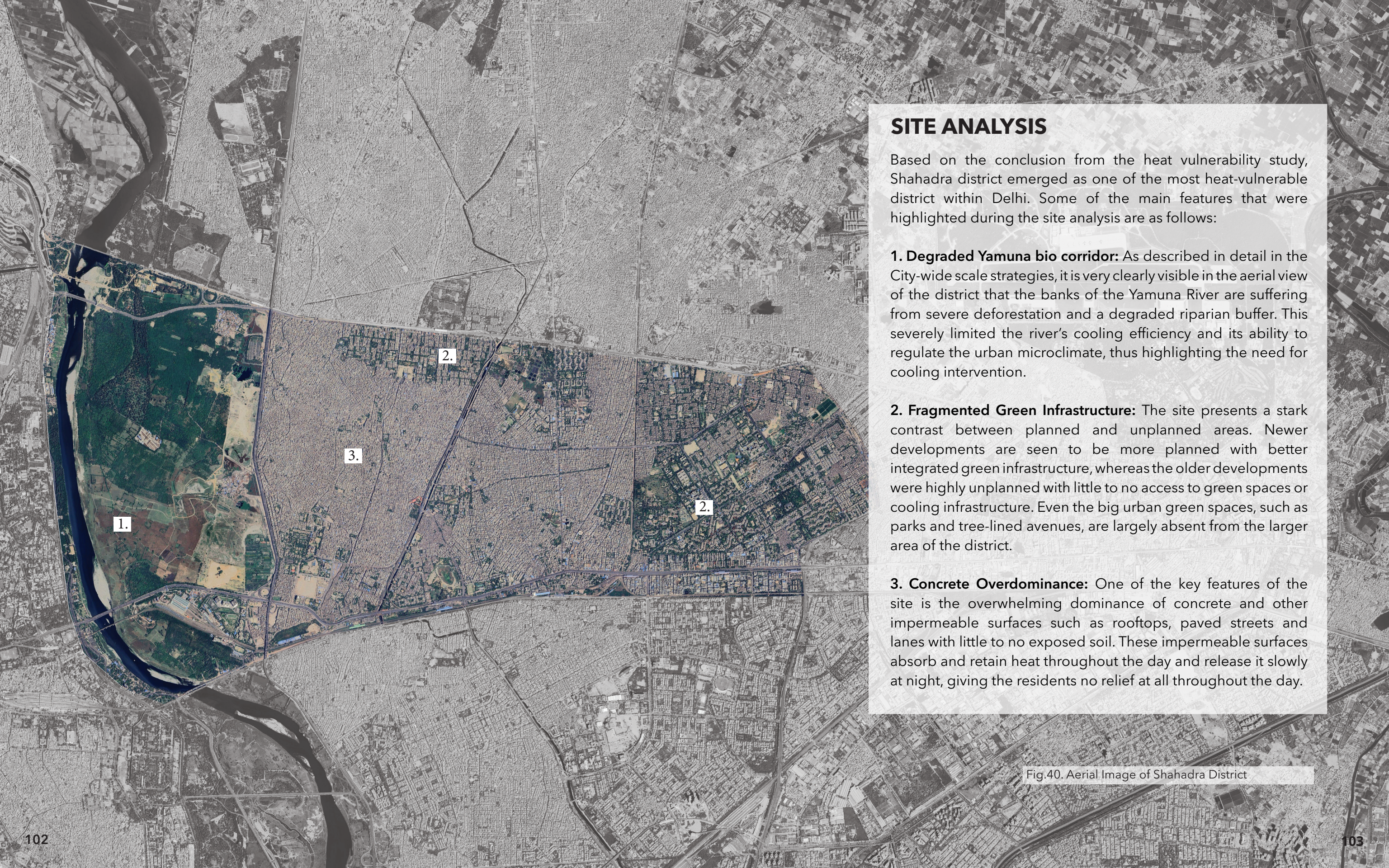
As concluded from the heat vulnerability and thermal comfort GIS analysis, certain districts within the city are more likely to bear the brunt of the heat as compared to others. These localized heat pockets are often a result of various factors such as densely built environments, high population density and lack of density. This highlights the need for district-level strategies to effectively mitigate the Urban Heat Island (UHI) effect.



City Scale

District Scale - Shahdara

Neighborhood Scale - Bhajanpura



SITE ANALYSIS

Based on the conclusion from the heat vulnerability study, Shahadra district emerged as one of the most heat-vulnerable district within Delhi. Some of the main features that were highlighted during the site analysis are as follows:

1. Degraded Yamuna bio corridor: As described in detail in the City-wide scale strategies, it is very clearly visible in the aerial view of the district that the banks of the Yamuna River are suffering from severe deforestation and a degraded riparian buffer. This severely limited the river's cooling efficiency and its ability to regulate the urban microclimate, thus highlighting the need for cooling intervention.

2. Fragmented Green Infrastructure: The site presents a stark contrast between planned and unplanned areas. Newer developments are seen to be more planned with better integrated green infrastructure, whereas the older developments were highly unplanned with little to no access to green spaces or cooling infrastructure. Even the big urban green spaces, such as parks and tree-lined avenues, are largely absent from the larger area of the district.

3. Concrete Overdominance: One of the key features of the site is the overwhelming dominance of concrete and other impermeable surfaces such as rooftops, paved streets and lanes with little to no exposed soil. These impermeable surfaces absorb and retain heat throughout the day and release it slowly at night, giving the residents no relief at all throughout the day.

Fig.40. Aerial Image of Shahadra District

PROPOSED STRATEGIES

ASSESSING EXISTING ROAD AND RAILWAY INFRASTRUCTURE FOR GREEN CORRIDOR DEVELOPMENT

As seen from major global precedents such as Medellin as well as the Chandigarh master plan, transforming the transit infrastructure for green corridor development is one of the most powerful urban cooling strategies. Drawing from these global precedents, one of the main strategies is to transform the existing road and railway infrastructure into cool green corridors. This proposed strategy will demonstrate how integrating tree-lined pathways and permeable surfaces along these existing infrastructures can significantly reduce both surface as well as ambient temperatures while improving the air circulation in dense neighbourhoods.

In Medellín, a similar intervention of green corridors led to a significant decrease in surface temperatures of up to 10.3°C degrees Celsius, and a 2-3°C reduction in ambient air temperatures. The roads and railway tracks selected here for the district-wide interventions are:

- 1. Pusa Road.
- 2. Jafrabad Road.
- 3. Delhi-Shamli-Saharanpur Road.
- 4. Grand Trunk Road.
- 5. Wazirabad Road.
- 6. Saboli Hault Railway Road.

- ROADWAYS
- RAILWAYS
- EASTERN YAMUNA CANAL

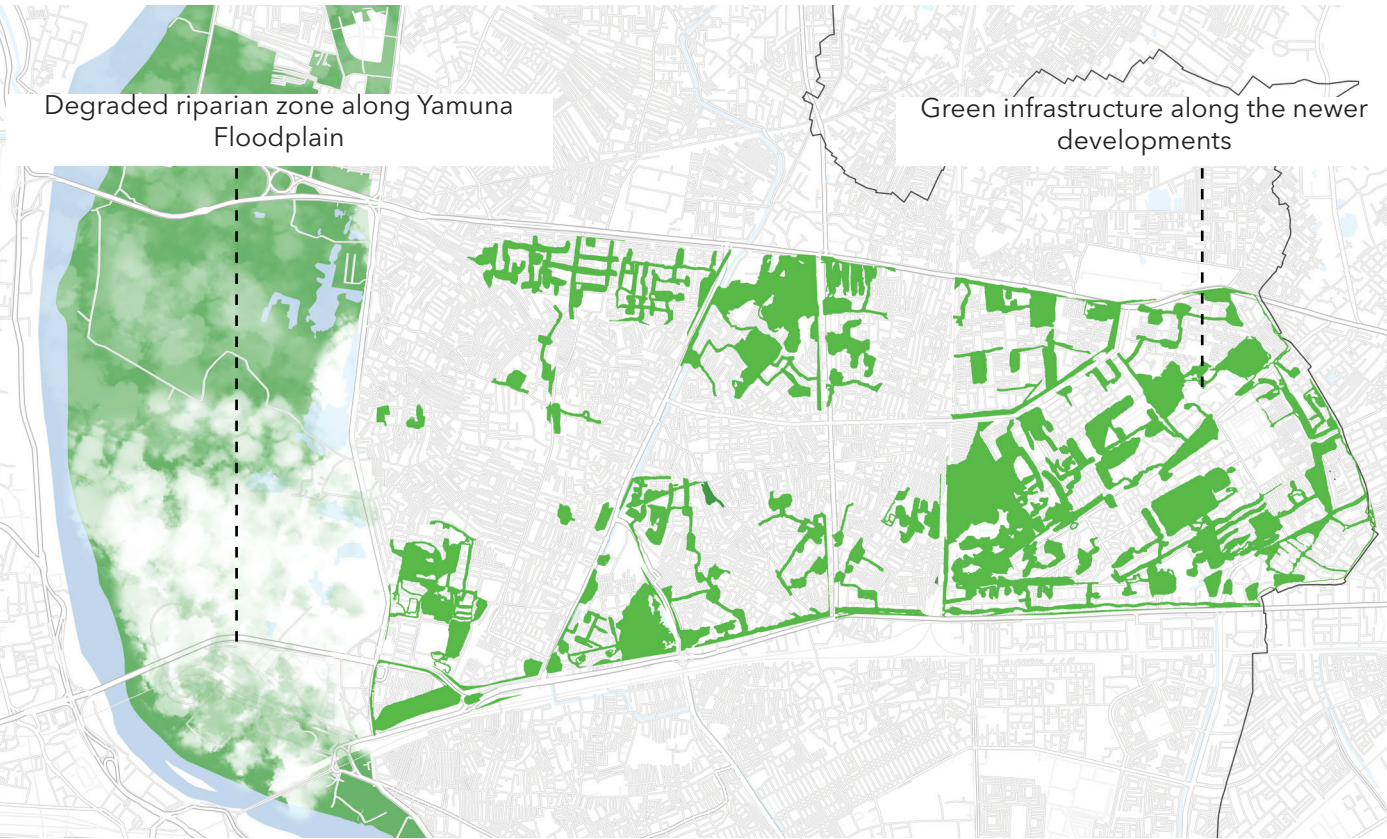


Fig.41. Existing District Plan

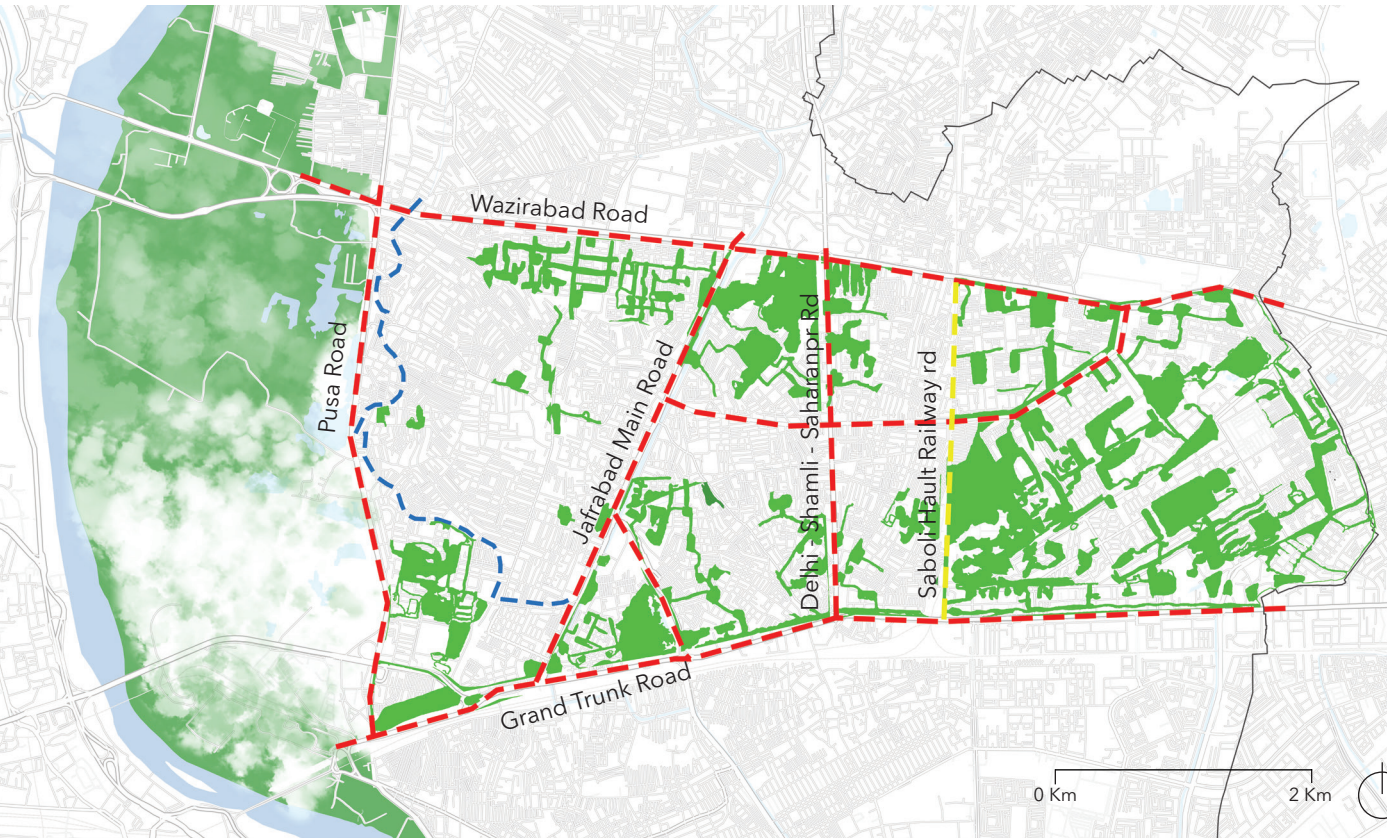


Fig.42. Assessing Road and railway infrastructure for the development of potential green corridors

PROPOSED STRATEGIES

1.Reforestation of the Yamuna Floodplain:

As a part of the city-wide strategies, the Yamuna bio corridor is restored using dense layered plantation along with a well-established riparian buffer.

2. Green Transit and Road Infrastructure:

Wind and Green Corridors. As described before, a total of 6 road and railway tracks are chosen in the Shahadra district. These tracks were chosen on the basis of road and railway track width, foot or pedestrian traffic, as well as the dominance of impermeable material. The selected routes will be transformed into green and wind corridors through:

- Double tree-lined streets or avenues with trees such as Neem, Arjuna, etc, with clear trunks and pruned lower branches to preserve visibility and clearance for movement.
- Bioswales, rain gardens and permeable pavements will be established alongside oversized streets or road networks to reduce surface temperatures as well as increase soil permeability.
- Major roads such as Pusa Road, Wazirabad Road and the Grand Trunk Road will act as the major wind ventilation corridors, improving the air circulation and facilitating the air into the district.

3. Green Cooling Matrix: A dense green cooling matrix is proposed across the district. The matrix will start with mapping the already existing green infrastructure, including green streets and existing big urban green spaces. These bigger green urban spaces and the existing green infrastructure will be bridged together by placing big parks of approximately. 0.5-2 ha are placed every 500 meters in dense zones. These spaces will act as heat sinks in the district, and the bigger patch sizes of the parks will provide an efficient and effective cooling radius. Further, all of the bigger green patches will be connected together using green tree-lined roadways.

This strategy will effectively transform the existing fragmented green infrastructure into a layered and well-connected cooling matrix, providing equitable access to cooling infrastructure, improving heat resiliency and restoring the social-ecological fabric of Shahdara. Together, all these district-level strategies will lay down an anchor for a foundation for all the neighbourhood-scale interventions that will be discussed later.

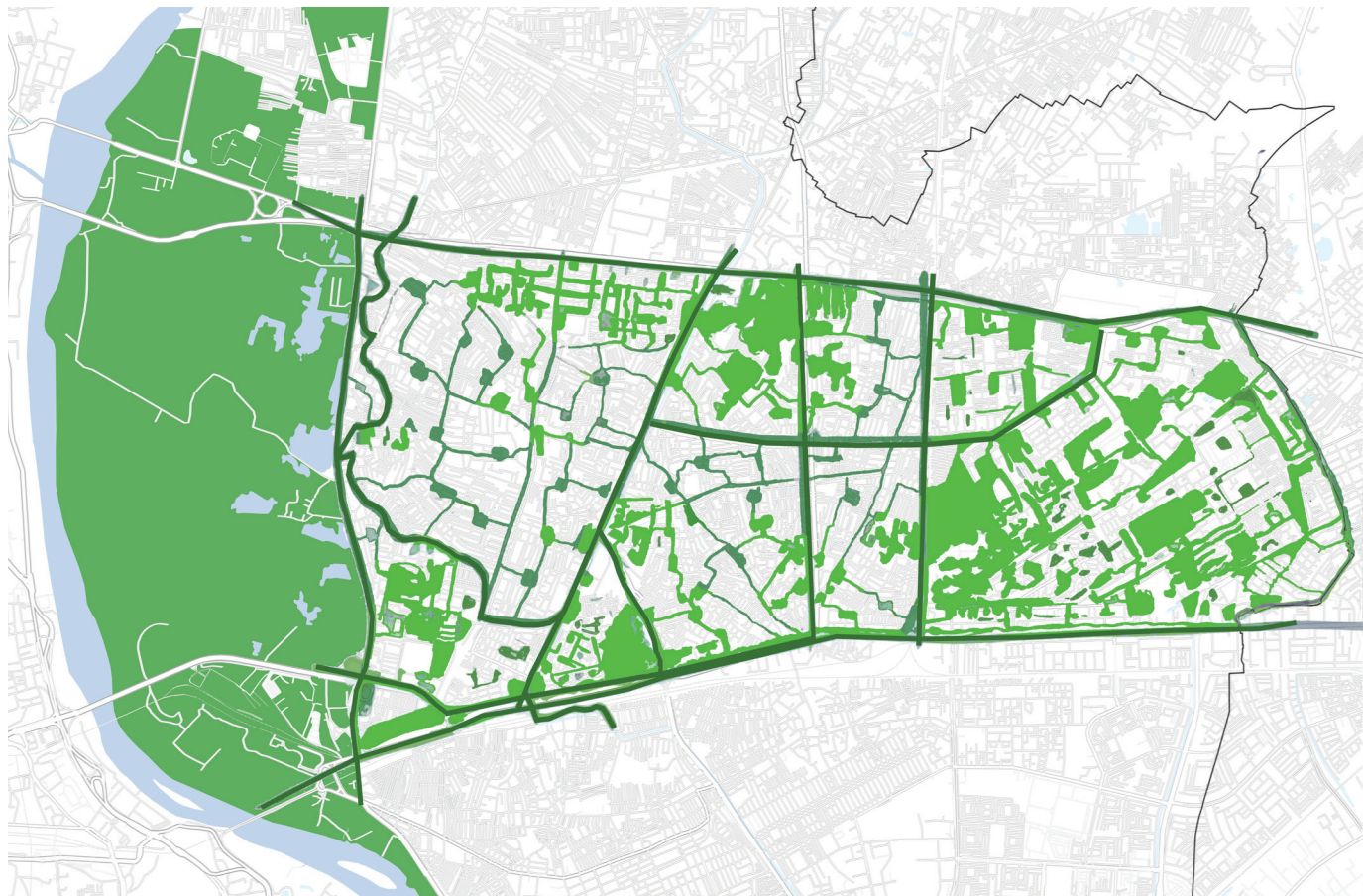


Fig.43.Proposed district-wide plan

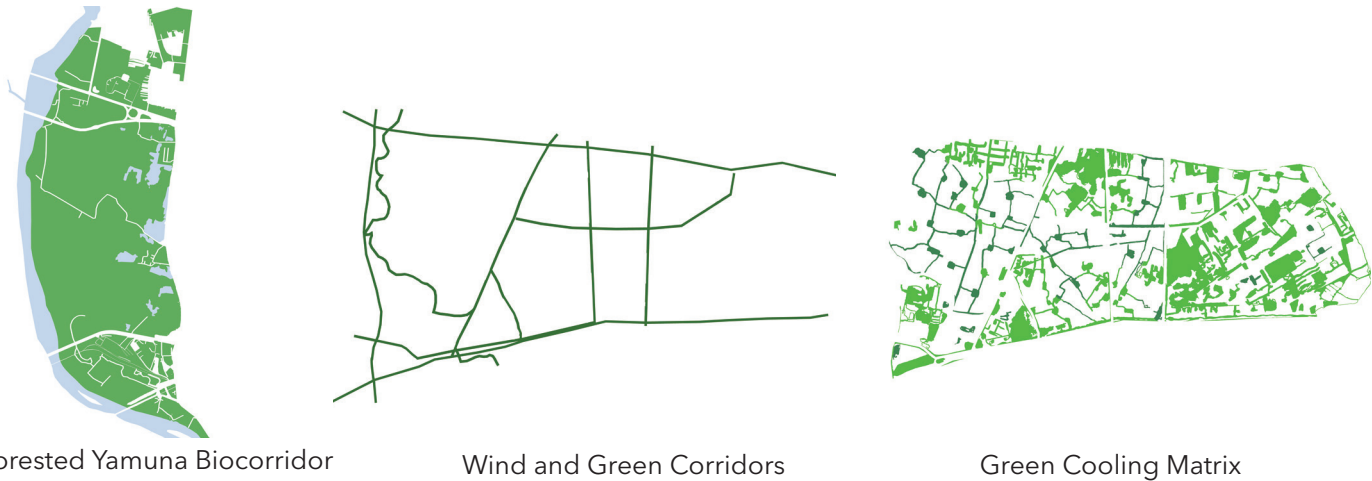
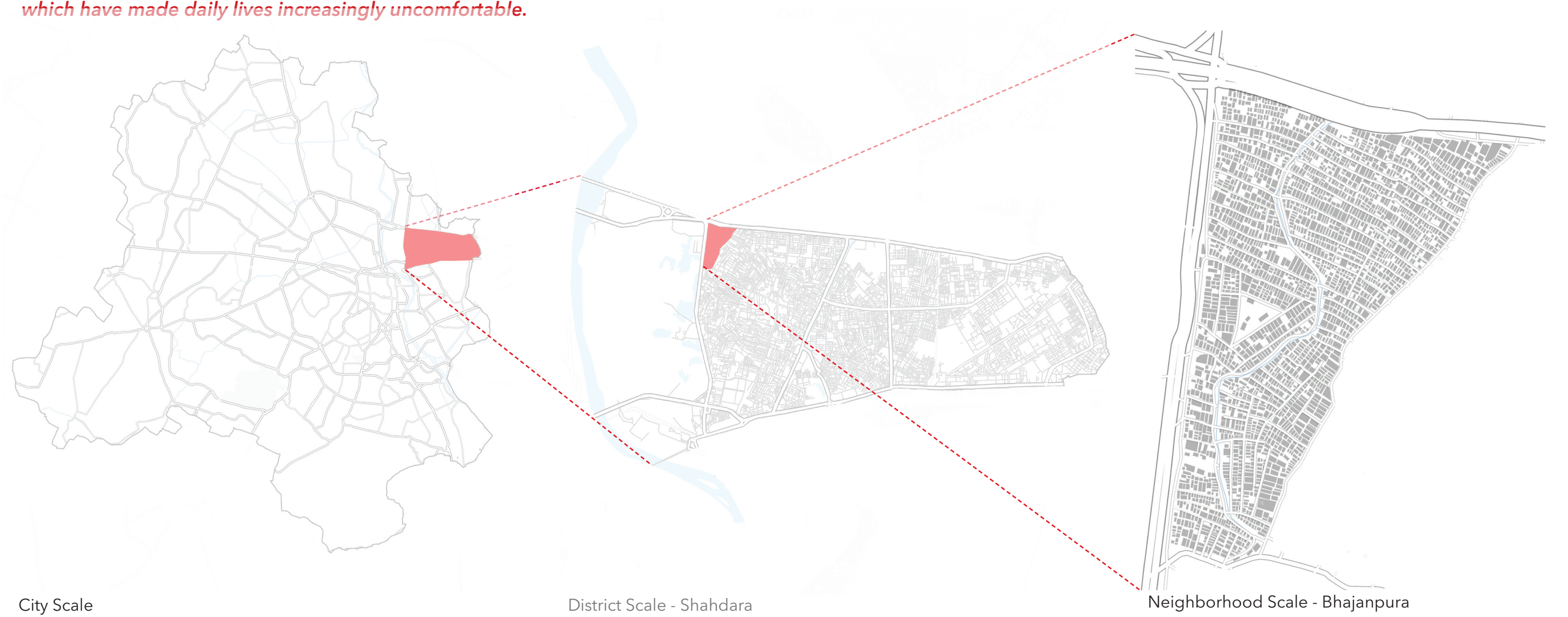


Fig.44. Proposed Landscape Elements

7.3. NEIGHBORHOOD SCALE

Bhajanpura, located in the heat-stressed district of Shahdara, was further chosen as the pilot site to explore how the landscape-based cooling interventions will work on the ground. Furthermore, Bhajanpura was also chosen based on several factors, such as it is one of the city's most densely populated neighbourhoods, fragmented green infrastructure and dominated by heat-trapping infrastructure, which have made daily lives increasingly uncomfortable.



City Scale

District Scale - Shahdara

Neighborhood Scale - Bhajanpura



SITE ANALYSIS

Bhajanpura is one of the most densely populated and oldest unplanned neighbourhoods in Delhi's Shahdara district. A site analysis highlighted several interlinked challenges that contribute to the rising urban temperatures and intensified the Urban Heat Island (UHI) effect in the neighbourhood are as follows:

1. Degraded Eastern Yamuna Canal: The eastern Yamuna Canal running through the neighbourhood is one of the biggest missed opportunities in the area. The canal, which was once a potential cooling asset, is now heavily polluted and choked with waste, significantly reducing its capacity to cool the surrounding.

2. Sparse and disconnected tree coverage: While a considerable number of trees were seen alongside the Pusa Rd, and sparsely scattered throughout the neighbourhood, a continuous canopy cover was absent. Thus, the cooling effect is not continuous and effective.

3. Tree Groves as social anchors: Although sparsely scattered throughout the neighbourhood, it was noticed that small tree groves or individual trees served as social anchors across the neighbourhood. Residents were often seen occupying these shaded spots and using them to rest and for social interaction, beautifully highlighting their vital role in the neighbourhood's social structure despite their limited number.

4. Heat-trapping urban morphology: The urban built form of Bhajanpura is highly unplanned with irregular street patterns and is dominated by impervious surfaces such as concrete rooftops and asphalt roads. Also, the neighbourhood had longer and narrower blocks, reducing walkability, and creating urban canyons that trap heat and make the microclimate hotter.

5. High population density: The selected neighbourhood spans just 0.41 km², supports an estimated population of over 14,760 people. Despite this high population density, the neighbourhood supports only two formal Urban Green Spaces.

Fig.45. Aerial Image of the selected neighbourhood site.

1. Polluted and choked
Easter Yamuna Canal



3. Trees as a source of
Social cohesion



2. Disconnected tree
cover and underutilized
spaces.



4. Heat Trapping Urban
Morphology.

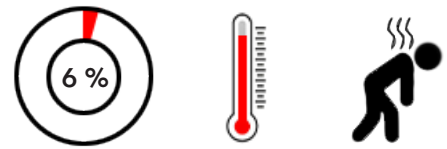


Fig.46. (1-4) Bhajanpura (Neighbourhood-wide) Site Analysis Images



EXISTING SITE CONDITIONS

EXISTING GREEN
INFRASTRUCTURE



Fractured
Green
Infrastructure
+ Canal

Building
Footprints
(Highly Dense
Neighborhood)

Road Network



Fig.47. Existing site conditions.

STRATEGIC LAND ACQUISITION

The Urban Regeneration Policy (DEV 03) in the Draft Delhi Master Plan 2041 focuses on revitalizing aging, underutilized, and unplanned urban areas, particularly those developed between the 1940s and 1970s. These areas often suffer from dilapidated infrastructure, inefficient land use, and inadequate public amenities.



Fig.48. (1-2) Deterring grey infrastructure in the neighbourhood.

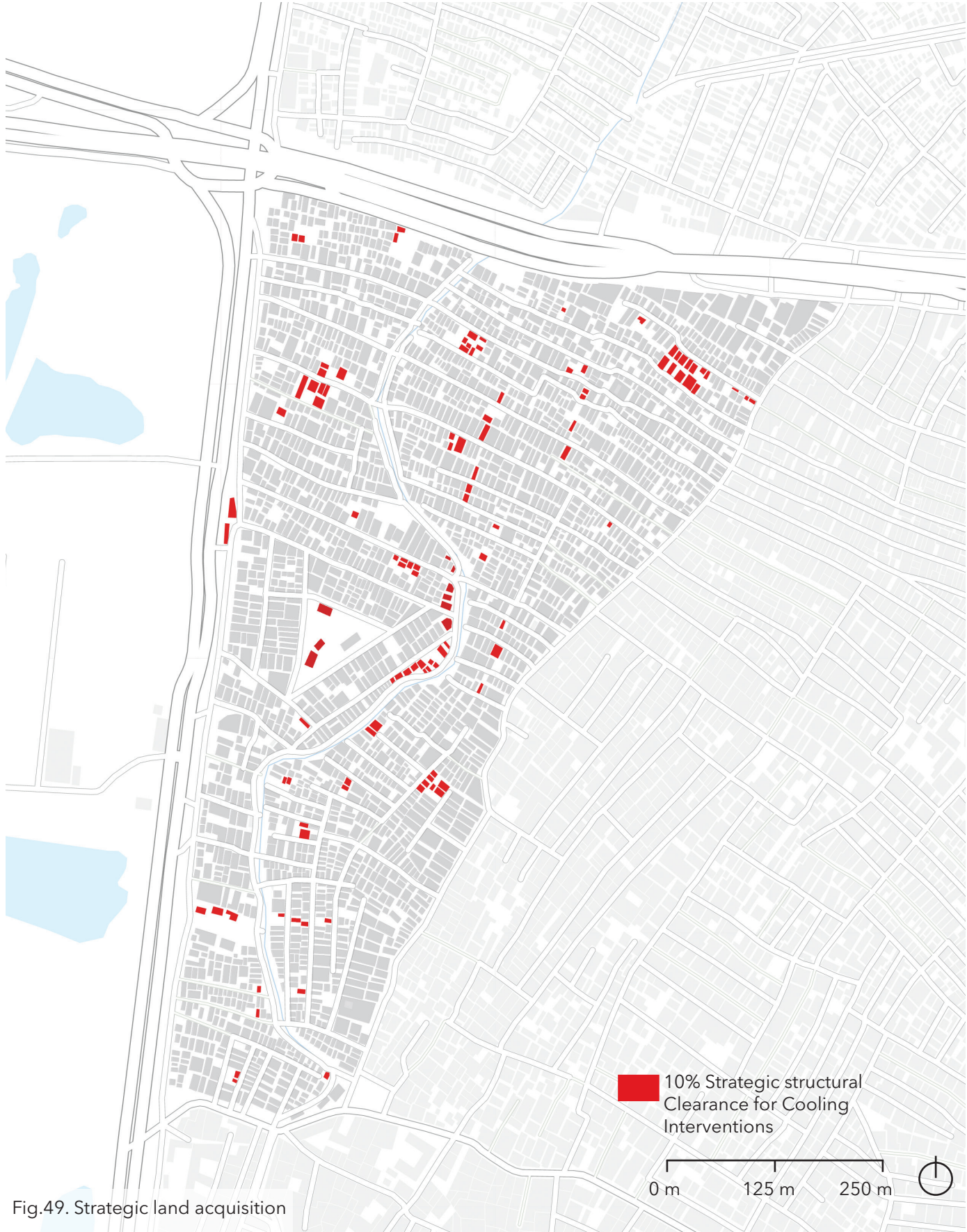


Fig.49. Strategic land acquisition

PROPOSED URBAN GREENING & COOLING FRAMEWORK

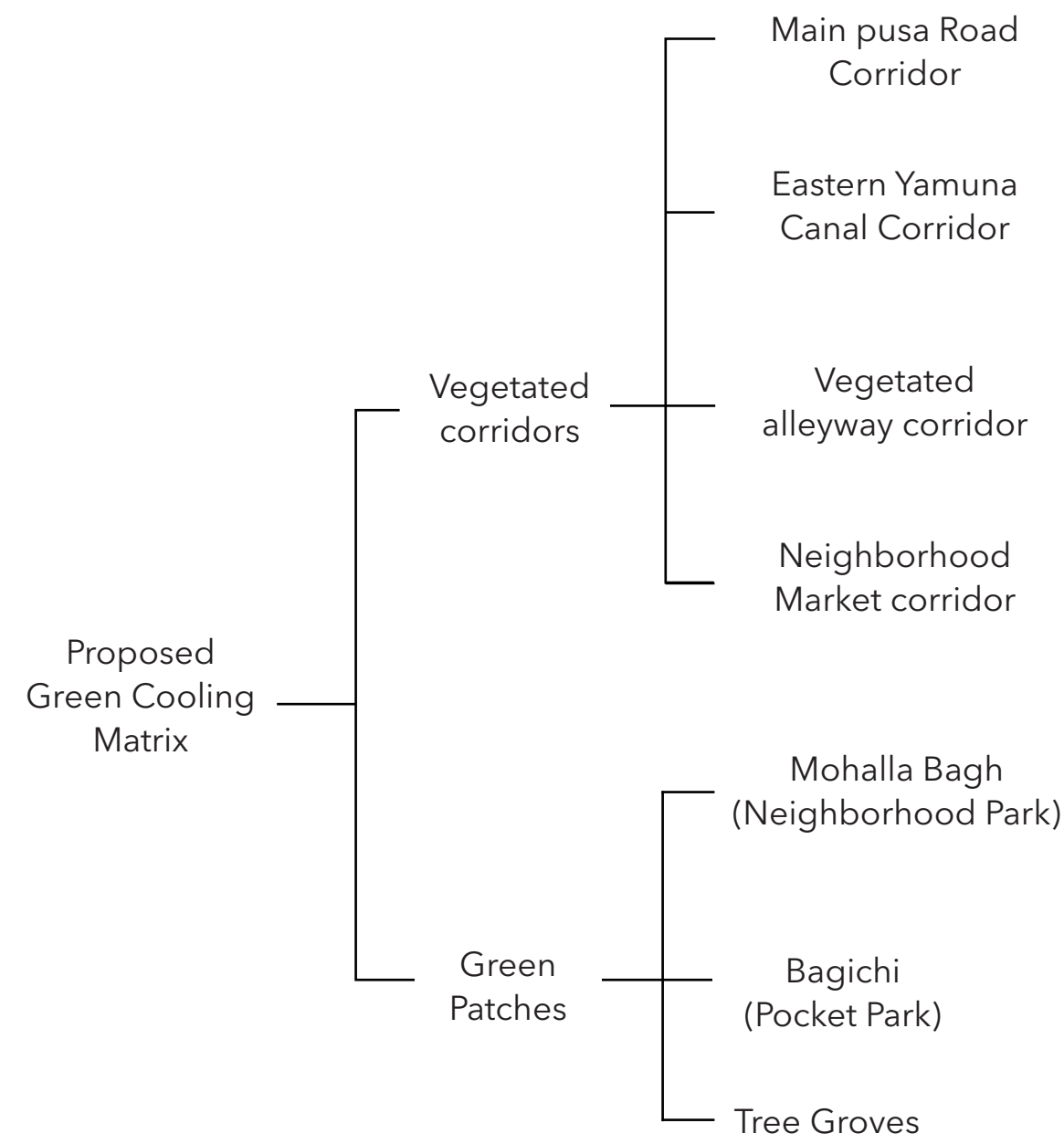
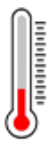
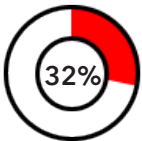


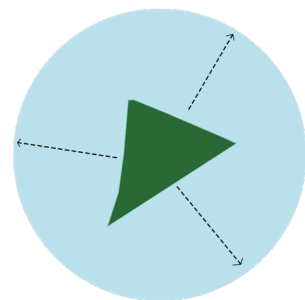
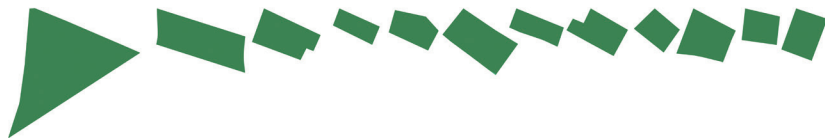
Fig.50. Proposed Cooling Network

PROPOSED GREEN
INFRASTRUCTURE TYPOLOGIES

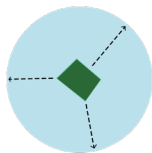


PATCHES

Mohalla Bagh (Neighborhood Parks) (500- 5000 Sq meters)



5000 sq m
120 m



500 sq m
60 m

Park Size
Cooling Radius

Bagichi (Pocket Parks) (60 - 300 Sq meters)



300 sq m
30 m



60 sq m
20 m

Park Size
Cooling Radius

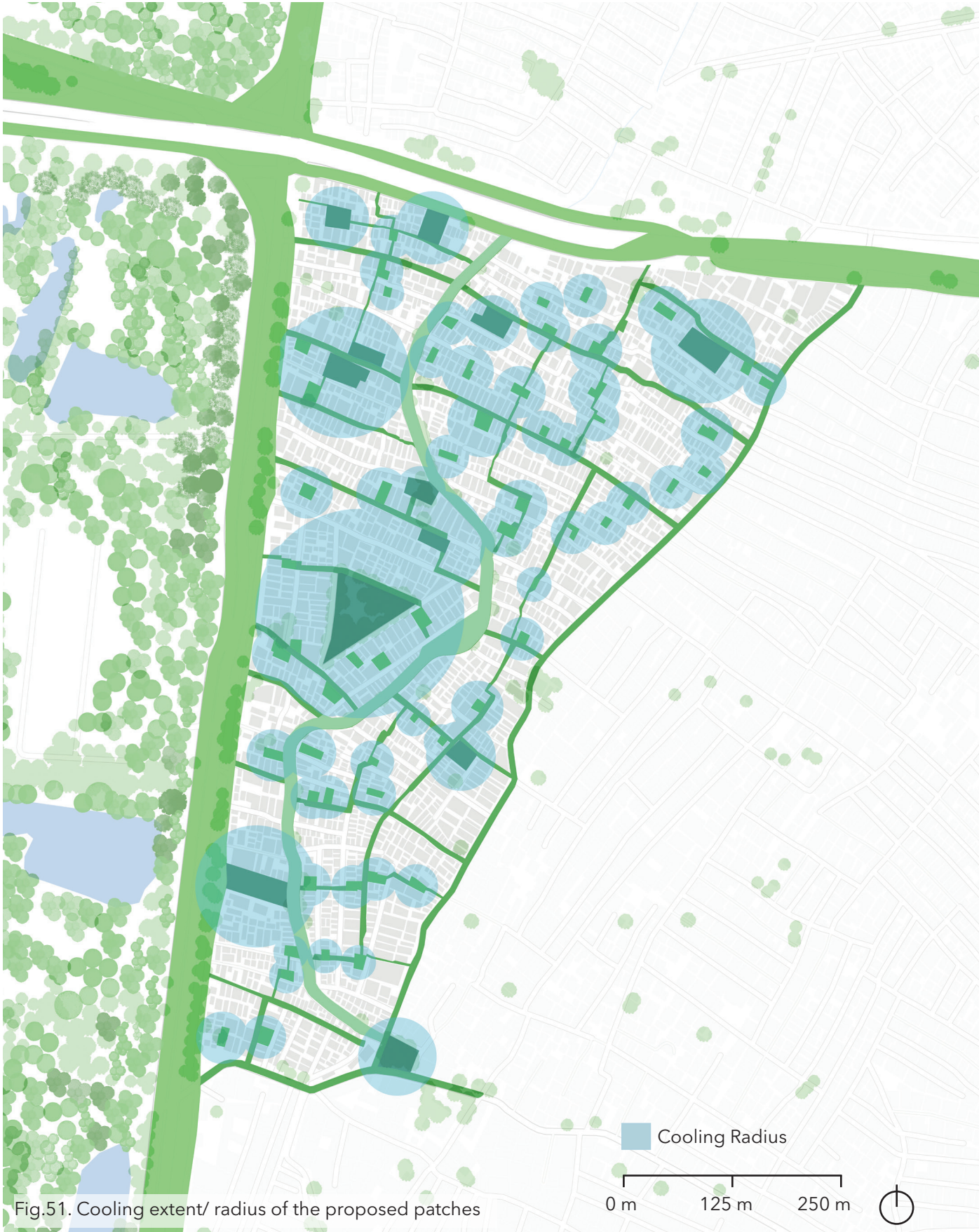
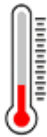
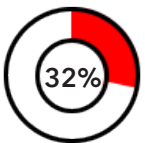


Fig.51. Cooling extent/ radius of the proposed patches

PROPOSED GREEN
INFRASTRUCTURE TYPOLOGIES



PATCHES

Mohalla Bagh (Neighborhood Parks) (500- 5000 Sq meters)



Bagichi (Pocket Parks) (60 - 300 Sq meters)



CORRIDORS



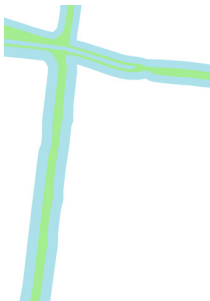
Green Alleyway
& Neighborhood
Market Corridor



6-7 m
5 m



Main pusa Road
Green Corridor



45 m
60 m



Eastern Yamuna
Canal Corridor



8-12 m
15 m

Corridor Width

Cooling Radius (On both sides)



Fig.52. Cooling extent/ radius of the proposed corridors



Fig.53. Detailed zoom-in of the proposed cooling network in the neighbourhood.

A. VEGETATED CORRIDORS



A series of linear vegetated corridors based on the street and road width are proposed to facilitate natural ventilation and improve the thermal comfort of the residents by using the underutilized and unused spaces. The proposed vegetated corridors tending to the local conditions of the Bhajanpura neighbourhood are as follows:

A.1. PUSA ROAD GREEN CORRIDOR

The main Pusa Road is transformed into one of the main cooling corridors. This transition begins by narrowing down the current 6-lane stretch to 4 lanes. This change makes space for wider sidewalks as well as an expanded central median. For the planting layout, double rows

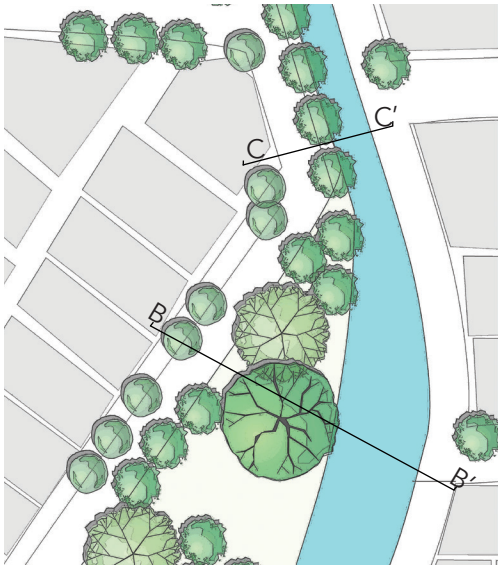
trees are planted on either side of the road, creating a cool canopy cover. The green median also supports a single row of tree planting in permeable soil, increasing urban water infiltration and thus promoting healthier root growth. These spatial and landscape-based interventions are also proposed to boost the microclimatic cooling through evapotranspiration.

Overall, this intervention is expected to lower the surface temperatures by 9 - 10°C and the ambient temperatures by 2- 3 °C. In addition, these corridors will enhance the air movement and ventilation by regulating the air movement from the forested Yamuna floodplain into the neighbourhoods.



Fig.54. Pusa Rd green corridor section AA'

2. EASTERN YAMUNA CANAL CORRIDOR



The Eastern Yamuna Canal offers a prime opportunity to function as a primary vegetated cooling corridor. Given the land availability along the canal in the densely populated neighbourhood of Bhajanpura, two types of spatial interventions are proposed. The first intervention targets the narrow roads alongside the canal. The intervention involves planting a single row of trees along the west side of the canal to maximize cooling efficiency through shade and evapotranspiration. The east side of the street is typically shaded by the adjacent buildings, making this intervention both spatially efficient and strategically feasible.

The second intervention targets the strategic reclamation of the land alongside the canal, extending the green space to support a larger, denser, and layered planted area. This intervention will not only enhance cooling through shade and evapotranspiration but also improve soil permeability and water infiltration, thereby creating healthy soil conditions. Species such as Gulmohar, Neem, and Amaltas are planted to create a vibrant urban space that enhances not only cooling efficiency but also strengthens the social fabric of the neighbourhood.

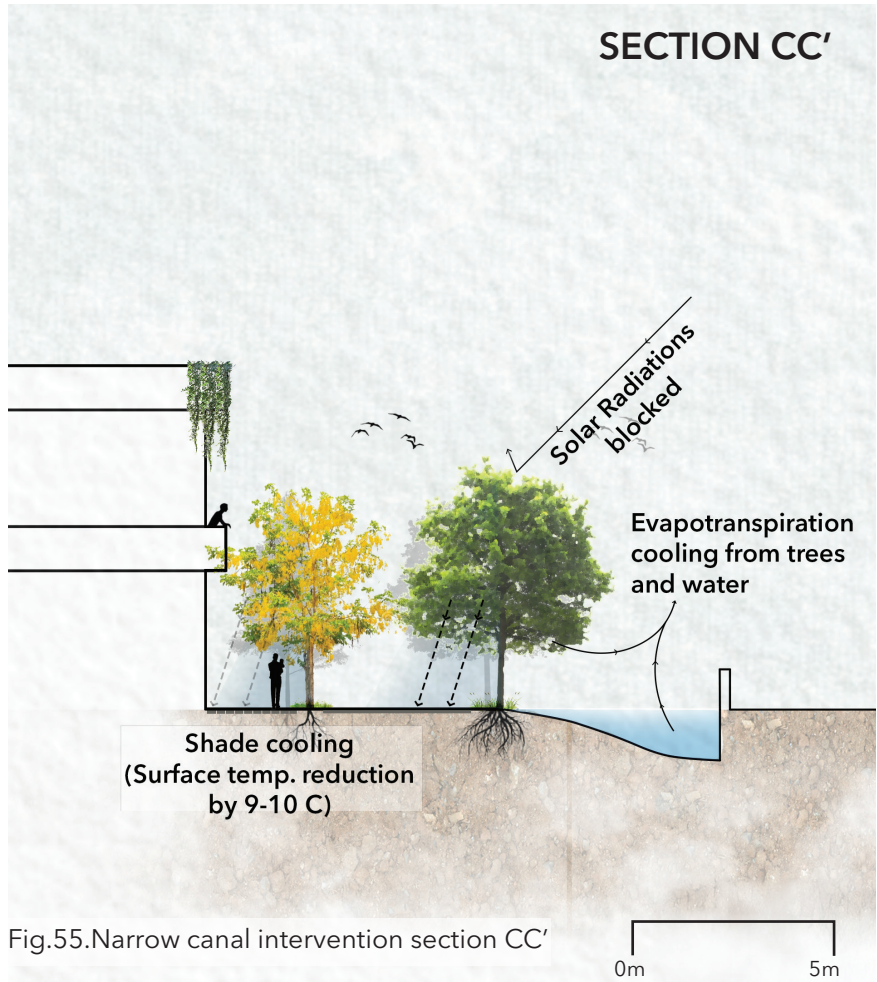


Fig.55.Narrow canal intervention section CC'

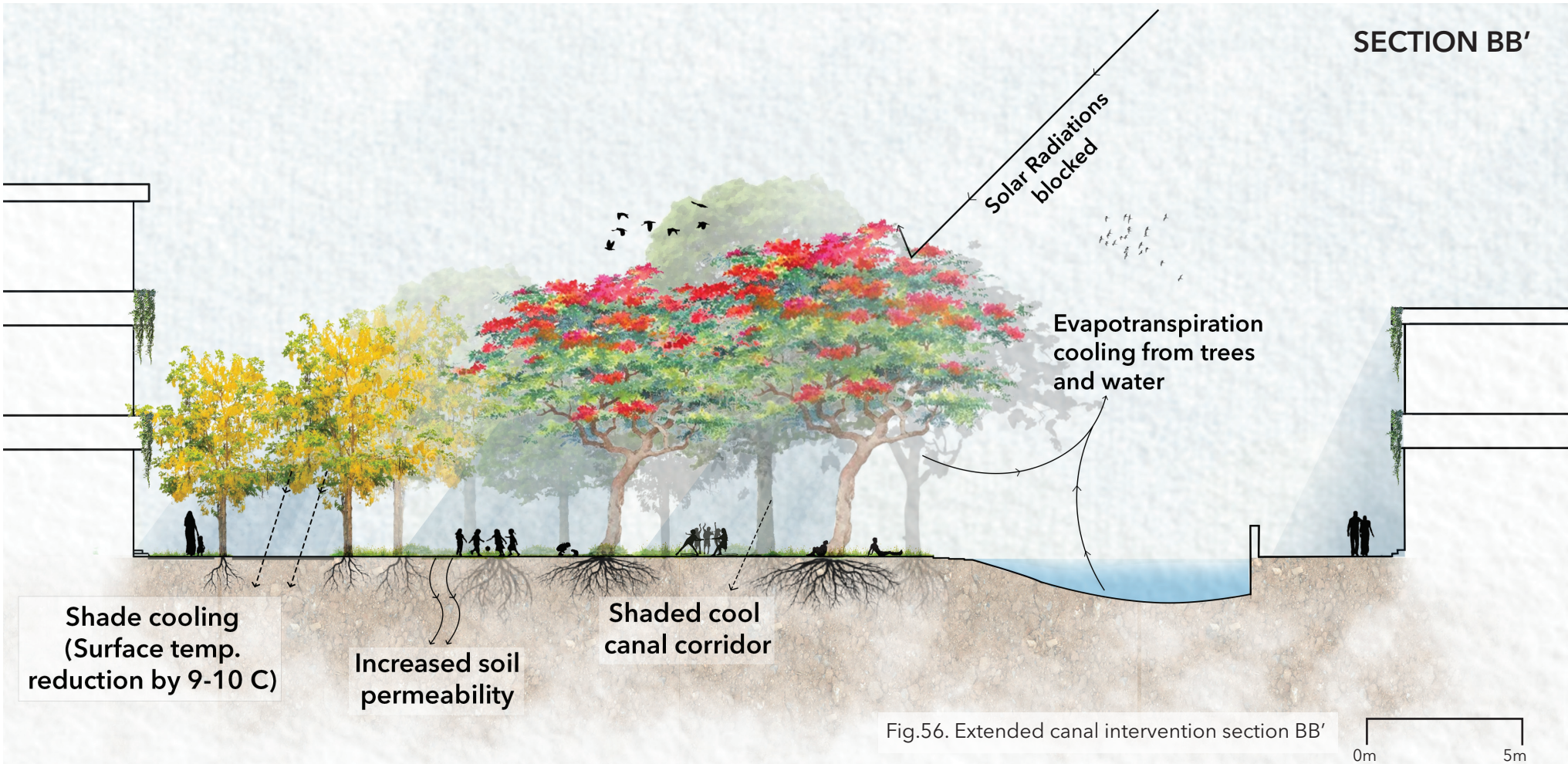
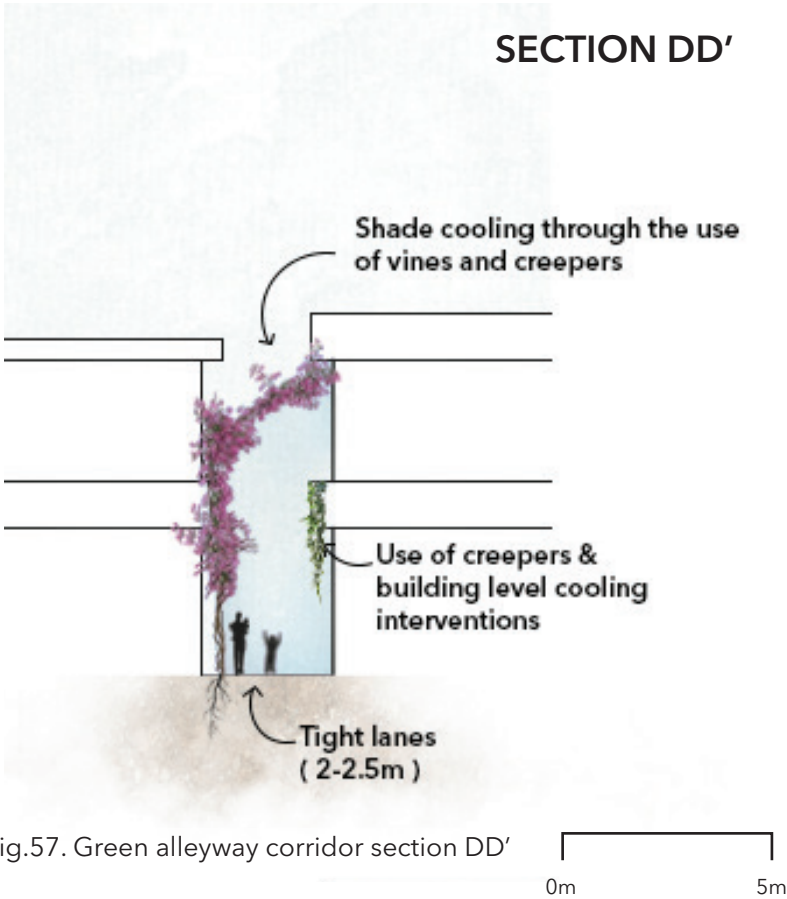


Fig.56. Extended canal intervention section BB'

3. GREEN ALLEYWAY CORRIDOR.



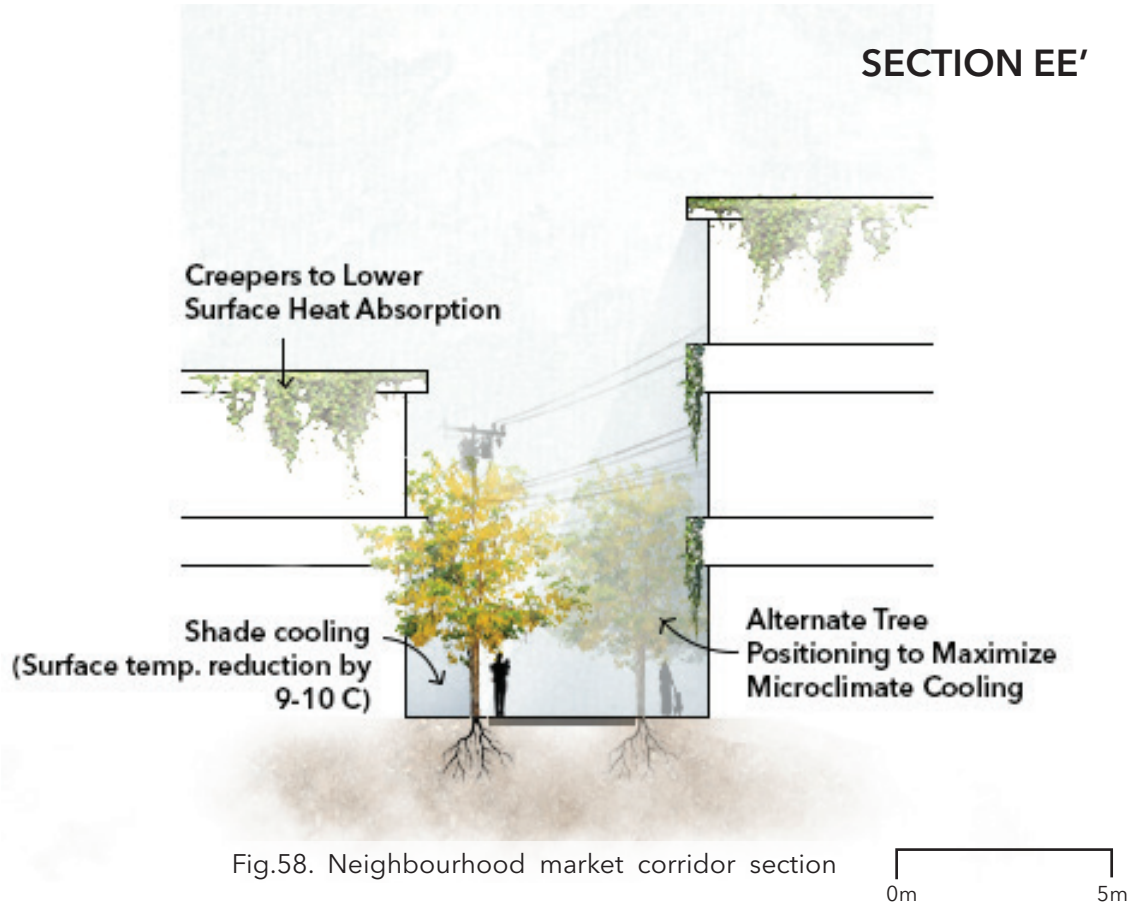
The narrow alleyways, spanning from 2-2.5 m in width, are proposed to be transformed into shaded green corridors within the neighbourhood. Due to restricted space availability for tree plantation, these lanes will be lined with bougainvillea-covered trellises, creating vibrant and cool pedestrian pathways. In such narrow alleyways, a series of passive cooling interventions at the building level are proposed. These initiatives will include cost-effective strategies such as white-coated rooftops, green roofs, and rooftop planters. Additionally, structural building elements such as recessed windows could be added to further reduce the surface area of the building exposed to the UV radiation and heat gain.



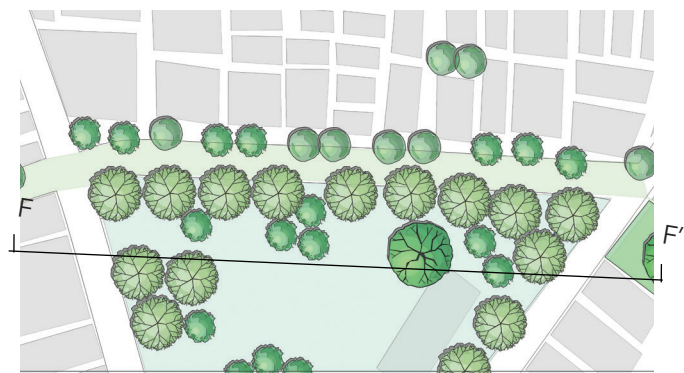
4. NEIGHBORHOOD MARKET CORRIDOR.



The Neighbourhood Market corridors, spanning 6.5-7.5 meters in width, are transformed into green buffers designed to mitigate heat in the urban microclimate. In this intervention, a mix of columnar and round-crowned tree species is introduced alongside the streets to reduce the heat gain from the road and enhance thermal comfort for both vendors as well as pedestrians. The planting layout includes the strategic staggered placement of trees to provide shade while maintaining spatial efficiency and ensuring enough room for street vendor activities. Wherever the spatial conditions permit (ex, Property setback, etc), double-lined tree planting may be introduced to create a continuous green canopy, enhancing natural cooling and improving the thermal comfort of the residents.



B. GREEN PATCHES



A strategically distributed matrix of green patches, including pocket and neighbourhood parks, is integrated throughout the neighbourhood based on the available plot sizes, cooling radii and thermal comfort. These patches will act as both thermal sinks and social nodes, creating small oases of comfort across the neighbourhood.

B.1. MOHALLA BAAGH (NEIGHBORHOOD PARK)

Spanning between 500 to 5000 square meters, these medium to large-sized mohalla baghs are spaced at approximately 125 meters, placed and designed to act as primary cooling hubs within the urban fabric of the neighbourhood. Each Mohalla baagh will incorporate layered vegetation starting from ground cover, shrub layer and then the trees. This layered planting strategy will not only create shaded cooling microclimates but will also help in increasing habitat biodiversity across the neighbourhood. These spaces will also increase community engagement by providing social infrastructure like shaded play areas, swings and open playgrounds for kids and adults.



B.2. BAGICHI (POCKET PARK)



Spanning between 60-300 square meters, these small Bagichii (pocket parks) are placed approximately 60 – 70 meters apart from each other. These small pockets will act as cooling bubbles within the neighbourhood and will serve as a bridge between the two bigger mohalla baaghs. For the planting strategy, the pocket parks are envisioned as two different iterations:

1st - the use of one large accent tree, such as a peepal or Bargad tree, along with a traditional chabutra. Creating space for people to gather and socialize. These Chabutras have long been a perfect spot for storytelling by elders as well as areas of high religious and spiritual activities. 2nd - planting strategy involves introducing a cluster of trees, such as Jamun trees, to create compact urban groves. These urban groves will enhance cooling through clustered canopy shade while also providing comfortable resting spaces. Once established, these models will be adapted and replicated across other underutilized or claimed spaces in the neighbourhood, expanding the cooling matrix and reinforcing the social-ecological cooling fabric of the area.

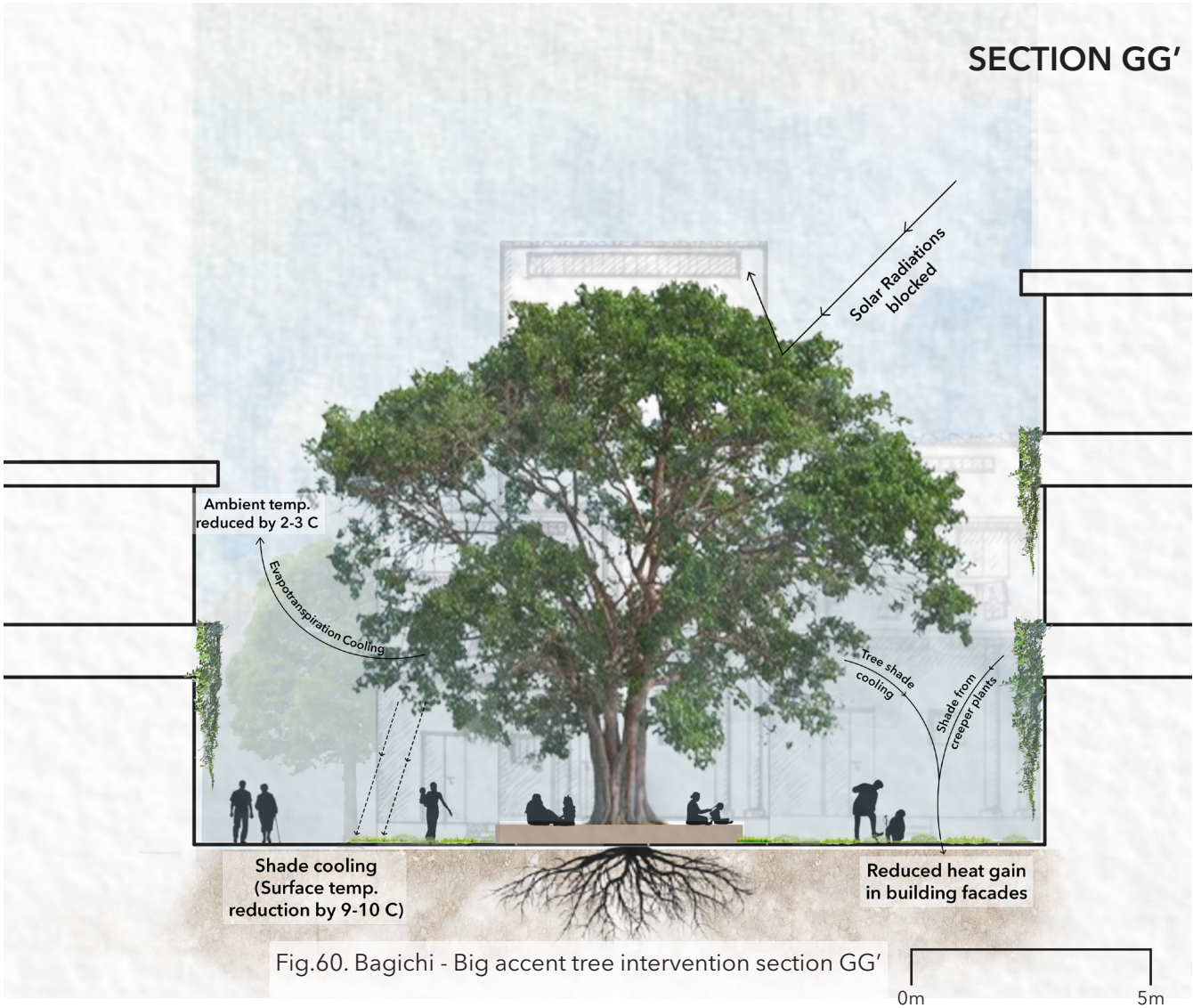


Fig.60. Bagichi - Big accent tree intervention section GG'

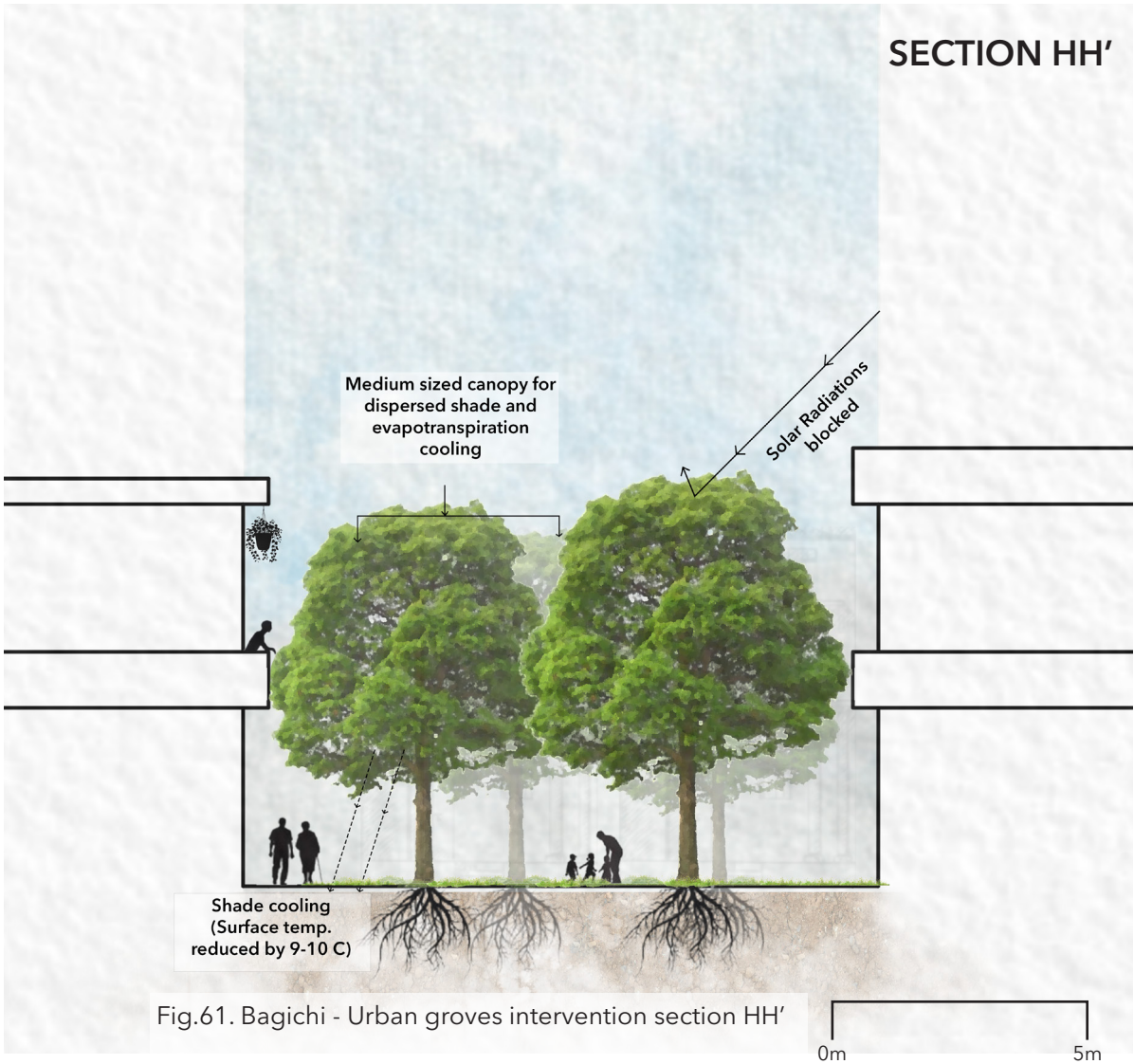


Fig.61. Bagichi - Urban groves intervention section HH'

PLANTING LIST

A. GRASSES AND GROUND COVER

Botanical and common name	Mature Height (m)	Mature Crown spread (m)	Notes
<i>Vetiveria zizanioides</i> (Vetiver Grass)	1-1.5	Clumping	Strong roots, soil stabilizer, drought-resistant,
<i>Cynodon dactylon</i> (Doob Grass)	0.1-0.3	Mat-forming	Native grass, low maintenance, perfect for pedetrain traffic in urban spaces.
<i>Typha angustifolia</i> (Cattail)	1-2	-	Perfect for biofiltration and in wetland and bank stabilization
<i>Chrysopogon zizanioides</i> (Khus Grass)	1-1.5	Clumping	Supports microvlimatic cooling, aromatic roots.

B. TREES

Botanical and common name	Mature Height (m)	Mature Crown spread (m)	Notes
<i>Terminalia arjuna</i> (Arjun Tree)	18-20	10-12	Native to canal edges and river zones.
<i>Ficus racemosa</i> (Goolar)	15-20	10-12	Native fig, attracts wildlife, suitable for urban cooling
<i>Delonix regia</i> (Gulmohar)	10-15	12	Provides dense shade, bears vibrant red colored flowers.
<i>Azadirachta indica</i> (Neem)	15-20	10	Medicinal tree, purifies air, and perfect for urban conditions

Botanical and common name	Mature Height (m)	Mature Crown spread (m)	Notes
<i>Cassia fistula</i> (Amaltas)	8-10	6-8	Low water need, seasonal color, tolerates harsh urban conditions
<i>Polyalthia longifolia</i> (Ashoka)	10-12	2-3	Tall and vertical form, perfect for narrow and tight lanes
<i>Ficus religiosa</i> (Peepal)	20	14-16	Sacred fig with spreading crown, massive shade tree, high rate of evapotranspiration.
<i>Ficus benghalensis</i> (Banyan)	20-25	20	Sacred tree, spreading crown, serves ecological and social functions
<i>Butea monosperma</i> (Palash)	10-12	8-10	Increases habitat biodiversity , produces flowers, create visual interest
<i>Morus alba</i> (Sahtoot)	8-10	6-8	Edible plant, child safe, increases biodiversity alongwith microclimate regulation
<i>Mangifera indica</i> (Mango)	12-15	10-12	Cultural tree, provides cooling via microclimate thermoregulation.
<i>Emblica officinalis</i> (Amla)	8-10	6-8	Medicinal edible tree, in-creases biodiversity.
<i>Syzygium cumini</i> (Jamun)	10-15	10	Native shade giving tree, drought resistant, edible fruit, attracts pollinators.

CONCLUDING REFLECTION

This thoroughly documented practicum demonstrates how a multi-scalar, landscape-based cooling framework can effectively reduce rising urban temperatures in a heat-vulnerable city like Delhi. However, it also explores the limits of this framework in this rapidly warming climate. By implementing the proposed cooling framework, the proposal can reduce the temperature by approximately 10-12°C in this heat-vulnerable city (reduction in temperature assumed based on various peer-reviewed studies and global precedents). While this practicum shows the transformative potential of landscape architecture in addressing the rising urban temperatures, it also outlines several key limitations, which are as follows:

Land ownership data gaps: The absence of publicly accessible land ownership data limits the precision of the proposed cooling interventions. Having access to this data would enable more spatially targeted and feasible implementation of the strategies.

Government adoption and policy integration: The success of the proposed framework depends heavily on its integration into the city's official planning departments and policies. Without strong political adoption, this framework will

remain only on paper and will never be put into action. It is essential to bridge the gap from policy on paper to policy in implementation

Proper zoning regulations: Effective zoning regulations are crucial to ensuring that green cooling strategies are integrated into new development rules and regulations. Green policy tools such as zoning incentives and mandatory green infrastructure development will amplify the added cooling impact of the framework.

Although the strength of this practicum lies in its bold, landscape-driven vision for urban cooling and heat mitigation, the above-mentioned limitations highlight the need for broader structural as well as collective action. Without government support, data transparency and zoning regulation, this cooling framework will fall short of its full cooling capacity.

Overall, the framework outlined here is not a final solution, but a compelling starting point towards urgent climate action.

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FIGURE OF LIST

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"The city is not a problem to be solved, but a context in which people live and adapt. Design for people, not for cars or technology."

– Jan Gehl, urbanist.